Encyclopedia of Football Medicine

Volume 2

Injury Diagnosis and Treatment

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Volume 2: Injury Diagnosis and Treatment

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Foreword

As modern football has progressed in recent years, the role of the team doctor has become ever more important to the success of its teams, not only in protecting the health and fitness of players, but also in providing a comprehensive and scientifically advanced medical support service. The role of the doctor now encompasses medical team planning and management, first aid techniques, injury prevention, health promotion, rehabilitation, and many more areas, meaning that the doctor is now one of the key positions in any successful football team.

As an organization, UEFA always seeks to further scientific research and to provide the best standards of medical care for players, and these books bring together some of the most eminent practitioners in all aspects of the now very specific domain of football medicine. All areas of the modern football doctor's toolkit are covered with advice on advanced treatment techniques, management of the medical team, and best practice in all areas of the doctor's role. UEFA's many years of work in football medicine and the extensive experience of the chapter authors make this an indispensable text for any doctor wishing to work in the field.

As we look toward the future and the further development and dissemination of football-specific medical expertise, I hope that this book will serve you well as a reference guide in a sport that is now so technically and scientifically advanced to be almost unrecognizable from the one within which I started my career.

I hope that you will enjoy this book and the book series.

Michel D'Hooghe, MD
Bruges, Belgium

Preface

The second volume of the *Encyclopaedia of Football Medicine*, entitled *Injury Diagnosis and Treatment*, regroups the most common football injuries while explaining their diagnosis and specific treatments. The content of this second volume was initially developed as the course manual of the second workshop of the UEFA Football Doctor Education Programme, which took place in Amsterdam in 2013. This book explores a variety of treatment methods for each injury, which is highly important for orthopaedics working in the field of football medicine.

Football is the most popular sport in the world, with more than 270 million people playing the game.[1] However, injuries in football remain a major issue, especially given how much is at stake in the game.[2,3] Awareness of injuries has increased over the years, and both UEFA and FIFA are concerned about the risk of injury and injury patterns in football, especially when it comes to the increasing numbers of hamstring injuries.[4,5] It was therefore essential for UEFA to develop this volume and the workshop to instruct football doctors on injury prevention and the good handling of them.

Prof. Jan Ekstrand was contracted by UEFA to run and develop this workshop with his working group consisting of Profs. Markus Waldén, Jón Karlsson, Peter Ueblacker, and Per Hölmich. Each expert developed a chapter focusing on the four most common types of injury in football (namely, ankle injuries, knee injuries, hip/groin injuries, and muscle injuries). These injuries are presented in detail along with key issues and solutions.

This manual introduces football doctors to a number of issues relating to injuries, with information supported by reliable scientific evidence from relevant football injury studies. The book starts with an overview of football injuries, depicting some of the crucial data of the UEFA Elite Club Injury Study. It then moves on to specific ways of managing injuries in competitive situations while describing the laws of the game. To understand the rest of the book, the third chapter explains the muscle epidemiology and injury mechanisms in football. It is then followed by specific examination and treatment of muscle injuries, groin injuries, knee injuries, ankle injuries, and overuse injuries.

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Chapter 1

Overview of Football Injuries

Jan Ekstrand

1

1.1 Introduction

The risk of injury for athletes participating in professional football is substantial. It has been estimated that the overall risk is about 1,000 times higher than for typical industrial occupations generally regarded as high-risk.[1] This makes the understanding of injury a critical aspect of the sport and an essential part of the toolkit of those responsible for the health and fitness of players.

Statistics show that a professional football team of 28 players can expect about 50 injuries that are serious enough to keep players out of trainings and matches in the course of a season (known as “time loss”), meaning an average of 1.8 injuries per player per season.[2,3] On average, 12% of the squad is unavailable owing to injury at any given point during the season, which makes the impact of injuries on a team’s performance quite considerable. Teams that are able to avoid or minimize injuries have been proven to have a greater chance of success in terms of their final league position than those that manage injuries less effectively.[4,5,6]

This manual introduces football doctors to a number of issues relating to injuries, with information supported by reliable scientific evidence from relevant football injury studies. Four of the most common types of injury in football (namely, ankle injuries, knee injuries, hip/groin injuries, and muscle injuries) are presented in detail, along with the following key issues:

- Which injuries a team doctor might experience in football, and which of these are the most common and pose the greatest risk to players.
- Why these injuries happen.
- How often they happen (in matches or in training, when during the season, etc.).
- How a team doctor can best manage these injuries (e.g., diagnosis, examination, and treatment).

1.2 The Value of Statistics to the Team and the Team Doctor

Injuries and players’ fitness are one of the most important areas in football—a sport where analysis of evidence-based statistics has only relatively recently been accepted as an important part of a team’s performance. The aim of the doctor, as the key authority on injuries within the team’s management structure, should be to use injury statistics to inform and support decisions, and to ensure, crucially, that team decisions are based on reliable scientific evidence wherever it is available. This is particularly important with regard to “return-to-play” decisions (decisions concerning a players’ fitness to return to football participation), where the doctor will regularly be questioned about injuries by the player, the coach, the club manager, the media, agents, and so on. The question “When can he/she play again?” is one that the team doctor should always be able to answer in an informed manner.

To ensure the validity of all instructions provided by this manual, reference is regularly made to the findings of the UEFA Elite Club Injury Study, formerly known as the UEFA Champions League Injury Study. This is a detailed longitudinal study of over 15 years’ duration documenting the types of injury incurred by teams participating in the UEFA Champions League, UEFA EURO final tournaments, and the final rounds of UEFA’s youth competitions, as well as the frequency of such injuries. The UEFA Elite Club Injury Study is the primary source of evidence-based data on injuries in football, and knowing its main findings can help doctors with numerous issues, such as the following:

- How often specific injuries occur.
- The mechanisms underlying those injuries.
- When players can return to training and matches after specific injuries.
- The risk of problems recurring.

Data from the UEFA Elite Club Injury Study is used in this manual to demonstrate numerous key points, such as the categorization, risk, and prevalence of injuries. The overall aim is to provide football doctors with a wide range of scientifically evaluated statistics and evidence-based examples to support their planning processes, daily activities, and decision-making. Such statistics offer vital insight into how injury affects both the individual player’s ability to take to the field and the team as a whole. This, in turn, allows doctors to both predict the likely prevalence of injuries and prepare their operations in advance with a view to managing likely injury situations effectively (**Fig. 1.1**).

1.3 What Is the Risk of Sustaining an Injury?

According to the FIFA and UEFA consensus on definitions and data collection procedures for studies of

Fig. 1.1 The majority of injuries occur in contact situations.

football injuries, a player is considered to be injured until medical staff allow full participation in training and the player is available for match selection.[7,8] The risk of injury cannot be evaluated simply by calculating the number of injuries incurred or the percentage of players who are injured. Instead, it is measured using a variable known as "exposure." Exposure is best defined as the frequency of participation in matches and training—essentially, a player's exposure to the risk of injury.

Usually, injury risk is expressed as the number of injuries per 1,000 hours of exposure. The total number of injuries is not very meaningful, so injury risk needs, instead, to be separated into the risk of injury during matches and the risk of injury during training. This is because the injury risk during matches is usually much higher than the risk from training, so if such a distinction were not made, a difference in total injury risk could simply be due to the fact that players participated in more matches than training sessions.

Table 1.1 compares the different levels of exposure for various groups of players, using data from the UEFA Elite Club Injury Study with similar studies on players in Sweden and Scandinavia. We can see that exposure to football increases as we approach the elite level owing to the increased frequency of training, increased attendance at training, and increases in the number of matches played.

As is clearly demonstrated, the number of matches played is substantially higher for Champions League teams than it is for Scandinavian top division teams, with some Champions League teams having more than 70 fixtures in a season. However, the number of matches played by the individual players at Champions League clubs is much lower, at around 30 matches per season, as these teams usually have large squads and will rotate their players to keep them fit and avoid "overmatching."

Given that many of the Champions League teams' matches are played abroad, involving longer journey times, the number of possible training sessions is lower, so the training-to-match ratio is lower for Champions League teams than it is for national leagues (at least in Scandinavia). Attendance rates at training average around 80% at professional and semiprofessional levels (bearing in mind that training is a mandatory part of the player's work), while they are, perhaps understandably, substantially lower at amateur level.

1.4 What Does This Reveal about Injury Risk at Different Levels of the Game?

Statistics indicate that injury rates during training are similar at professional and amateur level, with around three to five injuries per 1,000 training hours. Only at EURO final tournaments is the risk lower, probably because more training sessions are devoted to recovery (with a lower injury risk) on account of the intensive match schedule.

As suggested above (**Fig. 1.2**), the risk of suffering an injury during a match increases with the level of football. At Champions League, EURO, and national team level, there is an average of 25 to 30 injuries per 1,000 match hours, whereas the injury rate for amateurs averages less than half that amount (**Fig. 1.3**).

The injury risk during matches can be dependent on various factors, such as a player's age and the competition schedule. Both variables are shown in **Fig. 1.4**, which shows how injury risk increases with age, from men's Under-17 final tournaments through to EURO final tournaments. This finding probably reflects the increasing speed and intensity of play at elite level and players' increased weight as they get older (with the mean weight of senior players at EURO tournaments standing at 80 kg, compared

Table 1.1

Football activities over a one-year period (values expressed as means, maximum values in brackets).

	UEFA Champions League	National top division	Semiprofessionals	Amateurs (fourth division)	Amateurs (sixth division)
		Scandinavia	Sweden	Sweden	Sweden
No. of training sessions per team	217 (293)	233 (276)	129	85	65
No. of matches per team	59 (75)	43 (53)	37	34	34
No. of training sessions per match	3.6	4.9	4	2.7	2
Training attendance (%)	81 (94)	84	81	66	60
No. of hours of training per player	195 (406)	260 (380)	153	78	54
No. of matches per player per season	31 (75)	27 (60)	–	–	–

Notes: UEFA Champions League = 2001–2002 to 2013–2014 seasons; National top division = top divisions in Sweden and Norway (2010 and 2011 seasons); Semiprofessionals = second highest division in Sweden (1982 season); Amateurs (fourth division in Sweden) = amateur level (2003 season); Amateurs (sixth division in Sweden) = low amateur level (1982 season).

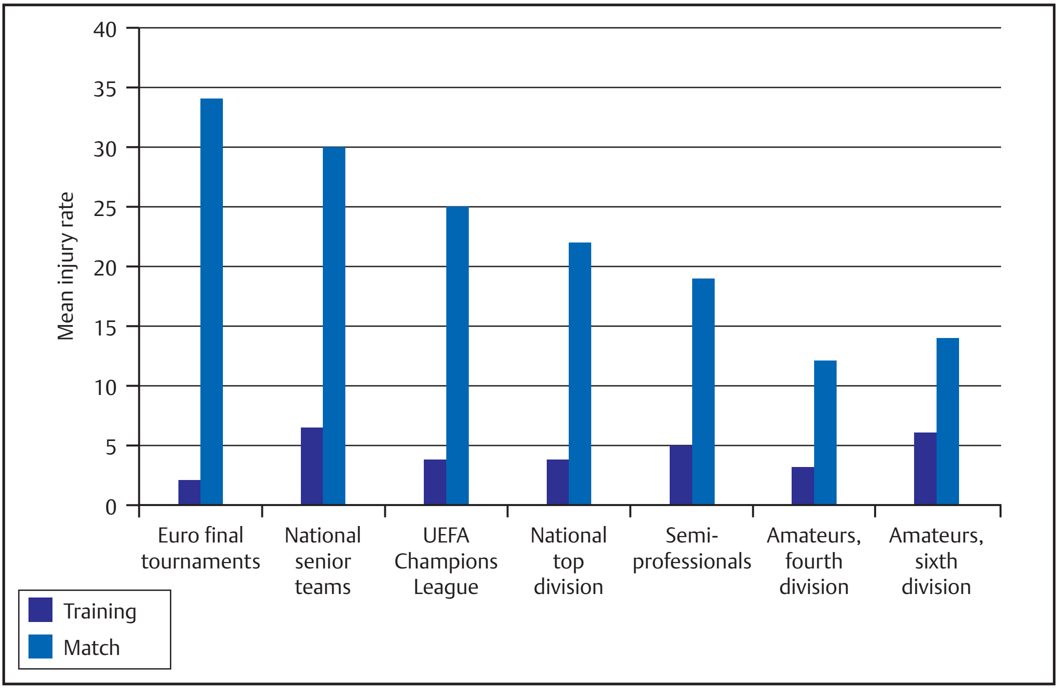


Fig. 1.2 Injury rates at different levels of men's football (values expressed as means).
Notes: UEFA Champions League = 2001–2002 to 2013–2014 seasons; National top division = top divisions in Sweden and Norway (2010 and 2011 seasons); Semiprofessionals = second highest division in Sweden (1982 season); Amateurs, fourth division in Sweden = amateur level (2003 season); Amateurs, sixth division in Sweden = low amateur level (1982 season).

with 79, 76, and 73 kg for Under-21, Under-19, and Under-17 players, respectively). The majority of injuries occur in contact situations, where the forces created depend on the weight and speed of the players involved.

Match play injury The risk of injury during matches at UEFA's men's youth final tournaments (i.e., those at Under-21, Under-19, and Under-17 levels) is similar to that faced by elite club teams participating in the UEFA Champions League between 2001–2002 and 2013–2014. However, the risk appears to increase for matches at senior EURO final tournaments.

Total injury risk The total injury risk is higher for players participating in EURO final tournaments than for players participating in the Champions League. However, the injury rate during training is lower during tournaments—probably again reflecting the high percentage of low-risk recovery training sessions during tournaments.

1.5 Has the Risk of Injury Increased or Decreased in Recent Years?

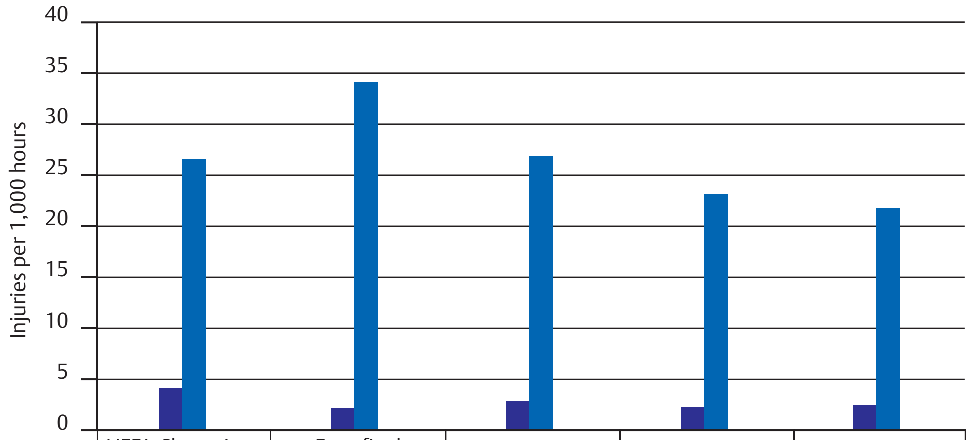
The ligament injury rate in European male professional football has decreased by about 30% between 2001–2002 and 2011–2012.[3,9,10] One possible explanation for this could be the implementation of

Fig. 1.3 Injury risk increases with age.

intensive treatment and rehabilitation strategies by teams, to complement more established preventive methods, such as proprioceptive training and bracing/taping (**Fig. 1.5**).[3]

Total injury rates for training and matches have remained high over the last decade, as have rates for both muscle injury and severe injury (**Fig. 1.6**).

Preventive actions targeting player-related risk factors may be insufficient for professional players, with the possible exception of ligament injuries. External risk factors, such as training load, playing style, and continuity of club medical and technical staff, should be considered in injury prevention, and should be investigated further.[3]



	UEFA Champions League	Euro final tournaments	Under 21	Under 19	Under 17
Training	4.1	2.2	2.9	2.3	2.5
Match	26.6	34.1	26.9	23.1	21.8

Fig. 1.4 Injury rates for various club and national team competitions (values expressed as means).
Notes: EUROs = EURO 2004, EURO 2008, and EURO 2012; UEFA Champions League = 2001–2002 to 2013–2014 seasons; Under-21s = final rounds of UEFA European Under-21 Championship between 2006 and 2011; Under-19s = final rounds of UEFA European Under-19 Championship between 2005 and 2010; Under-17s = final rounds of UEFA European Under-17 Championship between 2006 and 2011.

1.6 How Are Injuries Distributed over the Football Season?

Fig. 1.7 shows the distribution of traumatic and overuse injuries over the season for clubs participating in the UEFA Champions League. Traumatic injuries (i.e., injuries with a sudden onset and a known cause) are more common during the competitive season, while overuse injuries (i.e., injuries with a slow onset and no known traumatic cause) are most common during the preseason preparation period in July.

1.7 When Do Injuries Most Commonly Occur during Matches?

The incidence of traumatic match injuries tends to increase over time in both the first and the second halves, as **Fig. 1.8** demonstrates. Thus, the longer a player participates in the match, the greater the risk that he/she will incur a traumatic injury, particularly toward the end of the first half (**Fig. 1.9a** and **Fig. 1.9b**).

1.8 Which Types of Injury Are Most Common in Football?

Fig. 1.10 shows the most common locations for injuries. On average, 85 to 90% of all injuries are to the lower extremities, with the most common among male elite players being injuries to the thigh (25%), knee (18%), hip/groin (14%), and ankle (14%).

Fig. 1.5 External risk factors should be considered in injury prevention.

The majority (70%) of injuries are due to trauma, but almost one-third (30%) of injuries are due to overuse. Overuse injuries typically affect the hamstrings, groin, knee, and lower leg.

As can be seen in **Fig. 1.11**, muscle and tendon injuries are most common among elite players, accounting for almost half of all injuries (i.e., traumatic and overuse injuries combined). Concussions and lacerations/skin injuries are rare at elite level, with each making up just 0.8% of all injuries.

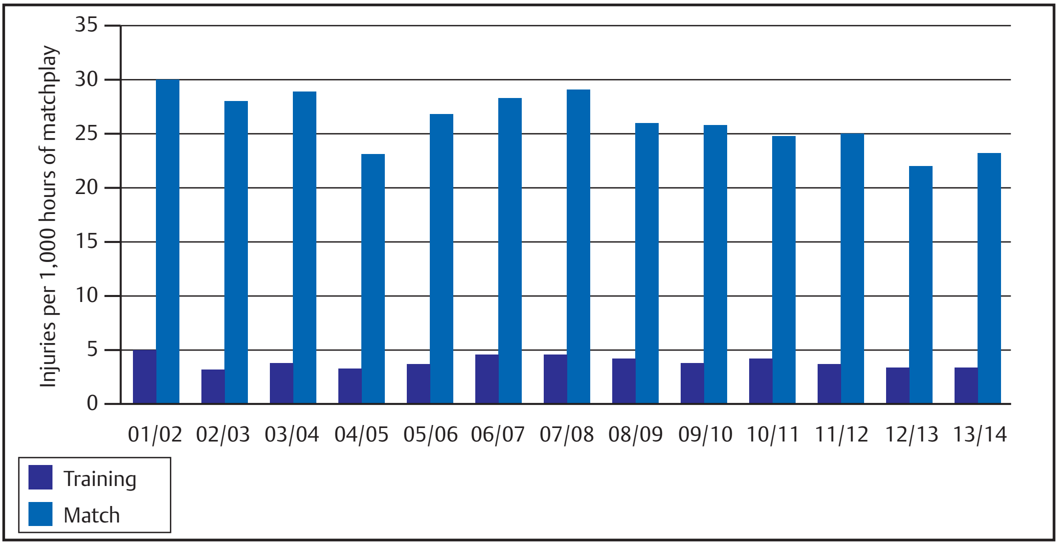


Fig. 1.6 Injury rates per season for UEFA Champions League teams.

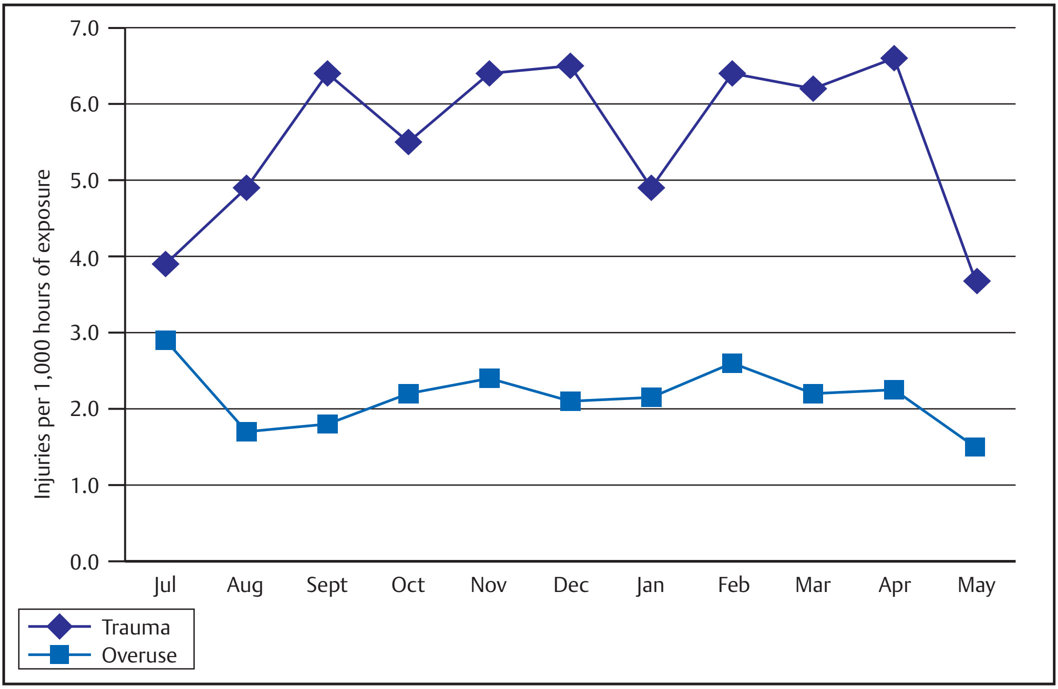


Fig. 1.7 Distribution of traumatic and overuse injuries over an autumn–spring season.

1.9 Returning to Play after an Injury

After an injury, medical staff are commonly approached by coaches, managers, and members of the media asking the typical question: "When can he/she play again?" This can be an extremely difficult situation to manage and great care should be taken by the doctor when making any estimates. Descriptive statistics in the UEFA Elite Club Injury Study provide some assistance, supplying mean and median periods of absence (as well as possible ranges) for common subtypes of injury.

Table 1.2 shows the 10 most common injury subtypes, their prevalence (expressed as a percentage of all injuries), the injury rate per 1,000 hours, and how many absences a doctor can expect in any given season. The table is based on 8,000 injuries incurred by Champions League teams between 2001–2002 and

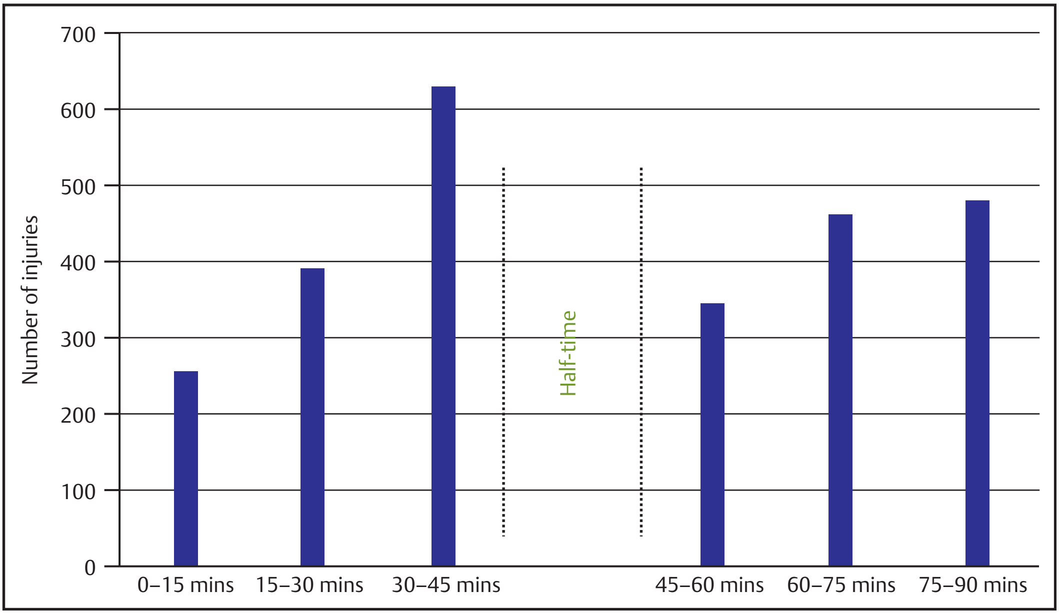


Fig. 1.8 Distribution of traumatic injuries during matches (UEFA Champions League; 2001/02 to 2011/12 seasons).

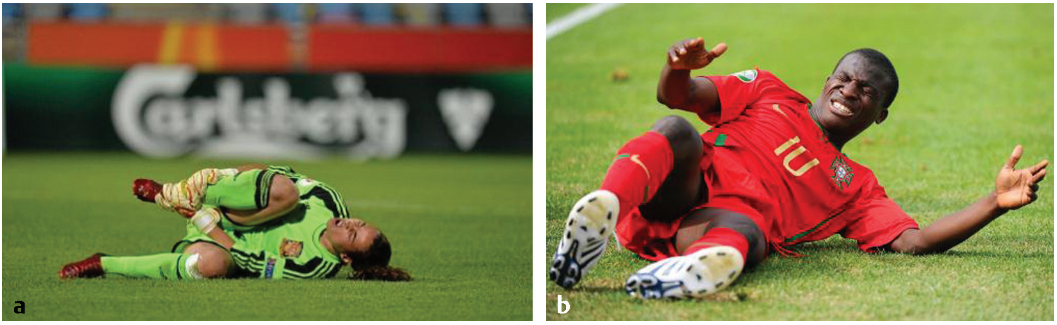


Fig. 1.9 **(a, b)** The longer a player participates in the match, the greater the risk of traumatic injury.

2011–2012. Absences are also expressed as the mean ± standard deviation. As the large standard deviations show, there is considerable variation in the number of days of absence for each injury. This is caused by outliers, as some players will be absent for an extremely long time (owing to surgery or complications, for example), while others will have very short absences. As a result, the mean is probably not the ideal figure for a doctor to use when trying to predict the period of absence after a specific injury.

In fact, the median absence in days is probably the most useful value when it comes to answering questions related to a player's expected absence. As the median is the numerical value separating the higher half of data from the lower, it is the most likely period of absence for the particular injury.

Table 1.2 covers more than 50% of all the injuries that a team doctor will see in the course of a season. Detailed recommendations regarding the diagnosis and treatment of the six most common injuries are presented in specific chapters of this manual. **Table 1.3** shows equivalent data for more severe injuries.

1.10 Which Injuries Have the Highest Risk of Recurrence?

The early recurrence of an injury is defined as an injury of the same type in the same location as the "index injury" (i.e., the original or first injury) which occurs no more than 2 months after the player's return to full participation following the index injury.[7] On the basis of this definition, an average of 12% of all injuries are reinjuries. The reinjury rate ranges from 7 to 21% across the various European leagues. However, in general, periods of absence caused by reinjuries are around 30% longer than those caused by index injuries. In general, overuse

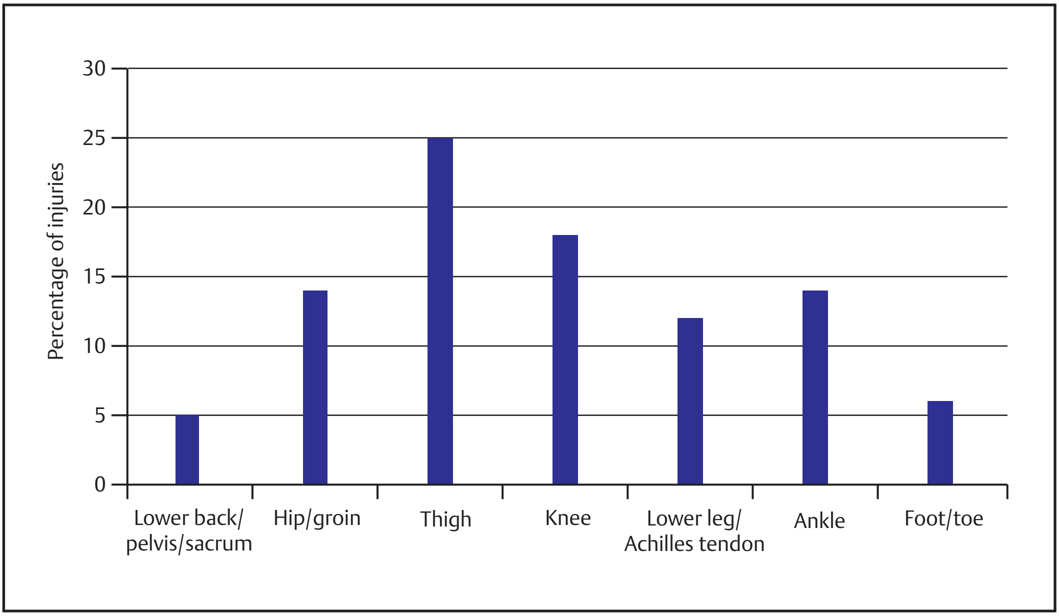


Fig. 1.10 The most common locations for injuries (UEFA Champions League; 2001–2002 to 2013–2014 seasons).

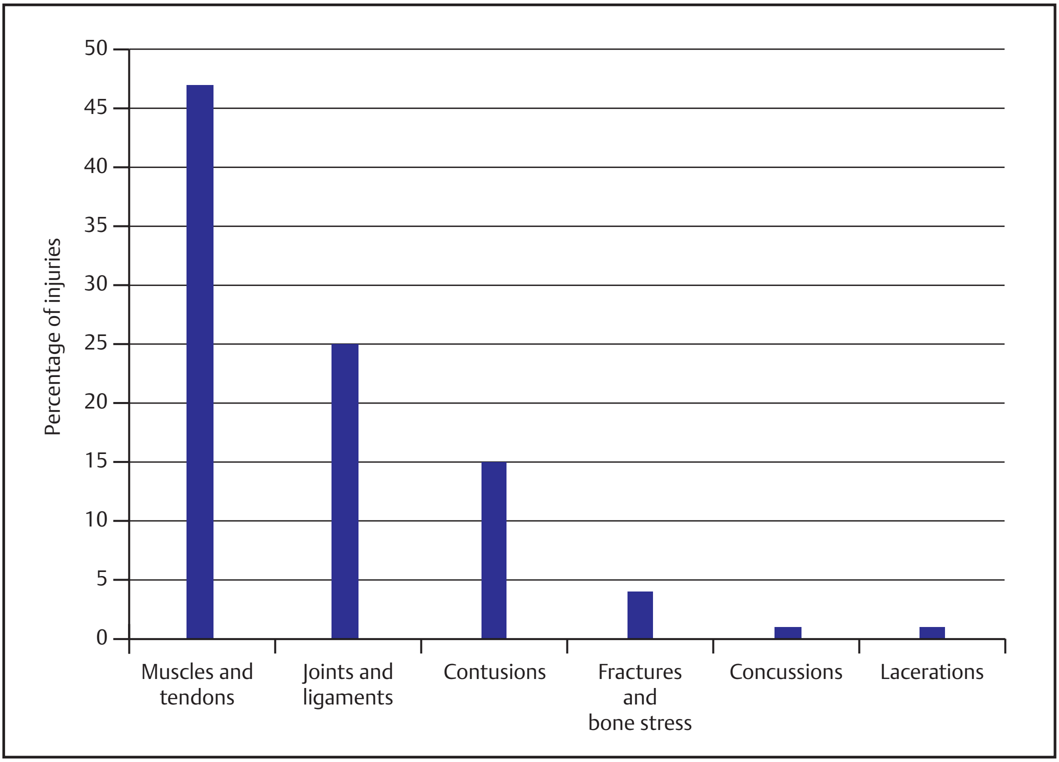


Fig. 1.11 The most common types of injury (UEFA Champions League; 2001–2002 to 2013–2014 seasons).

Table 1.2

Statistics on the ten most common injuries in elite European football

	Diagnosis	Injuries per team per season	Absence in days (median)	Absence in days (mean ± SD)	Absence in days (maximum)
1	Hamstring muscle injury	6–7	14	19±18	180
2	Adductor injury	4–5	9	15±19	196
3	Ankle sprain (lateral)	3–4	8	15±19	164
4	Quadriceps muscle injury	2–3	14	21±22	156
5	Calf muscle injury	2–3	15	19±16	95
6	Knee sprain (MCL)	2	16	23±23	202
7	Knee contusion	1–2	5	6±4	55
8	Thigh contusion	2–3	4	7±9	93
9	Achilles tendinopathy	1	10	23±37	205
10	Lumbalgia/lower back pain	1	5	10±19	168
	Total	24–31			

Abbreviations: MCL, medial collateral ligament; SD, standard deviation.

Table 1.3

Severe injuries as a percentage of total injuries and periods of absence

	Diagnosis	% of all injuries[a]	Absence in days (median)	Absence in days (mean ± SD)	Absence in days (max.)
1	Ruptured ACL	0.8	194	194±75	580
2	Ruptured Achilles tendon	0.1	169	161±65	274
3	Fractured tibia and fibula	0.1	124	131±32	167
4	Fractured MT 5	0.5	78	80±17	213
5	Fractured ankle	0.2	87	90±52	200
6	Lateral meniscus injury	0.9	43	57±48	210
7	Medial meniscus injury	0.6	35	47±37	193

Abbreviations: ACL, anterior cruciate ligament; MT5, fifth metatarsal; SD, standard deviations.
Note: [a]A figure of 1% would mean 0.7 injuries per team per season, so a team could expect to incur this injury around once a season on average.

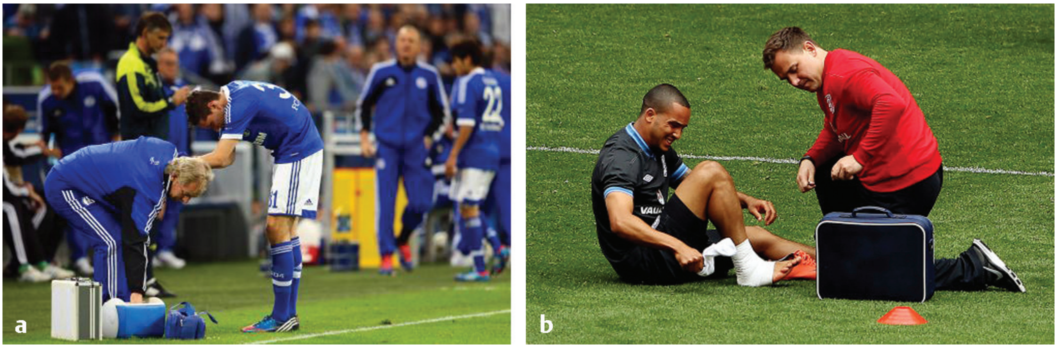


Fig. 1.12 **(a, b)** In general, overuse injuries recur more than traumatic injuries.

injuries recur more than traumatic injuries (**Fig. 1.12a** and **Fig. 1.12b**).

Table 1.4 shows several common recurrent overuse injuries.

1.11 Foul-Play Injuries

Around 20% of match injuries are due to fouls, with the majority being the result of a foul by an opponent, rather than a self-inflicted injury (**Fig. 1.13a** and **Fig. 1.13b**).[2] The most common foul-related injuries are ankle sprains (15%), knee sprains (9%), and thigh contusions (10%). Foul-related injuries are evenly distributed between the two halves of the match.[2]

Table 1.4

Statistics on common recurrent overuse injuries

	Diagnosis	% of all injuries	Absence in days (median)	Absence in days (mean ± SD)	Reinjury rate
1	Groin pain	8–12	9	15±19	29
2	Lower back pain	2	5	10±19	22
3	Achilles tendinopathy	2	10	23±37	34
4	Shin splints	1–2	4	8±10	31
5	Patellar tendinopathy	1.5	7	18±34	26
6	Plantar fasciitis	1	4	16±25	34
7	Stress fractures	0.5	80	90–130±40–90	29

Abbreviation: SD, standard deviation.

Fig. 1.13 (a, b) The majority of injuries are the result of a foul by an opponent, rather than a self-inflicted injury.

1.12 Noncontact Match Injuries

Match injuries resulting from player-to-player contact have declined over the last three UEFA EUROs (i.e., the final tournaments in 2004, 2008, and 2012), while noncontact match injuries have been on the increase. The same tendency has been seen at club level in the UEFA Champions League. Noncontact injuries have increased significantly over the review period as a percentage of all injuries in the UEFA Elite Club Injury Study, rising from 58% in the 2004–2005 season to 64% in the 2010–2011 season.[3]

1.13 Differences in Injury Risk across Europe

Waldén et al (2013)[11] studied the influence of the type of climate on the epidemiology of injuries in men's professional football in Europe. They reported that teams located in northern Europe, which has milder summers and cooler winters (i.e., teams from England, Scotland, Germany, Holland, Belgium, northern France, and northern Italy), had a higher injury rate, in general, than teams from southern Europe, which has a Mediterranean climate (i.e., teams from Spain, Portugal, and central/southern Italy). The types of injury that this applied to included both traumatic and overuse injuries.

There may be several factors contributing to this trend. One possible explanation could be climate-related differences, with harder pitches expected to result in greater ground reaction forces and increased loading of tissues. However, differences in training and numbers of matches could be just as important.[9]

However, for anterior cruciate ligament (ACL) injuries, particularly noncontact injuries, injury rates were significantly higher for teams training and competing in a Mediterranean climate. The authors suggest that one reason for the higher risk of ACL injuries in Mediterranean countries could be boots' greater traction on the ground as a result of the warmer climate.

1.14 Injuries and Playing on Artificial Turf

The older generations of artificial turf were seen to have disadvantages not only in terms of the distortion of play as a result of the unusual bounce and roll of the ball, but also with regard to injury risk, which was higher than for grass, particularly with regard to burns and skin injuries.[2,12] However, newer generations of artificial turf are increasingly being used within European football, and these offer football-specific features similar to those found in well-maintained natural turf pitches. Nevertheless, despite the widespread use of artificial football pitches by nonelite players and the formal recognition by FIFA in 2004 that they represent a suitable playing surface at elite level, acceptance by elite teams remains limited.

Differences in injury risks and injury patterns by comparison with natural grass have been studied for male and female elite players,[12,14] amateurs,[15] youth football,[16] and tournaments.[17] These studies found that there were no major differences between the two surfaces in terms of the overall injury risk, neither in training nor in matches, neither in men's nor in women's football, and neither at adult elite level nor at amateur youth level. This is certainly of interest in terms of the frequency of injuries. However, the studies suggest that there may still be differences in the pattern of the injuries sustained. These include indications of a lower risk of muscle injuries when playing on the new generation of artificial pitches compared with natural grass, as well as a higher risk of ankle ligament injuries.

1.15 Does Winning or Losing Affect Injury Risk?

It has been reported that the injury rate increases when matches are lost.[5,18] However, it is unclear whether sustaining injuries influences the final result of the match or if the result of the match influences the injury rate. Possible explanations for this could include the following:[19,20]

- *Injuries could reduce the overall ability of the team*
  The best available team will usually be selected to play. The team will therefore be weakened if a player is injured.
- *Injuries could have an indirect impact on the result through a team's game plan*
  The team's tactics will be planned on the basis of the starting 11. If anyone in the starting 11 gets injured and has to be substituted, the game plan will be disrupted.
- *The result could influence the injury profile*
  It may be that the result itself leads to an increase in the risk of injury, with players who are losing taking greater risks. It may also be that the risk of injury increases on account of the negative mental impact of the result. Players could also be more inclined to leave the field owing to injury if they are losing, rather than winning (**Fig. 1.14**).

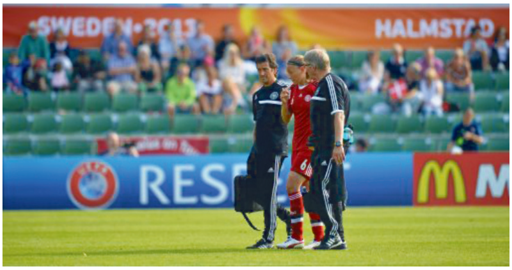


Fig. 1.14 Players could also be more inclined to leave the field owing to injury if they are losing, rather than winning.

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Chapter 2

Managing Injuries in Competitive Situations: The Laws of the Game

Jan Ekstrand

2.1 Introduction

A football doctor must have a good knowledge of the Laws of the Game in order to avoid situations that may compromise treatment or bring the team's medical staff into conflict with match officials. Examining and treating an injury is a much more complicated task when a match has been halted and players, officials, and spectators are waiting on the actions of the doctor. Rules on treatment are designed with a view to providing optimal medical care and also to take account of the need to resume the match as quickly as possible, with the minimum disruption to play.

The Laws of the Game are drawn up and maintained by the International Football Association Board (IFAB) and are published by Fédération Internationale de Football Association (FIFA). The IFAB was formed in 1886 and comprises the four United Kingdom associations—the football associations of England, Scotland, Wales and Northern Ireland—and FIFA. The IFAB meets at least once a year to debate and decide on any changes to the rules of the game. Although such changes are rare, in recent years the rules have been interpreted more strictly with the aim, in particular, of preventing injury. The 2014–2015 edition of the Laws of the Game (together with notes on the interpretation of the laws and guidelines for referees) can be found at http://www.fifa.com/worldfootball/lawsofthegame/index.html.

This chapter outlines the key rules in football that relate to the management of injuries in competitive situations. These are all essential for the football doctor to understand, particularly when quick decision-making by the doctor and match officials can be the difference between life and death for a player.

2.2 Rules and Regulations

The rules cited in the following sections are direct quotations from the 2014–2015 edition of the Laws of the Game.

2.2.1 Law 1—The Field of Play

Field Surface

"Matches may be played on natural or artificial surfaces, according to the rules of the competition."

"Where artificial surfaces are used in […] competition matches […], the surface must meet the requirements of the FIFA Quality Concept for Football Turf or the International Artificial Turf Standard, unless special dispensation is given by FIFA."

Safety

"Goals must be anchored securely to the ground. Portable goals may only be used if they satisfy this requirement."

Note that the referee will check the pitch and goals before the match. The goals must be constructed in such a way that players cannot injure themselves as a result of the goals being badly constructed or insufficiently anchored in the ground.

Commercial Advertising

"Advertising on the ground shall be at least 1 m (1 yd) from the boundary lines of the field of play."

There are also rules determining how close photographers behind the goal may be. The aim here is to prevent injuries if a player unintentionally ends up off the pitch.

2.2.2 Law 2—The Ball

Law 2 governs the dimensions and weight of the ball. Here, the emphasis is on the fact that no part of the ball should be a danger to the players.

2.2.3 Law 4—The Players' Equipment

Safety

"A player must not use equipment or wear anything that is dangerous to himself or another player (including any kind of jewellery [sic])."

Basic Equipment

The basic compulsory equipment for players comprises several items—including some that are for the players' protection, such as shin guards and footwear.

Nowadays, the use of shin guards is obligatory in all football matches. Law 4 states that shin guards should be *"covered entirely by the stockings,"* should be *"made of rubber, plastic or a similar suitable material,"* and should *"provide a reasonable degree of protection."*

The referee should check players' boots and other equipment before the match. The rules no longer determine what size the studs on boots should be and it is the referee who has the final say on whether someone can play (**Fig. 2.1a** and **Fig. 2.1b**). The referee will base his decision on whether the player's studs pose a *"danger to him or any other player."*

"In the event of any infringement of this Law […] the player at fault is instructed by the referee to leave the field of play to correct his equipment. Any player required to leave the field of play to correct his equipment must not re-enter without the referee's permission. The referee checks that the player's equipment is correct before allowing him to re-enter the field of

Fig. 2.1 **(a, b)** The referee should check players' boots and other equipment before the match.

play. The player is only allowed to re-enter the field of play when the ball is out of play.
A player who has been required to leave the field of play because of an infringement of this Law and who re-enters the field of play without the referee's permission must be cautioned."

2.2.4 Interpretation of Law 4 and Guidelines for Referees

Other Equipment

"A player may use equipment other than the basic equipment provided that its sole purpose is to protect him physically and it poses no danger to him or any other player.
All items of clothing or equipment other than the basic equipment must be inspected by the referee and determined not to be dangerous.
Modern protective equipment such as headgear, facemasks and knee and arm protectors made of soft, lightweight padded material are not considered dangerous and are therefore permitted.
Where head covers are worn, they must

- *be black or of the same main colour as the jersey (provided that the players*
- *of the same team wear the same colour)*
- *be in keeping with the professional appearance of the player's equipment*
- *not be attached to the jersey*
- *not pose any danger to the player wearing it or any other player (e.g.*
- *opening/closing mechanism around neck)*
- *not have any part(s) extending out from the surface (protruding elements)*

In view of the new technology that has made sports spectacles much safer, both for the wearer and for other players, referees should show tolerance when authorising their use, particularly for younger players.
If an item of clothing or equipment that has been inspected at the start of a match and determined not to be dangerous becomes dangerous or is used in a dangerous manner during the match, its use must no longer be allowed.
The use of electronic communication systems between players and/or technical staff is not permitted."

Jewelry

"All items of jewellery [sic] (necklaces, rings, bracelets, earrings, leather bands, rubber bands, etc.) are strictly forbidden and must be removed. Using tape to cover jewellery [sic] is not acceptable."
The fundamental rule ensuring the safety of players is that a player may not use equipment or wear anything which is dangerous to himself or another player. A player who wants to use a protective dressing made of plastic or plaster or involves metallic parts or a hard material of some kind must pad the dressing such that it is not dangerous to teammates or opponents. Padding means that the hard parts of the dressing should be covered with foam rubber, elastic bandages, or some other soft material. The referee must approve the dressing before the player can participate.

2.2.5 Law 5—The Referee

Injured Players

"The referee must adhere to the following procedure when dealing with injured players:

- *Play is allowed to continue until the ball is out of play if a player is, in the opinion of the referee, only slightly injured.*
- *Play is stopped if, in the opinion of the referee, a player is seriously injured.*
- *After questioning the injured player, the referee may authorise one, or at most two doctors, to enter the field of play to assess the injury and arrange the player's safe and swift removal from the field of play.*
- *Stretcher-bearers should only enter the field of play with a stretcher following a signal from the referee.*

- *The referee must ensure an injured player is safely removed from the field of play.*
- *A player is not allowed to receive treatment on the field of play.*
- *Any player bleeding from a wound must leave the field of play. He may not return until the referee is satisfied that the bleeding has stopped. A player is not permitted to wear clothing with blood on it.*
- *As soon as the referee has authorised the doctors to enter the field of play, the player must leave the field of play, either on a stretcher or on foot. If a player does not comply, he must be cautioned for unsporting behaviour.*
- *An injured player may only return to the field of play after the match has restarted.*
- *When the ball is in play, an injured player must re-enter the field of play from the touch line [sic]. When the ball is out of play, the injured player may re-enter from any of the boundary lines.*
- *Irrespective of whether the ball is in play or not, only the referee is authorised to allow an injured player to re-enter the field of play.*
- *The referee may give permission for an injured player to return to the field of play if an assistant referee or the fourth official verifies that the player is ready.*
- *If play has not otherwise been stopped for another reason, or if an injury suffered by a player is not the result of a breach of the Laws of the Game, the referee must restart play with a dropped ball from the position of the ball when play was stopped, unless play was stopped inside the goal area, in which case the referee drops the ball on the goal area line parallel to the goal line at the point nearest to where the ball was located when play was stopped.*
- *The referee must allow for the full amount of time lost through injury to be played at the end of each period of play.*
- *Once the referee has decided to issue a card to a player who is injured and has to leave the field of play for treatment, the referee must issue the card before the player leaves the field of play.*

Exceptions to this ruling are to be made only when:

- *a goalkeeper is injured;*
- *a goalkeeper and an outfield player have collided and need immediate attention;*
- *players from the same team have collided and need immediate attention;*
- *a severe injury has occurred, e.g. swallowed tongue, concussion, broken leg."*

This rule addresses the question of the referee's authority on the pitch. Law 5 clearly states that the referee must stop the match if, in his opinion, a player is seriously injured, and he must then ensure that the player quickly receives medical attention or is taken off the pitch. However, if the referee is of the view that the player is only slightly injured, he is permitted to let play continue.

Fig. 2.2 The referee must stop the match if, in his opinion, a player is seriously injured.

Furthermore, the guidelines also state that a player should not receive treatment on the field of play unless it is an injury to a goalkeeper or a severe injury like a fractured leg or a concussion. This is an important point for the football doctor to remember **(Fig. 2.2)**.

A referee is not liable for any kind of injury suffered by a player, for decisions to stop or not stop play to allow an injured player to be removed from the field of play for treatment, or for decisions to allow or not allow a player to wear certain apparel or equipment.

2.2.6 Law 12—Fouls and Misconduct

This law relates to the referee's duty to protect players from injury by awarding free kicks or penalty kicks for unlawful play. A player who enters a contact situation is obliged to do so in such a way that there is no risk of injuring an opponent or himself (as a foul can also lead to the offender himself being injured). In recent years, there has been a noticeable increase in the enforcement of the direct sending-off rule for dangerous play, which is a positive development from a medical viewpoint.

2.3 Laws, Referees, and the Football Doctor

Although the above laws might not affect the team doctor directly, they could all potentially have an impact on the health of a player if they were not adhered to, or if the doctor failed to understand their implementation and significance. Doctors are not expected to know all the details of the various laws, but they should know enough (i) to be able to carry out their role with confidence during a match and (ii) to be in no doubt as to where the boundaries lie in terms of what they can and cannot do, and what they can expect the referee to do to prevent and manage injuries on the field.

Consequently, team doctors should at least bear in mind during a match the points discussed in the following sections, so that uncertainty does not in any way compromise the expedient and effective treatment of injuries. A good understanding of the constraints under which the referee is forced to operate will also lead to a better relationship between officials and doctors, and therefore better communication in the event of a player needing treatment.

2.3.1 Injuries Should Only Be Assessed on the Field of Play, Being Treated Off the Field of Play[1]

The team's medical personnel may only enter the field of play if the referee considers that an injury is serious and requires a medical examination. In the event of unconsciousness or any other injury which the referee judges to be serious, medical personnel are called onto the field immediately. The basic rule is that the referee does not assess the injury, but simply asks the player: "Do you need medical attention?" If the player answers in the affirmative, or does not answer at all, help is called for. Only two people can come onto the pitch to assess the injury, and they may do so only if called on by the referee. The initial assessment should be as expedient as possible and a more comprehensive assessment of whether the player can or cannot continue should take place off the field of play. Treatment on the pitch should be limited to serious injuries, such as unconsciousness, severe bleeding, shock, or broken bones (where hurried movement could aggravate the injury). Once the player has been assessed by medical staff, the referee's job is to ensure that the game can restart as soon as possible, without compromising the health of the injured player.

The laws dictate that an injured player must leave the field either on a stretcher or on foot. Players who refuse to do so are penalized by means of a yellow card. In less serious situations, the referee can decide how the player should leave the field. However, all treatment of players must take place off the field of play. The faking of an injury is penalized by means of a yellow card, but doctors should also discourage this behavior among their players, given the risk that it could lead to the wrong decision being taken in the event of a real injury if the referee wrongly suspects faking.

A player who leaves the field for treatment or further examination must receive a clear signal from the referee before re-entering the field of play (**Fig. 2.3**).

Fig. 2.3 A player who leaves the field for examination must receive a clear signal from the referee before reentering.

2.3.2 UEFA Medical Regulations

Minimum Medical Requirements

The Union of European Football Associations (UEFA) Medical Regulations specify certain mandatory medical requirements for UEFA matches (and matchday-1 training sessions in certain competitions) to provide medical support for players, team officials, the referee team, and match officers. These requirements must be met by the host cub and include the following:

- Providing a trained pitchside doctor, stretcher teams, and emergency medical equipment (e.g., splints, defibrillators, cardiac drugs, and equipment for airway management and circulation).
- Providing a fully equipped medical room, with good access from the pitch area.
- Ensuring that an Advanced Life Support ambulance is located in a part of the stadium that permits easy and fast access from the pitch area and the medical room, and out of the stadium.

Team doctors should be familiar with the requirements of minimum medical requirements (MMR), particularly if they are responsible for ensuring that the requirements are provided at a match.

Doctor on the Bench

All teams must have a qualified doctor on the team bench at all matches.

2.4 The Risk of Underestimating the Seriousness of Injuries during Matches

It is important for a doctor to be aware of the risk of underestimating the seriousness of an injury during a match. Recent meta-analysis looking at 15 studies revealed that athletes have a higher pain threshold than nonathletes,[2] with the effect more pronounced in team sports and other synchronized activities.[3] This could be attributable to the release of endorphins into the bloodstream (as endorphins serve as natural pain relievers) or the result of increased adrenalin owing to stress prior to a match. A player who is pumped up with adrenalin and endorphins during an important match will have a higher pain threshold than he would do at rest, so there is a risk of the examining doctor underestimating the seriousness of an injury.

2.5 Experience of Injuries at UEFA EUROs and Youth Tournaments

UEFA has been carrying out injury studies during the final tournaments of UEFA EUROs and youth competitions since 2004. These studies not only help to demonstrate the prevalence of different types of injury, but also record information relating to the circumstances surrounding those injuries (timing, contact or noncontact, layoff times, etc.), even showing how they were dealt with by the referee at the time.
During the final rounds of 12 European competitions between 2006 and 2008 (1 UEFA EURO, and the final rounds of 2 UEFA European Under-21 Championships, 3 UEFA European Under-19 Championships, 3 UEFA European Under-17 Championships, and 3 UEFA European Women's Under-19 Championships), 17% of all match play injuries (contact and noncontact injuries) were caused by foul play (in the opinion of the referee) and resulted in absences from subsequent training sessions or matches.[4] In 75% of cases, the injured player was the one who was fouled, but 25% of those players injured themselves while committing fouls **(Fig. 2.4)**.
It is not clear from this study whether the remaining 83% of match injuries occurred in situations that complied with the laws of football or whether referees may have failed to recognize foul play in injury situations. However, in a substudy during UEFA EURO 2004, Hägglund et al[4] compared the official decisions of match referees with the views of teams' physicians on the question of whether incidents leading to injuries represented an infringement of the rules. Despite the fact that teams' opinions may well be highly subjective, the two were generally in agreement. The teams agreed completely with the official decisions in the nine cases where the referee considered the incident to be a foul, but also considered four more injuries to be the result of foul play. Three of those were slight or minor injuries causing absences of 3, 3, and 6 days, respectively. The fourth injury was a deep wound causing 29 days of absence. However, video analysis of that situation showed that the injured player played on, did not go down, and never called for medical help. The player's minimal reaction to that serious injury can probably be explained by the high pain threshold seen in players in important matches (as referred to above).
At the final tournaments of EURO 2004, EURO 2008, and EURO 2012, there was an average of one time-loss injury per match that resulted in a player missing a training session or match. About 60% of injuries occurred in contact situations, while around 40% were noncontact injuries such as muscle injuries. The tendency during these three EUROs was toward a decrease in contact injuries and an increase in noncontact injuries.
As many as 35 to 40% of contact injuries were due to foul play (according to the referee). Interestingly, one in seven of those injuries caused by fouls was an injury to the player committing the foul. It is clear that one way of avoiding injuries is for players to comply with the rules of the game. The small numbers of contact injuries and injuries caused by foul play during recent EUROs is probably a sign of the high standard of refereeing and teams' commitment to fair play.

Fig. 2.4 In some cases, players will injure themselves while committing a foul, but generally pose a greater threat to their opponent.

2.6 Summary

The specific role of a football doctor during a competition requires the physician to provide medical treatment and ensure player safety in a high-pressure environment where medical decisions must be balanced against the requirements of a spectator sport in which breaks in play are often short and infrequent. Although it is the responsibility of organizations such as FIFA and UEFA to establish rules that accommodate medical needs as much as possible, it is the responsibility of match officials, team doctors, and the pitchside doctor to apply these rules in practice, protecting both the integrity of the game and the safety of the players. This is not always an easy task, and it can only be achieved through cooperation and good communication between all parties, as well as appropriate respect for each person's work and authority, particularly with regard to the laws that each party is obliged to comply with.

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Chapter 3

Muscle Epidemiology and Injury Mechanisms

Jan Ekstarnd

3

3.1 Epidemiology of Muscle Injuries

A muscle injury is defined as a "traumatic distraction or overuse injury to the muscle leading to a player being unable to participate fully in training or matches." Muscle injuries represent almost one-third of all time-loss injuries in male elite football and account for more than one-quarter of all layoffs following injuries.[1,2]

There are many different types of muscle injury, and a wide range of terminology is used to describe them. Muscle injuries have to be classified in different groups in order to be able to provide a prognosis regarding recovery times and rehabilitation, and large sample sizes are needed in scientific studies if authoritative statements are to be made.

This chapter is based on 4,500 muscle injuries suffered by more than 3,500 players in elite teams across 18 European countries. All examples and statistics are taken from data collected via the UEFA Elite Club Injury Study between 2001 and 2012.

3.1.1 How Common Are Muscle Injuries?

On average, an elite male team with a squad of 25 players can expect about 15 muscle injuries each season **(Fig. 3.1)**. The majority of these will be thigh, groin, or calf injuries (**Table 3.1**).

Fig. 3.1 On average, a player sustains a muscle injury every other season.[1]

Table 3.1

Proportion of muscle injuries incurred per season by an elite male team (25 players)	
Thigh muscle injuries	Five or six hamstring and two or three quadriceps injuries per season
Groin muscle injuries	Four or five per season
Calf muscle injuries	One or two per season

3.1.2 Injury Risk during Matches

The risk of sustaining a muscle injury is six times higher during matches than during training (8.7 injuries per 1,000 match hours, compared with 1.4 injuries per 1,000 training hours).[1]

Two-thirds of all hamstring injuries suffered by players occur during matches—compared with half of all calf muscle, hip/groin, and quadriceps injuries.

3.1.3 Muscle Injuries and Age

The risk of sustaining a calf muscle injury during a match increases with age, but with quadriceps, hamstring, and hip/groin injuries, there is no such age effect (**Fig. 3.2**).[1]

3.1.4 Variations in Injury Risk during Matches

Thigh muscle injuries tend to occur more frequently toward the end of each half of a match (see **Fig. 3.3**).[1,2,3] A similar tendency is seen for hip/groin injuries in the first half, while the risk of suffering a calf injury is fairly constant until the last 15 minutes of the match, when the injury risk increases substantially.

3.1.5 Variations in Injury Risk over a Season

Fig. 3.4 shows the distribution of muscle injuries over a season for teams with an autumn–spring season. Muscle injuries are more common during the period from August to April, when most league matches are played. In January, when many leagues have a winter break and fewer matches are played, the risk of suffering thigh and hip/groin injuries (but not calf injuries) is reduced **(Fig. 3.5a, b)**.

3.1.6 Developments in Injury Risk over the Last Decade

Fig. 3.6 shows injury risk over a period of 11 seasons for teams participating in the UEFA Champions League. The injury risk for all muscle injuries (as well as the most common subtypes) was fairly stable over that period, with only small differences between seasons. This would suggest that any changes in rules, athleticism, or teams' playing styles during that period did not affect injury risk.

3.1.7 Artificial Turf

Ekstrand et al[4] compared injury risk in male elite football between matches played on third-generation artificial turf and matches played on natural grass in terms of the injury risk for male elite-level football. The study found a lower risk of lower-extremity muscle injuries during matches played on artificial turf compared with matches played on natural grass (6.2 vs. 3.7 injuries per 1,000 match hours).

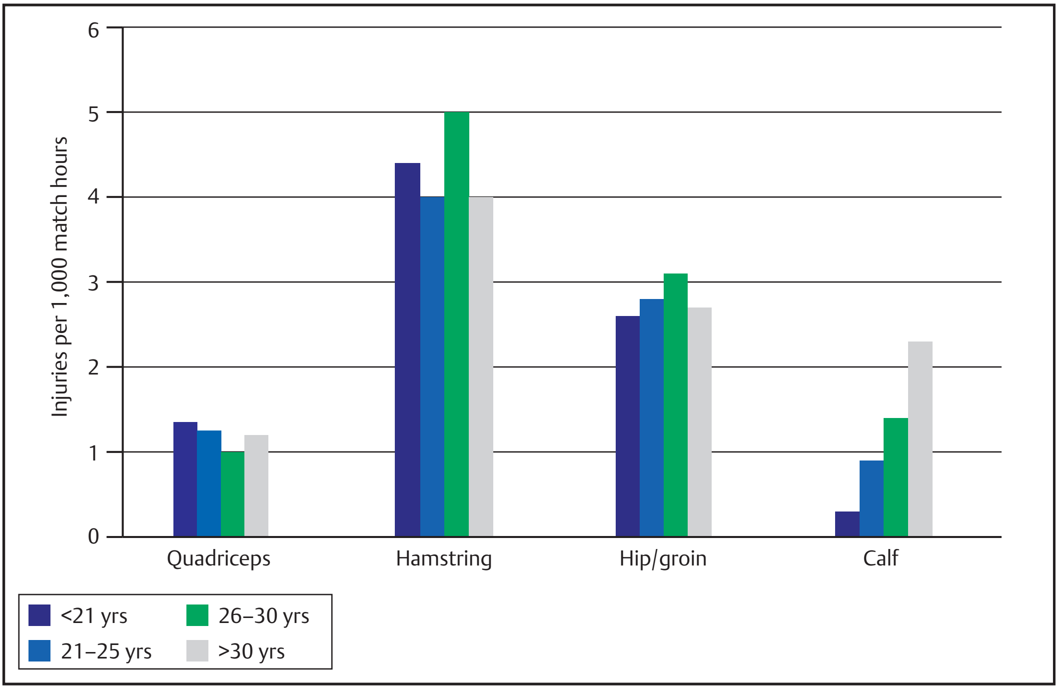

Fig. 3.2 The risk of sustaining a muscle injury during a match for different age groups.

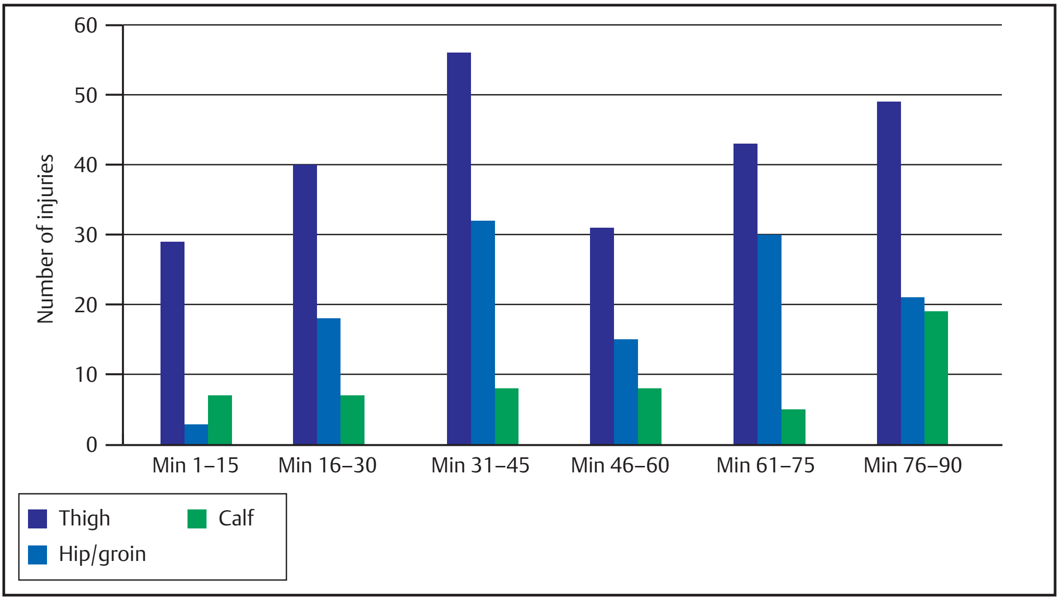

Fig. 3.3 Distribution of muscle injuries during a match.

3.1.8 Location of Muscle Injuries in Football Players

As can be seen in **Fig. 3.7**, 92% of all muscle injuries in football affect the lower extremities of the body. The hamstrings (37%), quadriceps (19%), adductors (23%), and calf muscles (13%) are the most common locations for injuries. At elite level, hamstring injuries are the most common injury type, representing 12% of all injuries.

3.1.9 Contact versus Noncontact Situations

As many as 96% of all muscle injuries occur in noncontact situations. Only 4% are sustained as a result of player-to-player contact (**Fig. 3.8**).

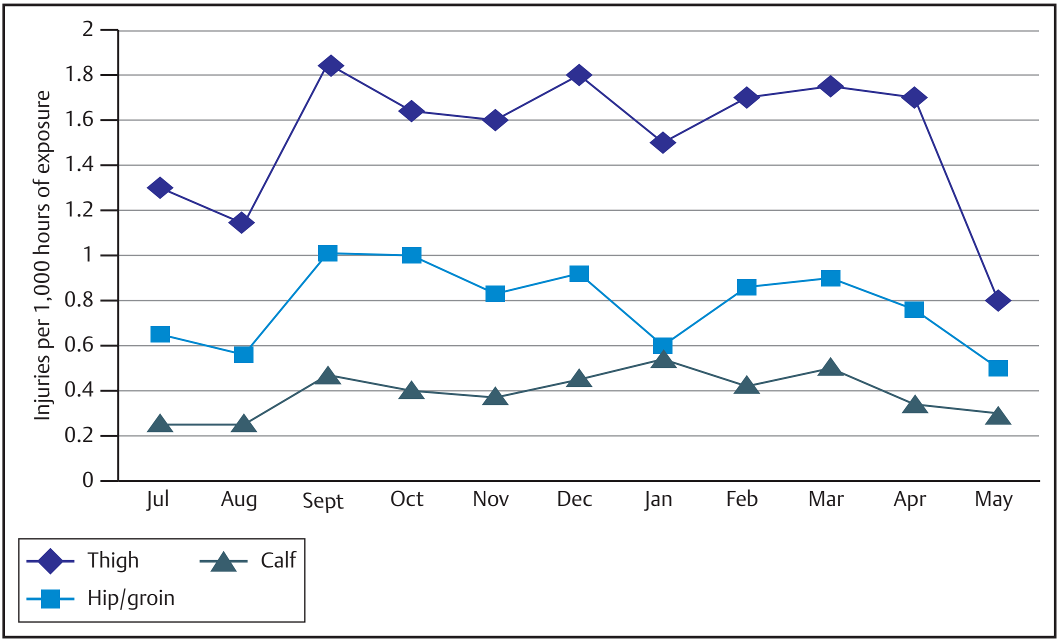

Fig. 3.4 Distribution of the most common muscle injuries over an autumn–spring season (injuries/1000 hours of total exposure)

Fig. 3.5 **(a, b)** In January, when fewer matches are played, the risk of suffering thigh and hip/groin injuries, but not calf injuries, is reduced.

3.1.10 Severity of Muscle Injuries and Length of Layoffs

As can be seen in **Fig. 3.9**, between 39 and 46% of all muscle injuries are of moderate severity, causing a player to miss between 8 and 28 days of training/matches. Between 9 and 13% of muscle injuries are more severe, causing the player to miss more than 28 days. In general, thigh and calf injuries are more severe than hip/groin injuries.

3.1.11 Reinjuries

About 16% of muscle injuries in elite football are reinjuries. The reinjury risk is higher for hip/groin injuries than for thigh and calf injuries (**Fig. 3.10**). On average, the layoff caused by the reinjury is 30% longer than that caused by the index injury (17 vs. 13 days).[1]

NOTE:

A reinjury is an injury of the same type, and in the same location, as an earlier index injury, occurring no more than 2 months after a player's return to full participation following the earlier index injury.

3.1.12 Hamstring Injuries

Magnetic resonance imaging (MRIs) suggest that the majority of hamstring injuries concern the biceps femoris muscle (84%).[5] Two-thirds of all hamstring injuries occur during matches, with players 11 times more likely to sustain a hamstring injury during a match than during training. Since hamstring injuries are known to be related to high-velocity loading (i.e., they are a sprinter's injury), this finding could be related to the high intensity of top-level matches.

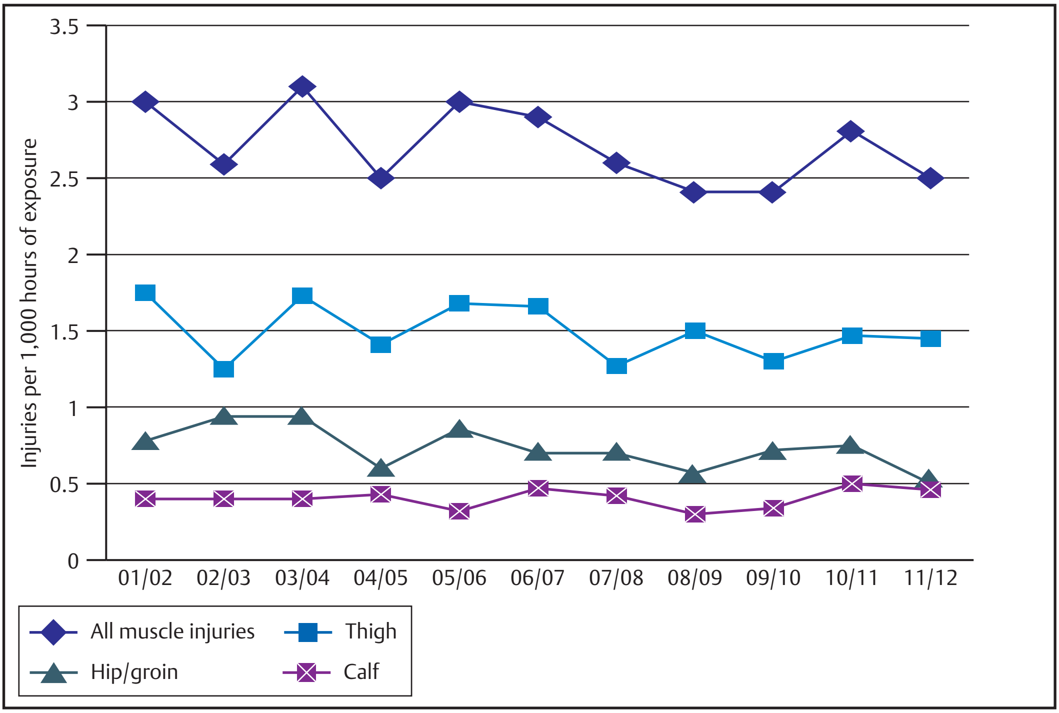

Fig. 3.6 Muscle injuries suffered by UEFA Champions League teams between 2001 and 2012.

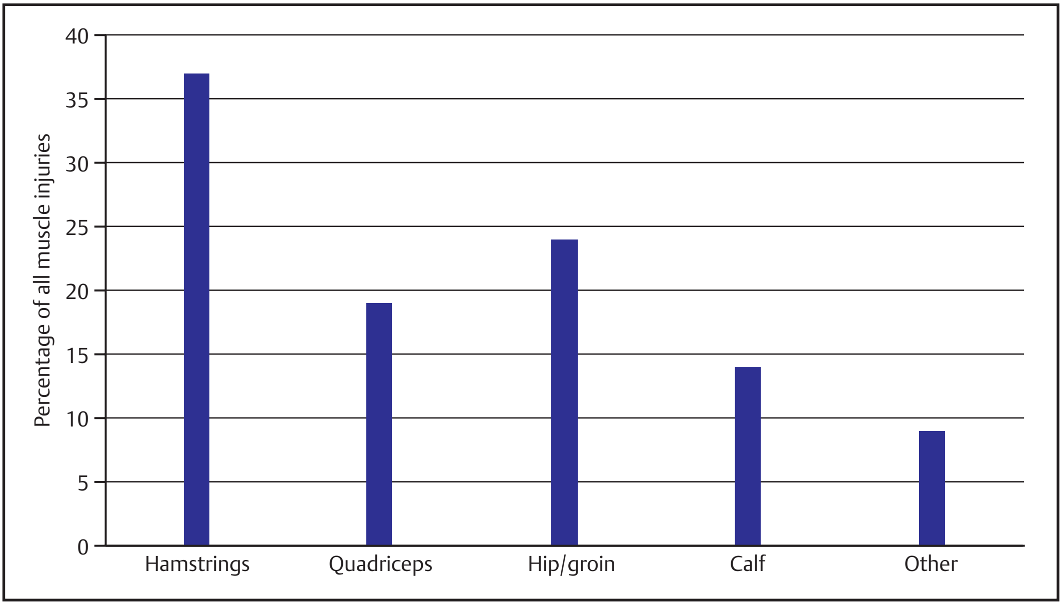

Fig. 3.7 Location of muscle injuries in football players.

Risk Factors for Hamstring Injuries

The majority of hamstring injuries (60–70%) are due to high-speed running or sprinting, while overuse and stretching/sliding each account for 5%, and shooting accounts for 4%.[5] Almost all hamstring injuries are noncontact injuries, with 95% being sustained without contact with other players.[5] Only 1.5% of injuries suffered during matches are due to foul play in the view of the referee. Around 15% of all hamstring injuries are reinjuries.[5] Recurrence of injuries to the biceps femoris are common (18%), while reinjuries to the semitendinosus and semimembranosus are rare (2% together).[6]

Fig. 3.8 Only 2% of muscle injuries sustained during matches are the result of foul play in the view of the referee.

Fig. 3.11 shows the distribution of thigh muscle injuries over an average season for teams participating in the UEFA Champions League. Hamstring injuries are more common during the competitive season (i.e., the period from September to May).

Consequences of a Hamstring Injury

In general, a football team with 25 players can expect about seven hamstring injuries per season, leading to total layoffs of about 110 days. On average, a hamstring injury causes a layoff of 16 (range: 1–128) days, with an average of 10 (range: 0–90) missed training sessions and 3 (range: 0–27) missed matches. A total of 14% of hamstring injuries are severe, causing layoffs of more than 4 weeks. Injuries sustained during matches cause significantly longer layoffs than injuries sustained during training (18.3 vs. 11.9 days; **Fig. 3.12**).

3.1.13 Quadriceps Injuries

The majority of quadriceps injuries occur during training, and MRIs suggest that they mostly concern the rectus femoris muscle (88%).[1] However, the risk of sustaining a quadriceps injury during a match is nearly four times higher than during training (1.1 vs. 0.3 injuries per 1,000 hours). The majority (62%) of quadriceps injuries occur in the first half of matches, with injury risk peaking between the 16th and 45th minutes. A total of 40% of all quadriceps injuries occur during this period.

The Impact of Shooting

As many as 23% of all quadriceps injuries occur when shooting, compared with just 4% of hamstring injuries. Findings from the UEFA Elite Club Injury Study indicate that the risk of suffering a quadriceps injury peaks at the end of the preseason preparation period. This could be explained by more intensive shooting practice during that period. As with hamstring injuries, the majority of quadriceps injuries are noncontact injuries, with 96% being sustained without any contact with other players. By contrast with hamstring injuries, only 9% of quadriceps injuries are reinjuries (**Fig. 3.13**).

Fig. 3.11 shows the distribution of quadriceps injuries over the season. The highest risk of sustaining a quadriceps injury is in August, at the end of the preseason preparation period. By contrast with hamstring injuries, there is no increase in risk during the competitive season.

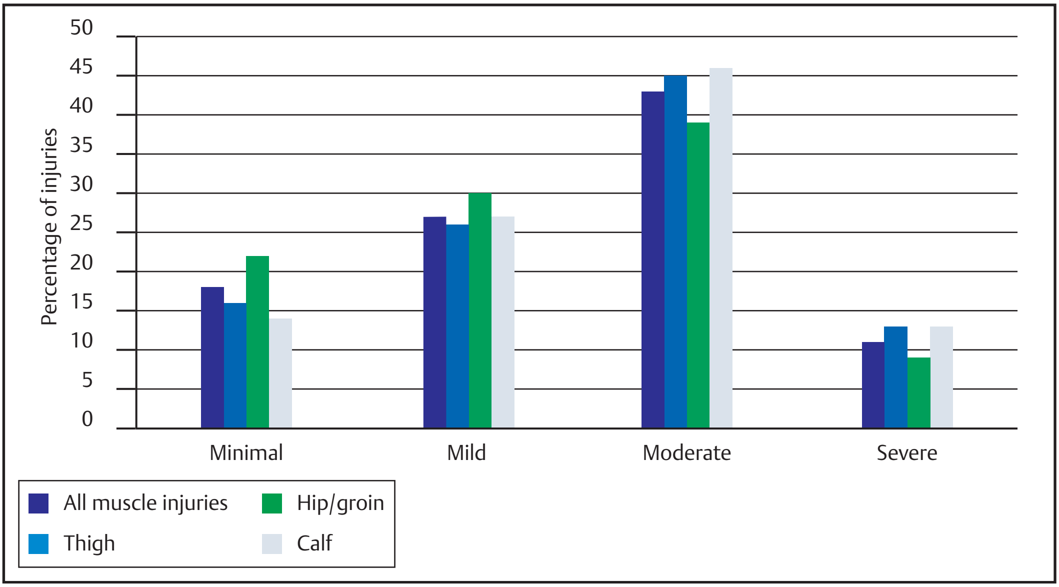

Fig. 3.9 Severity of muscle injuries.
Notes: "Minimal" = player misses 1 to 3 days of training/matches; "mild" = player misses 4 to 7 days; "moderate" = player misses 8 to 28 days; "severe" = player misses more than 28 days.

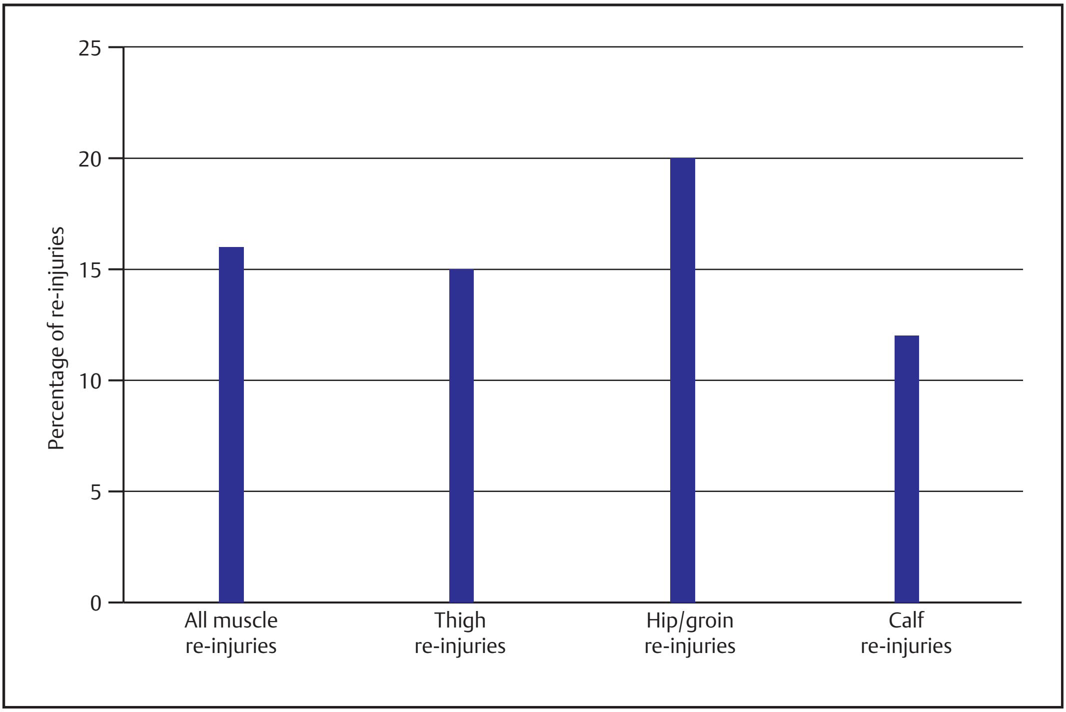

Fig. 3.10 Reinjuries as a percentage of total muscle injuries.

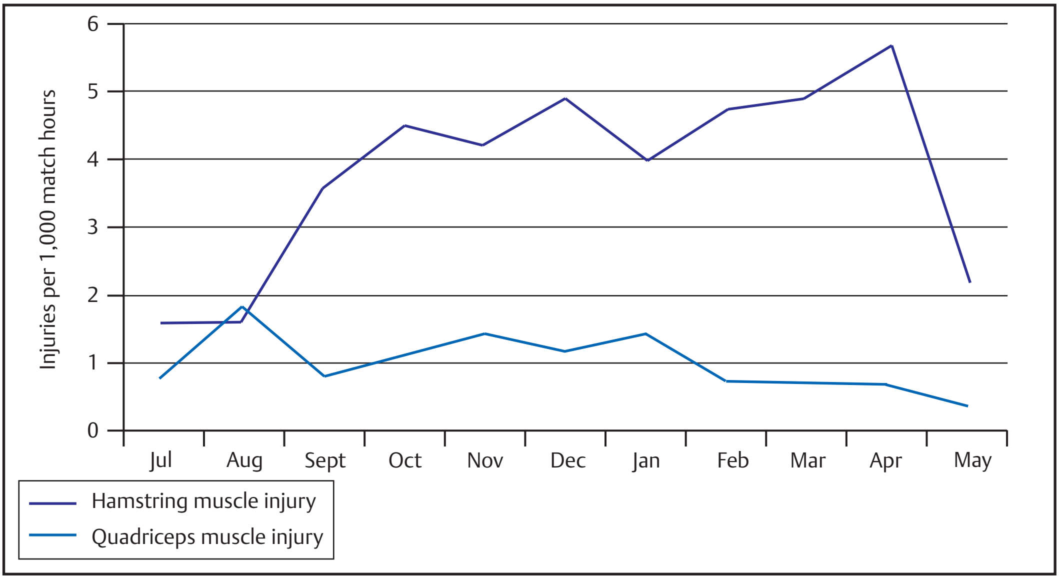

Fig. 3.11 The risk of sustaining a thigh muscle injury during a match over the football season (autumn–spring).

Consequences of a Quadriceps Injury

A team with 25 players can expect about three quadriceps injuries each season, with total layoffs of about 50 days. On average, a quadriceps injury causes a layoff of 18 days, with an average of 12 missed training sessions and 3 missed matches. A total of 19% of injuries will be severe, causing a layoff of more than 4 weeks. By contrast with hamstring injuries, there is no significant difference, in terms of layoffs, between injuries sustained during matches and injuries sustained during training.

Fig. 3.12 In general, a football team can expect about seven hamstring injuries per season, causing layoffs of about 110 days.

Fig. 3.13 As with hamstring injuries, the majority of quadriceps injuries are noncontact injuries.

3.2 Terminology and Clinical Categorization of Muscle Injuries

Muscle injuries are a heterogeneous group, differing in terms of their type, location, severity, and size, and this can make prognoses regarding recovery times and rehabilitation difficult.

Recently, however, new approaches have been proposed to improve classification, including an attempt by the Munich Consensus Group to categorize injuries as either functional or structural-mechanical injuries. Functional injuries are minor fatigue-induced or neurogenic injuries causing hardening of the muscle, while structural-mechanical injuries involve tears in muscle fibers.[7] The Munich muscle classification has been demonstrated to be valid in prognosticating return to play after thigh muscle injuries in professional male football players.[7] Structural injuries are associated with longer average layoff times than functional muscle disorders and subclassification of structural injuries correlates with return to play, while subgrouping of functional disorders shows less prognostic relevance.[8]

In the UEFA Elite Club Injury Study, injuries are classified on the basis of the definitions[1,5,8] given in the following sections.

3.2.1 Functional Muscle Disorders

Painful Muscle Disorders with No Evidence of Muscle Fiber Damage

- **Fatigue-induced muscle disorder**: Increase in muscle tone due to overexertion, change of playing surface, or change in training patterns. There is pain with activity, but not at rest. Increased muscle tone is noted in the affected muscle area, with mild, dull pain aggravated by palpation or stretching.
- **Delayed onset muscle soreness**: More generalized muscle pain following unaccustomed, eccentric deceleration movements, with the possibility of associated ruptures of sarcomeric Z-discs. This presents as an acute inflammatory pain in the affected muscle groups, with stiff and weak muscles plus pain at rest, usually peaking 24 to 72 hours after the activity that caused it. Images show no signal changes or only edematous signal changes in the muscle.
- **Spine-related neuromuscular muscle disorder**: Increase in muscle tone due to a functional or structural spinal disorder (including disorders affecting the sacroiliac joint). There is subjective tightness and pain with intense activity, stretching, and palpation. Such disorders are sometimes associated with changes in skin sensation. There is an increase in muscle tone over the entire length of the muscle on palpation. Symptoms improve with rest.
- **Muscle-related neuromuscular muscle disorder**: Spindle-shaped area of increased muscle firmness. This may result from dysfunctional neuromuscular control, such as reciprocal inhibition. This disorder presents as a pulling and cramp-like sensation within the muscle. It is aggravated by activity and improved by rest and gentle stretching. A spindle-like longitudinal firmness can be detected within the affected muscle belly on palpation.

3.2.2 Structural Muscle Disorders

Any Acute Indirect Muscle Disorder with Macroscopic Evidence of Muscle Fiber Damage

- **Minor partial muscle injury**: Structural muscle injury involving only an intrafascicle tear. This presents as acute, sharp pain, often at the muscle–tendon junction. There is focal pain on palpation with a possible palpable defect, and often there is no visible hematoma. Pain is aggravated by stretching and palpation. An intramuscular hematoma and a focal muscle defect can be observed in images, with the surrounding fascia usually remaining intact.

- **Moderate partial muscle injury**: Structural muscle injury involving an interfascicle or muscle bundle tear. This presents as acute, intense, stabbing pain, usually at the muscle–tendon junction, and is often associated with a fall by the player. The player often experiences a "snap." There is a palpable, defined defect in the affected muscle, which is painful both to touch and on gentle stretching. A hematoma can often be observed. The defect in the muscle/fascia and the hematoma are visible in images, together with an intermuscular hematoma.
- **Subtotal/complete muscle injury/tendon avulsion**: Structural muscle injury involving damage to the majority ("subtotal") or all ("complete") of the diameter of the muscle or a subtotal/complete tendon avulsion. This presents as acute, severe pain, and there is often a fall after injury. There is more severe pain with passive motion and palpation, and there is an immediate functional deficit, with the development of larger hematomas. There will be a large palpable defect, often at the muscle–tendon junction, or retraction of the avulsed muscle. An obvious muscle defect or tendon avulsion can be observed in images, as can the formation of a hematoma (**Table 3.2**).

3.2.3 Examination Procedures

Diagnostic procedures for thigh muscle injuries have been investigated for teams participating in the group and knockout stages of the UEFA Champions League between 2007 and 2012. All of the 1,100 thigh injuries recorded were examined clinically (with clinical examination constituting the basis for diagnosis), but the majority (85%) were also examined using some form of imaging. The majority (54%) were examined by means of an MRI, and one-third were examined using sonography.

A radiological classification of the severity of muscle injuries (a modified Peetrons classification[9]) is commonly used as in **Table 3.3** below.

3.2.4 Most Muscle Injuries Are Not Ruptures

Up to 70% of lower-limb muscle injuries are Grade 0 or Grade 1 injuries, showing no signs of muscle fiber disruption in MRIs.[5] However, these injuries account for the majority of layoffs.[5] This means that, from a club's perspective, these injuries represent a significant problem owing to their high levels of incidence, despite the fact that most hamstring injuries have a favorable prognosis and can be effectively handled conservatively. Surgical repair is normally reserved for total ruptures, such as avulsion injuries. However, these injuries are rarely seen in football, representing only a very small percentage of the hamstring injuries in the UEFA Elite Club Injury Study.

3.2.5 Radiological Grading Is Strongly Correlated with Layoff Times

Recently, Ekstrand et al[5] showed that radiological grading of hamstring injuries is strongly correlated with layoff times. Consequently, an MRI examination conducted 24 to 48 hours after a muscle injury is sustained could provide information about the expected layoff time. Accordingly, a negative MRI is associated with a shorter recovery time, normally around 6 to 8 days.[5]

Table 3.3

Radiological classification of the severity of muscle injuries	
Grade 0	Negative MRI, with no visible pathology
Grade 1	Edema, but no architectural disruption
Grade 2	Architectural disruption indicating a partial tear
Grade 3	Total rupture of muscle or tendon

Abbreviation: MRI, magnetic resonance imaging.

Table 3.2

Categorization of muscle injuries			
A. Indirect muscle disorder/injury	Functional muscle disorder	Type 1: overexertion-related muscle disorder	Type 1A: fatigue-induced muscle disorder
			Type 1B: DOMS
		Type 2: neuromuscular muscle disorder	Type 2A: spine-related muscle disorder
			Type 2B: muscle-related muscle disorder
	Structural muscle injury	Type 3: partial muscle tear	Type 3A: minor partial muscle tear
			Type 3B: moderate partial muscle tear
		Type 4: (sub)total tear	Subtotal or complete muscle tear Tendinous avulsion
B. Direct muscle injury		Contusion	
		Laceration	

Abbreviation: DOMS, delayed onset muscle soreness.

3.2.6 What Is the Practical Benefit of This Information for Doctors?

Team doctors are asked many questions about injuries by players, the coach, the club's manager, the media, agents, and so on—the most common being "When can he play?". Consequently, the doctor needs to provide specific information about various different football injuries. Thanks to the UEFA Elite Club Injury Study, very reliable data exists to show the frequency with which specific injuries occur, the mechanisms behind them, when players can return to training and matches after specific injuries, and the risk of problems recurring. Furthermore, as the injury study covers a very large number of injuries, we can see how muscle injuries differ from one another—i.e., hamstring injuries are different from quadriceps injuries, and so on. Information about these differences is important for the doctor to know.

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Chapter 4

Examination and Treatment of Muscle Injuries

Peter Ueblacker, Lutz Hänsel, Hans-Wilhelm Müller-Wohlfahrt

4.1 Introduction

The diagnosis of acute muscle injuries and the associated prognosis are based primarily on clinical findings, with radiological methods such as magnetic resonance imaging (MRI) or ultrasonography being used to provide additional information to confirm the diagnosis.[1,2,3,4]

Imaging is an important aspect of injury diagnosis, but when used in isolation, it is unlikely to offer the most accurate diagnosis. The doctor should, instead, seek to combine imaging with other available sources of information, such as the player's medical history, an inspection, a clinical examination, and functional testing, in order to reach the most informed decision.

This chapter describes the various factors that the football doctor should consider when examining, diagnosing, and treating a muscle injury. Advice is provided on the most effective and clinically proven techniques, which can help to achieve a swift return to football with a lower risk of reinjury.

Medical history + clinical examination (+ imaging) ⇒ diagnosis

4.2 Considerations in the Diagnosis of Injury

When making a diagnosis, the first step is to differentiate between different categories of injury—particularly between *indirect* and *direct* muscle injuries, and between *functional (nonstructural)* and *structural muscle injuries*. This is important because these injury types have a different prognosis, causing different absences.

A basic classification system with definitions is provided in **Table 4.1**.[5]

NOTE:

Imaging is usually precise enough to determine if there is a relevant tear or not. However, imaging alone is not appropriate for determining a diagnosis and the extent of a muscle injury.

4.2.1 Indirect Injuries

Indirect injuries are usually caused by internal forces. They are broken down into *functional (nonstructural)* and *structural* types.[5]

Functional (Nonstructural) Injuries

Functional injuries/disorders are minor injuries causing swelling, edema, and painful firmness of the muscle. Players are unable to compete because of *functional* limitations such as painful increases in muscle tone. These injuries are multifactorial and can occur for various reasons. They can represent a risk factor for *structural injuries (partial tears)*.

Structural Injuries

Structural injuries (tears) are induced by stretching and are caused by a sudden forced lengthening, in excess of the muscle's viscoelastic limits, during a powerful contraction (i.e., an internal force).

There are different types and grades of each category, as described in **Table 3.2**.

4.2.2 Direct Injuries

Direct injuries (i.e., contusions and - less frequently - lacerations) are caused by external forces, such as a direct blow from an opponent's knee. The most frequently contused muscles are the exposed rectus femoris, the vastus lateralis, and the vastus intermedius, which lies next to the bone. Contusion injuries can lead to bleeding, causing pain and a loss of motion, but muscle fibers are not typically torn by longitudinal distraction. For this reason, players with contusions can often continue playing for some time, whereas even a small *indirect structural* injury often forces the player to stop at once.

It has been shown that the incidence of *indirect* injuries is eight times higher (1.48/1,000 hours) compared to *direct* muscle injuries (0.19/1,000 hours; $p < 0.01$), *indirect* muscle injuries cause 19% of total absence, and *direct* injuries 1%, and that the mean layoff time for *indirect* injuries is 18.5 days, which differs significantly from *direct* injuries with 7.0 days ($p < 0.001$).[6] Foul play is involved in 7% of all thigh muscle injuries, in 2% of indirect injuries, and 42% of direct injuries.[7]

Table 4.1

Classification of muscle injuries

Indirect **muscle injuries**		*Direct* **muscle injuries**	
Functional muscle injury	*Structural* muscle injury	Contusion	Laceration
Painful muscle injury/disorder **without** macroscopic evidence (visible in MRI/ultrasonography) of a muscle fiber tear	Any acute distraction injury to a muscle **with** macroscopic evidence (visible in MRI/ultrasonography) of a muscle fiber tear	*Direct* muscle trauma caused by **blunt** external force (leading to diffuse or circumscribed hematoma)	*Direct* muscle trauma/wound (including the skin and subcutaneous tissue) caused by **sharp** external force

Abbreviation: MRI, magnetic resonance imaging.

4.3 Examination of Muscle Injuries

Diagnosis should always combine a wide range of information, as shown in **Fig. 4.1**. See **Table 4.2** and **Table 4.3.**

4.3.1 Medical History/Symptoms

The examiner should start with a precise history of the circumstances surrounding the injury, before reviewing the player's symptoms and identifying any previous related injury problems.[9,10] Where the player reports a sharp and sudden onset of pain (e.g., the player experiences a "snap" and well-defined, localized pain), a tear must be assumed (**Table 4.4**).

4.3.2 Inspection, Clinical Examination, Functional Testing, and Location of Injury

The next step in diagnosis is a careful clinical examination of the injured area (**Table 4.5**). This should include an inspection, palpation, a comparison with the contralateral side, and functional testing of the muscles.

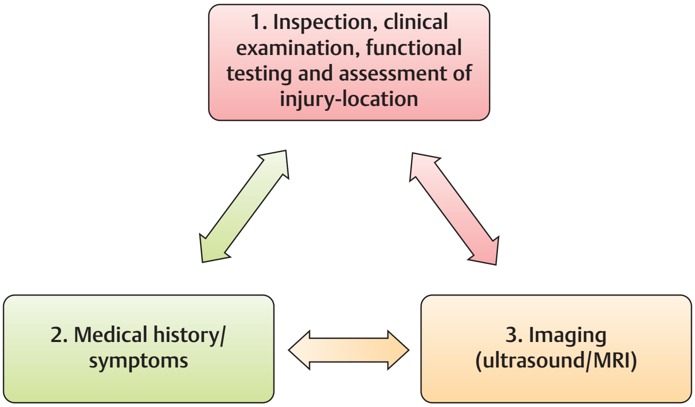

Fig. 4.1 Information sources used for diagnosis of injury.

Table 4.2

Evaluation of circumstances surrounding the occurrence of injury	
External/*direct* trauma?	External trauma suggests contusion.
Mechanism (sprinting, shooting, landing, overstretch, etc.)?	Sprinting is more likely to affect the hamstrings.[8]
	Shooting is more likely to affect the rectus femoris muscle.[8]
	Slow movements such as stretching can cause injuries involving longer absences.[9]
Fall after injury?	A fall points to a more severe injury with functional loss.

Table 4.3

Evaluation of symptoms related to injury	
Type of pain (pain at rest, cramp-like, sharp, etc.)?	Cramp-like pain indicates a more *functional* injury; sharp pain suggests the injury is *structural*.
"Snap" or "tearing"?	This suggests a *structural* injury/tear.
Onset of pain (slow or sudden)	Slow onset of pain indicates a *functional* injury; sudden onset suggests a *structural* injury.

Table 4.4

Assessment of previous problems that may affect injury	
Previous injury?	This can influence the current injury.
Scar?	Previous scarring can influence the current injury.
Muscle firmness/tightness or fatigue?	This can predispose the athlete to *structural* injuries.
Lumbar problems?	Dysfunction of the lower back can cause peripheral muscle complaints, such as muscle tightness.

Table 4.5

Inspection of injury site	
Swelling?	This usually determines the severity of the injury.
Hematoma?	This suggests a *structural* injury/tear.
Retraction of muscles?	This suggests a severe injury/tear.
Changes to contours of muscle?	This suggests a severe injury/tear.

Always start with an inspection of the injured leg. Is there any swelling or a visible hematoma (see **Fig. 4.2a**)? Inspect the contours of the muscle and ask the athlete to tense the muscles, and to pull the legs up. Assess how the muscle looks and whether there is any muscle retraction (see **Fig. 4.2b**).

NOTE:

Hematomas, muscle retraction, and changes to the contours of a muscle are only seen in *structural* injuries.

Strength assessment of the muscles is recommended, which should be done via manual resistance. A functional examination of the adjacent joints should be performed next, as well as dynamic testing of the tensed muscles. In the case of a hamstring injury, the range of motion of the hip and the knee in the injured leg can decrease relative to the healthy leg.[3] Passive straight leg raise (hip) and active knee extension test (knee) can be used to assess hamstring flexibility and maximum length. However, in the acute phase, these tests are usually limited by pain and thus are not very objective.[11]
Careful passive prestretching of the affected muscles can help to differentiate between a *tear* (which is usually painful on stretching) and a *functional* injury (which can be relieved with stretching in certain cases).

4.3.3 Palpation

Palpation gives the examining physician an impression of the affected muscles in comparison with the muscles of the uninjured, contralateral side.[12] Palpating a muscle indicates its tone, the condition of the musculature, and possible adhesions, scarring, etc., which is essential for evaluating the player's readiness to play again. While imaging such as ultrasonography and MRIs can supplement these impressions, they cannot replace them[5] (**Table 4.6**).
Palpation is performed with moderate pressure and movement. The fingers should repeatedly slide along the muscle from distal to proximal, back, and across the fibers, but should not only press down on the muscle. When conducting palpation, ask the athlete to demonstrate where the center of pain is located. Palpation reveals if there is any pressure pain, and whether the pain is localized or covers a larger area. It also helps to detect if the muscle is edematous, whether there is pain or relief on careful stretching, and if there is a palpable defect.[13]

NOTE:

Muscle tension/tightness etc. can be assessed only by means of clinical examination, not with imaging.

Palpation of the hamstrings, for example, is performed first with the knees fully extended. In this position, the muscles are slightly stretched (see **Fig. 4.3a**), whereas with flexed knees, the hamstrings are more relaxed (see **Fig. 4.3b**). The hand and finger(s) should slide over the muscles several times, getting an impression of the muscle tone and

Table 4.6

Assessment of findings from clinical examination/palpation	
Pressure pain? Localized or larger area?	This helps to identify injury location. – Localized pain is more likely in a *structural* injury. – Larger pain area tends toward *functional* injury.
Muscle tone?	This helps to determine injury type.
Edema?	This also helps to identify injury location and injury type.
Pain/relief on careful stretching?	Pain on stretching suggests a tear.
Palpable defect (approximate size)?	A defect is most likely to indicate a *structural* injury.

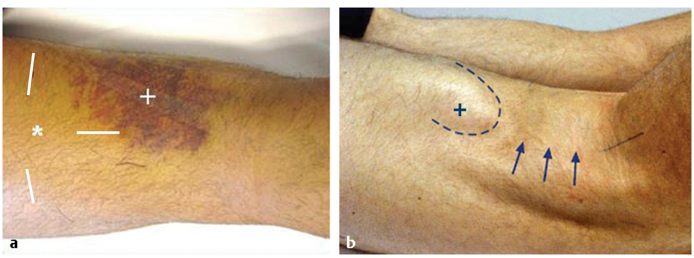

Fig. 4.2 **(a)** Hematoma visible on the surface (+) is not always located directly at the site of the injury. In this case, the hematoma (+) is located distally. The tear (which was revealed and marked using a clinical examination and ultrasonography) is in the biceps femoris muscle the center of the lines (–), at the point marked by the asterisk (*). **(b)** A proximally retracted muscle belly (+) surrounded by (–) after a subtotal muscle tear (blue arrows) of the long head of the biceps femoris muscle in an elite football player.

searching for an area with an increase in tone relative to the adjacent muscle.
At the same time, the athlete should be observed to note if there is any reaction to pressure on account of pain.[13]

NOTE:
A structural injury (i.e., a tear) is usually located within a firm muscle band.

NOTE:
A precise clinical examination of muscles takes time.

4.3.4 Location of Injury

Typically, *structural* injuries are located in the distal part of the biceps femoris, along the semitendinosus or semimembranosus muscle, or along the intramuscular tendon of the rectus femoris muscle (see **Fig. 4.4a, b**). It is usually the weakest point that tears.

In most athletes, this is the musculotendinous junction; in adolescents, it is the apophysis;[14] and in older patients, it is the tendon.
The location of the injury should be identified through clinical examination (**Table 4.7**). The examination should determine whether the muscle problem is within the muscle belly, in the muscle–tendon

Table 4.7

Assessment of findings from clinical examination/palpation

Injury location	
Muscle belly	This is typical of some *functional* injuries.
Muscle–tendon junction?	This is typical for *structural* injuries/tears.
Tendon–bone junction?	This is typical for tendinous avulsions.
Intramuscular tendon involved?	This is typical for *structural* injuries in certain muscles (e.g., Rectus femoris).

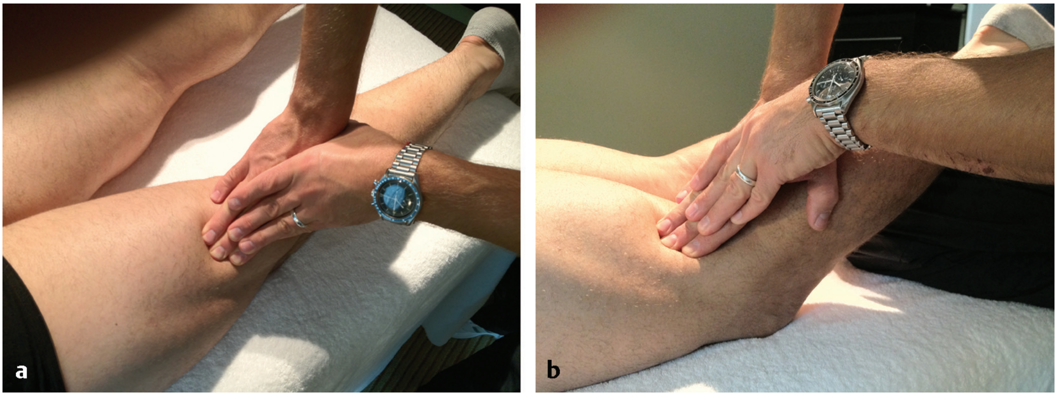

Fig. 4.3 **(a)** The examination is first performed with fully extended knees (i.e., passively slightly tensed hamstrings). **(b)** The second part of the examination. Here, the more relaxed muscles are palpated, the lower leg is supported underneath by the examiner's knee.

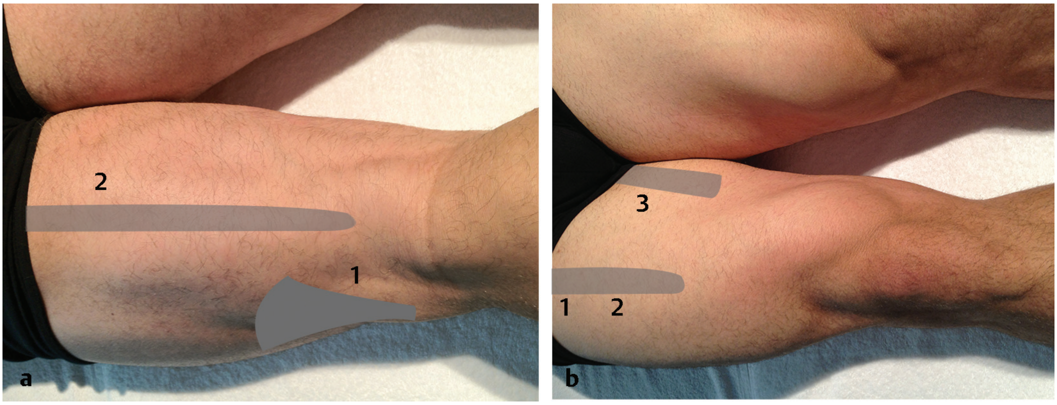

Fig. 4.4 **(a)** Posterior thigh; typical locations of structural injuries. Hamstrings: Tears occur most frequently in the muscle-tendon junction of the distal biceps femoris, caput longum (1). Structural injuries can also occur along the musculotendinous junction of the semimembranosus and semitendinosus muscles (2). **(b)** Anterior thigh. Rectus femoris and adductors: Structural injuries are frequently observed in the proximal rectus femoris (1), along its intramuscular tendon (2), and along the intramuscular tendon of the adductor longus muscle (3).

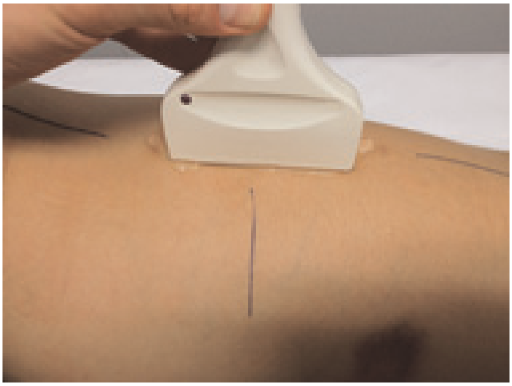

Fig. 4.5 After clinical examination (and/or an ultrasonography), the location of the injury (where the lines meet) can easily be marked on the skin to limit the field of view in a possible subsequent MRI and/or to find it for later treatment.

junction, in the tendon–bone junction, or along the intramuscular tendon.

NOTE:

Mark the location of the injury after the clinical examination (see **Fig. 4.5**).

4.3.5 Lumbar Spine/Referred Pain

Muscles act as a target organ and their state of tension is modulated by electrical information from the motor component of the corresponding spinal nerve. Thus, the irritation of a spinal nerve root can cause an increase in muscle tone.[12] It is known that back injuries are very frequent in elite athletes,[18,19] and lumbar pathologies such as a disk hernia at the L5/S1 level may present with hamstring and/or calf pain and limited flexibility, which may result in or mimic a muscle injury.[20] This is also known as "referred pain." Subtle impingement of the lumbar nerve roots in the lumbosacral canal may, in fact, also be a factor in age-related predisposition to hamstring injuries (**Fig. 4.6**).[3,20]

Although it is logical that a back-related muscle injury would require various forms of treatment, beyond simple treatment of those muscle–tendon injuries,[21] it could be argued that this is mainly a back problem, with a secondary muscular disorder. However, this secondary muscular disorder can prevent a player from training and competing and will require comprehensive treatment that addresses the primary problem, as well as facilitating the athlete's return to sport.[22]

Thus, differentiating between these disorders and others is important, not only because of the different pathogenesis, but also—more importantly—because of the different therapeutic implications.[23]

Fig. 4.6 Lower back pain is very frequent in athletes.

NOTE:

Athletes who undergo constant, intensive training have a higher incidence of degenerative disk disease and spondylolysis.

It is therefore important that the assessment of a muscle injury includes a thorough biomechanical evaluation, especially of the lumbar spine, pelvis, and sacrum.[23] Negative *structural* findings in the lumbar spine do not exclude nerve root irritation, and it should be remembered that lumbar dysfunctions, such as lumbar or iliosacral blocking, can also cause spine-related muscle injuries.[23] A diagnosis is established by means of a precise functional clinical examination. Spine-related muscle injuries are usually MRI negative, or the MRI reveals only a muscle edema.[20]

If the lumbar spine is suspected of involvement in a muscle problem, a thorough physical examination of the lower back should be performed as follows:

- The player should stand with his/her back to the examiner; an inspection will reveal if there is any (excessive) lordosis or scoliosis.
- The paravertebral muscles should be palpated to assess if there is any pain, firmness, muscle asymmetry, hypertrophy, or hypotrophy.
- The player should then be asked to bend forward, backward, and to both sides to reveal the range of motion of the lumbar spine and to see if there is any restriction of flexibility. The sacroiliac joint (SIJ) should be palpated if it is tender. Several tests can be used to reveal pelvis malrotation or a dysfunction of the SIJ. If necessary, a radiological examination should be undertaken (see **Fig. 4.7**).

Spondylolysis

Spondylolysis can cause muscular complaints, most commonly involving the hamstrings, owing to an increased kyphotic curve between L5 and S1, which causes an anterior shift in the center of gravity. This triggers a compensatory increase in hamstring tension to correct the pelvic tilt. The result is firmness and shortening of the hamstring muscles. Muscular complaints arising from spondylolysis and/or spondylolisthesis can successfully be managed conservatively in most cases (**Fig. 4.7**).

Laboratory Tests

Laboratory tests, such as testing for creatine kinase (CK), myoglobin (Mb), and lactate dehydrogenase (LDH), are of limited value when interpreting muscle injuries. CK and Mb levels are usually (highly) elevated after training stress. Tests are therefore not sensitive and specific enough to provide meaningful results (**Table 4.8**).[3,5]

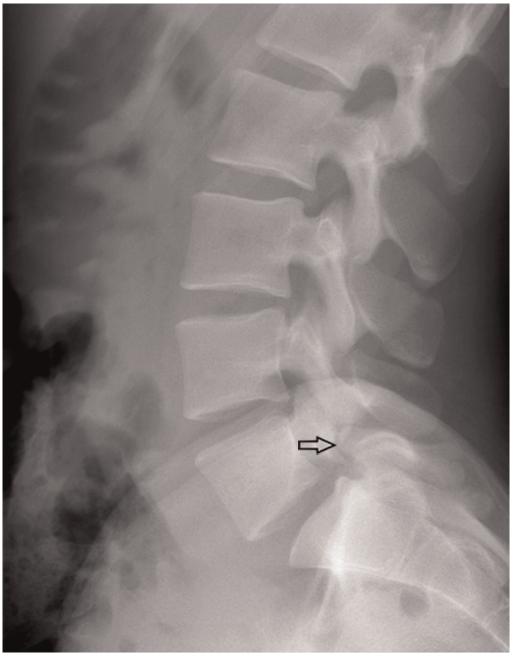

Fig. 4.7 Typical spondylolysis of the fifth lumbar vertebra in a 22-year-old elite-level professional football player presenting with muscular problems in the hamstrings. Interestingly, there was no medical history of back problems.

4.4 Imaging

Imaging (whether an ultrasonography or MRI) provides additional information about muscle injuries and achieves various objectives, including the following:

- Helping to locate the site of the injury.
- Revealing hematomas.
- Identifying defects/tears as well as showing their approximate size in the muscle tissue.
- Indicating whether the tendon is involved.

MRI is particularly helpful in identifying whether an edema is present and in what pattern. However, even the best images do not reveal information about muscle tone, pain, functional loss, or previous injuries, etc. The spatial resolution of diagnostic ultrasonography is higher than that of MRI, whereas MRI offers better contrast resolution (e.g., to demonstrate a hematoma/edema).

NOTE:

Imaging alone cannot offer an accurate diagnosis.

4.4.1 Ultrasonography

Ultrasonography is an important aspect of the diagnostic process for almost all muscle injuries, as it helps to locate the site of an injury and to exclude a higher grade of injury (i.e., a tear). Ultrasonography is usually easily available, allows dynamic examination, and is cost-effective, which makes it superior to MRI for follow-up examinations. However, it should be noted that ultrasonography of skeletal muscle requires a high level of skill on the part of the sports physician.

The procedure takes time, and familiarity with anatomy, and normal findings are essential for effective use of ultrasonography. With a little practice, the examiner can distinguish between a *functional (non-structural)* muscle injury with no evidence of *structural* damage and a *structural* injury involving a tissue defect. Usually, ultrasonography helps to assess the need for further investigation by means of MRI.

Table 4.8

Possible *functional* and *structural* causes of muscular dysfunction

Possible *functional* spinal causes of muscular dysfunction	**Possible *structural* spinal causes of muscular dysfunction**
Hyperlordosis	Pelvic obliquity
Locked sacroiliac or facet joint(s)	Real leg length difference
Functional leg length difference	Spinal and/or foraminal stenosis
Others	Foraminal stenosis
	Disk bulging and herniation
	Spondylolysis, spondylolisthesis
	Lumbosacral ligament
	Others

It is advisable that clinical examiners experienced in ultrasonography review the results themselves, as any delegation of this assessment to radiologists or technicians could risk misinterpretation of the information.

It is recommended to use a 7.5- to 10.0-MHz transducer, starting with a transversal section. A complete scan through the muscle should be performed for the purposes of anatomical orientation. Any apparent abnormalities should be compared with the contralateral side. The transducer pressure should be as light as possible, since compressing the muscle may obscure smaller injuries. The longitudinal section is added in locations where a disturbance of the muscle structure or a gap is suspected (**Table 4.9**).[24]

Some authors state that the best point in time for an ultrasonography is between 2 and 48 hours after the muscle trauma.[25] However, in some cases, where a dense, corpuscular hematoma obscures the defect in the first few hours after injury (see **Fig. 4.8a–e**), a follow-up may be needed to reveal the *structural* injury.

Recommendations for ultrasonography are given in **Table 4.10.**

NOTE:

The location of any injury or seroma/hematoma can be marked on the skin, either after the clinical examination or during ultrasonography, for later magnetic resonance imaging and treatment (see **Fig. 4.5**).

Table 4.9

Imaging considerations in diagnosis	
Location	For further treatment and/or to limit the field of view in subsequent MRI.
Edema?	For injury characterization.
Structural defect?	What is the size? And the prognostic consequence?
Seroma/hematoma?	What is the size? Is needle aspiration possible/needed?
Tendon involved? (Intramuscular or free tendon?)	What is the possible prognostic consequence?

Abbreviation: MRI, magnetic resonance imaging.

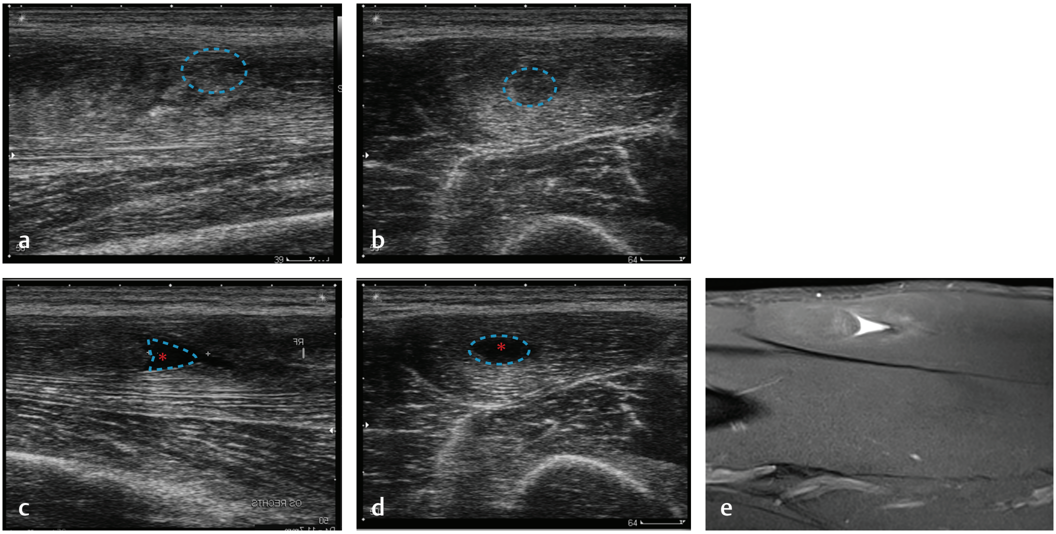

Fig. 4.8 **(a)** Hematoma echo-rich area longitudinal scans. **(b)** Hematoma echo-rich area transversal scans. **(c)** Hematoma retraction of the muscle fascicle longitudinal scans. **(d)** Hematoma retraction of the muscle fascicle transversal scan. **(e)** Sagittal section of a T2-weighted fat saturated image corresponding to (c).
(a,b) Ultrasonography 2 hours after an injury in an elite football player. A suspect area is visible (in **a**), owing to the corpuscular muscle hematoma (surrounded with --), but there is no obvious tear or retraction.
(c,d) Ultrasonography 12 hours later. The retraction of the muscle fascicle (--) is obvious, as is the tissue defect (*) in the muscle. The equivalent magnetic resonance (MR) image to **(c)** is shown in **(d)**. It is obvious, that in this case, MRI offers no additional information compared to a good ultrasonography image.
(a) and **(c)** Longitudinal scans. **(b)** and **(d)** Transversal scans. **(e)** A sagittal section of a T2-weighted fat saturated image.

Table 4.10

Recommendations for ultrasonography	
Use a 7.5- to 10.0-MHz transducer	For optimal resolution
Start with transverse scans	For the purposes of anatomical orientation
Scan completely through the muscle	Which will also help with anatomical orientation
Add a longitudinal plane	To confirm pathological findings
Compare with contralateral side	This helps to identify pathologies.
Light pressure of transducer on skin	As pressure could obscure smaller tears

4.4.2 Magnetic Resonance Imaging

MRIs are recommended whenever a *structural* injury is suspected. As with ultrasonography, MRIs help to do the following:

- Identify the location of the injury.
- Show any *structural* tear.
- Indicate its approximate size.
- See whether the tendon is involved.

MRI is better than ultrasonography as regards seeing whether an edema is present and what its pattern is. However, the diagnosis should not be based solely on the MRI report, and it is very important not to over-interpret MRIs.

High-resolution imaging is required for precise diagnosis. The quality of the imaging can differ significantly, since many radiologists choose a large field of view (e.g., showing both thighs and the pelvis, even though the clinical matter in question involves searching for a partial muscle tear several millimeters long in the biceps femoris muscle).

The argument that an MRI with a large field of view is the best initial test in order not to miss a muscle injury is only relevant if no clinical or ultrasonography examination has been conducted prior to the MRI. This should not happen, as MRI should not be performed before a clinical examination. When MRI follows a clinical examination, the field of view can be limited to the suspect area, as this will lead to a much higher spatial resolution.

If the site of the injury cannot be located precisely (e.g., if the sports physician is not present), an initial image with a large field of view should be captured in at least one plane in order not to miss a muscle injury. A large field of view ensures that the site of the injury is adequately covered.

Doctors are advised to use the following when conducting MRIs:

- A high field strength, with a minimum of 1.5 (and preferably) 3 T.
- A limited field of view (based on a clinical examination and ultrasonography).
- Skin markers to denote the area of the injury.
- Use of surface coils.
- Multiplanar imaging.

Slices at 1- to 3-mm intervals (of the injury area) should be used for MRIs of muscle injuries; otherwise, smaller tears could be missed. With a limited field of view, this does not increase the examination time.

Not even the best-quality MRI is sensitive enough to measure the extent of muscle tissue damage accurately on its own. It is not possible to judge from MRI scans of limited quality where an edema/hemorrhage (seen here as a bright signal) might be obscuring muscle tissue that has not been *structurally* damaged (see **Fig. 4.9a–c** and **Fig. 4.10a–d**).

The authors of this chapter recommend that the responsible team physician always view all images in

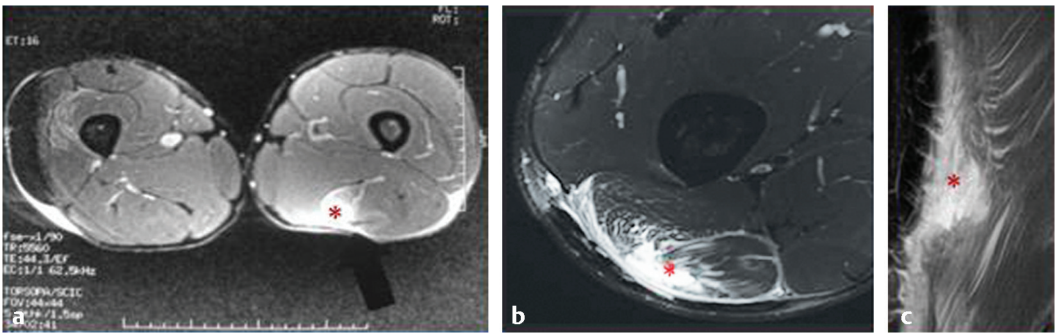

Fig. 4.9 (**a**) It is not possible to judge from this low-quality image if an edema or hematoma (* seen as a white spot/bright signal on the MRI) is obscuring muscle tissue that may have been structurally damaged. **(b,c)** High-resolution images (3T; surface coil; limited field of view) demonstrate more clearly the actual defect in the muscle structure (*). The torn muscle tissue can be determined more precisely within the bright signal. However, even though these images are of high quality, it is difficult to measure the actual defect size in the muscle tissue.

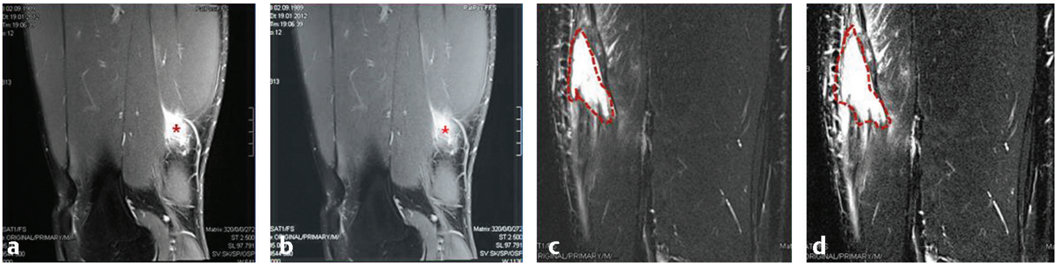

Fig. 4.10 The sagittal magnetic resonance imaging sections demonstrate that contrast and brightness (which can be adjusted by the examiner on the radiological monitors) can sometimes play a crucial role in the interpretation of muscle injuries. In **(a)**, for example, a high degree of brightness and a small amount of contrast can mimic a large muscle tear within the bright signal (*), leading to a potential misdiagnosis. **(b)** After adjusting the contrast and brightness, the actual defect in the muscle (with an adjacent edema) appears much smaller (*). **(c, d)** However, it is important to be aware that brightness and contrast do not influence the assessment of all structural muscle injuries. In the example of **(c)** and **(d)**, the brightness and contrast do not significantly influence the imaging in terms of the actual size of the tear. The size of the tissue defect (surrounded with –) remains the same.

order to gain her/his own impression of the injury, to compare it with the clinical findings, and to find out if a high/bright signal is in fact an overestimation of a *structural* tear.

It should be remembered that smaller muscle tears can be missed by MRIs. This makes it even more important to include information from the player's medical history and clinical examination in the diagnosis. However, the technology used to detect *structural* muscle injuries continues to evolve and become more sensitive. In a few years' time, it may be possible to better visualize tears and other pathological changes within the muscle. This should further improve our ability to effectively interpret and diagnose injuries.

NOTE:

Remember to view the images yourself. Do not just rely on a radiological report, which could potentially be misleading.

NOTE:

The resolution of the injury as detected by MRI can lag behind functional recovery, especially in contusion injuries.[26] A hematoma or edema can still be apparent on an MRI scan taken one month after return to play (RTP), when athletes are able to compete at the highest professional level without functional loss after a muscle contusion.[26] The issue of imaging lagging behind functional recovery has been also shown for *indirect* injuries.[27,28]

4.5 Treatment of Muscle Injuries

The biology of muscle healing is well described in the available literature.[10,29,30] The first treatment step is always to establish a precise diagnosis. This is crucial for treatment, as well as for a reliable prognosis. The risks of misdiagnosis are high: if the injury is diagnosed as being more serious than it actually is, the player and the team may lose important time, but if the injury is underdiagnosed, the player will potentially risk a reinjury.[31]

The current treatment principles for injured skeletal muscle have no firm scientific basis, and in the absence of any clear guidelines, accurate assessments of muscle injuries and effective communication between practitioners is often difficult to achieve. This can affect a player's progress in terms of rehabilitation and their RTP, and can also be expected to affect recurrence and complication rates for the injury.

Clinical experience in the treatment of muscle injuries has proven that a wait-and-see approach is not effective.[12] It is important to provide a prompt diagnosis and adequate treatment, especially for professional players, and a player who reports a muscle problem should be examined without delay. Prompt examination by a physician is of key importance, because there are differences between *functional* and *structural* injuries in terms of the postprimary care regimen and prognosis (**Fig. 4.11**).

Fig. 4.11 A player who reports a muscle problem should be examined without delay.

4.5.1 Immediate Management of Muscle Injuries

Standard immediate management of muscle injuries should follow the well-known RICE regimen (rest, ice, compression, and elevation) for acute treatment.[31]
Placing the injured extremity at rest immediately after the trauma prevents (in the case of a *structural* injury) further retraction of the ruptured muscle stumps (i.e., the formation of a large gap within the muscle), reducing the size of the hematoma and, subsequently, the size of the connective tissue scar.[10,31]
A cooling pressure bandage soaked in ice-cold water is a simple, fast, and convenient first-line treatment for athletic injuries. Even though there is some discussion about cooling and muscle injuries,[32] its liberal use is justified even in the event of uncertainty. The aim of this treatment is to minimize bleeding into the injury site and to control the inflammatory reaction that invariably follows a muscle injury.[33] Improper acute treatment (i.e., where RICE is not used) will not only delay the healing process, but also increase the risk of subsequent imaging overestimating the injury owing to the presence of a hematoma or edema (seen as a bright signal in the MRI; see above).[31]

NOTE:

Rest, ice, compression, and elevation (RICE) serve to minimize bleeding, control posttraumatic inflammation and scarring, and prevent further retraction of the ruptured muscle stumps.

Following a brief examination, the area of the muscle injury should be cooled immediately by placing a sponge soaked in ice-cold water over the broad area for approximately 20 minutes.[23] An elastic compression bandage should then be wrapped over the injury site. This compression bandage is kept cold and wet by soaking it intermittently with ice-cold water. The injured athlete should be placed in a position that relieves stress on the affected muscle and the leg should be elevated over the center of the body. After 20 minutes, the cold compression bandage should be removed and the injury reexamined by means of palpation and functional testing. This requires time, patience, and a calm atmosphere, as a definitive assessment of the severity of the injury should ideally be made during this baseline examination. Application of the ice-cold compression bandage should be repeated several times at intervals of 30 to 60 minutes.
Commercially available devices combine active intermittent compression and circumferential cooling in one treatment system. They can be used as a convenient part of the RICE regimen during the initial injury phase.

4.5.2 Immobilization/Taping

For immobilization, a firm adhesive tape is usually sufficient (see **Fig. 4.12**). A cast should not be used.

NOTE:

In most cases, crutches are not necessary. Immobilization is ensured by firm taping, which relieves the injured extremity.

The degree of immobilization required usually depends on the extent of the muscle injury. There is generally no need for crutches or a brace, but the player should be given precise instructions on which movements and exercises are allowed, and which should be avoided for the first few days after the injury, to prevent the muscle from stretching.
For example, in the case of a severe hamstring injury, since the hamstrings are biarticular muscles, their degree of tension is influenced by the position of the hip and knee joints. The hamstrings shorten when the hip is extended and the knee is flexed, and they become stretched when the hip is flexed and the knee is extended. As a result:

- Hip flexion should be allowed only when the knee is also flexed.
- Ordinary sitting is not a problem, but sitting with the legs extended should be avoided.
- The forces involved in ordinary walking cause no difficulties, but climbing stairs requires active extension of the hip while placing the entire body weight on one leg and should therefore be limited initially.[5]

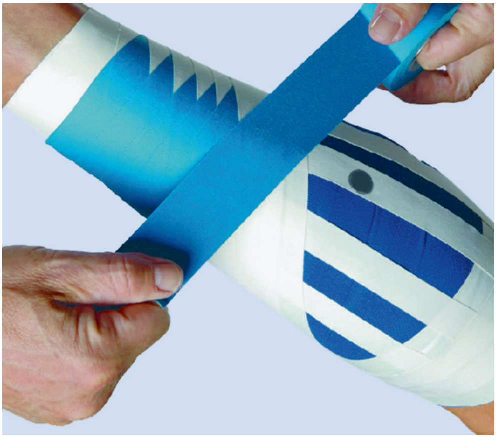

Fig. 4.12 Taping of an injured muscle. Key principles in muscle taping include the use of semicircular anchor strips and the symmetrical application of supporting strips. The affected muscle area should be relaxed during the actual taping.

Crutches are useful only for certain severe muscle injuries (especially on the calf), or when the injury is located at a site where immobilization is difficult (e.g., an avulsion injury affecting the distal gastrocnemius muscle).

It has been shown that early mobilization fosters more rapid and intensive capillary ingrowth in the injured area, better regeneration of muscle fibers, and a more parallel orientation in the regenerating myofibers. This is in comparison with immobilization, which used to be the preferred treatment for injured muscles.[10] It has also been shown that the biomechanical strength of the injured muscle returns to normal more rapidly using active mobilization than if the muscle is immobilized after the trauma.[10] In summary, a short period of immobilization after a muscle injury is beneficial in certain cases, but it should be limited to the first few days after the injury.[12,31] After a period of relative immobility, more active use of the injured muscle can gradually begin, to the extent that pain allows it.[5,10]

NOTE:

Early mobilization should be the aim when treating athletic muscle injuries.

Nonsteroidal Anti-Inflammatory Drugs

Nonsteroidal anti-inflammatory drugs (NSAIDs) have commonly been administered to treat muscle injuries in the past,[15] but today clinicians are more skeptical about their use, since both clinical and basic scientific studies have reported conflicting and even negative effects on the healing process.[34,35,36] Besides their anti-inflammatory properties, NSAIDs suppress the perception of pain by inhibiting prostaglandin synthesis, which may create problems, as an accurate and undistorted perception of the state of the injured muscle is of great importance for the player's rapid or progressive rehabilitation. Thus, NSAIDs are not recommended for the treatment of muscle injuries. Indometacin may be given if there are any signs of calcification/myositis ossificans (e.g., echo-rich particles in ultrasonography with a dorsal echo shadow).

4.5.3 Injection Therapy

Injection therapy is used in many countries, with positive results empirically. Evidence in the form of prospective randomized studies is still needed in order to verify these results and analyze the long-term effects. However, in 2008, a best practice statement indicated that almost all accepted knowledge in terms of treating muscle injuries currently has limited supporting evidence.[37]

Nevertheless, as injection therapy is frequently discussed within football medicine, and since players, coaches, and the media are often interested in this type of therapy, some basic information is provided here.

The aim of injecting therapeutic agents directly into affected or injured muscle tissue is:

- To regulate muscle tone by preventing a reactive increase in tone, or by relieving muscle firmness that is already present.
- To create optimum conditions for muscle regeneration.[37]
- If there is a hematoma/seroma, it can be punctured in the same session (**Fig. 4.13**).

There are several types of medication that are currently used for infiltration, and these are listed in the following sections.

Mepivacaine/Procaine

Local anesthetics such as mepivacaine or procaine block the voltage-dependent sodium channel on the axon. This keeps the nerve membrane from depolarizing at that site, temporarily blocking further conduction of action potentials past the site of action. Thus, an intramuscular injection of mepivacaine will functionally block all of the muscle fibers supplied by that axon (motor unit),[13] causing the treated muscle bundle to become "unexcitable" and lose its tone.[38]

Local anesthetics can produce local toxicity especially to nerves if they achieve sufficiently high concentrations.[39] Myotoxicity was never observed by the authors of this review after thousands of injections in various muscle injuries of football players using 0.5% mepivacaine (for technique and dosage, see below).

Traumeel

Traumeel is composed of several natural ingredients. Its precise mechanism is unclear, but it has been

Fig. 4.13 Infiltration treatment in an elite football player with a partial tear of the rectus femoris muscle along the intramuscular tendon. Needle aspiration of a seroma/old hematoma is performed through the central needle. The medicaments are injected around the injury along the injured muscle fascicle.

shown that Traumeel inhibits the secretion of the inflammatory mediators IL-1β, TNF-α and IL-8 from activated human lymphocytes by up to 70%.[40] It has also been found that glycoproteins from certain medicinal plants inhibit the influx of inflammatory cells and their mediators. Traumeel is also utilized for its localized antiedematous, dehydrating effects.[41]

Actovegin

One adjuvant agent that has successfully been used clinically to improve muscle regeneration is Actovegin, a deproteinized hemoderivative obtained by means of the ultrafiltration of calves' blood. Actovegin is not approved by the U.S. Food and Drug Administration (FDA) and is not available in all countries.

Actovegin consists mostly of electrolytes, essential trace elements, a mixture of amino acids, and intermediate products of carbohydrate and lipid metabolism. While several studies have examined the effects of Actovegin on various cell types and organ systems, the bioactive agent in Actovegin has not yet been identified,[34] and there is still controversy over its biological actions, especially in muscle tissue. Actovegin was not prohibited in sport at the time of publication (except if used intravenously), since it does not contain blood cells capable of increasing the transportation of oxygen, and there are several clinical studies confirming its safety.[34]

Although there is currently no indication from clinical studies that Actovegin is superior to other adjuvant treatment options, there is evidence that Actovegin has a positive impact on muscle regeneration following injury, particularly as regards muscle regeneration, fiber synthesis, detoning of firm muscle fibers, and the shortening of recovery times.[34,42] The 2008 publication on best practices also concluded that injection therapy using Actovegin could play an important role in the treatment of muscle injuries.[37] New data demonstrate that Actovegin can activate satellite cells and improve muscle cell proliferation. However, more objective evidence is needed before any definitive conclusions can be drawn.

Platelet-Rich Plasma

Autologous serum products have recently become the focus of growing interest in terms of the treatment of muscle and tendon injuries. Platelet-rich plasma (PRP) is increasingly being used in situations that require a rapid RTP, and more and more team doctors are reporting subjective data on positive effects on muscle injuries. Several positive reports from animal studies have been published,[43,44] but there have been few studies on humans. Hammond et al report a faster recovery time after a muscle injury in a small-animal study model using locally delivered PRP.[45]

Most major manufacturers in the world of orthopaedics and sports medicine market their own individual commercial equipment for PRP.[46] There are many different preparation protocols, with different concentrations of PRP,[46] so each is a biologically different product, with different potential uses.[47] Despite its increasing use in sports medicine, PRP has not been systematically studied and there is, as yet, no universal protocol for muscle injuries or other athletic injuries. A review by Harmon states that serious questions remain as to when and how PRP should be used in muscle injuries.[48]

Currently there are two high evidence level studies published that assessed whether PRP is effective in acute hamstring injuries. Interestingly, they have obtained contradictory results. Whereas one randomized, double-blind, placebo-controlled trial on 80 competitive and recreational athletes demonstrated no benefit for intramuscular PRP injections, as compared with placebo injections,[49] another randomized controlled trial with 28 patients concluded that a single autologous PRP injection combined with a rehabilitation program was significantly more effective in treating hamstring injuries than a rehabilitation program alone.[16] Thus, questions remain as to when and how PRP should be used in muscle injuries.[48]

The authors of this chapter see the useful indications for PRP only in the treatment of more severe muscle injuries and tendinous avulsions. Nonstructural and smaller structural muscle injuries should not be treated with PRP since PRP usually contains deleterious cytokines and growth factors, such as TGF-β1, that can cause fibrosis and inhibit optimal muscle healing.[17,50]

Certainly, more evidence is needed before any meaningful conclusions can be drawn and before PRP or other autologous serum products become routine in the treatment of muscle injuries in competitive athletes.

The following injection regimen has been proven useful: after diagnosis and localization of a muscle injury, five needles are placed along the injured muscle fascicle by continuously infiltrating mepivacaine (approximately 1 mL/needle). If necessary, needle aspiration of a hematoma can be performed through the central needle (**Fig. 4.13**). A mixture of Traumeel and Actovegin in a ratio of 1:2 (1.5 mL/needle) is infiltrated with light pressure.[5,31]

Injection Treatments and Antidoping Regulations

The above-mentioned substances were permitted by the World Anti-Doping Agency (WADA) and Fédération Internationale de Football Association (FIFA)/ Union of European Football Associations (UEFA) at the time of publication. Platelet-derived preparations administered as intramuscular injections were included in WADA's Prohibited List until 2010, but intramuscular usage has been allowed since 2011. Doctors should always check the status of any drug with WADA (http://www.wada.org>) and/or their national antidoping agency before administering it to professional athletes, particularly as substances can be added to or removed from WADA's Prohibited List from one year to the next.

Some substances can only be administered via intramuscular routes if the athlete has a therapeutic use exemption (TUE) approved by the relevant antidoping authority prior to administration. Doctors should always be familiar with the rules regarding TUE application and WADA's TUE approval criteria, which include the requirement that the therapeutic use of the Prohibited Substance or Prohibited Method would produce no additional enhancement of performance other than that which might be anticipated by a return to a state of normal health following the treatment of a legitimate medical condition. The use of any Prohibited Substance or Prohibited Method to increase 'low/normal' levels of any endogenous hormone is not considered an acceptable Therapeutic intervention.

NOTE:

Corticosteroids should not be used locally or systemically in the treatment of muscle injuries. Local corticosteroid therapy can slow healing by suppressing physiological responses to injury. It can also significantly increase the risk of a soft tissue infection and/or local soft tissue necrosis.

4.5.4 Treatment of Back-Related Muscle Disorders

In certain cases, such as spine-related neuromuscular disorders, infiltration of the lumbar spine can be used to support the mobilization of spinal segments, normalize muscle tone, and relieve pain.[5] Good empirical results have been reported by experts in this field, but evidence from studies is still lacking. Infiltration of the lumbar spine should be used with caution, and the treatment should be performed only by specialists with experience and knowledge of the method and the risk of complications. If it is used, an effort should be made to preserve mobility and improve stability with the aid of manual therapy, massage, and therapeutic exercises focusing on core strength.

4.5.5 Treatment of Muscle Contusions

The "blunt character" of the compressive external force contuses, rather than tears, the muscle tissue.[7] Diffuse localized or regional hemorrhaging is common, but does not always lead to the formation of an externally visible hematoma. Contusions are very often painful and may cause considerable functional disability in the affected area. In many cases, however, players become fully aware of the injury only after leaving the field. The greatest pain is felt on the day of the injury and the following day, and it subsides over the next few days. The player's medical history provides the first clue that a *direct* muscle trauma (i.e., contusion) has occurred, and this can then be confirmed using palpation, functional testing, and ultrasonography. It is particularly important that deep, circumscribed hematomas are identified, as these will require aspiration.

Acute care for muscle contusions is the same as for all other muscle injuries, and postacute care should always involve physiotherapy and physical medicine.[51] The day after the injury, the player will generally be able to perform cycling or aquajogging (wearing a compression bandage), and running at an easy pace may be started on the second day after the injury (depending on pain and swelling). Rehabilitation can usually can be more aggressive to the limit of pain tolerance, with function progressively increased as motion and strength return.[7,26] Exercises usually progress quickly, such that the injured player can, in most cases, return to full training and competition by the third or fourth day.

NOTE:

The extent of muscle contusions can vary greatly, but the rehabilitation plan can be based on clinical complaints like pain (which is not a useful indicator in indirect injuries), since there is usually no underlying structural injury in terms of a tear caused by longitudinal distraction.

4.5.6 Physiotherapy

Appropriate physiotherapy methods have an important role to play in the management of muscle injuries. Physiotherapy, rehabilitative exercises, and training therapy are essential components of the reconditioning of an injured structure, the restoration of coordination and proprioception, the normalization of movement patterns, the prevention of muscular atrophy, and the return to normal force development.[52]

More active treatment of the injured muscle should gradually begin after the initial phase, using the following specific exercises[10]:

- **Isometric training**. These are muscle contractions in which the length of the muscle remains constant and the tension changes.
- **Isotonic training**. Here, the muscle length changes, but the tension remains constant during muscle contraction.
- **Isokinetic, dynamic training (with minimal loads)**. This should be started once the abovementioned exercises can be performed without pain. Isokinetic exercises should be performed very carefully in order not to overload the injured muscle.

NOTE:

The key advantage that professional athletes have over recreational athletes lies in the continuous, intensive care provided by sports physical therapists, massage therapists, and rehabilitation trainers on a daily basis.

Physiotherapy, physical medicine, and progressive training regimens should never be conducted on a "trial-and-error" basis and should not be self-directed by the patient.[5] Instead, they should follow a well-structured timetable that is appropriate for the specific injury or disorder. Since the pain of a *structural* muscle injury often subsides shortly after the injury, this may tempt the patient to use the injured muscle at the preinjury level. Regular follow-ups by the doctor with an up-to-date assessment of the healing process are critically important in order to make any adjustments that may be needed in terms of the timing and nature of proposed therapies.

NOTE:

The lack of pain is not a good indicator during the rehabilitation process, since pain often subsides in a short period of time.

4.5.7 Rehabilitation Monitoring and Return to Play

In athletes with more severe muscle injuries, it is particularly important to conduct regular clinical examinations to evaluate the progress made in terms of healing.[22] Only meticulous palpation by an experienced examiner can supply useful information on muscle tone. A normalization of the muscle tone signifies that healing is progressing.

In any strengthening program, the injured muscle must gradually regain a normal functional tone without exhibiting regional or generalized protective reactions. These reactions are generally manifested by palpable, cord-like areas of muscle firmness and should always be taken as a warning sign. In all cases, the injured site itself (edema, discontinuity, scar tissue, retraction of the muscle bundle, etc.) should be thoroughly evaluated.

Progressive exercising of the injured limb in incremental stages not only retrains the muscles in complex movement patterns, but also provides valuable feedback for doctors and therapists (**Fig. 4.14a, b**). The player is ready to advance to the next stage only when he/she is free of complaints/pain.[22]

A precise rehabilitation plan has to be developed for every athletic muscle injury, including recommendations for sport-specific training with increasing intensity.[52] With a plan of this kind and thorough follow-up examinations, low recurrence rates can be achieved (**Fig. 4.15**).

The primary goal is to avoid players from being exposed to high loads too early and thus to avoid reinjury. In this context, it must be pointed out that there are no definitive and standardized RTP criteria. The value of strength testing before RTP is controversially discussed. It has been shown that normalization of isokinetic strength testing seems not to be a necessary result of the successful completion of a football-specific rehabilitation program.[53] The authors of this review are convinced that it is not

Fig. 4.14 **(a, b)** Rehabilitation after muscle injury. These figures demonstrate how to use a total body trainer with load removal of the injured leg.**(c, d)** These figures demonstrate how exercises for the lumbopelvic-hip complex can be performed without load on the injured leg.

Fig. 4.15 A precise rehabilitation plan has to be developed for every athletic muscle injury.

possible to develop relevant universal RTP recommendations in the near future.

The current discussion about premature RTP after surgery[54] must definitely be expanded to premature RTP after muscle injury.

4.5.8 Surgery

As mentioned earlier, the vast majority of muscle injuries can be resolved with nonoperative management, and only a small number of cases will require surgical intervention.[23,55] Complete avulsions with significant retraction of the muscle (meaning, in biomechanical terms, a total tear in the origin or insertion of the muscle), such as a proximal avulsion of the hamstrings, the rectus femoris, or a distal avulsion of the semitendinosus muscle, are unlikely to lead to healing at the anatomical origin.[7] Since an adverse effect on muscle strength and function is likely, surgical re-fixation using suture anchors should be aimed for in these cases.[7] In the case of proximal hamstring avulsions, surgical re-fixation should definitely be indicated for avulsions with > 2 cm of retraction.[30]

In contrast, complete tendinous avulsions of the proximal adductor longus tendon can be managed conservatively even if the tendon is significantly retracted.[56]

It should be remembered that a tendinous avulsion does not always undergo significant retraction or displacement from its anatomical origin. Consequently, some of these cases can be managed conservatively with excellent functional outcomes, avoiding the immediate risks associated with surgery and general anesthesia, as well as the development of postoperative adhesions and scarring, which players often regard as a serious limiting factor in terms of their return to football.

Surgical intervention after contusions or more severe muscle tears is only required when hematomas cause neurovascular compression. This is rare in athletic muscle injuries.

4.6 Prevention of Muscle Injuries

The results of recent studies confirm that preventive training measures can reduce the risk of muscle injuries.[52,57] A general distinction can be made between neuromuscular factors and factors related to training methods.[52] Possible aspects are improvement of neuromuscular function, stretching, eccentric exercises, such as “Nordic Hamstring,” improvement of the intermuscular coordination as well as training of the lumbopelvic stability.

Core exercises to stabilize the trunk have become increasingly popular in recent years for general injury prevention in high-level sports. This appears to be an important preventive measure from a physiological standpoint, since deficits in the neuromuscular control of the entire lumbopelvic region (called also the lumbopelvic-hip complex or “core”) are considered an important predisposing factor for muscle injuries.[52] Sherry and Best found that a rehabilitation program emphasizing trunk stabilization led to a significant reduction in reinjury rates compared with a training program based entirely on classic strength training and stretching.[58]

Many studies confirm that training to improve lumbopelvic stability and strength can significantly influence the function of the lower extremity muscles and that this type of training can also make an important contribution for the prevention of muscle injuries by optimizing the function of the lower extremity muscles.

4.7 Summary

This chapter aims to explain the basic principles governing the examination and treatment of athletic muscle injuries. Since it is important to provide a prompt diagnosis and adequate treatment, especially for professional athletes, doctors are always advised to combine various diagnostic modalities (such as the player’s medical history, an inspection, a clinical examination, functional testing, and imaging) in order to achieve an accurate diagnosis.

Acute treatment following the RICE principle is essential to minimize bleeding and control posttraumatic inflammation. An injury type-specific rehabilitation plan including recommendations for sport-specific training with increasing intensity has to be developed for every muscle injury. Early mobilization should be the aim in most cases and appropriate physiotherapy methods have an important role to play. Local injection treatment should be considered to control muscle tone, to create optimum conditions for muscle regeneration, to reduce scarring, and to puncture a potential hematoma or seroma. Surgery after muscle injury is only indicated in rare cases. Regular clinical follow-ups before RTP are usually necessary to evaluate the progress made with healing, and to prevent reinjury.

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Chapter 5

Groin Injuries

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5.1 Introduction

Injuries to the hip/groin region are some of the most common injuries in football. According to the Union of European Football Associations (UEFA) Elite Club Injury Study, they account for around 14% of all time-loss injuries.[1] A male professional team will suffer an average of seven groin injuries per season, with more than half leading to layoffs of a week or more. Groin injuries appear to be less common among female footballers.[2] This chapter will provide an overview of the diagnosis and treatment of the most common traumatic soft tissue injuries and overuse injuries affecting the hip/groin area.

5.2 Groin Anatomy

The two hip bones—the os coxae—are connected to the spine at the sacroiliac joints and to the lower extremities at the hip joints. Anteriorly, the hip bones join at the pubic symphysis. Together with the sacrum and coccyx, they comprise the pelvic girdle. The pelvic girdle is very stable, with small movements occurring at the pubic symphysis and in the sacroiliac joints. The hip bone is formed by three separate bones, which fuse with skeletal maturity: the ossa ilium, ischium, and pubis. These three bones join together in a Y-shaped area of cartilage in the acetabulum. The hip joint is a large ball-and-socket joint where the acetabulum articulates to the femoral head. A cartilage ring, the labrum, which helps to provide stability to the joint by deepening the socket, covers the bony rim of the acetabulum.

The term “groin area” usually refers to the junction between the lower abdomen and the anteromedial part of the thigh. Numerous muscles act as stabilizers for the pelvis and have their origins and insertions on the pelvic girdle. Consequently, many muscular attachments are found on the iliac crest of the os ilium, as well as the superior and inferior rami of the os pubis. The insertion of the rectus abdominis muscle and the origins of the adductor muscle group are located medially, near the pubic symphysis. The adductor muscle group consists of five separate muscles: the adductor longus, the adductor brevis, the adductor magnus, the gracilis, and the pectineus. The abdominal wall muscles (the rectus abdominis, the transversus abdominis, and the internal oblique and external oblique muscles) are located above the inguinal ligament. The aponeurosis of the external oblique muscle is part of the anterior wall of the inguinal canal, and the aponeurosis of the internal oblique and transversus abdominis muscles are part of the posterior wall of the inguinal canal as they insert into the pubic bone as the conjoint tendon (the falx inguinalis).

NOTE:

The relationship between the abdominal muscles and the adductor muscles is a superficial connective tissue connection. The important main insertion of these muscles are individual into the pubic bone and they do not have a direct biomechanical relevant connection to each other.

Located anterolaterally and proximally on the femur, distal to the inguinal ligament, are the muscle bellies of the sartorius muscle, which has its origin at the anterior superior iliac spine (ASIS), and the rectus femoris muscle, which has its origin at the anterior inferior iliac spine (AIIS). The iliopsoas muscle is located deeper in the groin and consists of the iliacus muscle, arising from the wing of the os ilium, and the psoas major muscle, arising from T12 to L5. The iliopsoas inserts on the lesser trochanter of the femur and acts as a strong hip flexor. Located posterolaterally are the gluteus muscles, which consist of three layers: the gluteus maximus (the primary function of which is hip extension), followed by the gluteus medius in the middle layer (the primary functions of which are abduction and rotation of the hip), and the gluteus minimus in the deepest layer (the primary function of which is abduction).

Anteriorly, the neurovascular bundle is located superficially in the femoral triangle below the inguinal ligament and between the iliopsoas and adductor longus muscles. The femoral artery is a continuation of the external iliac artery. Medial to the artery is the femoral vein, and lateral to the artery is the femoral nerve. The femoral nerve emanates from the lumbar plexus (L2–L4), innervating the quadriceps muscle and a large cutaneous portion of the anteromedial thigh. Other important nerves innervating the groin area are the ilioinguinal, iliohypogastric, and genitofemoral nerves. The ilioinguinal and iliohypogastric nerves emanate from the nerve roots of T12 and L1. They traverse the psoas major muscle and pierce the transversus abdominis superomedial to the ASIS, and then “zigzag” through the three layers of the abdominal wall muscle. They finally become cutaneous through an opening in the external oblique near the external orifice of the inguinal canal. The ilioinguinal nerve supplies sensory branches to the pubic symphysis, the superomedial aspect of the femoral triangle, and either the root of the penis and the anterior scrotum in the male or the mons pubis and labia majora in the female. In contrast, the iliohypogastric nerve only innervates a small cutaneous region just superior to the pubis, and there is frequently overlap in terms of sensory innervation with both the ilioinguinal and genitofemoral nerves. The latter arises from L1 and L2 and is split into the

genital and femoral branches near the inguinal ligament. The genital branch then enters the inguinal canal and innervates, for example, the cremaster muscle and the skin of the scrotum and the adjacent superomedial thigh in the male, and the labia majora and the adjacent superomedial thigh in the female.
Finally, there are a few important bursae in the hip and groin area. For example, anteriorly, between the hip joint capsule and the iliopsoas muscle, the iliopectineal bursa can be found, and lateral to the greater trochanter and the external rotators of the hip is the trochanteric bursa.

5.3 Clinical Examination

Groin injuries are often a major diagnostic challenge, with a number of differential diagnoses for the clinician to consider. For example, 18 different diagnostic entities were recently recorded in the UEFA Elite Club Injury Study for the groin area,[3] the most common being adductor- and iliopsoas-related injuries. However, the third most common diagnostic entity was unspecified groin pain, reflecting the fact that these injuries often present with diffuse and vague symptoms. The underlying primary causes of longstanding groin pain can sometimes be difficult to detect, even in experienced hands, especially as secondary symptoms such as further musculotendinous pain often develop over time. A multidisciplinary approach can sometimes be helpful, and referrals to other practitioners for a second opinion may also be needed. Female players with groin pain should often be examined with a view to ruling out potential gynecological causes.

NOTE:

Previous hip/groin injuries are the most important risk factor when it comes to suffering new groin injuries.

A diagnosis should be made on the basis of a thorough patient history, accompanied by a systematic clinical examination. With acute-onset injuries, the examiner should be able to identify:
- If the player felt a "snap" or "pop" when the injury occurred.
- If the player was able to continue playing or had to leave the pitch.

With gradual-onset complaints, it is important to:
- Find out if there has been any change of training load, footwear, or playing surface.
- Carefully establish a pain history.

Buttock and groin pain can indicate hip joint dysfunction. A very common indicator of this is the "C sign" (**Fig. 5.1**), where the patient puts a hand over the lateral part of the hip region, pointing to the posterior part with the thumb, to the lateral part with the palm, and to the anterior part with the other four fingers, indicating that the pain is deep in there where those three points meet.

Fig. 5.1 C-sign.

Anterior groin pain in the midportion of the thigh can be the result of iliopsoas-related pain, while more medial groin pain can be due to adductor-related pain. The possibility of a stress fracture of the pubic bone or the femoral neck should also be considered when anterior groin pain is indicated. When pain is reported in the abdominal muscles, Valsalva-like maneuvers such as coughing and sneezing are usually painful.
The muscles, tendons, nerves, ligaments, and joints in the hip and groin region all interact with and are dependent on each other. Pain and dysfunction in the hip joint, whatever the cause, will affect the surrounding muscles and tendons and can lead to secondary problems. Primary conditions in the surrounding tissue can affect the functioning of the hip joint, leading to synovitis and other painful conditions. It is important to be aware of this interdependence when diagnosing and treating patients with hip and groin pain. It is therefore extremely important to examine both the surrounding extra-articular structures and the hip joints systematically. The synergies between the muscles acting across the pelvis, sacroiliac joints, and hip joints are important for the correct functioning of most movements that involve the extremities. A number of muscle groups interact in the groin area—the adductors, the iliopsoas, and the abdominal muscles—and these are the primary musculotendinous structures that are at risk of being injured in football.

A clinical examination of the groin area should consist of the following:
- Visual inspection.
- Evaluation of range of motion (ROM).
- Impingement tests.
- Muscle strength tests.
- Palpation.

- Local neurological examination.
- Other groin-specific tests.

NOTE:

The lower back and the sacroiliac joints should also be examined in a player with groin pain.

5.3.1 Visual Inspection

During the visual inspection, the examiner needs to look for identifying factors such as limping or other types of gait disturbance, swelling, a hematoma, muscle hypotrophy, and leg length discrepancies.

NOTE:

The visual inspection should always be carried out with the patient walking, standing, and lying down.

5.3.2 Evaluation of Range of Motion

The typical ROM for a footballer's hip is 120 degrees of flexion, 30 degrees of extension, 40 to 45 degrees of internal and external rotation, 30 degrees of adduction, and 40 degrees of abduction. Since the passive ROM is usually greater than the active ROM, the passive ROM should always be included in the examination, even if the player has a pain-free and symmetrical active ROM. In patients with femoroacetabular impingement (FAI), internal rotation is typically reduced to less than 30 degrees.

5.3.3 Impingement Tests

Having tested the passive ROM of the hip joint, the doctor should then conduct the two common tests for FAI: the flexion, adduction, and internal rotation (FADDIR) test and the flexion, abduction, and external rotation (FABER) test. These tests have high sensitivity, but very low specificity; they cannot by themselves diagnose an intraarticular hip problem, but on the other hand if both tests are negative, it is unlikely that a hip joint injury is present.

Flexion, Adduction, and Internal Rotation Test

The FADDIR test, or the anterior impingement test, is carried out with the patient supine (**Fig. 5.2**). The hip is flexed at 90 degrees, adducted, and then rotated internally. The test is considered positive if the known pain in the groin is reproduced during the maneuver. It is important to know that the impingement test will also give rise to pain if the player has an iliopsoas-related injury, on account of the sore muscle being folded (flexion), twisted (adduction), and pulled (internal rotation).

Flexion, Abduction, and External Rotation Test

In the FABER test, the player lies in the supine position. The legs are moved passively into a "figure four" position. The hip and knee joints are flexed, the hip is abducted and rotated externally, and the ankle is placed just above the contralateral knee. Gentle pressure is applied to the medial side of the knee and a contralateral pressure is exerted on the ASIS to balance the pelvis. The test is considered positive if the known pain is reproduced during the maneuver. If the test results in pain posteriorly or laterally, the sacroiliac joints, the lower back, the hip abductors, and the hip rotators should be considered as possible causes of the pain.

Fig. 5.2 Impingement test.

NOTE:

The impingement tests are highly sensitive, but the degree of specificity is considerably lower, meaning that it is not always easy to ascertain the specific location of the injury.

5.3.4 Muscle Strength Tests

Muscle strength should be evaluated against resistance. This is usually done manually by the examiner, but other methods (such as using hand-held dynamometers) may also be helpful.[4]

NOTE:

The strength of the adductor, iliopsoas, and rectus abdominis muscles should always be assessed systematically when physically examining a footballer with groin complaints.

5.3.5 Palpation

Important anatomical structures to palpate include the pubic symphysis and the immediately adjacent bone, the inguinal ligament and the inguinal canal region, and tendon attachments and muscle bellies (in particular for the adductor longus and the iliopsoas).

The pubic symphysis and the conjoined tendon insertion at the pubic tubercle just medial to the inguinal ligament is palpated in the supine position, as is the area 1 to 2 cm proximal to that insertion.

The palpation of the adductor longus is carried out with the patient supine (**Fig. 5.3**). The hip is flexed, abducted, and rotated externally, with the knee slightly flexed. The examiner, using the right hand on the right leg and the left hand on the left leg, palpates the adductor longus muscle belly with two fingers and follows the tendon to the insertion at the pubic bone. The insertion area, including the bone, is tested with firm pressure up to a radius of about approximately 1 cm^2.

The iliopsoas can be palpated both above the inguinal ligament at the level of the ASIS and under the ligament medial to the sartorius muscle and lateral to the femoral artery (**Fig. 5.4a**, **b**). The patient lies supine and proximal palpation is performed with both hands, using fingers to make the palpation as gentle as possible. The fingers are gently pressed posteriorly while pushing the abdominal structures away to reach the iliopsoas muscle. The subject must be relaxed. During distal palpation, the iliopsoas muscle can be identified by asking the patient to elevate the examined leg 5 cm and the correct placement of the palpating fingers can be confirmed.

Fig. 5.3 Adductor palpation.

The external orifice of the inguinal canal should be palpated with the patient standing. The orifice is normally the size of a fingertip, but in players with an inguinal hernia, an enlarged orifice is often noted, with the contents of the hernia pushing against the finger when the patient coughs.

NOTE:

The hip joint and the iliopectineal bursa are located too deep in the groin to be palpated.

5.3.6 Local Neurological Examination

A simple neurological examination of the groin area and the lower extremities should always be included to rule out referred pain from the lower back and detect hyperesthesia or hypoesthesia along the cutaneous distribution of the ilioinguinal and genitofemoral nerves.

5.3.7 Other Groin-Specific Tests

The physical examination of a player with groin pain should always also include a squeeze test for adductor-related symptoms and the Thomas test for iliopsoas-related symptoms. A nerve block test to check for ilioinguinal/iliohypogastric nerve entrapment can also be useful, as can a hip joint block test to check for intraarticular pathologies such as osteoarthritis (OA) and labral and/or cartilage lesions. Ultrasonography is often helpful, as the accuracy has been

Fig. 5.4 **(a, b)** Iliopsoas palpation.

5

Fig. 5.5 Adductor squeeze test.

Fig. 5.6 Thomas test.

shown to be higher than for landmark-based injections, when placing the blocks.

Adductor Squeeze Test

The adductor squeeze test is performed with the patient supine (**Fig. 5.5**). The examiner stands at the end of the treatment table with the hands and forearms between the subject's feet to hold them apart. The subject's feet point straight up, and the subject presses them together with maximum force without lifting the legs or pelvis. The test is positive if it produces pain in the adductor muscle complex.[5]

Thomas Test

The Thomas test is carried out with the patient lying supine with the legs hanging over the edge of the treatment table (**Fig. 5.6**). The subject then flexes one hip by clasping the knee in both hands and pulling it down to his/her chest. The other leg hangs relaxed over the edge of the table. The examiner stands at the end of the table supporting the position by pressing the side of his/her trunk against the foot of the flexed leg. The examiner then places one hand on the femur of the hanging leg just above the knee and presses the leg down to stretch the iliopsoas passively. The test is positive if the known groin pain is reproduced.

NOTE:

The Thomas test can also identify tightness in the tensor fascia latae (which can be seen from hip abduction during the test) and tightness in the rectus femoris (which can be seen from incomplete knee flexion during the test).

Nerve Block Test

In the nerve block test, the player has to perform an exercise that elicits recognizable pain, such as a straight-leg lift. The examiner then injects a local anesthetic into the area where the ilioinguinal and iliohypogastric nerves pierce the internal oblique muscle. If the nerve block is successful, the skin of the lower abdominal wall and inguinal region (the pubic symphysis and the superomedial aspect of the femoral triangle, as well as the root of the penis and the anterior scrotum in the male or the mons pubis and labia majora in the female) is anesthetized. If the straight-leg lift or another pain-provoking exercise can now be performed without pain, the nerve block test indicates that there may be a symptomatic nerve entrapment. However, in the case of genitofemoral nerve entrapment, blocking the ilioinguinal and iliohypogastric nerves as described above should leave the pain or abnormal sensation unchanged, but blocking the L1 and L2 roots should result in pain relief.

Hip Joint Block Test

In a hip joint block test, the player also has to perform a typical exercise that elicits recognizable pain. The examiner then injects a local anesthetic into the hip joint, preferably ultrasonography guided. If the block is successful, the pain-provoking exercise can now be performed without or with lesser pain than before.

5.4 Radiological Examination

According to the UEFA Elite Club Injury Study, almost one-third of all adductor-related injuries and half of all iliopsoas-related injuries are diagnosed solely on the basis of clinical examinations.[3] Radiographic abnormalities are common in highly active male and female footballers,[6] and current evidence on the use of radiographs, ultrasonography, and magnetic resonance imaging (MRI) is based on a relatively small

Fig. 5.7 Anteroposterior radiograph with femoroacetabular impingement morphology bilaterally.

Fig. 5.8 Anteroposterior radiograph of bony changes at the pubic symphysis.

number of heterogeneous studies, which are of varying methodological quality.[7] Consequently, the correlation between players' symptoms and identified radiological abnormalities may be low. Caution should therefore be exercised when using radiological imaging in the diagnosis of injuries.

Standard radiographs should still be carried out in many cases, and other modalities such as MRI or ultrasonography can often be used as well.[3] If the patient history and the clinical examination suggest FAI, an anteroposterior pelvic radiograph (**Fig. 5.7**) and a true lateral radiograph should be obtained. The α angle is measured using the lateral view by drawing a best-matching circle around the femoral head. A straight line is then drawn from the center of the femoral neck to the center of the femoral head, followed by another line from the center of the femoral neck to the superolateral point where the head joins the neck. An angle of more than 55 to 60 degrees is usually considered pathological.

Plain radiographs are also used in skeletally immature adolescent players to detect osseous avulsions in acute proximal or distal musculotendinous distraction injuries and epiphysiolysis of the growth plate of the femoral neck. Another reason for obtaining radiographs at an early stage of diagnosis is the fact that, even in seemingly healthy players, neoplasms such as chondrosarcoma and Ewing's sarcoma may be possible causes of unexplained groin pain.

Historically, considerable attention has been paid to radiological findings such as osteolysis and widening of the pubic symphysis and sclerosis along the rami of the os pubis (**Fig. 5.8**). This condition was originally called symphysitis or osteitis pubis, but these bony changes have since been shown to be common also in asymptomatic footballers, thus merely reflecting the considerable strain that the pelvic girdle is exposed to in football.

Herniography is a simple and reliable method of diagnosing an inguinal hernia or showing weakness in the abdominal wall. However, herniography shows only the anatomy, not the symptoms, so incipient hernias—especially bilateral hernias—identified via herniography must be correlated with the clinical symptoms before a decision is made regarding treatment.[8] Herniography is an invasive procedure, so it is now often replaced by dynamic ultrasonography, which allows the assessment of a variety of differential diagnoses, such as musculotendinous pathologies.[9] Similarly, MRI is also highly sensitive, allowing the observation of musculotendinous pathologies and, when used dynamically, weakness in the abdominal wall, making it another potential alternative to herniography. The main advantage of using MRI, however, is the ability to diagnose occult bony injury, including stress fracture and bone marrow edema (BME). As with the changes in the symphysis joint in radiographs, BME near the pubic symphysis has been shown to be very common also in asymptomatic footballers,[10] which reflects the amount of stress that the pelvic girdle is exposed to. Finally, MRI (ideally gadolinium contrast-enhanced MRI) are also excellent for observing joint cartilage lesions and labrum tears.

5.5 Groin Strains

Musculotendinous distraction injuries are very common in football, regardless of the player's competitive level, and they are typically the result of noncontact injury mechanisms. Acute pelvis-related muscle tears are essentially no different from other acute muscle injuries and should be classified and treated in the same way. These injuries are categorized as either partial or complete tears, and this classification can have some prognostic value, since some total muscle tears or nonosseous tendon avulsions may need surgery.

Osseous avulsions are seen fairly often in adolescents. In footballers, these primarily affect the AIIS and the origin of the rectus femoris muscle and typically occur during kicking. The second most common complaint is an injury to the ASIS and the origin of the sartorius muscle, typically as a result of jumping. Occasionally, the insertion of the iliopsoas at the lesser trochanter can also be avulsed. Regardless of the location, the avulsed fragment is rarely significantly dislocated, so nonsurgical treatment is possible in most cases. Return to football after nonsurgical treatment of minimally displaced bony avulsions is often possible within 3 to 4 months. Surgical fixation might be required if the fragment is very big or substantially dislocated (i.e., more than 2 cm).

5.5.1 Adductor Tears

Epidemiology and Diagnostics

Adductor longus strain is the single most common muscle tear in the groin area.[3] The rectus femoris and the iliopsoas are the second most common and abdominal muscle tears are quite rare.[11] Partial tears are located near the origin or in the muscle belly. Avulsions and total proximal tears are less common. The typical injury mechanism occurs when the player is kicking or changing direction.[11] The adductor squeeze test is positive, with pain and weakness. MRI and ultrasonography are highly sensitive, allowing adductor injuries involving fiber tears to be observed (**Fig. 5.9**).

Treatment and Return to Play

In the acute setting, the treatment of choice is rest, ice, compression, and elevation (RICE). There is a broad consensus in favor of early mobilization with a progressive rehabilitation program for all partial tears. Even a total adductor longus tear, including nonbony avulsions, can be managed nonsurgically, since there are numerous agonists and functional loss is minimal, but surgical fixation if the retraction is more than approximately 2 cm is justifiable. A player can usually return to play within 2 to 4 months, depending on the location and size of the lesion.

Prognosis

The prognosis is usually good, but reinjuries can be a problem. Full rehabilitation of all the muscles related to the hip and pelvis—not just the injured adductor muscle—is imperative to restore associated pelvic muscle instability and prevent a recurrence of the injury.

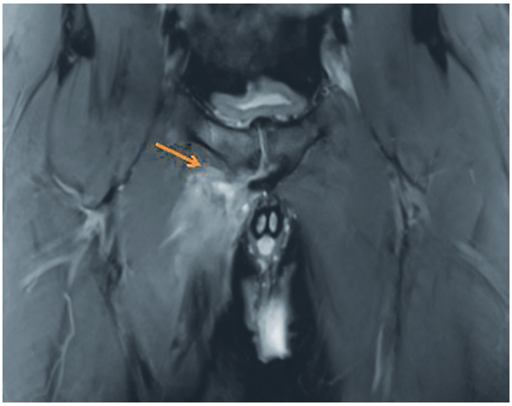

Fig. 5.9 Adductor longus tear. (This image is provided courtesy of Sonia Branci.)

5.5.2 Iliopsoas Tears

Epidemiology and Diagnostics

Partial tears are almost always found close to the distal musculotendinous junction and typically occur when kicking the ball or changing direction.[11] Total muscle tears are rare. The player experiences pain and weakness during resisted hip flexion, and the Thomas test is positive.

Treatment and Return to Play

The recommended immediate treatment is RICE, followed by early mobilization. A player can usually return to play within 2 to 4 months, depending on the location and size of the lesion.

Prognosis

The prognosis is generally better than for an adductor tear.

5.5.3 Abdominal Muscle Strains

Epidemiology and Diagnostics

Acute muscle injuries to the abdominals are in general very rare. Partial tears are typically seen near the insertion, whereas total tears and avulsions are extremely rare.[11] The most frequent injury mechanisms in football are kicking or heading the ball. The player experiences pain during palpation, resisted straight-leg lifts, and head lifts. MRI and ultrasonography are often helpful when diagnosing these injuries.

Treatment and Return to Play

As with other partial tears, the recommended treatment is RICE and physical therapy.

Prognosis

A recent study has found that abdominal-related injuries combined with adductor-related injuries have a less favorable prognosis than other groin injuries.[12]

5.5.4 Other Muscle Tears in the Groin Area

Epidemiology and Diagnostics

Rectus femoris injuries are as frequent as iliopsoas injuries. They typically occur when kicking the ball.[11] With this injury, the player experiences pain and weakness not only on hip flexion, but also on resisted knee extension. The hip flexors (iliopsoas, rectus femoris and sartorius) are difficult to distinguish from each other clinically so MRI and ultrasonography could be helpful in differentiating between these various muscles.

Treatment and Return to Play

As with other partial tears in the groin area, the recommended treatment is RICE and physical therapy. In the case of a total nonosseous avulsion with significant tendon retraction affecting the rectus femoris, surgical fixation is needed.

Prognosis

The prognosis is usually good, but layoffs can sometimes be long and reinjuries can be a problem.

5.6 Cartilage and Labrum Injuries

Due to the development of hip arthroscopy during the last 10-15 years, cartilage lesions and acetabular labrum injuries in the hip joint have drawn increased attention. The evidence for diagnosis and treatment are still developing but a large experience has recently been documented in the literature.

5.6.1 Cartilage Injuries

Epidemiology and Diagnostics

Cartilage injuries are divided into four grades depending on the cartilage appearance and the depth of the lesion (**Table 5.1**). This information can be based on either the findings during surgery, using criteria established by the International Cartilage Repair Society (ICRS), or via MRI.[13] Only Grade 4 lesions with an osteochondral component can be seen on conventional radiographs, so MRI with cartilage visualizing sequences and MRI arthrography are the preferred diagnostic tools if a cartilage injury is suspected.

Idiopathic osteochondritis dissecans (OCD) of the hip joint is rare, but it occasionally affects the femoral head. This condition is also divided into four grades, using criteria established by the ICRS:

- Grade 1: stable lesion with a softened area covered by intact cartilage.
- Grade 2: stable lesion with partial discontinuity of the cartilage.
- Grade 3: unstable lesion with complete discontinuity of the cartilage.
- Grade 4: lesion with a loose and dislocated fragment.

The fragment is fully surrounded by joint fluid in a Grade 3 lesion (“dead in situ”), and with Grade 4 the fragment can be either within the bed or in the joint as a loose body, with an empty defect.

Treatment and Return to Play

Grade 1 and 2 lesions are usually treated nonsurgically or with arthroscopic debridement, while Grade 3 and 4 lesions (“full-thickness” cartilage tears) often need more advanced surgical treatment. There are, however, no studies reporting on the success rates of the various types of treatment, return-to-play rates or expected layoff periods after surgical treatment for footballers. Clinical experience suggests that a deep cartilage lesion affecting the hip joint has a poor prognosis in terms of a return to football, similar to the prognosis for such injuries affecting the knee and ankle joints.

Prognosis

The outcome is generally better for younger players and for smaller lesions.

Table 5.1

Grading of cartilage injuries

	Surgery	Magnetic resonance imaging
0	Normal	Normal
1	Soft indentation and/or superficial fissures and cracks	Abnormal intrachondral signal, but normal chondral surface
2	Lesions extending down < 50% of cartilage depth	Mild surface irregularity and/or focal loss of < 50% of thickness.
3	Cartilage defects extending down > 50% of cartilage depth, as well as down to the calcified layer and down to (but not through) the subchondral bone. Blisters also belong to this group.	Severe surface irregularity, with focal loss of 50–100% of thickness
4	Complete loss of cartilage cover, with exposure of the subchondral bone	Complete loss of articular cartilage, with exposure of the subchondral bone

5.6.2 Labral Tears

Epidemiology and Diagnostics

Awareness of traumatic labral tears in professional footballers has risen in recent years, especially with increased access to more sensitive MRI, including the use of arthrograms and 3 T machines. The increased use of hip arthroscopy in the examination and treatment of intraarticular hip injuries has changed the understanding of hip injuries in younger adults, and the ability to treat these injuries has developed accordingly. A combination of the excessive loads that are characteristic of football and a coexisting FAI can lead to an injury to the labrum/cartilage complex. The symptoms of hip joint–related pain often develop gradually, and sometimes other clinical situations can occur, such as rotational trauma, which can lead to a traumatic longitudinal tear in the anterior labrum.[14] The anterior impingement test is often painful in such cases.

Treatment and Return to Play

There is no evidence pointing to an optimal method of treatment for such lesions. However, smaller and less significant lesions can probably be treated nonsurgically. Where lesions do require surgery, arthroscopic debridement and repair, with trimming of the acetabular rim and fixation of the labrum, as well as resection of any coexisting cam deformity, is the most commonly used method. The expected layoff period after surgical treatment is 3 to 6 months.

Prognosis

The outcome is usually good, and the vast majority of players can return to their previous competitive level.[14]

5.7 Long-Standing Groin Pain

With many overuse-related conditions, there is a slow onset of symptoms, with pain typically declining after the warm-up and increasing at the end of the training session or match. The player often continues playing, without seeking medical advice at an early stage, and there is a substantial risk of the player entering a vicious circle of pain.

NOTE:

A player with long-standing groin pain is more difficult to assess than a player with an acute complaint.

The etiology and pathology of these injuries is still not fully understood. The “clinical entity approach” was suggested in 2007,[15] and has been adopted by more and more clinicians and researchers around the world. This approach uses standardized reproducible examination techniques to identify the anatomical structures causing the groin pain and is very useful in directing the treatment strategy. Recently, this concept was slightly modified during the Doha agreement meeting on terminology and definitions in groin pain in athletes.[16] The defined clinical entities for groin pain are as follows: adductor-, iliopsoas-, inguinal-, pubic-, and hip-related groin pain.
Regardless of the pathology suspected initially, a targeted progressive exercise treatment program lasting 6 to 12 weeks is almost always the most appropriate first-line treatment.[15] Alternative training such as cycling and pool-based exercise is recommended initially, followed by more football specific training as the exercise program starts to work and the symptoms disappear. There is generally no reason to use anti-inflammatory drugs.

NOTE:

Treating long-standing musculotendinous groin pain with a local corticosteroid injection followed by a short layoff is not recommended, because of the high recurrence rate.

5.7.1 Adductor-Related Groin Pain

Epidemiology and Diagnostics

Adductor-related pain is very common in football,[1] with adductor injuries accounting for almost two-thirds of all hip/groin injuries in the UEFA Elite Club Injury Study.[3] Pain is located medially in the groin and may radiate down further into the thigh through the adductor group. The clinical signs of the diagnostic entity “adductor-related groin pain” are defined as (1) tenderness at the origin of the adductor longus and/or the gracilis at the inferior pubic ramus and (2) groin pain on resisted adduction.[15] A decline in adductor muscle strength and groin pain on full passive abduction are also frequent signs. Ultrasonography and MRI can often show pathologies at the enthesis (**Fig. 5.10**).

Treatment and Return to Play

With long-standing problems, some absence from training is inevitable as the functionality and strength of the adductor muscle group is reestablished and pain is brought under control. This is done using an evidence-based exercise treatment program including specific adductor muscle exercises.[17] Alternative training methods—including stationary cycling and other types of fitness training that do not place the adductor region under stress—should be used to maintain the player’s fitness level. A player can be expected to return to football in 6 to

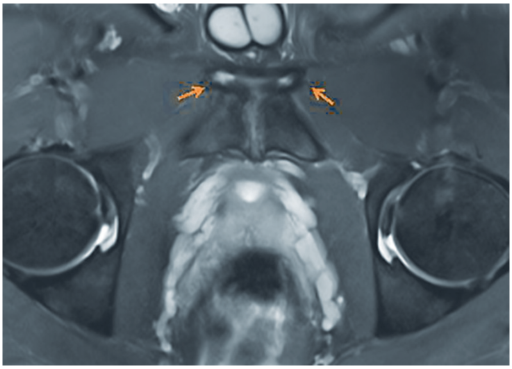

Fig. 5.10 Bilateral adductor longus tendinopathy. (This image is provided courtesy of Sonia Branci.)

12 weeks. Adductor surgery is rarely recommended nowadays, but adductor tenotomies used to be a very common procedure in the treatment of long-standing adductor-related groin pain.[18]

Prognosis

The prognosis is usually good.

5.7.2 Iliopsoas-Related Groin Pain

Epidemiology and Diagnostics

Iliopsoas-related pain is another common cause of groin pain in footballers.[15] Typical causes are activities such as barbell training and uphill running. The pain is localized in the anterior part of the proximal thigh, more laterally than adductor-related groin pain, and is therefore a very important differential diagnosis for hip joint problems. The clinical signs of the diagnostic entity "iliopsoas-related groin pain" are defined as (1) tenderness when palpating the muscle through the lower abdominal wall and (2) pain on passive stretching of the muscle during the Thomas test.[15] Additionally, the iliopsoas muscle is often tight and tender when palpated just distal to the inguinal ligament. Resisted isometric testing of the muscle with 90 degrees of hip flexion often results in muscle weakness and pain. Ultrasonography can often show pathologies in the area of the distal tendon.

Treatment and Return to Play

There are no evidence-based rehabilitation programs, but the general principles of the treatment program used for adductor-related injuries could be used here as well, with a particular focus on specific exercises for the hip flexor muscles. In most cases, players can return to play in 3 to 6 weeks.

Prognosis

The prognosis is generally better than for adductor-related pain.

5.7.3 Pubic-Related Groin Pain

Epidemiology and Diagnostics

Symphysitis (osteitis pubis) has already been discussed, but rectus abdominis-related pain, although uncommon in football, can also be sorted under this entity.[3,15] Pain is here located medially in the groin, more proximally than adductor-related pain. The clinical signs of the diagnostic entity "rectus abdominis-related groin pain" are defined as (1) tenderness at the insertion of the rectus abdominis at the superior pubic ramus and (2) groin pain on resisted abdominal flexion (e.g., during straight-leg lifts or head lifts in the supine position).

Treatment and Return to Play

As with iliopsoas-related injuries, there are no evidence-based programs. The general principles of the treatment program used for adductor-related injuries could, however, be used here as well, but with a particular focus on specific abdominal muscle exercises.

Prognosis

The prognosis may be less favorable than for other long-standing groin injuries, perhaps as a result of late diagnosis and the development of compensatory adductor and iliopsoas-related problems occurring at the same time.

5.7.4 Inguinal-Related Groin Pain

The most frequently encountered inguinal-related conditions in footballers are hernias (either manifest or incipient) and peripheral nerve entrapment.

Inguinal Hernia

Epidemiology and Diagnostics

Only a small minority of male players with long-standing groin pain will have an obvious indirect inguinal hernia on clinical examination.[8] On such occasions, the diagnosis is simple and no further examination is needed. An ultrasonography or other imaging may, however, be warranted in less standard cases. A hernia usually causes pain in the groin when intra-abdominal pressure is increased (e.g., during jumping and kicking). Symptoms also occur during coughing or sneezing, which also increases intra-abdominal pressure.

Treatment and Return to Play

An indirect inguinal hernia is treated by means of surgery, involving the removal of the hernia sac and the repair of the abdominal wall. This surgery can be performed as an open or endoscopic procedure, with or without net augmentation.[19] Sometimes, the symptoms are bilateral and surgery is performed on both sides simultaneously. However, it is debatable whether prophylactic surgery should be carried out on the contralateral side if it is asymptomatic. A player can normally return to football after 4 to 6 weeks, the recovery being somewhat faster after endoscopic surgery. As with most groin injuries, all of the muscles related to the hip and pelvis should be included in the treatment in order to rectify pelvic muscle instability, which is always an associated problem.

Prognosis

The prognosis is usually good. The recurrence rate is lower after net implantation than after a simple suture repair.[19]

Incipient Hernia

Epidemiology and Diagnostics

Many terms have been used to describe this diagnostic entity, including "abdominal wall weakness," "sports hernia," "athletic pubalgia," and "Gilmore's groin." This is a fairly common injury among footballers, accounting for 4% of all hip/groin injuries recorded in the UEFA Elite Club Injury Study.[3] The condition often coexists with the entrapment of various regional nerves, most frequently the genital branch of the genitofemoral nerve. In this condition, no manifest hernia can be palpated, but there is often an enlarged and tender external orifice on palpation. Referred pain to the scrotum and perineum is common. Inguinal-related pain is experienced "deep" in the groin, slightly more proximally than adductor-related pain. As with manifest hernias, increased intra-abdominal pressure (such as that caused by coughing or sneezing) will usually cause increased pain. Diagnosis of the condition could be helped by herniography, but often a dynamic examination using ultrasonography is a better choice when it comes to observing the weakness of the abdominal wall during maneuvers that increase intra-abdominal pressure.[9]

Treatment and Return to Play

There are no evidence-based nonsurgical treatment programs, but the general principles of the treatment program used for adductor-related injuries could be used here as well, with a particular focus on specific abdominal muscle exercises. With long-standing incipient hernias, surgery is a common option. The basic principles of the surgical procedure and the postoperative regime are identical to those for manifest hernias, apart from the fact that there is no hernia sac to invert or remove.

Prognosis

With the correct diagnosis, the prognosis is usually good.

5.7.5 Hip-Related Groin Pain

Groin pain can also be caused by injuries or diseases affecting the hip joint. Early-onset OA is known to have occurred in former footballers,[20] and there is evidence that various degrees of hip joint dysplasia and FAI are significant risk factors when it comes to developing premature OA.[21,22,23]

Femoroacetabular Impingement

Epidemiology and Diagnostics

Early results from the UEFA Elite Club Injury Study found that FAI was rarely reported as a cause of groin pain.[3] However, over the last decade, greater attention has been paid to FAI, and with the improved understanding of the mechanisms that cause damage to the labrum and cartilage, the hip joint has become an integrated part of the understanding of groin pain in athletes.[23,25] Consequently, with increasing awareness of this condition, it is possible that more cases of FAI will be reported in the study in future years.
With FAI, the arc of hip motion is limited. This may be the result of either (1) an acetabulum that is functionally too big (i.e., deep or maloriented), causing the neck to collide with the acetabular rim and labrum (known as "pincer FAI"); (2) a misshapen femoral head/neck offset with a nonspherical head (known as "cam FAI"); or (3) a combination of the two (known as "mixed FAI").[23] Bilateral involvement is common. Recently an international agreement meeting in Warwick, UK, defined FAI syndrome as: motion-related clinical disorder of the hip with a triad of symptoms, clinical signs and imaging findings. It represents symptomatic premature contact between the proximal femur and the acetabulum.[24]
The FADDIR and FABER tests are usually positive, and an MRI arthrogram or a 3 T MRI is often required to examine whether an intraarticular injury is present or whether the FAI seen on the radiograph is merely a coincidental finding. The injection of a local anesthetic in the hip joint—guided by ultrasonography—can also be very helpful for diagnostic purposes.

NOTE:

It is important to be aware of the large number of asymptomatic radiological cases of femoroacetabular impingement.

Treatment and Return to Play

There is no evidence indicating the optimal method of treatment for such lesions. Smaller and less

Fig. 5.11 Hip joint osteoarthritis.

significant lesions can probably be treated nonsurgically. Surgically, the arthroscopic resection of pincer and/or cam deformities and concomitant debridement or repair of coexisting labral tears and cartilage injuries is the most common approach. The expected layoff period after surgical treatment is 3 to 6 months.

Prognosis

The prognosis after surgery is usually good when in experienced hands (note, however, that there is a long learning curve for hip arthroscopy).

Hip Joint Osteoarthritis

Epidemiology and Diagnostics

OA manifests itself as groin pain and reduced hip joint ROM, especially internal rotation. It mainly affects players over the age of 30 (**Fig. 5.11**).

Treatment and Return to Play

Short-term relief can sometimes be achieved with a corticosteroid injection or arthroscopic debridement. However, more definitive surgical treatment such as arthroplasty is career ending.

Prognosis

With clinically manifest OA, the prognosis is usually not good, with a clear threat to the player's future career.

5.7.6 Other Conditions Causing Groin Pain

A variety of conditions, including referred pain from the lumbar spine, stress fractures, gynecological conditions, and tumors, etc., can also cause long-standing groin pain, but only peripheral nerve entrapment will be discussed here.

Nerve Entrapment

Epidemiology and Diagnostics

The peripheral nerves in the groin area that are most commonly affected by entrapment are the ilioinguinal, iliohypogastric, and genitofemoral nerves. With ilioinguinal nerve entrapment, pain and sensory impairment are located around the symphysis, the superomedial aspect of the femoral triangle, and either the root of the penis and the anterior scrotum in the male or the mons pubis and labia majora in the female. In the case of genitofemoral nerve entrapment, these symptoms are located around the cremaster muscle and the skin of the scrotum and the adjacent thigh in the male, and the labia majora and the adjacent thigh in the female. In contrast, loss of sensation is usually minimal with iliohypogastric nerve entrapment.

NOTE:

The characteristics of groin pain can vary considerably with peripheral nerve entrapment.

Diagnosis can be difficult, but localized tenderness where the nerve penetrates the fascia is common. The player rarely notices any altered skin sensation, but the examiner can usually identify skin hyperesthesia or hypoesthesia along the cutaneous distribution of the ilioinguinal and genitofemoral nerves. A positive nerve block test is considered sufficient for a diagnosis in most cases.

Treatment and Return to Play

A corticosteroid injection is usually administered during the diagnostic nerve block test, and that can sometimes lead to a lasting improvement. Transcutaneous electrical nerve stimulation (TENS) may also be tried. If these methods are not successful, surgical exploration and neurolysis or a neurotomy should be considered. The rehabilitation period after surgery is short, typically 4 weeks.

Prognosis

The prognosis is usually good. A permanent loss of sensation will follow a neurotomy, but that rarely causes problems for the player.

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Chapter 6

Knee Injuries

Markus Waldén

6.1 Introduction

Knee injuries are common in football, regardless of players' age, sex, or competitive level. In the Union of European Football Associations (UEFA) Elite Club Injury Study, knee injuries account for around 18% of all injuries that cause time loss.[1] This chapter provides an overview of the diagnosis and treatment of the most common traumatic soft tissue injuries and overuse injuries.

6.2 Knee Anatomy

The knee joint is the largest synovial joint in the body, primarily allowing flexion and extension, but also some degree of internal and external rotation in the flexed knee (as a modified hinge joint). The joint consists of two articulations: the tibiofemoral and patellofemoral joints. The articular surfaces are covered by a thin layer of hyaline cartilage, and two articular disks (the medial and lateral menisci) partly divide the tibiofemoral joint spaces. The peripheral outer thirds of the menisci are vascularized to some extent in adults (the "red zone"), but the central inner two-thirds (the "white zone") are completely avascular (**Fig. 6.1a–c**).

The knee joint is stabilized by several extra-articular and intraarticular ligaments. The medial collateral ligament (MCL) is composed of two distinct parts, originating around the medial femoral epicondyle. The superficial part (sMCL) is an extra-articular ligament, with the fibers inserted around 5 cm below the joint line, next to the pes anserinus. The deep part (dMCL) is a capsular reinforcement, with the fibers inserted into the medial tibial condyle just below the joint line. The primary function of the MCL is to protect the knee from being bent open by stress applied to the lateral side of the knee (i.e., a valgus force).

In contrast, the lateral collateral ligament (LCL) is a complete extracapsular ligament running from its origin near the lateral femoral epicondyle to the head of the fibula. It protects the lateral side from being bent open by stress applied to the medial side of the knee (i.e., a varus force). The popliteal arcuate ligament (PAL) originates on the apex of the head of the fibula, crosses the popliteus tendon, and passes into the posterior capsule. It is an important element of the posterolateral corner (PLC) and acts mainly as a PL stabilizer in conjunction with the LCL. Similarly, the posterior oblique ligament, a distal expansion of the semimembranosus tendon, is the most important element of the posteromedial corner (PMC).

The anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL) are found inside the knee joint. The ACL originates on the anterior intercondylar area of the tibia and inserts into the intercondylar notch on the lateral femur below the lateral transcondylar ridge. It consists of the anteromedial (AM) bundle and the PL bundle. The ACL is the main stabilizer of anteroposterior displacement, but is also important (especially the PL bundle) for rotational stability. The PCL originates on the posterior intercondylar area of the tibia and inserts into the inside of the medial femoral condyle and the notch roof, preventing posterior displacement of the tibia relative to the femur.

Anteriorly, the quadriceps tendon connects the quadriceps muscle group to the patella, and the patellar tendon connects the patella to the tibial tuberosity. Posteriorly, the single muscle in the knee joint, the popliteus muscle, and the neurovascular

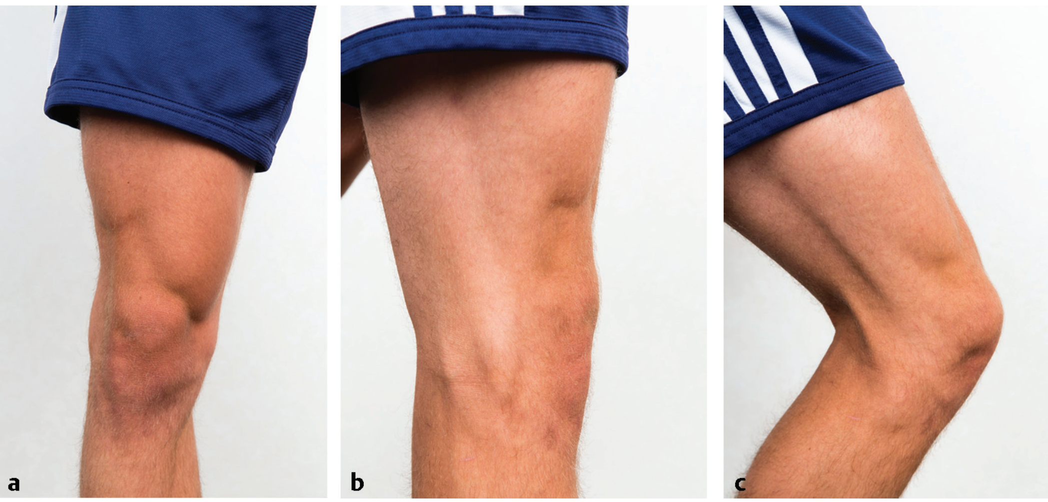

Fig. 6.1 **(a–c)** The knee joint.

bundle are found. Laterally, the thick iliotibial band (ITB) covers the vastus lateralis muscle and inserts into Gerdy's tubercle on the anterolateral tibial plateau. Finally, there are numerous bursae surrounding the knee joint, which can be either communicative (e.g., the suprapatellar bursa) or noncommunicative (e.g., the prepatellar bursa).

6.3 Clinical Examination

More significant knee injuries are sometimes difficult to examine in an acute setting owing to pain, swelling, and muscle spasms. It is therefore important to correctly identify the circumstances of the injury and the mechanisms involved by carefully establishing the relevant history. The examiner should aim to identify the following:

Information Relating to the Point of Injury

- If there was player contact when the injury occurred or beforehand.
- If the foot was free or planted on the ground.
- If the player felt a "snap" or "pop" when the injury occurred.
- If the player was able to continue playing or had to leave the pitch, etc.

Other Information

- If the player has previously suffered knee injuries.
- If the player has previously undergone knee surgery.

Even when the injury history is more or less typical,[2] ACL injuries are often overlooked in a standard clinical setting (**Fig. 6.2**). This is usually less of a problem in top-level football thanks to the qualified medical support at clubs.[3]

NOTE:

A "snap" or "pop" reported by the player at the incident usually means a ligament tear.

Fig. 6.2 Even when the injury history is more or less typical, anterior cruciate ligament injuries are often overlooked in a standard clinical setting

The key factor in injury diagnostics is a careful clinical examination of the joint. This examination should consist of the following:

- Visual inspection.
- Evaluation of range of motion (ROM).
- Muscle strength tests.
- Palpation.
- Laxity tests.
- Meniscus tests.
- Patellofemoral tests.
- Other knee-specific tests.

6.3.1 Visual Inspection

During the visual inspection, the examiner needs to look for gait disturbance, swelling, hematoma, muscle hypotrophy, lower limb malalignment, etc.

6.3.2 Evaluation of Range of Motion

Footballers' ROMs vary widely, but habitual hyperextension of up to −10 degrees is sometimes seen, especially among female players. If the player has a pain-free and symmetrical active ROM, the value of additional passive ROM testing is limited.

6.3.3 Muscle Strength Tests

Muscle strength should be evaluated against resistance. This is usually done manually by the examiner, but hand-held dynamometers or other strength testing devices might be of value in some cases.

6.3.4 Palpation

Always begin your palpation in areas where you have a low suspicion of tenderness. Important anatomical structures to palpate are the patella, the origins and insertions of tendons and ligaments, and the joint line. Additionally, the recesses should be compressed to evaluate any intraarticular effusion, with or without pressing the patella against the femur ("dancing patella" sign).

6.3.5 Laxity Tests

There are numerous manual laxity tests,[4] and it is impossible to be an expert on all of these. Instead, familiarize yourself with six to eight tests and use these routinely each time you examine a knee. It is important to remember that when evaluating laxity, side-to-side comparisons should always be carried out relative to the contralateral knee, which is often better than estimating the actual millimeters of laxity. It is often wise to start the examination with the unaffected knee, to ensure that the player is relaxed; having a relaxed player is imperative if proper laxity testing of the knee ligaments is to be achieved.

Collateral Ligaments

The laxity of the collateral ligaments are evaluated using valgus and varus stress tests at full extension and semiflexion (30 degrees). With the patient supine, the examiner holds the ankle with one hand and places the other hand on the lateral or medial aspect of the knee and applies a valgus or varus stress (**Fig. 6.3a, b**). The tibia should be slightly externally rotated to uncoil the cruciate ligaments. Alternatively, the examiner may secure the lower leg between his/her waist and forearm, and simultaneously palpates the joint lines with the fingertips while the valgus and varus stress is applied. During testing, the opening of the joint line and the quality of the endpoint (firm, soft, or absent) should be evaluated.

MCL and LCL injuries are often graded as follows on the basis of their severity[5]:

- With a Grade I injury, there is tenderness over the ligament, but no (or only a minimal) increase in laxity (up to 5 mm).
- With a Grade II injury, there is a moderate increase in laxity (5–10 mm) with semiflexion, but not extension.
- With a Grade III injury, the increase in laxity with semiflexion is gross (> 10 mm), without any endpoint, and is also seen, to some degree, with extension.

The grading of gapping in terms of millimeters has, however, been questioned, so this should be used with caution.[6] A practical description of isolated and combined collateral injuries based on the laxity testing can be found in **Table 6.1**.

Anterior Cruciate Ligament

The anterior drawer, Lachman, and pivot-shift tests are all supposed to be routinely used for evaluating the laxity and the integrity of the ACL.

Anterior Drawer Test

The anterior drawer test is performed with the patient supine, the hip flexed at 45 degrees and the knee at 90 degrees (**Fig. 6.4**). The examiner sits on the examination table in front of the knee in question, grasping the tibia just below the joint line of the knee. The thumbs are placed along the joint line on either side of the patellar tendon, and having ensured that the hamstring muscles are relaxed, the tibia is drawn forward. An increased anterior tibial translation and a lack of a firm endpoint indicate either a sprained AM bundle or a complete ACL tear.

Lachman Test

The Lachman test is considered the most sensitive test evaluating the integrity of the ACL, especially in an acute setting (**Fig. 6.5a, b**). It is performed with

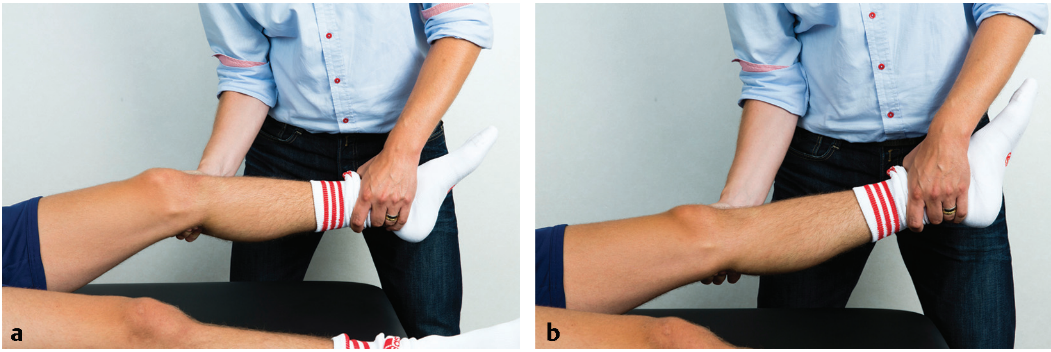

Fig. 6.3 **(a, b)** Valgus and varus stress tests.

Table 6.1

Interpretation of openings with valgus and varus stress tests on the knee joint

	Medial opening with semiflexion	Medial opening with extension	Lateral opening with semiflexion	Lateral opening with extension
No opening	MCL intact	MCL intact or MCL injury; PMC intact	LCL intact	LCL intact or LCL injury; PLC intact
Slight opening	MCL injury	MCL and PMC injury	LCL injury	LCL and PLC injury
Marked opening	MCL and PMC injury; possibly ACL and/or PCL injury	MCL and PMC injury; possibly ACL and/or PCL injury	LCL and PLC injury; possibly ACL, PCL and/or ITB injury	LCL and PLC injury; possibly ACL and/or PCL injury

Abbreviations: ACL, anterior cruciate ligament; ITB, iliotibial band; LCL, lateral collateral ligament; MCL, medial collateral ligament; PCL, posterior cruciate ligament; PLC, posterolateral corner; PMC, posteromedial corner.

the patient supine and the knee resting in the hands of the examiner, with around 30 degrees of knee flexion. Once the patient is relaxed, the examiner pulls on the tibia to assess the amount of anterior translation and the quality of the endpoint, as with the anterior drawer test. An increased anterior tibial translation and a lack of a firm endpoint indicate either a sprained AM or PL bundle or a complete ACL tear.

Pivot-Shift Test

The pivot-shift test is performed with the patient supine and the leg resting in the hands of the examiner with full extension. Once the patient is relaxed, the examiner lifts the leg and rotates it internally, then flexes the knee while applying a valgus stress (**Fig. 6.6**). The pivot-shift phenomenon is caused by anterior subluxation of the lateral tibial plateau with full extension in the ACL-deficient knee, and when slowly flexing and abducting the knee from this position the joint is abruptly reduced at 30 to 40 degrees with a palpable, and sometimes audible, movement or "jerk." With a Grade I injury, there is a smooth glide with a slight shift; with a Grade II injury, there is a marked shift and reduction; and with a Grade III injury, the tibia is locked anterior to the lateral femoral condyle initially, and there is a dramatic reduction with a gross shift. A positive pivot-shift test indicates either a sprained PL bundle or a complete ACL tear.

Posterior Cruciate Ligament

The laxity and the integrity of the PCL are usually evaluated using the posterior drawer, the posterior sag, and the quadriceps active tests.

Posterior Drawer Test

The posterior drawer test is considered the most sensitive of these tests and is performed with the patient supine, the hip flexed at 45 degrees and the knee at 90 degrees (**Fig. 6.7**). The examiner sits on the examination table in front of the injured knee, grasping the tibia just below the joint line of the knee. The thumbs are placed along the joint line on either side of the patellar tendon. Ensure that the patient is relaxed, and then move the tibia posteriorly. An increased posterior tibial translation and/or a lack of a firm endpoint indicate either a partial or a complete PCL tear.

Posterior Sag Test

The posterior sag test is a static test where the patient lies supine with the hip flexed at 45 degrees and the knee at 90 degrees, as in the starting

Fig. 6.4 Anterior drawer test.

Fig. 6.6 Pivot-shift test.

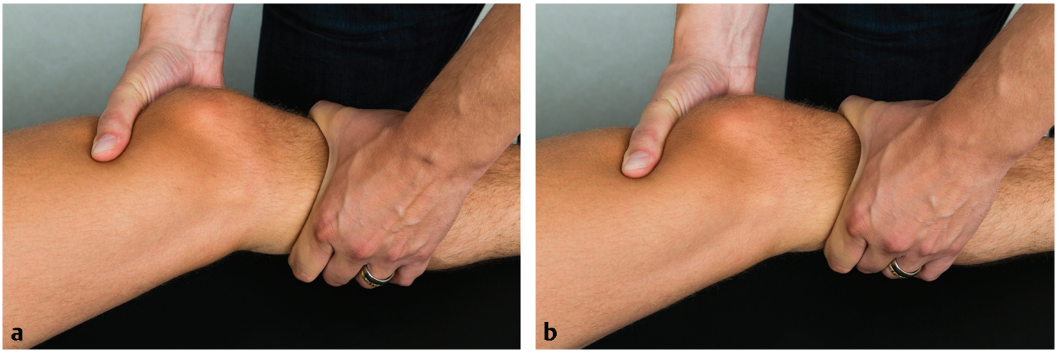

Fig. 6.5 **(a, b)** Lachman test.

Fig. 6.7 Posterior drawer test.

Fig. 6.8 Posterior sag test.

position for the drawer tests (**Fig. 6.8**). The examiner looks at the knees from the side and evaluates any asymmetry in the anatomical positions of the tibias and femurs. A positive test is when the proximal tibia is found to "sag" posteriorly.

Quadriceps Active Test

The quadriceps active test is a dynamic laxity test where the patient lies supine with the hip flexed at 45 degrees and the knee at 90 degrees, as in the posterior sag test. The examiner asks the patient to attempt to slide the foot anteriorly. A "sagging" tibia will move in an anterior direction as a result of the contraction of the quadriceps when the patient attempts to slide the foot.

Posteromedial and Posterolateral Corners

A standard clinical examination of the injured knee joint must also include some tests that evaluate the PMC and PLC.

Slocum Drawer Test

The PMC can easily be tested by means of the Slocum drawer test, which is similar to an anterior drawer test, but with the foot rotated 30 degrees externally. In an ACL-deficient knee, the anterior tibial translation should be less pronounced with the foot rotated externally. Thus, a positive test involves external tibial rotation failing to reduce translation relative to the neutral position.

Dial Test

In this test, the patient lies prone with the knees flexed. While rotating the feet externally, the examiner checks for any asymmetrical external rotation with 90 and 30 degrees of knee flexion (**Fig. 6.9**). The test is considered positive if there is more than 10 degrees of increased external rotation at 30 degrees (suggests PLC injury) and possibly also at 90 degrees (suggests combined PLC and PCL injury).

Fig. 6.9 Dial test.

NOTE:

Certain laxity tests should always be used in a clinical examination of an acutely injured knee: valgus and varus stress tests, anterior and posterior drawer tests, and the Lachman test.

6.3.6 Meniscus Tests

The integrity of the menisci is typically evaluated using specific rotation tests; the most frequently used are the McMurray, Apley, and Thessaly tests. In addition, the knee is usually also moved into hyperextension and hyperflexion.

McMurray Test

In the McMurray test, the examiner passively extends the supine player's knee, starting from a completely flexed position, while simultaneously palpating the joint line and rotating the foot outward to test for medial meniscus damage and inward to test for lateral meniscus damage (**Fig. 6.10a, b**). In a true positive test, there is both pain and clicking in the joint space where the meniscus is damaged. However, clicking is not always observed, and pain is the standard indicator.

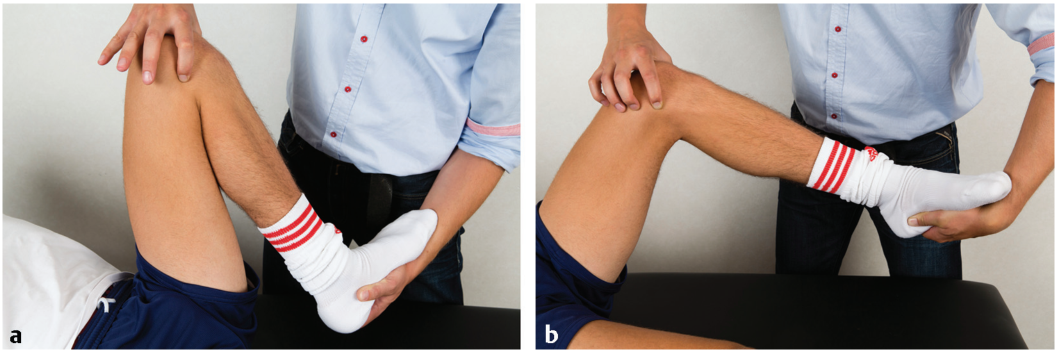

Fig. 6.10 **(a, b)** McMurray test.

Fig. 6.11 Apley test.

Apley Test

In the Apley test, the prone player has the knee flexed at 90 degrees, while the lower leg is rotated inward and outward by the examiner (**Fig. 6.11**). With medial meniscus damage, there is pain over the interior joint space on outward rotation of the lower leg, while lateral meniscus damage is denoted by pain over the lateral joint space on inward rotation of the lower leg. The sensitivity of the test can be improved if the pain is increased while the examiner compresses the joint during lower leg rotation, and can be reduced by traction of the lower leg.

Thessaly Test

In the Thessaly test, the player is standing flat-footed with full weight-bearing on the side to be tested. The other leg does not bear weight and is flexed at the knee. The player holds the hands of the examiner in order to keep balance and flexes the knee to approximately 20 degrees. From this position, the player actively rotates the knee inward and outward three times. With meniscus damage, there is pain, and possibly clicking, over the joint space.

Hyperextension and Hyperflexion Tests

Another common strategy involves passively moving the knee into maximum hyperextension and hyperflexion in an effort to squeeze the menisci between the femur and tibia and thereby provoke pain. With hyperextension, the anterior horns are compressed, and with hyperflexion, the posterior horns are compressed.

6.3.7 Patellofemoral Tests

The most frequently used tests in assessing patellofemoral stability are the patellar tracking test, the (manual) patellar translation test, and Fairbank's patellar apprehension test.[4] In addition, pain from the patellofemoral joint can often be elicited using the grinding test.

Patellar Tracking Test

In the patellar tracking test, the patella might be laterally subluxated in the extended knee at rest, and when the knee is actively flexed, the patella is engaged in the trochlear groove at approximately 30 to 40 degrees of flexion. In mild cases, this is seen as a smooth "jerk," but it may also present with a gross reduction in which the patella follows a J-shaped path (positive "J sign").

Manual Translation Test

The manual translation test evaluates lateral patellar hypermobility and is performed with the patient supine and the quadriceps relaxed (**Fig. 6.12a, b**). With the knee extended or slightly flexed, the examiner gently pushes the patella laterally with both thumbs on the medial border of the patella. A translation of more than two quadrants of the patella's width is usually considered pathological.

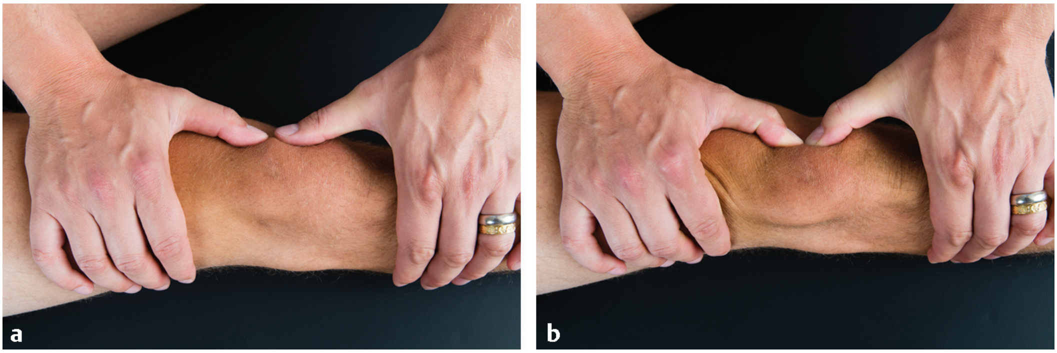

Fig. 6.12 (a, b) Patellar translation test.

Patellar Apprehension Test

The patellar apprehension test (sometimes also called the “Smillie test”) is a continuation of the manual translation test where the patient’s reaction is also noted. The test is positive if the patient is uncomfortable and apprehensive or expresses fear that the patella will dislocate. The testing can be reinforced by asking the patient to flex the knee, which will usually result in pain and/or quadriceps muscle contraction to resist the subluxation.

Patellofemoral Grinding Test

Pain from the patellofemoral joint can often be elicited using the patellofemoral grinding test (sometimes also called “Clarke’s test” or “Cleveland’s test”). In this test, the patient lies supine with both knees supported by a kneepad. The examiner presses the patella distally with one hand on the superior border of the patella and then asks the patient to contract the quadriceps muscle. If the patient’s pain is reproduced during this maneuver, the test is considered positive and is indicative of a patellofemoral disorder.

6.3.8 Other Tests

The tests used most frequently to diagnose runner’s knee are the Noble and Ober tests. Occasionally, the popliteus tendon also needs to be examined.

Noble Test

In the Noble test, the patient lies supine with the knee flexed at 90 degrees. From this position, the knee is extended, with concomitant pressure over the lateral femoral epicondyle. If the pain is reproduced at around 30 degrees, the test is considered positive.

Ober Test

The Ober test is used to assess the tightness of the ITB. The patient lies on the unaffected side with the knee flexed at 90 degrees. The examiner then abducts and extends the affected leg while stabilizing the pelvis and, from this position, tries to adduct the leg. The test is considered positive if the leg cannot be adducted and indicates tightness of the ITB.

Popliteus Test

Popliteus tendon pathology is usually evaluated in the prone position, with the knee flexed at 45 degrees and rotated internally against resistance, with concomitant palpation of the PL joint line. If pain and tenderness are reproduced during this maneuver, the test is considered positive.

6.4 Joint Aspiration

With intraarticular knee injuries (such as ACL injuries, patellar dislocations, and red zone meniscus lesions), the knee joint usually swells up within 6 hours of the injury occurring owing to bleeding (hemarthrosis). Approximately 70% of adult players with blood extravasation in the knee joint after rotational trauma will have damage to the ACL.[7] Consequently, patients with traumatic hemarthrosis should always be suspected of having an ACL injury, even if a clinical examination is difficult to perform in an acute setting (**Fig. 6.13**). Rapid swelling should be evacuated by puncturing the knee joint under sterile conditions for diagnostic, therapeutic, and joint-protective reasons. The aspiration confirms the bleeding, but there might also be fat droplets in the blood, which usually indicates a concomitant osteochondral or bony injury (diagnostic purpose). The patient usually feels instant pain relief after aspiration, since the capsular distension is reduced (therapeutic purpose). Finally, iron from degraded hemoglobin has been shown to be chondrotoxic,[8] so the aspiration might have the effect of protecting the cartilage in the joint, as much of the blood is removed from the knee (joint-protective purpose).

Fig. 6.13 Patients with traumatic hemarthrosis should always be suspected of having an anterior cruciate ligament injury, even if a clinical examination is difficult to perform in an acute setting.

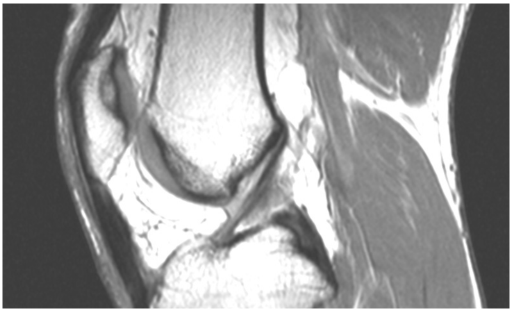

Fig. 6.15 Magnetic resonance imaging of a normal anterior cruciate ligament.

NOTE:

Rapid knee swelling (hemarthrosis) after loaded rotational trauma to the knee joint in a skeletally mature player should be regarded as an anterior cruciate ligament injury until proven otherwise.

6.5 Radiological Examination

A significant knee injury, especially one involving rapid swelling, should always be referred for at least standard radiographs in order to rule out a fracture. This is especially important in still growing adolescent players, where an ACL injury can, for example, occur as an avulsion fracture with a detached ligament origin on the tibia. There can sometimes be a concomitant fracture of the growth plate of the distal femur or a so-called "Segond fracture" (**Fig. 6.14**). The latter is almost pathognomonic of an ACL injury and represents a bony avulsion from the lateral tibial plateau, most probably at the insertion of the anterolateral ligament, and is sometimes mistaken for a distal bony avulsion of the LCL. The radiograph can also identify any osteochondral lesions or loose bodies that might be associated with a patellar dislocation.

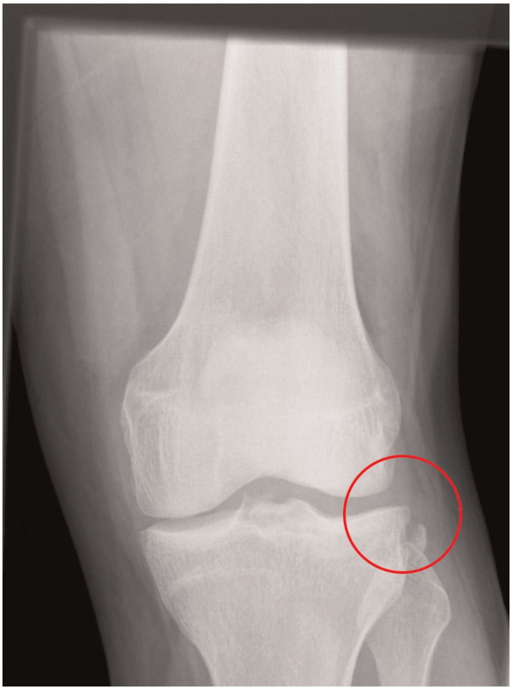

Fig. 6.14 Radiograph of a Segond fracture.

Fig. 6.16 Magnetic resonance imaging of an anterior cruciate ligament rupture.

Referral for magnetic resonance imaging (MRI) is used as a matter of routine in elite footballers,[3] but other patients with traumatic hemarthrosis might also benefit from referral for an MRI at an early stage.[9] The advantage is that the main diagnosis is established early, such as with ACL injury (**Fig. 6.15** and **Fig. 6.16**), which is particularly important if the diagnosis was uncertain after the initial clinical examination. In addition, an MRI can often also detect concomitant cartilage injury, which could be of great significance for treatment and the prognosis. Many cartilage injuries are not usually visible on a conventional radiograph and are also difficult to posit or diagnose clinically.

6.6 Knee Sprains

Distraction injuries affecting the stabilizing connective tissue around the knee joint (i.e., the joint capsule and ligaments) are very common with both contact and noncontact injury mechanisms. Ligament injuries are often roughly categorized as either partial or complete tears; this classification usually has a prognostic value, with complete tears leading to longer layoffs in general and potentially requiring surgical treatment.

6.6.1 Collateral Ligament Injuries

Epidemiology and Diagnostics

MCL injuries are the most common knee ligament injury in football, accounting for around 4% of all injuries in the UEFA Elite Club Injury Study.[10] In practical terms, this means that a male elite team should expect to incur two to three MCL injuries per season. Primary damage to the collateral ligaments occurs mainly during collisions, tackles, and other types of physical impact where the lower leg bends inward or outward. MCL injuries are much more common than LCL injuries and often occur without associated lesions. This is in contrast to LCL tears, which are rarely isolated. Clinically, there could be some local swelling with isolated Grade I and II injuries, but no intraarticular swelling. Significant intraarticular swelling generally indicates a more serious injury, such as concomitant cruciate ligament damage (**Table 6.1**).

Treatment and Return to Play

The treatment of choice for isolated collateral ligament injuries, regardless of the degree of laxity, is a progressive rehabilitation program. Surgical ligament repair or reconstruction might be needed if the PMC or PLC is also injured, or if there is a ligament avulsion with a bony detachment. A stabilizing knee brace is often used with Grade II and III lesions, being worn for 2 to 6 weeks and 6 to 8 weeks, respectively. Full extension and flexion is usually allowed immediately, as is controlled resistance training. Full extension and full flexion is sometimes restricted slightly with a Grade III lesion. Most players can return to full football activity within 10 to 12 weeks after a Grade III lesion, within 6 to 8 weeks after a Grade II lesion, and within 2 to 4 weeks after a Grade I lesion.

Prognosis

With an isolated collateral ligament injury, the prognosis is usually good, and most footballers recover completely without needing a surgical procedure. Occasionally, chronic pain and tenderness around the medial epicondyle develops as a result of a low-grade deep MCL lesion. This can usually be treated successfully by means of a corticosteroid injection.[11] With combined injuries, the long-term prognosis is usually determined by the primary lesion (e.g., an ACL tear).

6.6.2 Anterior Cruciate Ligament Injuries

Epidemiology and Diagnostics

ACL injuries are severe injuries that, in more than half of all cases, are associated with other concomitant injuries to the knee joint, such as collateral ligament tears and meniscus or cartilage lesions. Although they receive considerable attention, ACL injuries account for less than 5% of all injuries in football,[12] and less than 1% of all injuries in elite football.[3] Interestingly, the ACL injury rate is more than twice as high for female footballers as it is for their male counterparts,[12] and female players in the late pubertal and early postpubertal periods are especially at risk.[3,13] On average, a female elite team will suffer around 0.7 ACL injuries per season and a male elite team around 0.4 ACL injuries per season.[3] The underlying causes of this gender disparity are widely discussed in the literature, but are still essentially unclear.[14]

Most ACL injuries occur in noncontact situations (**Fig. 6.17**),[3,15] and the most frequent injury mechanism is a cutting maneuver with a near-extended knee and the foot planted on the ground (pressing), followed by an awkward landing on one leg after a heading duel.[15] Some degree of knee flexion, knee abduction (valgus), and tibial rotation are often involved,[16] and (especially with female players) a so-called “valgus collapse” is sometimes seen.[17] An increased anterior tibial translation is usually easy to

Fig. 6.17 Most ACL injuries occur in noncontact situations.

feel during the immediate on-field examination owing to neuromuscular inhibition of the lower limb. However, this becomes more difficult as the pain and swelling become more pronounced over the next few hours.

Treatment and Return to Play

The recommended treatment for an ACL injury is controversial from a scientific perspective and is currently debated worldwide.[18] It generally depends, however, on the player's age, symptoms, and (desired) activity level. There is a common belief among football doctors that it is hard or even impossible to continue playing football without a stable knee, so most total ACL tears in high-level footballers are treated with reconstructive ligament surgery.[3,19] Depending on the preferences of the surgeon and the patient, either patellar tendon or hamstring tendon autografts are most frequently used, normally with similar clinical outcomes.[20] Allografts should probably not be used for index surgery on footballers because of their higher failure rates.

The recovery time after ACL reconstruction is traditionally assumed to be approximately 6 months, but this period is arbitrary and lacks scientific support.[21] Furthermore, there are no valid and accepted criteria governing a player's return to play action.[22] According to the UEFA Elite Club Injury Study, a majority of professional players with total tears were able to go back to playing within a year of surgery.[3,19]

The underlying reasons for this high return-to-play success rate in professional football are probably multifactorial and include (1) referral to experienced high-volume knee surgeons, (2) use of MRI on a routine basis to obtain an established diagnosis immediately, (3) proper treatment of any associated joint injuries, and (4) individualized daily physical therapy by the club physical therapist. Importantly, however, the average layoff period in the UEFA Elite Club Injury Study was almost 7 months prior to the first full unrestricted training session and another month prior to the first match appearance. Consequently, if this 7- to 8-month layoff period is the time it takes to get back on the pitch for an elite professional player, it is unrealistic to expect that a nonelite youth or amateur player should be able to return to action after approximately 6 months postsurgery. In addition, the "ligamentization process" for the tendon graft takes more than half a year and a more realistic discharge time for a football player, on condition that the player pass the clinical test battery, is probably around 9 to 10 months in most cases in order to reduce the risk of reinjury.[23] As shown recently in the UEFA Elite Club Injury Study, subsequent injuries (such as graft tears and other secondary intra-articular injuries) may occur in the very end of the rehabilitation period or shortly after the release for return to play.[19]

In contrast, partial ACL tears are often treated without surgery initially, and players with isolated AM bundle tears can usually return successfully to football within 2 to 4 months.[3] However, PL bundle tears sometimes lead to unacceptable rotational instability, interfering with performance, and might need surgery.[19]

Prognosis

Although the short-term functional outcome is regarded as good in most cases and many players are able to return to full participation in football, a return to action remains associated with a risk of future injuries to the reconstructed ACL or other intraarticular structures, as well as contralateral knee injuries.[22,23] A risk of early-onset osteoarthritis in the long term after an ACL injury has also been well documented.[24]

6.6.3 Posterior Cruciate Ligament Injuries

Epidemiology and Diagnostics

PCL injuries are uncommon in football. The injury mechanism is often a direct blow to the anterior aspect of the proximal tibia, which is driven straight back in relation to the femur. In this respect, goalkeepers are believed to be especially prone to this kind of injury mechanism when colliding with an attacking opponent. The symptoms are generally milder than for an ACL injury, with less swelling, but the player usually feels considerable soreness on the back of the knee.

Treatment and Return to Play

The recommended initial treatment for partial and total PCL tears in footballers is almost always nonsurgical. Players with "isolated" total tears can usually return successfully to football within 3 to 4 months. Primary surgery could, however, be considered for combined (multiligament) injuries or if the bony ligament insertion has become detached. Delayed reconstruction owing to persistent subjective instability in spite of proper bracing and structured rehabilitation is occasionally needed, and in these cases the rehabilitation and layoff period mimics that for ACL reconstruction.

Prognosis

Functional stability is usually excellent, even with a total PCL tear, and most footballers cope well with playing despite the injury. In addition, subsequent knee injuries are rarely seen, in contrast to ACL injuries, and the long-term knee prospects are also more favorable.

NOTE:

MCL injuries are the most common knee ligament injury in football and are more frequent than LCL injuries. ACL injuries are considerably more frequent than PCL injuries.

6.7 Meniscus and Cartilage Injuries

The inner parts of the menisci and the joint's hyaline cartilage have very limited healing potential, since they are completely avascular structures. The capacity for self-restoration of joint cartilage is low, and any newly formed tissue will consist of fibrous cartilage that is of lesser quality than the original hyaline cartilage.

6.7.1 Meniscus Injuries

Epidemiology and Diagnostics

Meniscus lesions can occur either in isolation or in combination with collateral and/or cruciate ligament injuries. The typical injury mechanism is a twisting of the knee, with the medial meniscus injured by external rotation of the lower leg and the lateral meniscus injured by internal rotation of the lower leg. Meniscus lesions can be classified as either traumatic (mainly occurring as a result of a macrotrauma in previously healthy meniscus tissue) or degenerative (i.e., part of incipient or established cartilage degeneration).
Among the general population, damage to the medial meniscus is approximately five times more common than damage to the lateral meniscus (owing to degenerative tears). In younger athletes, however, lateral meniscus lesions are seen more frequently than medial lesions. There are different types of meniscus tears (**Fig. 6.18**). Traumatic tears are often vertical or longitudinal, whereas degenerative tears are typically oblique or horizontal. Other classic meniscus lesions are the radial tear and the flap tear. The so-called “bucket handle tear” is usually an unstable vertical tear in the posterior horn, which is split, with the anterior part able to move forward and interfere with knee extension. In the latter tear, the knee joint could become “locked” at 20 to 30 degrees of flexion and the knee becomes very painful if full passive extension is attempted.
With an acute meniscus lesion, swelling does not usually occur until the day after the event as a result of joint fluid exudation (not bleeding, as in the case of an ACL injury). Rotational pain at the joint line and catching are other symptoms typical of a meniscus injury. Lateral meniscus lesions are sometimes associated with vaguer and less typical symptoms than medial meniscus lesions.

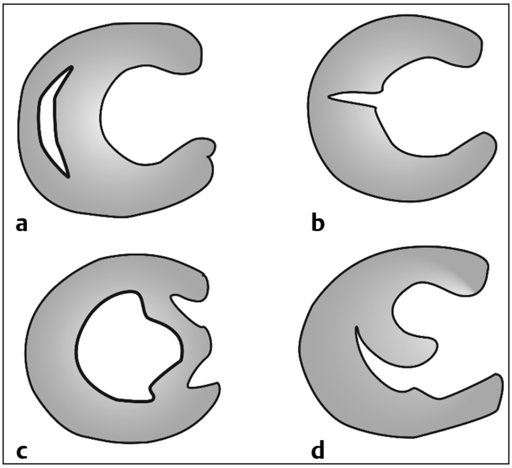

Fig. 6.18 Different types of meniscus tears. **(a)** Vertical tear; **(b)** Radial tear; **(c)** Bucket-handle tear; **(d)** Flap tear.

Treatment and Return to Play

Small and stable peripheral tears can usually be treated without surgery or at least monitored over a period to see if the symptoms ease/deteriorate. More substantial and unstable peripheral tears need arthroscopic surgery, involving either suturing (meniscus repair) or the removal of the injured parts (meniscus resection), depending on the pattern and location of the tear and the preferences of the surgeon and patient (**Table 6.2**). If a bigger meniscus repair is performed, the player usually needs to be immobilized in a deep flexion-restricting orthosis for 4 to 6 weeks and cannot play again until 4 to 5 months after surgery. In contrast, a player can often return within 4 to 8 weeks after a small meniscus resection.
Theoretically, a meniscus repair could potentially protect the joint cartilage over time, but there is no long-term scientific support for this belief as yet.

Table 6.2

Treatment of meniscus tears

	Meniscus repair	Meniscus resection
Vertical	Red–red and possibly red–white tears	White–white tears
Horizontal	Possibly red-red tears	Red–white and white–white tears
Radial	No	Yes
Flap	No	Yes

Radial tears, flap tears, and central (white–white) tears are usually treated with resection (**Table 6.2**). In addition, a meniscus transplant is a salvage procedure that could be an alternative if a subtotal or total meniscectomy is needed or has been performed previously.[25] However, this is also controversial, and evidence for the efficacy of meniscus transplants is limited.

Prognosis

The short-term prognosis after a meniscus injury is usually good. Layoffs after resection are usually longer for lateral meniscus tears (6–8 weeks) than for medial meniscus tears (4–6 weeks). Failures are seen in around one-quarter of cases after meniscus repair, while reinjuries are rarely seen after meniscectomies. The risk of early-onset osteoarthritis after a meniscus injury is, as with ACL injuries, well known.

6.7.2 Cartilage Injuries

Epidemiology and Diagnostics

No epidemiological study has yet reported the knee cartilage injury rate in football. Cartilage injuries can be completely asymptomatic, but may also give rise to symptoms similar to those of meniscus lesions, with joint line pain, swelling, and catching.

Cartilage injuries are divided into four grades depending on the cartilage appearance and the depth of the lesion (**Table 6.3**). This information can be based on either the findings during surgery, using criteria established by the International Cartilage Repair Society (ICRS), or via MRI.[26] Only Grade 4 lesions with an osteochondral component can be seen on conventional radiographs, so MRI with cartilage visualizing sequences is the preferred method of radiological examination if a cartilage injury is suspected. It should, however, be noticed that MRI often underestimates the size of the lesion compared with surgery.

Osteochondritis dissecans (OCD) is a condition where cartilage (either with or without bone) becomes soft or even loose and detached from the underlying bone plate. It is most commonly seen in youth players and is typically located on the medial femoral condyle. OCD is visible on a radiograph, but an MRI is usually necessary to assess the extent of the damage and decide on treatment. This condition is also divided into four grades, using criteria established by the ICRS:

- Grade 1: stable lesion with a softened area covered by intact cartilage.
- Grade 2: stable lesion with partial discontinuity of the cartilage.
- Grade 3: unstable lesion with complete discontinuity of the cartilage.
- Grade 4: lesion with a loose and dislocated fragment.

The fragment is fully surrounded by joint fluid in a Grade 3 lesion (“dead in situ”), and with Grade 4 the fragment can be either within the bed or in the joint as a loose body, with an empty defect.

Treatment and Return to Play

Grade 1 and 2 cartilage lesions are usually treated nonsurgically or with arthroscopic debridement, while Grades 3 and 4 (“full-thickness” cartilage tears including high-grade OCD) often need further surgical treatment. Although numerous surgical treatments for cartilage injuries in adults exist, the most commonly used techniques with footballers are microfracture and various forms of autologous cartilage implantation (ACI).[27] There are, however, conflicting findings in the literature on players’ ability to return to football and the layoff period after surgical treatment for “full-thickness” tears. One study using the first-generation ACI technique reported that only one-third of the 45 players in question returned to football, returning after an average of 18 months.[28] A more recent study compared microfracture (21 players) with a

Table 6.3

Grading of cartilage injuries

	Surgery	Magnetic resonance imaging
0	Normal	Normal
1	Soft indentation and/or superficial fissures and cracks	Abnormal intrachondral signal, but normal chondral surface
2	Lesions extending down < 50% of cartilage depth	Mild surface irregularity and/or focal loss of < 50% of thickness
3	Defects extending down > 50% of cartilage depth, as well as down to the calcified layer and down to (but not through) the subchondral bone. Blisters also belong to this group.	Severe surface irregularity, with focal loss of 50–100% of thickness
4	Complete loss of cartilage cover, with exposure of the subchondral bone	Complete loss of articular cartilage, with exposure of the subchondral bone

second-generation ACI technique (20 players) and found return rates of 80% and 86% and layoff periods lasting 6.5 and 10 months, respectively.[27]

A loose body can sometimes be successfully repositioned and reattached in an acute setting, but after approximately a week the fragment will have swollen and will fit badly into the defect. In this case, the loose body has to be removed, with concomitant treatment of the defect using any of the aforementioned techniques. If the surface of the cartilage is intact in an unstable or loose OD, healing can be stimulated by fragment fixation and drilling of the subchondral bed.

Prognosis

In general, the prognosis is better for younger players and those who have experienced symptoms for a shorter period prior to treatment.[28] If the cartilage or osteochondral fragment has become detached and is floating as a loose body, the outcome is worse than if the cartilage fragment is still in place.

6.8 Dislocations

Dislocation of the patella in the patellofemoral joint is one of the most frequently seen dislocations in the body. Multiligament tibiofemoral dislocation is, however, usually the result of severe high-energy trauma (e.g., road traffic accidents), rather than a football injury, and will not be discussed further here.

6.8.1 Patellar Dislocation

Epidemiology and Diagnostics

Patellar dislocation is a fairly common injury in athletes, including footballers.[29] The patella always dislocates laterally, and the dislocation can be either complete (luxation) or partial (subluxation). Recent research data suggest that there is no difference between male and female players in the overall rate of patellar dislocation,[29] although it is commonly believed that teenage girls are at the greatest risk, as with ACL injuries.

Accepted risk factors for patellar dislocation are joint hypermobility, patella alta, trochlear dysplasia, and increased Q angle. Injury could occur following a direct blow to the medial side of the patella with the knee in flexion, but noncontact mechanisms are more common, with a powerful quadriceps contraction and simultaneous knee flexion and external tibial rotation.

The stability of the patellofemoral joint is dependent on the bone geometry, the joint capsule and ligaments (passive stabilizers), and the surrounding muscles (active stabilizers). The most important active stabilizer is the vastus medialis oblique, and at nearly full knee extension, the primary restraint to lateral patellar translation is the medial patellofemoral ligament (MPFL).

The patella is often reduced spontaneously with active knee extension, and if the examiner does not have this diagnosis in mind, it can easily be overlooked and misinterpreted as other medial-sided injuries such as MCL injury or a medial meniscus lesion. With a first-time patellar dislocation, there is a rupture of the joint capsule on the medial side of the patella, together with a sprain, tear, or avulsion of the MPFL. On examination, there is swelling and tenderness over the MPFL and increased lateral patellar translation, making the test painful or uncomfortable for the player. Sometimes the patella is still dislocated on examination, in which case the diagnosis is obvious.

Radiographs should always be performed on a first-time patellar dislocation, and MRI is often also required. Sometimes a small bone chip is detached from the patella and is visible from an axial (Merchant) view. Importantly, this fragment seldom has articular surface involvement. It represents an MPFL avulsion and should not, therefore, be interpreted as an intraarticular loose body. When the patella collides with the lateral femoral condyle, however, this can result in true loose cartilage or an osteochondral body (**Fig. 6.19**).

With recurrent instability, computed tomography (CT) can also be of value for studying bony geometry in addition to radiographs and MRI. This may involve the grading of any trochlear dysplasia and measurement of the tibial tuberosity–trochlear groove

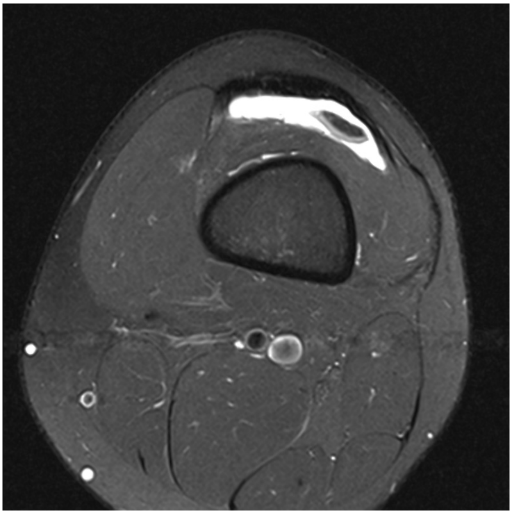

Fig. 6.19 Magnetic resonance imaging of loose cartilage body.

(TTTG) distance as an estimation of the Q angle, before decisions are made about possible surgery.

Treatment and Return to Play

If the patella is dislocated on presentation, reduction is usually achieved just by fully extending the knee. Sometimes the patella needs to be pushed medially and slightly anteriorly with gentle pressure after obtaining full knee extension in order to achieve the reduction. Treatment of first-time dislocations usually consists of short-term immobilization in a patella-supporting brace, followed by structured rehabilitation. Acute arthroscopic MPFL repair or open repair of midsubstance MPFL tears is not superior to nonsurgical management.[30] If the radiograph reveals a loose body, this can be either reduced and fixated or removed using arthroscopic surgery, as with cartilage injuries in general. Initially, the majority of primary patellar dislocations can probably be treated nonsurgically, but occasionally surgery could be required (**Table 6.4**).

With recurrent instability, however, stabilizing surgery might be necessary. There is no consensus on how many subsequent instability episodes are needed before surgery is discussed. The majority of recurrent patellar dislocations can be managed surgically with reconstruction of the MPFL (many techniques described in the literature), since most patients will have an acceptable TTTG distance and a low to moderate trochlear dysplasia. In more severe cases, a concomitant trochleoplasty and/or medialization and distalization of the tibial tuberosity might be needed.

There are no studies reporting return to play rates in footballers after a primary patellar dislocation, but the percentage returning to previous levels of physical activity is reported to be only slightly higher than 50% on average.[30] Clinical experience suggests that a player can often return after approximately 2 to 3 months following nonsurgical treatment of an index event.

Prognosis

The prognosis varies and is usually worse for repeated episodes of instability. Less than half of patients will develop recurrent instability.[29,30]

NOTE:

Patellar dislocation is easy to overlook if it is not considered when the player is examined.

6.9 Tendon Ruptures

Complete ruptures of the knee extensor tendon mechanism can affect both the patellar and the quadriceps tendons. Quadriceps tendon rupture is, however, more a result of tendon degeneration in middle-aged men than a football injury, and will not be discussed further here.

6.9.1 Patellar Tendon Rupture

Epidemiology and Diagnostics

Patellar tendon rupture is a rare football injury. In the UEFA Elite Club Injury Study, no total rupture and only two acute partial ruptures were identified between 2001 and 2009.[1] The tendon can rupture at the osseotendinous junctions (most commonly proximally) or in the midsubstance itself. Tendon ruptures after (multiple) local corticosteroid injections are described in the literature, as are ruptures associated with the use of anabolic androgenic steroids.

Standard radiographs should always be used to confirm a high-riding patella and identify any bony avulsions. MRI is of more value if a partial rupture is suspected in order to evaluate the percentage of fiber disruption, but is seldom needed for total rupture unless the surgeon wants it for preoperative planning. Ultrasonography might be an alternative to MRI with total ruptures.

Treatment and Return to Play

A partial rupture of less than approximately half of the width can be treated without surgery, while subtotal and total ruptures need surgery. If the rupture is located at the osseotendinous junctions, the tendon can be reinserted through drill holes in the patella and tibial tuberosity, respectively, or by using suture anchors. In contrast, midsubstance ruptures are managed using direct end-to-end suturing.

Table 6.4

Treatment of primary patellar dislocation	
Osteochondral fracture of patella or femur	Surgery (fragment fixation and possibly concomitant MPFL reinsertion or reconstruction)
Bony avulsion with articular surface	Surgery (fragment reinsertion)
No fracture, but unstable patella[a]	Surgery (MPFL reinsertion or reconstruction; possibly individual additional procedures)
No fracture and stable patella	No surgery

Abbreviation: MPFL, medial patellofemoral ligament.
[a]Patella pops out of place spontaneously with active flexion and extension.

Postoperative treatment usually consists of immobilization in a brace for 4 to 8 weeks. As with patellar dislocation, there are no studies reporting return-to-play rates in football, but clinical experience suggests that a player can return after approximately 6 to 8 months.

Prognosis

Patellar tendon rupture is a severe injury for a player which might interfere with the playing career, but the prognosis is usually acceptable to good in most cases.

6.10 Overuse Syndromes

Various overuse syndromes are commonly seen in and around the knee joint. The most frequently seen conditions in adult football players are patellofemoral pain syndrome (PFPS), jumper's knee, and runner's knee. The most common condition seen in skeletally immature players is the Osgood–Schlatter disease.

6.10.1 Patellofemoral Pain Syndrome

Epidemiology and Diagnostics

PFPS presents with anterior knee pain and is most frequently observed among female players, especially adolescent girls.[31] Pain is brought on by physical activity, but is also typically observed during everyday activities such as descending stairs, squatting, or prolonged sitting with the knees flexed (sometimes called the positive "theater or movie sign"). The condition is often bilateral, although one knee could be more symptomatic than the other. This condition used to be known as "chondromalacia patellae," but this term should be avoided, as changes to cartilage does not always occur with this condition.

PFPS is considered a diagnosis of exclusion and is based on the player's medical history and findings during the clinical examination. MRI and arthroscopy are not necessary, but radiographs might be needed to rule out other pathologies, especially if symptoms are unilateral.

Treatment and Return to Play

Many different surgical treatments have been tried to treat this condition, such as cartilage debridement and lateral release. However, these have usually had unpredictable results. Surgery is now rarely indicated and treatment usually consists of short-time painkillers as needed, together with "whole-body" physical therapy addressing not only the knee, but also the alignment and the muscles of the core and hip. Bracing or taping of the patella often provides some relief as well as arch-supporting foot insoles. Short periods of rest may be needed now and then, but the condition is not usually associated with longer layoffs.

Prognosis

Although the pain is long-standing and not always self-limiting with treatment, the overall prognosis is usually good, especially in younger players, and there is no reason for players to give up football, in spite of their pain.

6.10.2 Tendinopathy

Epidemiology and Diagnostics

Patellar tendinopathy, or jumper's knee, is not as common in football as it is in jumping sports such as volleyball and basketball, but it has nevertheless recently been shown to account for 1.5% of all injuries in the UEFA Elite Club Injury Study.[32] Most of these injuries are proximal, with pain and swelling located around the osseotendinous junction of the patella, but sometimes (less than 10% of cases) pain is more distal. Occasionally, the painful area is located above the patella at the junction with the quadriceps tendon, so-called "inverted jumper's knee." The pathogenesis of tendinopathies is not fully clear, but the affected tendon suffers from degeneration, with tenocyte degeneration and collagen fiber disorganization, as well as ingrowth of blood vessels and fibrous tissue in the tendon. The condition does not seem to be a true inflammatory syndrome, so the term "tendinitis" is a misnomer and should be avoided.

Clinically, in all extensor tendinopathies of the knee, pain can be provoked by asking the player to do exercises such as one-legged knee squats or forward lunges. The tenderness and any local swelling are found directly under the apex of the patella in classic patellar tendinopathy or at the tibial tuberosity in distal patellar tendinopathy. The clinical examination is easier if the patella is gently pushed distally, with the distal part slightly everted during tendon palpation, since the changes to the tendon are often located in the posterior tendon, adjacent to the Hoffa fat pad. Diagnosis is usually clinical, but ultrasonography using the power or color Doppler techniques or MRI is valuable if further examinations are needed.

Treatment and Return to Play

The first step in treatment is always alternative forms of physical activity until pain is reduced. Although the mechanisms underlying the injury are not fully understood, eccentric training is the most documented evidence-based nonsurgical treatment. Many other types of treatment exist, such as low-intensity pulsed ultrasonography, sclerosing injections, and shockwave therapy, but all have limited evidence in support of their efficacy. Corticosteroid injections into the tendon are not recommended by most practitioners owing to the risk of complete tendon rupture. Surgery is necessary in certain refractory cases, and this can be performed either arthroscopically or as open surgery.

Prognosis

Symptoms are usually mild initially, and the player can continue playing in spite of the pain for varying lengths of time, perhaps with a few short interruptions. However, many injuries deteriorate over time if the player continues playing football. Consequently, injuries may be considerably more difficult to treat at later stages, requiring long rehabilitation periods and sometimes surgery.

6.10.3 Apophysitis

Epidemiology and Diagnostics

Symptoms similar to those seen in adults with tendinopathies can be seen in adolescents with so-called "traction apophysitis" or "osteochondrosis." These conditions affecting the knee are called Sinding-Larsen–Johansson and Osgood–Schlatter diseases, depending on the location of symptoms. The Osgood–Schlatter disease is characterized by a prominent and painful tibial tuberosity and occurs more frequently in boys than in girls, whereas the Sinding-Larsen–Johansson disease affects the apex of the patella. Pain occurs during activities such as running, jumping, and squatting. Additionally, pain is present when ascending or descending stairs and while kneeling, and impact on the affected area can be very painful. Radiographs are sometimes useful, especially if symptoms are unilateral, but the diagnosis should normally be made on the basis of the medical history and the clinical examination. The radiographs typically show bony fragmentation at the osseotendinous junctions and rule out other pathologies.

Treatment and Return to Play

Treatment is symptomatic with the purpose of relieving traction and pressure on the apophysis. The young player can be recommended not to take full part in specific jumping or shooting practice, in order not to aggravate the symptoms, but is allowed to participate in matches. Treatment usually consists of painkillers after activity as needed, together with physical therapy and bracing or taping of the patellar tendon.

Concomitant tightness is often present in the quadriceps and ITB, and specific stretching exercises can be tried. Surgery is rarely indicated for adolescents, but if the condition remains once skeletal growth has stopped and the radiograph reveals a large bone fragment in the attachment of the patellar tendon, this can be removed by open surgery.

Prognosis

The condition is usually self-limiting, with symptoms resolving within 1 or 2 years, usually by the time skeletal maturity has been reached. In a minority of players, these symptoms continue unabated into adulthood or there can be remaining local problems because of a large detached bone fragment located behind or in the tendon attachment.

6.10.4 Iliotibial Band Syndrome

Epidemiology and Diagnostics

Iliotibial band syndrome (ITBS), or runner's knee, occurs most often in long-distance runners, as the name suggests. However, it is frequently also seen in footballers. The distal part of the ITB slides back and forth over the lateral femoral epicondyle during running, resulting in a friction syndrome that causes pain and irritation of fat and underlying connective tissues. Sometimes an ITB pseudobursitis can occur between the band and the femur. In football, this condition generally arises during preseason training, where there is often a great deal of running. Some suggested factors underlying the condition are excessive foot pronation, leg length discrepancies (with the longer leg affected), and tightness of the ITB. Inappropriate shoes and hard surfaces are also thought to contribute to the development of the condition.

There are usually no symptoms or clinical findings at rest, but progressive lateral knee pain occurs during running or cycling activities. Clinical examination should ideally be carried out both before and after physical activity, with the player typically being tender over the band at the level of the lateral femoral epicondyle (approximately 3 cm above the joint line). The Noble and Ober tests can also be positive.

Treatment and Return to Play

Treatment consists of alternative training, correction of training errors, and stretching exercises for the band itself, but also the gluteus medius and tensor fascia latae muscles. Correction of predisposing anatomical factors (e.g., foot orthoses aimed at reducing excessive pronation or leg length discrepancies) can often provide some relief. A local corticosteroid can be injected in cases with signs of ITB bursitis. Surgical release is rarely needed.

Prognosis

The prognosis is generally good, with symptoms usually resolved within weeks.

6.10.5 Synovitis

Epidemiology and Diagnostics

Inflammation of the joint capsule is a frequent complaint and is usually secondary to previous intra-articular knee injuries, such as a history of ACL injury.[23] Synovitis is most commonly encountered during preseason training, when players do a great deal of running, or early after a return to football following a traumatic knee injury. Hard playing surfaces and frequent alterations to playing surfaces could contribute to the development of the condition.

Treatment and Return to Play

Treatment consists of a brief period of rest and alternative training, such as cycling and pool exercises. Anti-inflammatory drugs are also recommended, and so, potentially, is an intraarticular corticosteroid injection.

NOTE:

Intraarticular injections of corticosteroids and local anesthetic could be chondrotoxic and should be used with caution, especially in younger players.

Prognosis

The short-term prognosis is good and most players can return to football quickly, but the recurrence of symptoms is seen fairly often.

6.10.6 Bursitis

Epidemiology and Diagnostics

Of the numerous bursae around the knee joint, the prepatellar and pes anserinus bursae are those most commonly inflamed. Symptoms include swelling and pain directly over the patella in the case of prepatellar bursitis and approximately 5 cm below the medial joint line in the case of pes anserinus bursitis. Diagnosis is clinical.

Treatment and Return to Play

Treatment consists of a brief period of rest, compression, cold therapy, anti-inflammatory drugs, and possibly a local corticosteroid injection. In recurrent and refractory cases, the affected bursa could be removed surgically.

Prognosis

The prognosis is good and most players are able to return to football quickly.

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Chapter 7

Ankle Injuries

Markus Waldén, Jón Karlsson

7.1 Introduction

Injuries to the ankle region are very common in football.[1] According to the Union of European Football Associations (UEFA) Elite Club Injury Study, they account for approximately 14% of all injuries resulting in time loss.[2] This chapter will provide an overview of the diagnosis and treatment of the most common traumatic soft tissue injuries and overuse injuries affecting the ankle region.

7.2 Ankle Anatomy

The ankle joint (talocrural joint) is a synovial hinge joint that connects the distal tibia and fibula with the proximal talus, allowing mainly flexion and extension motion, but also some rotation, supination and pronation. The bony arch formed by the articular surface of the tibia (plafond) and the medial and lateral malleoli is a rectangular socket referred to as the ankle "mortise." The articular surfaces are covered by a thin layer of hyaline cartilage. Owing to its bony architecture, the ankle joint is more stable in dorsiflexion than in plantar flexion. This means that almost all ligament injuries happen in plantar flexion.

The ankle joint is stabilized by several extra-articular ligaments. These can be divided into three groups:[3]

- Lateral collateral ligament complex.
- Medial (deltoid) ligament.
- Syndesmotic ligament complex.

The lateral collateral ligament complex is composed of three distinct parts originating around the lateral malleolus: the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL). Similarly, the syndesmotic ligament complex also has three distinct parts, giving axial, rotational, and translational stability to the distal tibia and fibula: the anteroinferior tibiofibular ligament (AITFL), the posteroinferior tibiofibular ligament (PITFL), and the interosseous tibiofibular ligament. The interosseous membrane also adds to the stability of the syndesmosis. In contrast, the medial ligament is a single unit that consists of two layers: the superficial and deep layers.

Anteriorly, the tendons of the anterior muscle compartment of the lower leg pass under the extensor retinaculum, together with the superficial and deep peroneal nerves and the dorsal pedal artery. Posteromedially, the posterior tibial and long toe flexor tendons are located with the posterior tibial artery and the tibial nerve. The peroneal tendons are located posterolaterally, behind the lateral malleolus, and posterior to the ankle joint is the Achilles tendon.

7.3 Clinical Examination

Ankle injuries can often be easily diagnosed with the aid of a thorough patient history and a systematic clinical examination. The examiner should be able to identify the following:

- If there was player contact when the injury occurred or beforehand.
- If the foot was free or planted on the ground.
- If the player felt a "snap" or "pop" when the injury occurred.
- If the player was able to continue playing or had to leave the pitch.

Asking for details of any previous ankle injuries or ankle surgery is often helpful.

The clinical examination of an ankle injury should consist of the following:

- Visual inspection.
- Evaluation of range of motion (ROM).
- Muscle strength tests.
- Palpation.
- Laxity tests.
- Other ankle-specific tests.

7.3.1 Visual Inspection

During the visual inspection, the examiner needs to look for gait disturbance, swelling, a hematoma, muscle hypotrophy, lower limb malalignment, etc.

NOTE:

The visual inspection should always be carried out with the patient walking, standing, sitting, and lying down.

7.3.2 Evaluation of Range of Motion

The typical active ROM for a footballer is approximately 10 to 15 degrees of dorsiflexion and 45 to 50 degrees of plantar flexion. The value of additional passive ROM testing is limited if the player has a pain-free and symmetrical active ROM. Comparison with the other side is always necessary.

7.3.3 Muscle Strength Tests

Muscle strength should be evaluated against resistance. This is usually done manually by the examiner, but hand-held dynamometers or other strength testing devices might be of value in some cases.

7.3.4 Palpation

Always begin the palpation in areas where you have a low suspicion of injury. Important anatomical structures to palpate include the joint line, the ligaments, and the posterior parts of the malleoli—as well as the Achilles tendon, including its insertion, and the base of the fifth metatarsal bone. It is important that the fibula and the interosseous membrane

Fig. 7.1 Anterior drawer test.

Fig. 7.2 Talar tilt test.

are palpated from the ankle to the proximal tibiofibular joint to identify or rule out any concomitant injury higher up.

7.3.5 Laxity Tests

In contrast to the knee, there are only a few manual laxity tests for the ankle joint. However, as with the knee, it is extremely important to compare the laxity with the nonaffected side.

Lateral Collateral Ligament Complex

The lateral ligaments are evaluated using the anterior drawer and talar tilt tests. The anterior drawer test is used to assess the ATFL, while the talar tilt test is used to assess both the ATFL and the CFL.

Anterior Drawer Test

With the patient supine and the knee flexed at 20 degrees, the examiner holds the hindfoot with one hand and places the other hand on the distal part of the lower leg and moves the talus forward in the ankle mortise (**Fig. 7.1**). During testing, the anteroposterior translation and the quality of the endpoint (firm, soft, or absent) are evaluated. The test is considered positive if the anterior drawer motion is at least 5 mm more than that seen in the contralateral healthy ankle.

Talar Tilt Test

In the talar tilt test, the patient sits with the knees flexed at 90 degrees (**Fig. 7.2**). While the distal tibia and fibula are stabilized with one hand, inversion stress is applied to the ankle with the other hand cupped under the heel. The test is considered positive if the talar tilt is 20 degrees or more, or if it is at least 10 degrees more than that seen in the contralateral healthy ankle.

Medial Ligament

The ankle eversion stress test is commonly used to assess the integrity of the deltoid ligament. Laxity testing of the medial ligament is usually more

Fig. 7.3 Eversion stress test.

difficult to carry out and interpret than for the lateral ligaments.

Eversion Stress Test

The patient sits with the knees flexed at 90 degrees (**Fig. 7.3**). While the distal tibia and fibula are stabilized with one hand, eversion stress is applied to the ankle with the other hand cupped under the heel.

Syndesmotic Ligament Complex

The stability of the inferior tibiofibular joint, especially the AITFL, is commonly evaluated using the external rotation test (Kleiger's test) and the squeeze test.

Fig. 7.4 External rotation test.

Fig. 7.5 Squeeze test.

External Rotation Test

In the external rotation test, the patient lies supine with the foot in a neutral position (**Fig. 7.4**). The lower leg is stabilized and the examiner passively rotates the foot externally. The test is regarded as positive if this maneuver elicits pain at the site of the AITFL.

Squeeze Test

In the squeeze test, the patient lies supine with the feet in a neutral position (**Fig. 7.5**). The examiner firmly and slowly squeezes the tibia and fibula together just above the AITFL. The examiner holds it for a few seconds, and then quickly releases the pressure. If there is pain from the AITFL upon release, the test is considered positive, indicating an AITFL injury.

NOTE:

Laxity testing and evaluation can be difficult in an acute setting because of pain and swelling. It is usually better to wait until 4 or 5 days after the injury before conducting laxity tests.

7.3.6 Other Tests

It has been reported that Achilles tendon ruptures are overlooked in up to 20% of patients in a general setting.[4] Consequently, the Thompson (or Simmonds–Thompson) test should always be included in the routine clinical examination of the ankle region, as should tests for anterior and posterior ankle impingement.

Thompson Test

During the Thompson test, the patient lies prone with the feet over the edge of the examination table (**Fig. 7.6a, b**). The examiner flexes the knee approximately to 20 to 30 degrees to unload the gastrocnemius muscle and then squeezes the midportion of the calf muscle from side to side. The normal response to this maneuver is plantar flexion of the foot/ankle, while a lack of plantar flexion is considered a positive Thompson test, indicating a total rupture of the Achilles tendon.

Impingement Tests

Testing for anterior impingement requires the ankle to be quickly moved—passively—from a neutral position to hyperdorsiflexion. The test is considered positive if the player experiences sudden pain anteriorly. Similarly, for posterior impingement, forced hyperplantar flexion will elicit ankle pain posteriorly. The posterior impingement test should be done with the knee flexed in order to uncouple the gastrocnemius muscle.

7.4 Radiological Examination

A significant ankle injury should always be referred for at least a standard radiographic examination in

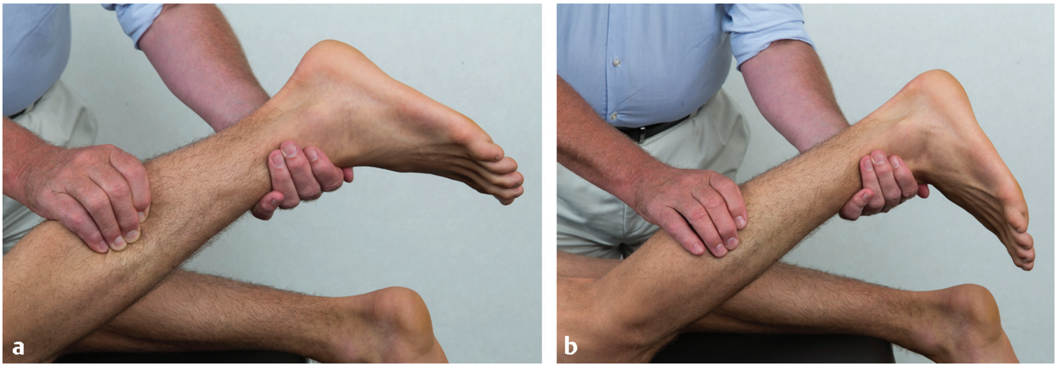

Fig. 7.6 **(a)** Thompson test: normal reflectory plantar flexion with intact Achilles tendon. **(b)** Thompson test: no movement of the foot in case of ruptured Achilles tendon.

order to rule out a fracture and identify any osteochondral lesions or loose bodies inside the joint. Magnetic resonance imaging (MRI) is highly sensitive, allowing occult skeletal injuries, articular bone marrow lesions, and cartilage lesions to be observed, as well as soft tissue pathologies such as tears in ligaments and tendons. In experienced hands, ultrasonography can also be used to examine the ligaments and tendons around the ankle joint, for instance injury to the peroneal tendons.

Stress radiographs play no role in the routine diagnosis and care of acute ankle sprains, but may occasionally be used in the investigation of chronic functional ankle instability. It should, however, be borne in mind that there is little correlation between the findings of stress radiographs and symptoms of functional instability.

7.5 Ankle Sprains

Distraction injuries to the stabilizing connective tissue around the ankle joint (i.e., the joint capsule and the ligaments) are very common, resulting from both contact and noncontact injury mechanisms. Ligament injuries are often roughly categorized as either partial or complete tears; this classification usually has a prognostic value, with complete tears leading to longer layoffs in general, but rarely needing surgical treatment. Ankle sprains used to be the most common football injury,[5] but the injury rate has fallen considerably over the last 20 to 30 years and appears to be continuing to decline.[6] This is probably due to successful implementation of research on the football field, i.e., increased knowledge among medical practitioners about preventive measures.

7.5.1 Lateral Ligament Injuries

Epidemiology and Diagnostics

Lateral ankle sprains are the single most common ligament injuries in football, accounting for around 7 to 8% of all injuries in professional football and half of all ankle injuries.[6,7] This means that a male elite team can expect three to four lateral ankle sprains per season (**Fig. 7.7a, b**). Many lateral ankle sprains occur as a result of player contact, often involving tackling or foul play.[8,9] A football-specific injury mechanism involving a direct impact on the medial aspect of the lower leg by an opponent tackling before or at the point of foot strike, resulting in forced inversion of the ankle joint, has been well described.[9]

In two-thirds of lateral ankle sprains, only the ATFL is injured. In another 20% of cases, the CFL is also injured (**Fig. 7.8a–c**).[10] Isolated injuries to the CFL and PTFL are rare.

Lateral ligament sprains are often divided into three categories on the basis of their severity (see **Table 7.1**). This classification is mainly of prognostic value.

It is important that a careful clinical examination is carried out in all cases, even if the diagnosis appears to be obvious. This is because there are several differential diagnoses that need to be considered, including fractures of either the lateral malleolus or the posterior process of the talus, bony avulsions of the base of the fifth metatarsal bone, osteochondral/cartilage injury, as well as a partial (longitudinal) rupture or dislocation of the peroneus brevis tendon. A delayed clinical examination after 4 to 5 days (or a second examination at that point) is often of higher quality and more reliable than an earlier examination.[11]

NOTE:

A twisted ankle is not always a sprain, and a systematic clinical examination should always be conducted to rule out other—sometimes more severe—soft tissue (or bone) injuries in the ankle region.

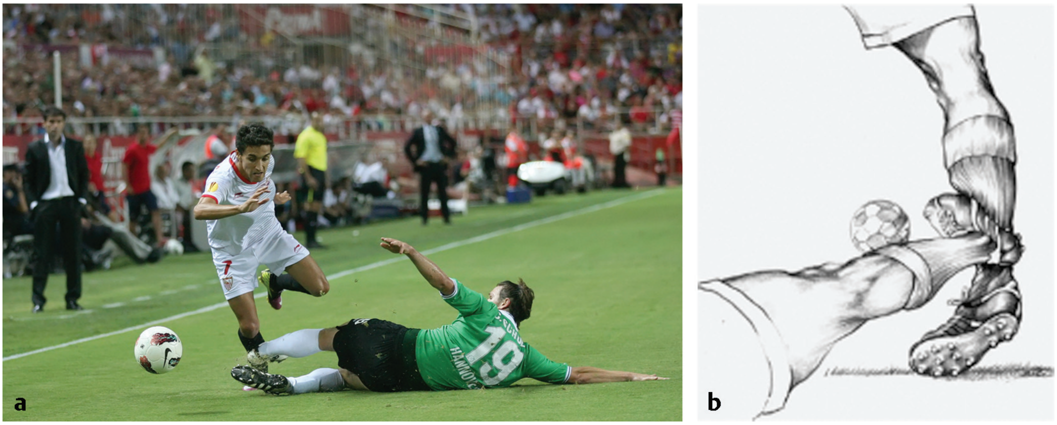

Fig. 7.7 **(a)** Typical injury mechanism for lateral ankle sprain. **(b)** Typical injury mechanism for lateral ankle sprain. (Image by Tommy Bolic, used courtesy of Oslo Sports Trauma Research Centre/Tommy Bolic. Image originally published in Andersen et al 2004[9].)

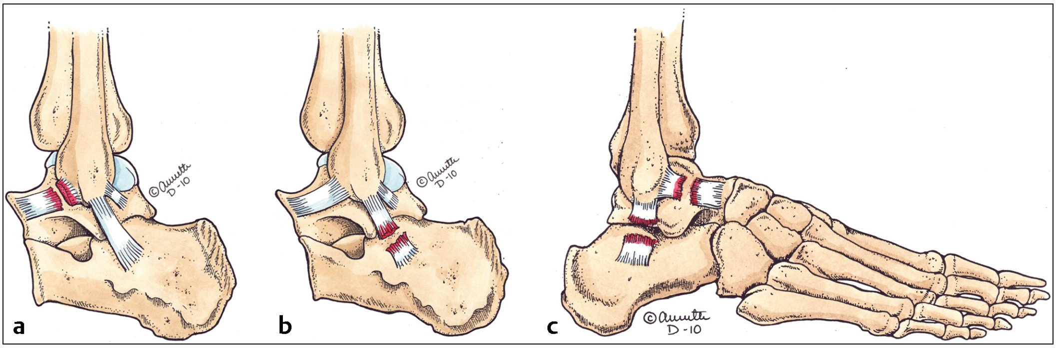

Fig. 7.8 **(a)** Rupture of the anterior talofibular ligament. **(b)** Rupture of the calcaneofibular ligament. **(c)** Rupture of both ligaments, the ankle joint is rendered unstable. (These images are provided courtesy of Annette Dahlström.)

Table 7.1

Grading of lateral ankle sprains

	ATFL	CFL	PTFL	Clinical presentation
Grade I	Partial tear	Intact	Intact	ATFL tender, with minimal swelling and no increase in laxity
Grade II	Total tear	Partial tear	Intact	ATFL and CFL tender, with swelling, restricted ROM, and some increase in laxity
Grade III	Total tear	Total tear	Partial tear	ATFL, CFL, and PTFL tender, with marked swelling, severely restricted ROM, and significant increase in laxity

Abbreviations: ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; PTFL, posterior talofibular ligament; ROM, range of motion.

Treatment and Return to Play

In an acute setting, the most common treatment is rest, ice, compression, and elevation (RICE), although the scientific evidence for this is limited.[12] Most sports medicine practitioners advocate early mobilization, with an accelerated rehabilitation program, regardless of the amount of ligament involvement and the degree of laxity.[13] With appropriate immediate treatment and early mobilization, almost half of all professional footballers can return to full activity within approximately 1 week following a lateral ankle sprain.[6]

Short-term immobilization in an acute setting—and even acute ligament repair—might be considered for a small minority of players. Some players have concomitant associated joint injuries, such as osteochondral injuries and/or loose bodies, and might need arthroscopic surgery. Moreover, a minority of players develop functional instability, which might require surgical reconstruction if rehabilitation is not successful. These players usually have positive anterior drawer and talar tilt tests and repeatedly experience the ankle giving way. The primary surgical technique is anatomical ligament reconstruction (which involves imbricating and reinserting the damaged ligaments, sometimes reinforcing them with local tissue such as periosteum, or the extensor retinaculum), followed by a short period of immobilization (10–14 days in a plaster cast being the recommended period, followed by 4 weeks of ROM training using an ankle brace) and physical therapy.[14] A player can usually return to football within 3 months following reconstructive surgery.

Prognosis

The prognosis after a first-time ankle ligament injury is usually good, and most footballers can return to play quickly, often with the use of an ankle support (taping or bracing) for at least 2 to 3 months (or until the end of the season). Reinjuries used to be common,[5] but they are less of a problem today, with only around 10% of all lateral ankle sprains in professional football recurring within a few months of the player returning to football.[6,7] This is probably a result of the successful adoption and implementation of various secondary prevention strategies, such as balance board training and bracing/taping.[15,16,17,18]

NOTE:

Ankle sprains are very common in football, and lateral ligament injuries are considerably more common than medial or syndesmotic ligament injuries.

7.5.2 Medial Ligament Injuries

Epidemiology and Diagnostics

Medial ankle sprains are much less common than lateral ankle sprains and account for a maximum of approximately one-tenth of all ankle sprains in professional football.[6,7] The injury mechanism is eversion and external rotation, and the typical injury is a partial tear located in the anterior part of the deltoid ligament. The injury often coexists with a low (lateral malleolus) or high fibula fracture, and this must always be borne in mind when evaluating medial ankle injuries. As with lateral ankle sprains, there are several differential diagnoses that should be kept in mind. These include bony avulsions of the tuberosity of the navicular bone, osteochondral injuries or cartilage lesions of the anteromedial aspect of the talus, etc.

Treatment and Return to Play

The recommended immediate treatment is RICE, followed by early mobilization and full weight-bearing if tolerated. Acute ligament repair is very rarely recommended for isolated injuries. The layoff period is often considered to be longer than for lateral ankle sprains, but the average layoff period in the UEFA Elite Club Injury Study is identical for medial and lateral ankle sprains (approximately 2 weeks), and half of all players with medial sprains were able to return to football within a week.[6]

Prognosis

The prognosis for this type of injury is generally very good. Pain and swelling can persist for several weeks, but the recurrence rate for this injury is low.

7.5.3 Syndesmotic Injuries

Epidemiology and Diagnostics

Syndesmotic injuries are uncommon, accounting for approximately 4 to 5% of all ankle sprains in professional football.[6,7] These injuries are often called "high" ankle sprains, since the area that is most tender and swollen is located more proximally than with ATFL injuries. The injury mechanism is forced external rotation with a slightly dorsiflexed ankle. As with deltoid ligament injuries, this injury is commonly associated with a fracture of the fibula. The injury could, however, occur as an isolated lesion and can be difficult to detect in such cases.

The AITFL is the weakest ligament of the syndesmotic complex and is therefore the most vulnerable to injury. Typically, the AITFL is torn and the PITFL is intact (i.e., there is a partial syndesmotic injury); however, tears in both the AITFL and the PITFL are sometimes seen, in which case the results of external rotation and squeeze tests are frequently positive. Syndesmotic injuries should always be examined by means of at least standard ankle radiographs to assess any avulsions or increased tibiofibular clear space. There is no visible joint incongruence with partial tears, but tibiofibular diastasis might be seen in total tears on radiographs (**Fig. 7.9a, b**). Ideally, a dynamic examination will also be carried out using fluoroscopy or ultrasonography. MRI can also be useful in many occasions.

Treatment and Return to Play

The recommended treatment in an acute setting is RICE and the use of crutches, with no or only partial weight-bearing. There is a lack of consensus with regard to the treatment of these injuries, but partial tears (based on normal radiographic parameters) are generally treated nonsurgically and total tears (based on pathological radiographs or fluoroscopy findings) are treated by means of surgical fixation, using one or two screws passing over the syndesmosis.[19] Regardless of the type of treatment, syndesmotic ankle sprains in football are associated with considerably longer layoffs than lateral and medial ankle sprains.[6] Following surgical fixation, players are usually allowed to return to football within 10 to 14 weeks (**Fig. 7.9a, b**).

Prognosis

The prognosis for syndesmotic injuries is good in most cases, but calcification of the syndesmosis (synostosis) or problems with hardware after surgery may sometimes occur and secondary surgery could be required. The recurrence rate for this injury is low.

NOTE:

Syndesmotic (high) ankle sprains often result in long layoffs and may require acute surgical fixation.

7.6 Cartilage Injuries

The magnitude of the problem with cartilage lesions affecting the tibial plafond and talar dome is probably widely underestimated. The healing potential is limited, since hyaline cartilage is avascular.

Epidemiology and Diagnostics

No epidemiological study has yet reported the ankle cartilage injury rate in football. These injuries can be asymptomatic, but often joint line pain, swelling, and catching are reported. They are commonly located anterolaterally or posteromedially (more common) on the talus, but traumatic injuries can also be located on the tibial plafond (less common). Cartilage injuries are divided into four grades depending on the cartilage appearance and the depth of the lesion (**Table 7.2**). This information can be based on either the findings during surgery, using criteria established by the International Cartilage Repair Society (ICRS), or via MRI.[20] Only Grade 4 lesions with an osteochondral component can be seen on conventional radiographs, so MRI with cartilage visualizing sequences is the preferred method of examination if a cartilage injury is suspected.

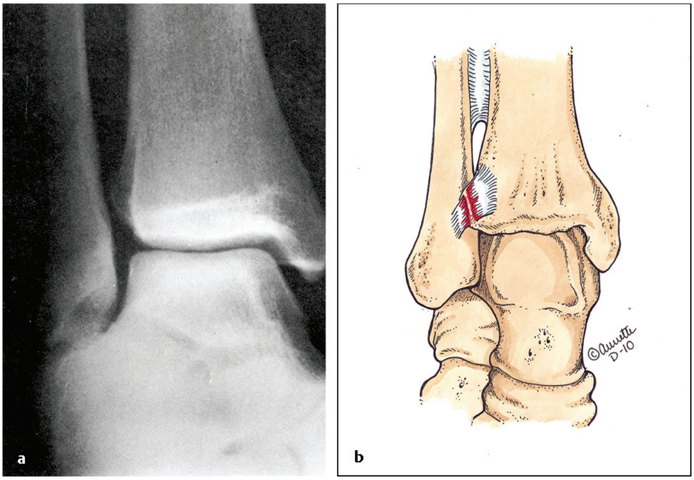

Fig. 7.9 **(a)** Radiograph showing increased space between the tibia and fibula. **(b)** Rupture of the anteroinferior tibiofibular ligament. (This image is provided courtesy of Annette Dahlström.)

Table 7.2

Grading of cartilage injuries

	Surgery	Magnetic resonance imaging
0	Normal	Normal
1	Soft indentation and/or superficial fissures and cracks	Abnormal intrachondral signal, but normal chondral surface
2	Lesions extending down < 50% of cartilage depth	Mild surface irregularity and/or focal loss of < 50% of thickness
3	Cartilage defects extending down > 50% of cartilage depth, as well as down to the calcified layer and down to (but not through) the subchondral bone. Blisters also belong to this group.	Severe surface irregularity, with focal loss of 50–100% of thickness
4	Complete loss of cartilage cover, with exposure of the subchondral bone	Complete loss of articular cartilage, with exposure of the subchondral bone

Osteochondritis dissecans (OCD) is a condition where cartilage (either with or without bone) becomes soft or becomes detached from the underlying bone plate as a loose body inside the joint. It is most commonly seen in youth players and is always located on the talus. OCD is visible on conventional radiographs, but an MRI is usually necessary to assess the extent of the damage and decide on treatment. Computed tomography (CT) is helpful in establishing a correct diagnosis of the skeletal injury, while MRI is more useful to study the cartilage damage. This condition is also divided into four grades, using criteria established by the ICRS:

- Grade 1: stable lesion with a softened area covered by intact cartilage.
- Grade 2: stable lesion with partial discontinuity of the cartilage.
- Grade 3: unstable lesion with complete discontinuity of the cartilage.
- Grade 4: lesion with a loose and dislocated fragment.

The fragment is fully surrounded by joint fluid in a Grade 3 lesion ("dead in situ"), and with Grade 4 the fragment can be located either within the bed or in the joint as a loose body, with an empty defect.

Treatment and Return to Play

Grade 1 and 2 cartilage lesions are usually treated nonsurgically or with arthroscopic debridement, while Grades 3 and 4 ("full-thickness" cartilage tears including high-grade OCD) often need further surgical treatment. Several surgical techniques exist, but there are no studies reporting on footballers' ability to return to play or their expected layoff periods after surgery. On the basis of clinical experience, the rehabilitation period is often long, and return to play might take several months—even as much as 6 months. In cases involving a microfracture, the postoperative rehabilitation period is prolonged owing to a period of nonweight-bearing activity. Other more recent surgical techniques, such as various forms of autologous cartilage implantation and biological membranes, are less proven in this context.

Prognosis

Outcomes for cartilage injuries are generally better for younger players and smaller lesions.

7.7 Tendon Ruptures

Partial and total tendon ruptures in the ankle region typically concern the Achilles tendon. Although ruptures of the peroneal (typically a longitudinal rupture of the peroneus brevis tendon) tendons are sometimes encountered, posterior tibial tendon injury occurs infrequently in footballers.

7.7.1 Achilles Tendon Rupture

Epidemiology and Diagnostics

Rupture of the Achilles tendon is an uncommon football injury; only two partial ruptures and seven total ruptures were identified between 2001 and 2012 in the UEFA Elite Club Injury Study.[21] Total ruptures are more common than partial ruptures, and only a small minority of players experience long-standing Achilles tendon pain before the rupture. The player often recalls a noticeable "snap" or "pop" at the time of the incident.

The rupture can—albeit rarely—be located at the osseotendinous junction (distal rupture), but it is more commonly located in the midsubstance, 2 to 6 cm from the os calcis (**Fig. 7.10**). Tendon ruptures after multiple local steroid injections have been described in case reports, as have ruptures associated with the use of fluoroquinolones.

An MRI is of value if a partial rupture is suspected, in order to evaluate the degree of fiber disruption. However, an MRI is seldom needed to diagnose a total rupture, as the clinical examination should be straightforward in most cases, with a palpable gap in the tendon, no plantar flexion strength, and a positive Thompson test (**Fig. 7.6a, b**).

Treatment and Return to Play

A partially ruptured Achilles tendon is treated with a few weeks of functional bracing in a walker boot, whereas total ruptures—particularly in young and highly active players—should almost always be treated surgically. If the rupture is located at the osseotendinous junction, the tendon can, for example, be reinserted through drill holes in the os calcis. Midsubstance ruptures are managed using direct

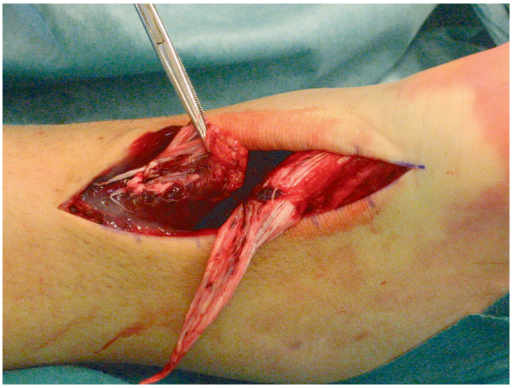

Fig. 7.10 Total Achilles tendon rupture.

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end-to-end suture repair. Postoperative treatment usually consists of a short period (10–14 days) of immobilization in an equinus position and nonweight-bearing activity, followed by functional bracing, early weight-bearing as tolerated, and early mobilization for a further 4 to 6 weeks. There are no studies reporting the rates of return to football, but clinical experience suggests that a player can often return to play after 5 to 6 months. The risk of a further rupture after surgical treatment is very low (approximately 2–4%), and after 5 to 6 months the risk is negligible.

Prognosis

The prognosis after a ruptured Achilles tendon is usually good, but functional deficits often persist for up to a year after this injury.[22] The vast majority of reinjuries occur within 10 to 12 weeks, or directly after the bracing period, but thereafter the rupture rate is higher on the contralateral side.

7.7.2 Peroneal Tendon Rupture

Epidemiology and Diagnostics

Complete full-thickness ruptures of the peroneal tendons are very rare injuries, which seldom occur in football. Partial longitudinal ruptures of the peroneus brevis are, however, quite often seen after inversion trauma to the ankle joint, especially in the case of recurrent inversion injuries where the ankle repeatedly gives way.[23] The player complains of pain, swelling, and discomfort behind the lateral malleolus, often after being allowed to return to football following a lateral ankle sprain. Ultrasonography and/or MRI typically show a midsubstance longitudinal rupture directly behind the lateral malleolus (**Fig. 7.11a, b**). There is typically swelling and tenderness on palpation behind the lateral malleolus.

Treatment and Return to Play

Total ruptures of the peroneal tendons require acute surgery. Partial ruptures can be treated without surgery if the clinical symptoms are minimal. In the case of recurrent pain and chronic swelling behind the lateral malleolus and radiological signs of a partial rupture of the peroneus brevis, surgery is almost always needed. In such cases, the tendon is reconstructed after the degenerated intratendinous part has been excised. The peroneal retinaculum is commonly stabilized at the same time. There are no studies reporting an expected layoff period or the rate of return to football, but clinical experience suggests that a player can often return after approximately 3 to 4 months.

Prognosis

The prognosis after surgical treatment of peroneal tendon ruptures is usually good.

7.8 Tendon Dislocations

Complete ruptures of the tendon retinaculae can affect the two peroneal tendons posterolaterally, making them susceptible to dislocating out of their bony groove during ankle movements. Posterior tibial tendon dislocation is extremely rare, and will not be discussed further here.

7.8.1 Peroneal Tendon Dislocation

Epidemiology and Diagnostics

Dislocated peroneal tendons are uncommon in football and are the result of a retinaculum tear. As with tendon ruptures, the player often recalls an audible “snap” or “pop.” The tendons are commonly relocated spontaneously, so the injury is often initially misdiagnosed as a sprain.

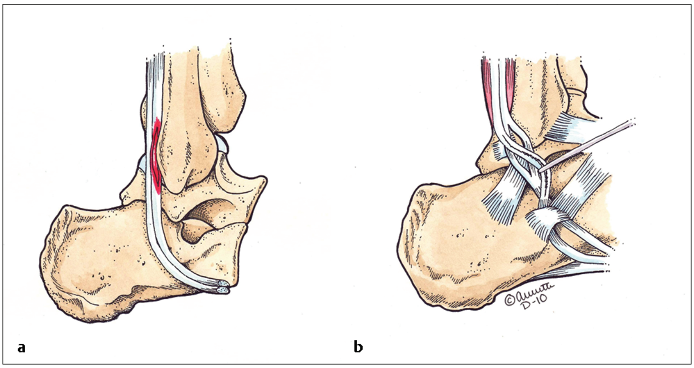

Fig. 7.11 **(a)** Partial longitudinal rupture of the peroneus brevis tendon. **(b)** Partial longitudinal rupture of the peroneus tendons. (These images are provided courtesy of Annette Dahlström.)

Treatment and Return to Play

Nonsurgical treatment involving 4 to 6 weeks of immobilization in a plaster cast used to be recommended for dislocations picked up in an acute setting. Owing to the inconsistent results with this method of treatment, most attending physicians now advocate surgery to reattach and reinforce the superior peroneal retinaculum, often in combination with deepening of the retrofibular groove.[24] Clinical experience suggests that most players can return to play within 10 to 14 weeks following surgery.

Prognosis

The prognosis after surgical stabilization is usually satisfactory.

7.9 Overuse Syndromes

The ankle region is often affected by overuse syndromes, the most common in adult football players being Achilles tendinopathy, followed by anterior and posterior ankle impingement syndromes.

7.9.1 Tendinopathy

Epidemiology and Diagnostics

Achilles tendinopathy is a common football injury and has recently been shown to account for just over 2% of all injuries in the UEFA Elite Club Injury Study.[21] Most of these injuries are located in the midportion of the tendon, but sometimes the pain is more distal and located at the insertion (**Fig. 7.12a, b**). The condition is mainly reported during preseason preparations and tends to be found in older players.[21] The pathogenesis of tendinopathies is not fully clear, but the affected tendon suffers from tenocyte degeneration and collagen fiber disorganization, as well as ingrowth of blood vessels and fibrous tissue in the tendon. The condition does not appear to be a true inflammatory syndrome, so the term “tendinitis” is a misnomer and should be avoided. Diagnosis is usually clinical, but MRI and/or ultrasonography can be useful if further examinations are needed.

Treatment and Return to Play

The first step should always be alternative forms of physical activity until the pain has subsided. Although the mechanisms underlying the injury are not fully understood, eccentric and eccentric–concentric training are the best documented nonsurgical protocols. Many other types of treatment exist, such as low-intensity pulsed ultrasonography, sclerosing injections, platelet-rich plasma (PRP) injections, and shockwave therapy, but all have limited evidence in support of their efficacy. Corticosteroid injections into the tendon are not recommended, owing to the risk of complete tendon rupture. In certain refractory cases of midportion and insertional tendinopathy, surgery can become necessary.

Prognosis

Symptoms are usually mild initially, and the player can continue playing in spite of the pain for a period of time, or with only short interruptions.[25] However, many injuries worsen over time if the player continues playing football. Consequently, injuries may be considerably more difficult to treat at a later stage, leading to long rehabilitation periods and sometimes surgery. The rehabilitation period after surgery is usually several months, with players often having to wait 4 to 6 months before they can return to play.

7.9.2 Anterior Ankle Impingement Syndrome

Epidemiology and Diagnostics

Considering that anterior ankle impingement used to be called “footballer’s ankle,”[26] it would be reasonable to think that this was a common injury among footballers. However, although the frequency of this injury is probably underestimated in studies using a time-loss injury definition,[25] anterior ankle

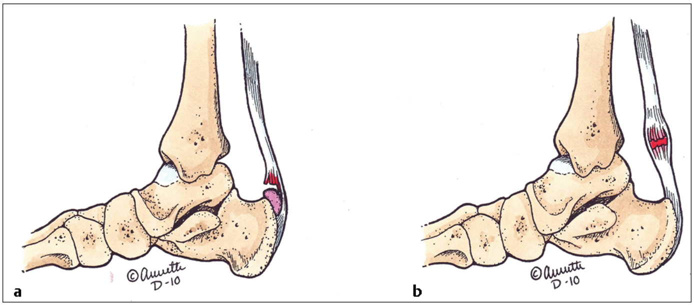

Fig. 7.12 **(a)** Tendinopathy at the insertion of the Achilles tendon. **(b)** Tendinopathy at the mid-portion of the Achilles tendon. (These images are provided courtesy of Annette Dahlström.)

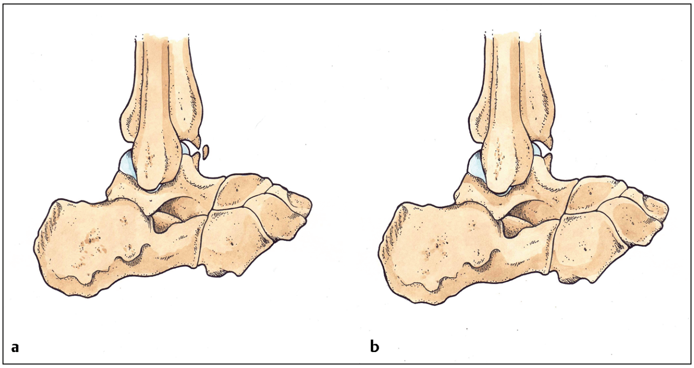

Fig. 7.13 **(a,b)** Anterior ankle impingement syndrome. (These images are provided courtesy of Annette Dahlström.)

impingement syndrome accounts for only 0.6% of all ankle injuries in the UEFA Elite Club Injury Study.[6] Typical symptoms include joint line pain, swelling, and limited (and painful) dorsiflexion. The impingement can either be osseous, involving spurs on the anterior talus and/or tibia, or soft tissue impingement resulting from local scar tissue formation (including meniscoid lesions) or a distal fascicle of the AITFL.[27] Standard radiographs are often needed to be accompanied by an oblique radiograph (30-degree external rotation of the ankle) to detect anteromedial osteophytes.[28]
Anterior impingement typically affects the dominant (kicking) ankle, and it has previously been shown that a typical ankle injury mechanism is forced plantar flexion where the injured player strikes an opponent's foot when attempting to shoot or clear the ball.[9] It has therefore been suggested that this anterior capsular traction contributes to the development of "footballer's ankle." Since the anterior joint capsule attachments are proximal and distal to the areas where talotibial spurs originate (**Fig. 7.13a, b**), this theory has recently been questioned.[28]

Treatment and Return to Play

Initially, the injury is treated with anti-inflammatory drugs and ankle support (e.g., tape), with the aim of reducing the movement of the ankle and thereby reducing the pain. In some cases, a corticosteroid injection may be useful. However, although this treatment may be helpful for a period of time, surgery is often still needed in the longer term. In such cases, arthroscopic removal of the bony spurs or other impinging soft tissue is preferred. Players can often return to play after just 4 to 6 weeks.

Prognosis

The prognosis after surgery is good and recurrence rates are relatively low.

7.9.3 Posterior Ankle Impingement Syndrome

Epidemiology and Diagnostics

Although first described in ballet dancers, this syndrome is now encountered in many other sporting activities, including football.[29] In the UEFA Elite Club Injury Study, posterior ankle impingement accounted for less than 3% of all ankle injuries, but these outnumbered anterior impingement injuries by more than three to one.[6] Again, the problem is possibly underestimated when injuries are defined on the basis of time spent on the sidelines.[25] The player complains of posterior ankle pain with plantar flexion and when pushing off as a result of an acute inversion trauma or plantar flexion trauma, which either occurs as repetitive microtraumas or a single forced plantar flexion trauma (**Fig. 7.14**). There are several different bony structures that could be

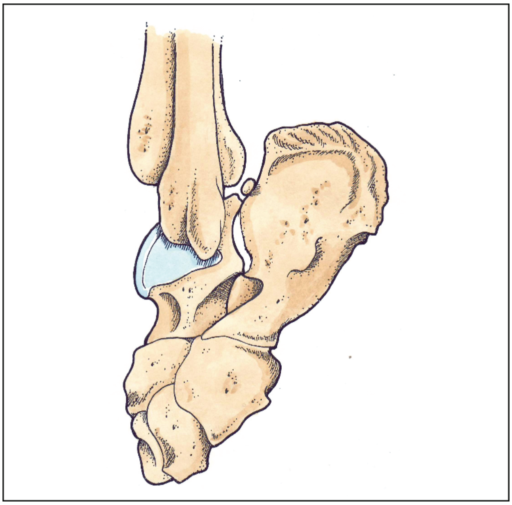

Fig. 7.14 Posterior ankle impingement syndrome. (This image is provided courtesy of Annette Dahlström.)

involved in posterior ankle impingement, such as a prominent or elongated posterior lateral talar tubercle (Stieda process), an os trigonum, or a fracture of the posterior process of the talus, as well as soft tissues such as the flexor hallucis longus (FHL) or the posterior ligaments (mainly the PTFL and PITFL).[27] A standard lateral radiograph is often sufficient to detect any bony abnormalities, but when it comes to soft tissue impingement, standard radiographs typically fail to show pathologies, so MRI/CT should be used, together with a careful clinical examination and standard radiographs.

Treatment and Return to Play

Treatment should always start with a nonsurgical approach, using anti-inflammatory drugs and ankle taping to reduce plantar flexion movement. Local corticosteroid injections are sometimes used in the early stages, but in many cases surgical treatment is needed. Arthroscopic surgery is preferred to open surgery, and this procedure is used to remove osteophytes or a symptomatic os trigonum, as well as carrying out debridement with an FHL release in the case of impingement. Recently, elite footballers who had undergone posterior ankle arthroscopies were shown to have returned to full training after an average of 5 weeks, being cleared for participation in matches 1 week later.[29]

Prognosis

The prognosis is generally good after surgery and recurrence rates are low.

7.9.4 Synovitis

Epidemiology and Diagnostics

Joint inflammation is a common secondary complaint when the ankle joint has previously suffered a sprain or cartilage injury.

Treatment and Return to play

Treatment consists of a short period of rest and alternative training such as cycling or pool-based exercises. Anti-inflammatory drugs are recommended, and intraarticular corticosteroid injections may also be helpful. Arthroscopic surgery is very infrequently needed.

NOTE:

Intraarticular injections of corticosteroids and local anesthetics can be chondrotoxic and should be used with caution, especially for young players.

Prognosis

The short-term prognosis is good and most players can return to play quickly, but the recurrence of symptoms—whether sooner or later—is relatively common. It is therefore very important to carefully seek out the underlying cause of the synovitis.

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Chapter 8

Overuse Injuries

Markus Waldén, Jan Ekstrand

8.1 Introduction

There are two main types of injuries in football: traumatic injuries and overuse injuries. Traumatic (accidental) injuries have a sudden onset and are caused by acute forces (e.g., tackling or a burst of speed) which exceed the durability of a tissue such as ligament, muscle, or bone. Traumatic injuries account for around two-thirds of all football injuries, whereas the remaining one-third are overuse related.[1]

Specifically, overuse injuries account for 28% of all time-loss injuries in the Union of European Football Associations (UEFA) Elite Club Injury Study.[2] As has been pointed out recently, however, defining injury on the basis of time loss is suboptimal when studying complaints related to overuse.[3,4] The main reason for this is that symptoms are very mild in the early stages and the player can continue playing, in spite of the pain, for a period of time. This chapter presents a general overview of the etiology and pathogenesis of overuse injuries and discusses the classic case—stress fractures of the lower limbs—in more detail, as well as looking at other common overuse-related conditions affecting the lower leg. Overuse injuries affecting the groin, knee, and ankle are described in separate chapters.

8.2 Etiology and Pathogenesis

Overuse injuries in football are defined as having an insidious onset of symptoms, without any (macro) trauma.[5] A typical example of the early stages of musculoskeletal overuse is the experiencing of pain during the warm-up before physical activity, with the pain then disappearing (or being substantially reduced) during the activity itself, but then recurring with increased intensity after the activity has finished. The player often continues playing, without seeking medical advice at an early stage, and there is a substantial risk that the player will enter a vicious pain circle, where the continued activity will cause further tissue microtrauma and more pain (**Fig. 8.1**).

There is almost always no single identifiable cause in the etiology of overuse injuries,[6] and they usually occur as a result of a combination of intrinsic (player-related) and extrinsic (environmental) factors (**Table 8.1**).

Insufficient rehabilitation following a previous injury, combined with a premature return to football, is a common factor if the player takes his/her own decisions. Training errors (e.g., excessive increases in load, intensity, and/or frequency) are also very common.

NOTE:

"Too much, too soon" is a common training error leading to a variety of overuse injuries.

8.3 Clinical Examination

Overuse injuries are often a diagnostic challenge, with a number of differential diagnoses to consider, and the diagnostic basis is (as always) a thorough patient history, combined with a clinical examination. It is important to find out if there has been any change in training load, footwear, or playing surface. A careful pain history is also required, including questions such as "When does it hurt?", "Where does it hurt?", "What provokes the pain?", and "What alleviates the pain?".

In the physical examination, it is important not only to examine the affected body part, but also to use a more systematic approach in order to identify any underlying anatomical malalignment, such as leg length discrepancy, genu valgum, or excessive foot pronation. The player sometimes needs to be examined after physical activity, for example, after running on a treadmill. This is particularly valuable for conditions such as runner's knee and chronic exertional compartment syndrome (CECS).

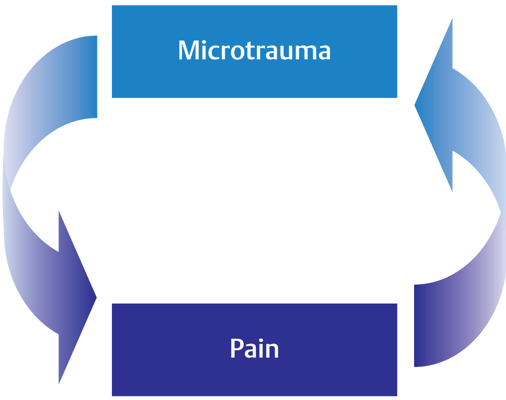

Fig. 8.1 Vicious pain circle in the presence of an overuse injury.

Table 8.1

Intrinsic and extrinsic factors associated with overuse injuries

Intrinsic factors	Extrinsic factors
Previous injury	Heavy load
Insufficient rehabilitation	High intensity
Anatomical malalignment	High frequency
Age (either old or young)	Monotonous training
High or low body mass	Inadequate technique
Female	Equipment or footwear
Psychological factors	Weather or surface conditions

8.4 Radiological Examination

Radiographs rarely add diagnostic value, except in the case of manifest osteoarthritis or stress fractures. A stress fracture, however, is not usually seen on radiographs during the first 3 to 4 weeks. On the other hand, ultrasonography allows the investigation of a variety of differential musculotendinous diagnoses and can therefore be valuable in the radiological examination of tendinopathies. Magnetic resonance imaging (MRI) is also highly sensitive, allowing the observation not only of musculotendinous pathologies, but also of occult bony injuries such as stress fractures and bone marrow edemas. Historically, bone scans were used to complement radiographs in order to demonstrate increased bony uptake in stress fractures, with radiographs proving negative at an early stage. Nowadays, however, bone scans have been completely replaced by MRI, which also show this pathology at an early stage.

NOTE:

Magnetic resonance imaging is now the gold standard in terms of examining stress fractures, but the difference between excessive bone stress and an incomplete stress fracture is sometimes still not clear.

8.5 Treatment of Overuse Syndromes

Regardless of the pathology suspected, alternative training is always recommended, followed by more structured and specific exercises. Alternative training (i.e., "relative rest"), such as cycling and pool exercises, can often be initiated immediately, whereas absolute rest and immobilization should be avoided. Analyses of training methods and the anatomy of the lower limbs are important in order to correct any training errors and anatomical malalignment.

NOTE:

The cornerstone of the treatment of overuse injuries is alternative training and avoidance of pain-inducing activities until symptoms ease, affected tissues heal, and strength is restored.

8.5.1 Anti-Inflammatory Drugs

Anti-inflammatory drugs, usually referred to as Nonsteroidal Anti-Inflammatory Drugs (NSAIDs), and corticosteroid injections may be useful to treat certain conditions such as bursitis and paratenonitis. However, in general there is no reason to initiate or continue using NSAIDs in long-standing complaints. This is because NSAIDs can aggravate the vicious circle by removing pain, and true inflammation is most often not involved in the condition at this stage.

Recent studies during the Federation of International Football Associations (FIFA) international tournaments have shown an alarmingly high use of NSAIDS among football players.[7,8] In the light of the described potential adverse effects of frequent use of NSAIDs, which include anaemia,[9] decreased renal blood flow,[10] potential negative effect on bone healing, and musculoskeletal injuries[11,12]—combined with the fact that NSAIDs have no effects on the majority of overuse injuries and may even aggravate some of them—a more restrictive use of NSAIDs is recommended.

8.6 Stress Fractures

Stress fractures are uncommon in football, accounting for around 0.5% of all time-loss injuries in high-level football,[13] but they are important to diagnose, since some can be serious (such as fractures of the anterior tibia and the femoral neck).

Stress fractures result from repeated submaximal loads, causing fatigue of the bone, and are usually associated with increases in weight-bearing activity such as running and jumping. Younger players are particularly prone to this injury, and more injuries are seen during the preseason preparation period.[13] Changes in surface conditions and footwear are thus important factors to consider, as is disordered eating in female players.[13]

NOTE:

The female athlete triad consists of disordered eating, menstrual dysfunction, and osteoporosis.

8.6.1 Hip and Pelvis

Epidemiology and Diagnostics

Stress fractures are most frequently encountered in the os pubis (typically the inferior ramus), followed by the femoral neck, but they can be located anywhere along the hip and pelvis, including the sacrum and ischium. Recently, pelvic fractures have been shown to account for 6% of all stress fractures in high-level male players.[13] Initially, the player can normally walk without any difficulty, but the groin pain gradually worsens over a few weeks to the point where the player also feels pain at rest and while walking.

A stress fracture in the pelvic ring should be suspected if there is severe localized soreness when pressure is applied to the symphysis or other parts of the pelvis, whereas a stress fracture in the femoral neck should be suspected if there is pain with hip joint rotation or when applying longitudinal pressure.

NOTE:

A player with a suspected stress fracture in the femoral neck should immediately unload the hip and be referred for an acute/subacute MRI.

Treatment and Return to Play

Treatment of pelvic stress fractures involves absolute rest from pain-inducing activities (running, jumping, kicking, etc.). Alternative training such as cycling with low resistance and pool exercises is permitted if it can be carried out without pain. In severe cases with pain at rest, the player should be treated very carefully initially. The player should not return to football until the localized tenderness has completely disappeared. If a stress fracture in the femoral neck is suspected, the player should immediately relieve pressure on the affected leg by using crutches until the diagnosis has been radiologically confirmed or excluded, since continued stress can lead to displacement of the fracture.

The treatment of a stress fracture in the femoral neck depends on the location. If the fracture is located superiorly, the player can be treated nonsurgically, with crutches and no weight-bearing initially. If the fracture is located inferiorly, however, there is a high risk of it progressing to a complete fracture with displacement. In this case, osteosynthesis should be performed without delay.

Prognosis

The prognosis after a stress fracture in the pelvis is good. For a stress fracture in the femoral neck of the femur, the prognosis is worse, regardless of the treatment, and setbacks in recovery occur fairly frequently.

8.6.2 Lower Leg

Epidemiology and Diagnostics

The tibia and fibula are some of the most vulnerable bones when it comes to developing stress fractures. Fractures are commonly located in the upper half of the tibia and approximately 5 to 10 cm above the lateral malleolus, respectively. In a recent study, tibial fractures accounted for 12% of all stress fractures in high-level male footballers, whereas only 1 of the 51 stress fractures recorded (0.5%) was located in the fibula.[13] Tibial fractures can be broken down into anterior and posterior fractures, and this classification often has some etiological and prognostic value. Fibular and posterior tibial stress fractures are usually associated with running, whereas the rarer anterior tibial stress fracture is associated with jumping activities. The diagnosis is often fairly straightforward, since there is typically very distinct localized tenderness around the fracture on physical examination and percussion over the area is very painful.

Treatment and Return to Play

Treatment of stress fractures of the lower leg involves absolute rest from pain-inducing activities, and partial unloading using crutches is often recommended (6–8 weeks for the tibia and approximately 4 weeks for the fibula). Alternative training such as cycling with low resistance and pool exercises is only permitted if it can be carried out without any pain. In severe cases with pain at rest, immobilization in a plaster cast for 3 to 4 weeks might sometimes be required for tibial fractures. Extracorporeal shock wave therapy (ESWT) has been reported to be effective in a small study looking at football players with stress fractures of the tibia and the fifth metatarsal.[14] Most fractures heal without the need for surgery, but if an anterior tibial stress fracture shows no signs of healing after 4 to 6 months, surgery should be considered. However, there is no consensus as to the recommended surgical method.

Prognosis

The prognosis for fibular and posterior tibial stress fractures is usually good, whereas anterior tibial stress fractures are associated with delayed unions and the development of complete fractures.

NOTE:

Stress fractures of the lower leg should be followed both clinically and radiologically until they have healed to allow for a safe return to football.

8.6.3 Fifth Metatarsal

Epidemiology and Diagnostics

In modern professional football, fractures of the fifth metatarsal account for the vast majority of the stress fractures. In a recent study, as many as 78% of the stress fractures recorded for high-level male footballers were located in the fifth metatarsal, whereas only 1 of 51 stress fractures recorded (0.5%) was located in another bone in the foot.[13] Despite being the most common stress fracture among footballers, fifth metatarsal fractures are quite rare in comparison to other injury types and a team of 25 players can expect a fifth metatarsal fracture only every fifth season.

Fractures of the fifth metatarsal, both traumatic and stress-related, can be located at the proximal base or more distally along the diaphysis (**Fig. 8.2**). Traumatic avulsion fractures are located at the tuberosity of the fifth metatarsal bone (zone A) and are never caused by overuse. The so-called Jones fracture involves the intermetatarsal joint and is located at the border of the metaphysis and diaphysis (zone B) and the true stress fracture is located in the proximal diaphysis distal from the intermetatarsal joint (zone C). Fractures in zones B and C are located in close anatomic proximity and are often difficult to differentiate.

Fifth metatarsal stress fractures in zones B and C typically affect young players at the start of the season, which could suggest that an increase of load during the preseason period might influence the risk of incurring this injury.[15] Many players complain of prodromal lateral foot pain the weeks before they sustain their manifest fracture, which often occurs after an insignificant twisting trauma, leading to a "crack" in the medial cortex.[15] Radiographs often show a periosteal bone reaction, thickening of the cortex, and intracortical radiolucency starting at the lateral-plantar side (**Fig. 8.3**). Despite these radiological changes that are typical of bone stress, the stress fracture is sometimes misdiagnosed as a traumatic fracture.

Treatment and Return to Play

The majority of elite players with fifth metatarsal stress fractures are treated surgically. Return to full team training is often possible within 3 months regardless of surgical or nonsurgical treatment, although recovery rates can vary considerably.[15] There is no consensus on how best to treat fifth metatarsal stress fractures, although evidence suggests there to be fewer problems with healing (delayed union) and a faster recovery time following surgery than with nonsurgical treatment.[15] In a recent study, delayed union or nonunion was seen in as many as two-thirds of the fractures treated nonsurgically compared to only one-third in fractures treated surgically.[15] The use of intramedullary screw fixation with or without bone grafting is the most commonly used surgical method. This provides central compression without compressing the lateral-plantar cortex, an area where a gap is often seen in fifth metatarsal fractures. Compression on the lateral-plantar cortex can be obtained with tension band wiring,[15] but no studies have so far shown this method to be superior to other surgical methods. There is also some evidence that ESWT can be useful in fifth metatarsal stress fractures, particularly if healing problems exist.[14]

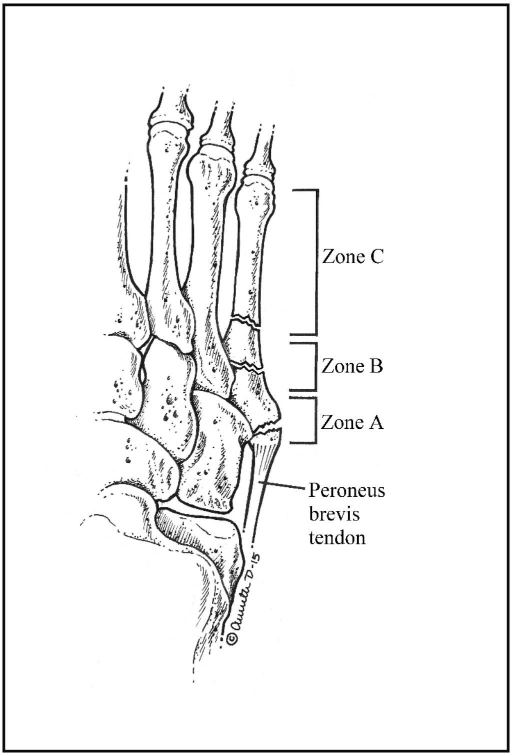

Fig. 8.2 Anatomical fracture zones of the fifth metatarsal bone.

Fig. 8.3 Fifth metatarsal fracture with associated periosteal stress reaction. The red circle shows the fracture in zone C.

NOTE:

There is currently a lack of evidence pointing to an optimal surgical method for treating stress fractures of the fifth metatarsal.

Prognosis

The prognosis is mainly dependent on clinical and radiological healing. If the fracture heals, return to football is often possible within 3 months. The recurrence rate for this injury after complete healing is low.

8.6.4 Other Stress Fractures of the Foot

Epidemiology and Diagnostics

The best-known stress fractures of the foot are the so-called "march fractures," which are commonly seen during military service. These are typically located to the distal part of the second or third metatarsal bones. However, as tarsal stress fractures, they rarely occur among footballers.

NOTE:

Tarsal stress fractures are difficult to diagnose and liberal referral to magnetic resonance imaging is recommended.

Treatment and Return to Play

March fractures heal without any specific treatment, but running and jumping on hard surfaces should be avoided during the healing process. Return to play is possible after 4 to 6 weeks. In contrast, tarsal stress fractures are best treated with immobilization in plaster cast or orthosis for 8 to 10 weeks as even walking may compromise or delay healing. Patients should therefore use crutches initially. Return to football should not take place until local tenderness at the injury site has gone.

Prognosis

March fractures have an excellent prognosis, whereas tarsal stress fractures might be associated with delayed union and persistent symptoms.

8.7 Other Overuse Conditions Affecting the Lower Leg

Long-standing pain in the lower leg is common and there are numerous differential diagnoses. Information from the player regarding the distribution of pain is sometimes valuable when diagnosing lower leg injuries other than stress fractures: anterior and medial pain is almost always caused by anterior compartment syndrome and medial tibial stress syndrome (MTSS), whereas the most common causes of lateral pain are lateral compartment syndrome and peroneal tunnel syndrome, and posterior pain is commonly caused by posterior compartment syndrome, an accessory soleus muscle, or an Achilles tendinopathy.

8.7.1 Chronic Exertional Compartment Syndrome

Epidemiology and Diagnostics

This syndrome can affect all four compartments of the lower leg (anterior, lateral, superficial posterior, and deep posterior), either in isolation or in combination. The condition typically has a gradual onset caused by exercise. When the intracompartmental pressure exceeds the capillary blood pressure of the muscle, the small vessels collapse, which results in localized ischemia. There is pain in the affected compartment, which becomes hard and tender on palpation. Symptoms disappear when the activity is curtailed, but reappear the next time the patient performs exercises of that kind.[6] Bilateral complaints are common. Occasionally, neurological deficits are seen, but the absence of a pulse is not a sign of CECS and should lead the physician to consider popliteal artery entrapment or another differential diagnosis.

Increased intramuscular pressure during activity used to be regarded as the gold standard for diagnostics, but a recent study identified a considerable overlap with asymptomatic subjects in terms of intramuscular pressures.[16] Consequently, and given the lack of an accepted pressure threshold for CECS, a clinical diagnosis (preferably using a physical examination before and after running on a treadmill or similar) is usually sufficient. Radiology is negative and should only be used to rule out other pathologies, if needed.

The three muscles of the anterior compartment (anterior tibial, extensor hallucis longus, and extensor digitorum longus) are commonly involved in this condition, which is usually the result of running exercises. The muscles of the lateral compartment (peroneus longus and peroneus brevis) are often involved to some extent as well, with the result that the term "anterolateral compartment syndrome" is sometimes used. Isolated lateral compartment syndrome is more infrequent, but can be associated with lateral ligament insufficiency of the ankle. The superficial (gastrocnemius and soleus) and deep (posterior tibial, flexor hallucis longus, and flexor digitorum longus) posterior muscles are more seldom affected in football players.

Treatment and Return to Play

The first step is nonsurgical and consists of alternative training, together with the correction of training errors and anatomical malalignments. Ultimately, though, a reduction in the activity level or a move from football to less demanding sports is a necessity. Diuretics and anti-inflammatory drugs have been tried historically, but they have no place in the treatment of this condition today. If the player wants to continue playing football at the same performance level, a fasciotomy of the affected compartment(s) is often warranted. After a successful decompression of the muscle compartment(s), return to football is often possible within 6 to 8 weeks.

Prognosis

Nonsurgical treatment is rarely successful in the case of long-standing symptoms, but surgery is performed without any guarantees of a successful outcome. The surgical risks (wound rupture, wound infection, iatrogenic nerve damage, bleeding, etc.) are higher (10–15%) than for most other orthopaedic procedures. The recovery period for posterior CECS is usually longer than for anterolateral CECS.

NOTE:

Approximately 75% of patients are satisfied after a fasciotomy for compartment syndrome.

8.7.2 Medial Tibial Stress Syndrome

Epidemiology and Diagnostics

Medial tibial stress syndrome (MTSS), otherwise known as "shin splints," is a frequent cause of posteromedial lower leg pain. The exact cause of the condition is unknown,[17] but the earlier theory of an inflammatory response in the periosteum has not been verified. The term "tibial periostitis" should thus be avoided. Female players and those with excessive foot pronation are thought to be most at risk. The player typically reports an elongated diffuse pain, with concomitant tenderness along the middle and distal thirds of the posteromedial tibia. There is usually no increased pain or tenderness with percussion by contrast to stress fractures. Bilateral complaints are common as for CECS, but by contrast, the player can continue playing, in spite of the pain, without interruption. Even if MTSS and CECS can mimic each other, there a few important differences in the pain history (**Table 8.2**).

Radiographs are typically normal in MTSS, but may sometimes show an elongated thickening of the posteromedial cortical bone at later stages of the condition. Bone scan also shows an increased uptake in the same location at earlier stages than for radiographs. However, the clinical examination is usually straightforward, without any need for radiological confirmation.

Table 8.2

Medial tibial stress syndrome (MTSS) versus chronic exertional compartment syndrome (CECS)

	MTSS	CECS
Pain during warm-up	++	–
Pain during activity	+	+++
Pain after activity (> 30 min)	++	–
Bilaterality	++	++
Nonsurgical treatment successful	++	–
Surgery recommended	–	++

Treatment and Return to Play

Nonoperative treatment is almost always successful.[17] Several options exist, usually consisting of alternative training, together with correction of training errors and anatomical malalignments. Shock-absorbing insoles are also frequently recommended, particularly in the case of hyperpronation or other malalignments of the foot. ESWT has also shown some promising results.

Prognosis

Although there may be some recurrence of symptoms, the long-term prognosis is good and surgical release of the fascia is rarely required.

8.7.3 Paratenonitis

Epidemiology and Diagnostics

In contrast to the tendon itself, a true inflammation of the tendon sheath or paratenon can occur in the tendons of the lower leg (e.g., the Achilles tendon and the anterior tibial tendon). At more acute stages, a fibrinous exudate fills the tendon sheath, with the paratenonitis typically accompanied by a crepitus that can be easily felt when moving the ankle joint, in addition to swelling and tenderness. This condition is seen most frequently in untrained subjects who start to play football or players who are exposed to rapid and dramatic increases in training volumes.

Treatment and Return to Play

A prompt recovery is frequently seen with rest and heparin injections (15,000 IU intravenously once daily for 3–4 days). Alternatively, anti-inflammatory drugs and a short period of immobilization in an orthosis or plaster cast can be tried. Players can return to football as soon as they are symptom free and underlying training errors and anatomical (foot) malalignments have been corrected.

Prognosis

The prognosis is usually good, with a low risk of recurrence and little need for surgery.

8.7.4 Accessory Soleus Muscle

Epidemiology and Diagnostics

Only a very small percentage of the population have an accessory soleus muscle, and the prevalence of this condition among footballers is unclear. The tendon either is inserted separately in the os calcis directly or merges with the Achilles tendon. Pain and swelling is seen during exercise around the distal third of the posteromedial tibia and the tarsal tunnel. The diagnosis can be verified using ultrasonography or an MRI.

Treatment and Return to Play

Although not evidence based, the recommended first-line treatment is, in most cases, a simple fasciotomy. Removal of the muscle is usually recommended only if this procedure fails. There are no data available in the literature on footballers returning to action after treatment for an accessory soleus muscle.

Prognosis

The prognosis is usually good after surgery.

8.7.5 Peroneal Tunnel Syndrome

Epidemiology and Diagnostics

Peroneal tunnel syndrome, which involves entrapment of the superficial peroneal nerve at the site of fascial penetration, approximately 10 cm superior to the lateral malleolus, is the most common nerve entrapment of the lower leg. Symptoms of entrapment are a vague exercise-related anterolateral pain with a concomitant disordered sensation on the dorsum of the foot. Percussion over the nerve produces tingling or pain (positive Tinel's sign). Occasionally, entrapment of the common peroneal nerve can also occur at the neck of the fibula. Neurological examinations at rest are completely normal, as are nerve-conduction studies and intramuscular pressure measurements for most patients.

Treatment and Return to Play

There are no studies looking at football players, but in persistent cases surgical nerve decompression is often recommended. Only a minority have a coexistent lateral compartment syndrome, so a routine fasciotomy in addition to neurolysis is not recommended.

Prognosis

Up to about 75% of patients are satisfied after surgery.

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