Motor Skills Training in Orthopedic Sports Medicine

Mustafa Karahan
João Espregueira-Mendes
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Editors

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Teaching is essential in our profession. As our Mentors taught us, we are committed to the education of those following in our path so they may excel beyond us in the future. The practice of medicine has changed drastically in recent years so that teaching comes in a variety of modalities such as research, courses, publications, and hands on trainings in clinics. We dedicate this book to those who passionately support education, in its many forms, in their practice.

Foreword

Designing an ideal teaching environment is a difficult task. Most important part of it is finding motivated faculty. This book provides a lesser important part which is concise collection of information on how to create a teaching environment.

Preface

Orthopaedic sports medicine is based on knowledge but mostly executed through motor skills. Throughout orthopedic surgery residency programs, directors place major emphasis on skills training. Many additional opportunities are available to supplement the trainee for proper skills training. An orthopedic surgeon interested in wholeness of the profession in essence should be a practitioner, teacher and a researcher. Teaching inspires us and is an historical element of the medical profession. Even the surgeons who are not in the academic environment are interested in teaching juniors. Motivations for teaching are manyfold, therefore is an attractive activity thus increasing the number of courses. Colleagues with goodwill wish to run courses and share their knowledge and meanwhile take the steps up in the career ladder.

The enthusiasm to run courses unfortunately does not always reflect into competence in setting up courses. The surgeon designs and runs courses based on his/her previous experience. Orthopedic surgeons have not traditionally tapped into the discipline of designing courses which is actually the “Science of Education”. This book is an attempt to bring multi-professionals into answering the basic question “How can we optimally design and run an orthopedic sports medicine motor skills course ?”. The question was approached from various aspects.

Initially, Professor Kurosaka, past president of ISAKOS, and his team aimed to define what it takes to be a “sports surgeon”. They described what modern sports medicine is and what it takes to have the “orthopedic sports medicine surgeon” title. It was underlined that continuous education, training, assessment or decision-making are required to be successful.

In the second chapter, we took a trivial dive into the “Principles of psychomotor skills training”. We as surgeons are excessively involved in the practical side of teaching. There is an ocean of “Science of teaching” that we surgeons need to be familiar with if we want to be more effective teachers.

Professor Chan and his team detailed how to teach concepts of surgical skill and strategy of designing a program. His team being very experienced in holding courses for so many years had a lot of examples to refer to.

Courses themselves should follow a curriculum within a wholeness. The course as a whole then should be within a major curriculum. Dr Pitts, an expert in curriculum development, provided the elements of how to set up a curriculum.

An engineer by training, Gabrielle Tuijthof presented the essential arthroscopic skills that is required to be taught in the courses based on the available evidence reflecting the Dutch experience gathered over the years.

Professors Tauro and Pedowitz wrote about the basic training modalities focusing on the FAST system adopted by the AANA. They also informed about the animal/human cadavers in addition to the bench models in wide usage.

Virtual simulators are the promising future of the motor skills education. Dr. Tuijthof describes in detail the current situation and the future of simulators in surgical skills training.

Aspects of a course design in practical detail are beautifully presented by the Australian team composed of Professors Alasdair Thomas, Greg Bain and Donald Bramwell. The chapter ends with a checklist, tips for a succesful course in addition to do's and don't do's of a course.

It is general knowledge that "one cannot progress, if you cannot measure it". Professor Cohen, past president of ISAKOS, wrote about the validation methods and how progress can be measured. Most popular global rating scales are included in his chapter.

As we mentioned earlier, a teaching event should be made in a continuum which should end with a certification. Naturally the trainee will be certified within the boundaries of the course. However, how the course will be positioned within a major certification program such as national or continental or even global is an important issue under focus. Professor Mineiro, President of the European Board of Orthopaedics and Traumatology Examination Committee, has undertaken this task and wrote certification of surgical skills.

We have not encountered a book at a global scale on a similar topic addressing our community. We heartily wish that it will be a contribution to training better surgeons for the future.

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Fundamentals of Being a Sport Surgeon

1

Daisuke Araki and Masahiro Kurosaka

1.1 Introduction

Sports medicine is a fast-growing health care field as adults commonly participate in sports in order to engage in regular physical activity, which is considered important for the health of individuals and society. Sports medicine focuses on helping athletes improve their athletic performance, recover from injury, and prevent future injuries or disorders.

In the history of sports medicine, Herodicus, a Greek physician who lived and practiced in the fifth century BC, is regarded as the first sports medicine doctor [3]. He combined his knowledge of physical education and medicine to develop new treatments to benefit athletes. Therefore, Herodicus is given credit for being the "father of sports medicine" and the first physician in the history of medicine who actually combined sports with medicine [7].

In modern times, the field of sports medicine has become broad and encompasses the following elements:

- Comprehensive health care for the active patient, including diagnosis and surgical or nonsurgical treatment of sports- or activity-related and unrelated injuries and illnesses

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- Special knowledge of the principles of athletic conditioning or training
- Use of techniques to prevent and treat muscular, skeletal, and articular conditions in athletes
- Focus on injury prevention and rehabilitation, including injuries common to specific sports
- The principles of antidoping education
- Nutritional guidance to maintain athletes' condition and to build strength and endurance in support of athletic performance
- Side-line team coverage

In the orthopedic field, medical professionals, including doctors, nurses, physiotherapists, athletic trainers, acupuncturists, nutritionists, and sports pharmacists, provide comprehensive support and care to return injured athletes to their preinjury level. Among these various specialties, sports orthopedic surgeons provide surgical treatment for athletes playing at the high school, college, and professional levels and for recreational athletes from every age group. Sports orthopedic surgeons often specialize in knee ligament injuries, shoulder disorders, ankle arthroscopy, and reconstructive ligament procedures. Therefore, it is essential that sports orthopedic surgeons learn surgical indications, surgical procedures, postoperative rehabilitation protocols, and conservative treatment of these sports-related injuries.

Sports orthopedic surgeons also serve as team doctors, along with team athletic trainers and physiotherapists. These surgeons' role in medical treatment has evolved in much the same manner as the athletic trainer. Sports orthopedic surgeons often work with physiotherapists to create rehabilitation plans and with athletic trainers to develop exercise regimens. These team doctors are generally sports physicians or sports orthopedic surgeons with either fellowship training in sports medicine. Though it is not essential to be a sports physician or a sports orthopedic surgeon, these special training have focused on the comprehensive treatment of athletes in an ideal way.

1.2 Sports Medicine Surgeon Requirements

The first step to being a sports orthopedic surgeon is to become a medical doctor. Once a doctor, the aspiring sports orthopedic surgeon has to complete an internship and an orthopedic surgery residency program, subsequently. This residency program gives doctors the opportunity to learn clinical and surgical skills and knowledge that are specific to orthopedic surgery [4]. Doctors should also gain experience related to the sports scene while completing their residency. These experiences could include, for instance, volunteering on a medical check, taking on leadership roles, and shadowing physicians.

The next step is to complete a fellowship program in sports medicine. Sports medicine is one of the orthopedic subspecialties that focuses on the musculoskeletal system. Sports orthopedic surgeons specialize in treating sports-related injuries or disorders, providing preponderantly to athletes. The sports medicine fellowship programs provide orthopedic surgeons to focus specifically on sports medicine and hone their clinical or surgical skills in that area. Several sports medicine departments offer sports medicine fellowship program, and applicants are trained in clinical assessment, evaluation, rehabilitation, and surgical techniques of sports-related injuries. In addition, these programs also offer doctors to undergo extensive clinical hours with local high school, college athletic departments, or professional athletic teams including side-line coverage. During this time, doctors receive hands-on experience performing preliminary examinations in the clinic or side-line and surgical training in the operation room. Therefore, they also learn how to treat head or spinal cord injuries and prescribe protective equipment. Physiotherapy is also required for doctors to learn how to return athlete to the sports field. Yin and coauthors report that fellowship training has a strong impact on surgical and nonsurgical treatment decisions. In addition, fellowship experience has a higher impact than residency training on industry-related decision-making, including choice of surgical equipment, implants, and bracing [8]. Therefore, sports medicine fellowships should be essential for sports orthopedic surgeons. Continuous education, training, assessment, or decision-making are the key to achieving excellent long-term clinical outcomes.

So far, there has been much focus on technical skills training. However, nontechnical skills such as situation awareness, decision-making, communication skills, teamwork, and leader skills are also mandatory for sports orthopedic surgeons [1, 2, 5, 6]. Sports orthopedic surgeons communicate with not only the athlete but also the parents, coaches, and the athletic trainers. Consequently, sports orthopedic surgeons need to keep up to date not only with a general knowledge of orthopedic surgery and a specialized knowledge of conditioning, nutrition, training, and antidoping control but also with their sense of humanity (Fig. 1.1).

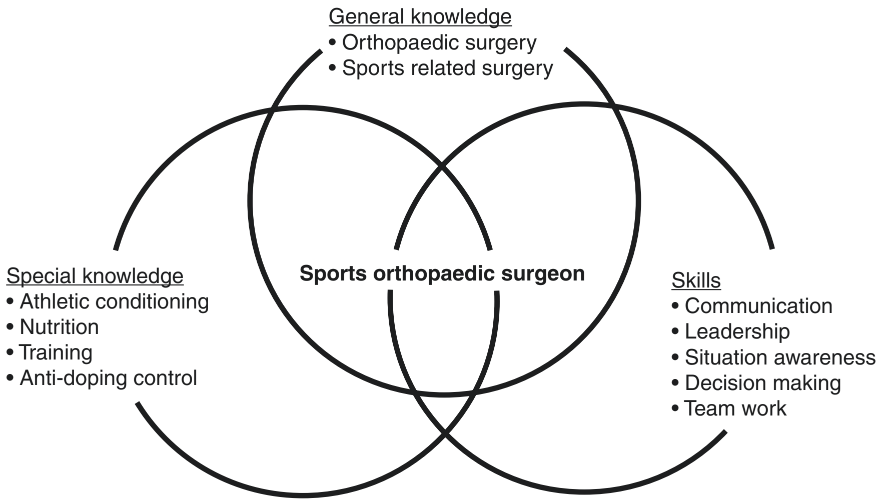

Fig. 1.1 Triangle pearls for sports orthopedic surgeon

1.3 Role of Sports Orthopedic Surgeons in Medical Teams

In sports medicine, a medical team generally consists of sports physicians, sports orthopedic surgeons, athletic trainers, physiotherapists, sports pharmacist, and other specialists. Sports physicians mostly work with the team and play a role in primary care. Sports physicians do not operate on athletes but can refer to a sport orthopedic surgeon when surgery is required. However, the roles of team members differ by countries and regions. Sports orthopedic surgeons can also play the role of sports physician, for which leadership and communication skills are essential.

For instance, the Japanese Volleyball Association's medical committee has 50 members, including specialists. Sports orthopedic surgeons, including knee, ankle, and shoulder specialists, belong to this committee. Some accompany the Japanese national volleyball team to matches, such as the FIVB World Cup, World Championships, World League, World Grand Prix, and Olympic games. In case a player is injured, the team doctor can refer that player to the sports orthopedic surgeon for prompt treatment. The team doctor can also contact specialists for training, nutrition, antidoping controls, and other medical problems. In addition, the athletic trainer is always on the front lines of sports scene and athlete care. They are a vital piece in the team approach to taking care of athletes and their injuries. Team doctors have to communicate with athletic trainers and lead the medical team in order to provide athletes with comprehensive treatment.

Conclusion

Today's society demands more specialization both inside and outside of the sports field. Sports orthopedic surgeons specialize in treating sports-related injuries, catering predominantly to athletes. Sports medicine is a subspecialty of orthopedics and focuses on the musculoskeletal system. The main goals of the sports orthopedic surgeon are to examine, treat, and prevent sports-related injuries and disorders. However, sports medicine as a speciality is still in the early years of subspecialty, and standards vary widely around the world. Therefore, to treat injured athletes to a high level and to improve performance, sports orthopedic surgeons must constantly study the latest knowledge and improve their personal skills in communication, team work, and leadership.

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2 Motor Learning Principles for Arthroscopic Motor Skill Teaching

João Espregueira-Mendes and Mustafa Karahan

2.1 Introduction

Surgical training traditionally been based on master-apprentice model since Hippocrates. However, the demands of a standardized health system, increased sub-specialization, ever advancing surgical techniques, and technology have created unfavorable conditions for surgical training. Therefore, the need for more efficient and effective ways of teaching and learning has emerged.

Experienced surgeon's performance during an operation appears simple, elegant, and incredibly efficient, whereas the learner's performance in the same setting may be clumsy and highly inefficient. The road from learner to being an expert is very complex, and it is not possible to explain it simply. Furthermore, the answer does not lie in a single scientific discipline. To understand the principles of learning and performance of motor skills, one must be familiar with the science of motor learning.

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Understanding how humans learn and perform undoubtedly helps establishing effective teaching strategies. For example, to understand fully the generation and learning of a complex surgical skill, one must have a basic understanding of the brain mechanisms that allow for error detection, of the various biomechanical constraints acting on the movements underlying the skill, and of the sources of sensory information that are integrated to guide the evolution of these movements.

Arthroscopy is a surgical procedure by which the internal structure of a joint is examined for diagnosis and/or treatment using a telescope. Arthroscopy was popularized in the 1960s and is now widely utilized throughout the world. Arthroscopic surgical procedures require basic unique surgical skills, which are acquired throughout residency or postgraduate programs.

2.2 Motor Skill

A motor skill is a voluntary musculoskeletal system movement that is goal oriented and is performed to achieve an object [1]. It is developed as a result of practice; a skill must be learned or relearned. Motor skills can be described according to different classification systems [2]. Arthroscopic surgical skills would be described as fine motor skills because a gross motor skill would be a skill requiring large muscle groups.

The features of movement organization differ between motor skills [3]. A discrete skill is one where a single component is the skill itself. A continuous skill is a skill composed of repetition of the same skill as in suturing. Skills that are used in arthroscopic surgery would be called serial skills, which mean that it is composed of multiple components performed consecutively.

Arthroscopic surgical skills are closed motor skills because the joint being operated on does not change throughout the operation. An open skill is performed in an unpredictable, ever-changing environment.

Regulatory conditions determine the movement characteristics necessary for a successful performance of a motor skill. Motor abilities are prerequisite for skilled performance. Accordingly, the degree to which a learner could potentially develop proficiency at a particular motor skill is dependent on whether he or she possesses the necessary underlying abilities. Arthroscopic surgical skills require varying degree of contribution from most of the listed below referred to as Fleischman's taxonomy of motor abilities [4] Table 2.1.

2.3 Movement Preparation

Movement preparation is started when a surgeon generates a goal directed action to accomplish a task in surgical setting. As the movement is continued, information regarding its advancement is fed back to the surgeon. Information which is called "intrinsic feedback" can be used to make adjustments towards perfection of the movement.

Table 2.1 Fleischmann's taxonomy of abilities

Perceptual motor abilities	*Control precision*	Ability to make highly controlled movement adjustments, especially those involving larger muscle groups
	Multi-limb coordination	Ability to coordinate numerous
	Response orientation	Ability to rapidly select a response from a number of alternatives, as in choice reaction time (RT) situations
	Reaction time	Ability to rapidly initiate a response to a stimulus
	Speed of limb movement	Ability to make a gross rapid limb movement without regard for reaction time
	Rate control	Ability to make continuous speed and direction adjustments with precision when tracking
	Manual dexterity	Ability to control manipulations of large objects using arms and hands
	Finger dexterity	Ability to control manipulations of small objects primarily through use of fingers
	Arm-hand steadiness	Ability to make precise arm-hand positioning movements where involvement of strength and speed are minimal
	Wrist-finger speed	Ability to move the wrist and fingers rapidly
	Aiming	Ability to quickly and accurately direct hand movements at a small object
Physical proficiency abilities	*Static strength*	Ability to generate maximum force against external object
	Dynamic strength	Muscular endurance or ability to exert force repeatedly
	Explosive strength	Muscular power or ability to create maximum effort by combining force and velocity
	Trunk strength	Dynamic strength of trunk muscles
	Extent flexibility	Ability to move trunk and back muscles through large ROM (range of motion)
	Dynamic flexibility	Ability to make repeated, rapid flexing movements
	Gross body coordination	Ability to coordinate numerous movements simultaneously while the body is in motion
	Gross body equilibrium	Ability to maintain balance without visual cues
	Stamina	Cardiovascular endurance or ability to sustain effort

Movement is performed under certain factors.

1. Response preparation
2. Attention
3. Arousal

2.3.1 Response Preparation

The short time lapse between the moment a stimulus is presented and the initiation of a response is known as reaction time. Reaction time is a measure of the time needed to prepare a response.

Under a given situation, as the amount of movement selections increases, the amount of time needed to prepare a response increases. If the trainee is given advanced information about what will occur next but also when it will occur has a positive effect on reducing response time.

2.3.2 Attention

Beginners have limits to number of procedures they can pay attention at any given time. In addition, as the procedure at target increases in complexity, the attentional demands will increase and further reduce attentional space that would otherwise be used for additional tasks. Designing tasks with less complexity for the beginners will help them not to be overloaded attentionally.

The instructor should be careful about the verbal exchange during performance with the learner because attentional limits may be exceeded even when correcting performance. The learner in time needs to know where and when to focus his/her attention so they can improve their attentional interchanging skills.

2.3.3 Arousal

Arousal is the physiological state of the individual that may vary from deep sleep to intense excitement which is not the same thing as anxiety. Higher anxiety, due to probable failure, may increase arousal. Lower levels of arousal will be preferred as a task increases in complexity.

As arousal decreases, a performer's attentional focus expands. Wide attention focus unfortunately will lead relevant and irrelevant stimulus to become available to the performer. Unnecessary focus of the performer will cause response delays and a resultant decrease in performance is inevitable. Optimal arousal levels will enable the learner to concentrate on the relevant stimulus ignoring the irrelevant ones. This narrowing of attentional focus is termed *perceptual narrowing* [5].

2.4 Motor Control

Once a learner puts together what movement to perform in a given situation, he/she subconsciously retrieves the appropriate learned motor program from memory. Followed by the retrieval estimated parameter values are added that will achieve the desired outcome. The details of the targeted movement are therefore organized in advance by the motor program and sent to the rest of the body to be executed.

2.4.1 Neural Mechanisms

The nervous system with the central nervous system (CNS) and the peripheral nervous system (PNS) is responsible for activating movement preparation, execution, and control. The peripheral nervous system is further subdivided into an afferent and an efferent division. Although numerous sensory receptors exist, visual system leads by far. Seventy percent of all the body's sensory receptors are located in the eyes, and 40 % of the cerebral cortex is assumed to be involved in processing visual information.

2.4.2 Vision

Vision is not only used in to detect stimuli which then is used to make movement decisions but is also used to assess the important feedback to guide the resulting action. The dominant eye processes and transmits a few milliseconds faster to the brain. We see objects in three dimensions although retina is a two-dimensional structure. A beginner initially will have difficulty using instruments under three dimensions while receiving images from the two-dimensional monitor. The visual system uses a variety of abilities for the interpretation process.

Linear Perspective: When we know the sizes of the objects, distant objects appear smaller.
Clarity: Distant objects seem dimmer or less clear.
Interposition: Closer objects obscure distant images.
Shadows: Amplitude of the shadows gives us clues on differentiation between closer and distant objects.
Motion: Closer objects move faster than distant objects.

2.4.3 Proprioception

As the learner starts a movement, *proprioception* provides the information about initial body and limb position which then is followed by continuous feedback that is used to be evaluated for precision towards the intended goal. Because the learner is still trying to acquire a movement style, his/her frame of reference for movement correctness has yet to be developed.

2.5 Motor Learning

Motor learning of the skills are retained in stages, and learners progress from a low to a high degree of automacy.

Initially, learners try to understand what the goal is and how to achieve it. Observation of a procedure is especially necessary to transform the stored information into action. Learners will master sooner if the target task is similar to a task that they have already been accustomed to which is called *skill transfer*. Previous learning can transfer either negatively or positively.

The basic aim of training in bench model knee is to maximize the amount of positive transfer to operating on a patient. Skill transfer is important because practicing in the real situation is not desirable until high levels of skill have been obtained. Effect of positive transfer depends largely on the similarity between the skills. Similarity in how or what things are done (functional similarity) is more important than physical similarity. Positive transfer between two skills also depends on the degree to which the first skill has been learned. In two very similar skills, a well-learned first skill will likely to promote positive transfer to learning of the second skill [6].

Reinforcement is a very crucial part of the motor skills teaching process. Positive reinforcement is used to introduce new skills into the learner where as negative reinforcement is used to get rid of bad behavior the learner may have.

Learning the skill alone is not sufficient for mastering. *Retention* of the skills is the next goal which the instructors must focus on. The instructors' must assist the learner in retaining the information. Retention will be successful if a skill is well established during training, if the break between episodes of skill performance is short, and if the skill is rehearsed regularly. Retention may not be successful because of poor skill acquisition, poor links between relevant information in memory, and due to a trouble transforming the memory into movement.

Feedback about performance will motivate the learner and help fine tune the future executions and enhance learning. The learner may either receive feedback intrinsically or extrinsically (e.g., video replays).

2.6 Learning Stages

The learner goes through phases when he/she is learning a new skill. Although there are several models to describe phases of learning, Fitts and Posner's three stage model seems best to describe the process [7].

2.6.1 Cognitive Stage

The learner is first introduced to the new motor skill aiming to acquire an understanding of the movement's requirements. The learner's movements will be initially sloppy, inconsistent, and grossly erroneous. At this stage, the learner is unable to determine the specific cause of the fault and eventually correct it.

2.6.2 Associative Stage

The learner gradually adopts a particular movement pattern which in time becomes more consistent with decreasing number of errors. At this stage, not only the errors are detected, attempts to correct them are observed.

2.6.3 Autonomous Stage

Once the movement is repeatedly practiced and a proficient level is reached, the task is automated. The attention is directed to decision-making and multiple tasks can be performed simultaneously.

2.7 Principles of a Learning Environment

One of the problems facing today's medical practice is how to teach motor skills in some kind of organized fashion that will optimize the use of time but produce a satisfactory learning experience for the learner.

2.7.1 Task Analysis

In designing a training course there is a choice between breaking down complex tasks into individual components or teaching the whole task as one entity. Breaking down the complex task and training seems to be more effective for serial tasks than continuous or discrete tasks and for low aptitude or inexperienced learners. Thus, the trainee can learn the individual components before assembling them into the whole technique. However, part-task training can lead to an inappropriate view of the whole task.

2.7.2 Course Program Designing Principles

When scheduling following principles based on the taxonomy of the psychomotor domain should be kept in mind [tax].

1. Conceptualization—the learner must understand the cognitive elements of the skill, that is, why it is done, when it is done, when it is not done, and the precautions involved. The learner must know the instruments and tools involved in the skill's performance.
2. Visualization—the learner must see the skill demonstrated in its entirety from beginning to end so as to have a model of the performance expected. This leads to learner imitation.
3. Verbalization—the learner must hear a narration of the steps of the skill along with a second demonstration. If the learner is able to narrate correctly the steps of the skill before demonstrating there is a greater likelihood that the learner will correctly perform the skill. This leads to learner manipulation.
4. Practice—the learner having seen the skill, heard a narration, and repeated the narration, now performs the skill.
5. Correction and reinforcement—skill errors need immediate correction. Positive reinforcement should be used to enhance correct performance.

6. Skill mastery—the ability to routinely perform a sequence of skills in a practice situation without error. This leads to learner articulation.
7. Skill autonomy—the ability to regularly perform the skill as a routine in real life situations without error. This leads to learner naturalization.

2.7.3 The Environment

The environment of the course should not shadow the actual contents of the teaching activity but must create a pleasant environment for learning.

2.7.4 Adult Learner

Part of being an effective instructor involves understanding how adults learn best. Compared to children and teens, adults have special needs and requirements as learners (Table 2.2). The learners must be familiarized through ice-breaking sessions. Learners provide clues about their learning preference.

2.7.5 Learning Styles

All learners have distinctive preferences for receiving and processing new information called the individual learning style.

Since no two individuals possess identical learning styles, the incorporation of instructional strategies that accommodate each learner is an important consideration when designing the learning environment. Learners can simply be reduced to three types: analytical learners, global learners, and a combination of both (Table 2.3).

Table 2.2 Qualities of an adult learner

Autonomous	Should be involved in the teaching process
Goal oriented	Must be shown how they will attain their goals
Relevancy oriented	Must see a reason for learning
Practical	Must explain how will the information be useful to them
Respect	Adults expect to be treated as peers
Motivation	Talk about their reasons for enrolling and decrease barriers

Table 2.3 Types of learners

Element	Analytical learner	Global learner
Sound	Work best in silence	Work best when there is background noise or music
Lighting	Prefer room to be well illuminated	Prefer soft lighting
Design	Prefer to work at a desk, table, etc.	Prefer to work in an easy chair, on bed, etc.
Persistence	Need to finish a task once started	Need frequent breaks; prefer to work on several tasks simultaneously
Structure	Prefer guidelines, specifications, procedures, rules, etc.	Prefer less structure, which allows for creativity
Social	Prefer to learn alone or with a practitioner	Prefer to learn with peers
Intake	Rarely eat, drink, smoke, or have other distracters while learning	Prefer to eat, drink, smoke, or have other distracters while learning

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How to Teach Concepts of Surgical Skills and Strategy of Designing a Programme

3

K.M. Chan, P.C. Ho, Patrick Yung, L.F. Tse, Clara Wong, and P.H. Chan

3.1 Introduction to Importance of Surgical Skills Training

Training of surgical skills in arthroscopic surgery is a much discussed subject. In recent years, there has been rapid development of arthroscopic skills application in various anatomical regions. There is a general idea in some countries that arthroscopic surgical skills are essentially a "video game" requiring "hand-eye co-ordination" skills, which may be well-adapted to the high-tech equipment training model and robotic assistant technology employed in arthroscopic surgeries. However, apart from hand-eye co-ordination skills, arthroscopic surgeons must also be trained using cadaveric human models because only real life situations and cadaveric human models can provide the best environment for acquisition of such surgical skills and are thus irreplaceable. In order to set a standard training programme to facilitate the training of surgeons, it is important that the basic concept of arthroscopy skill acquisition is coupled with a well-designed programme. Through the implementation of such a programme, with careful monitoring of the system and accreditation of the process, an important document could be produced and widely adopted in various centres around the world.

Arthroscopic training should be centred on a cadaveric model in a well-developed wet lab setting. The following is a list of standard setup and equipment that should be strictly adhered to:

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1. Well-equipped laboratory e.g. multi-purpose cadaveric mounting device, cadaveric mounting, high-density compatible video cameras, wide-angle and high-resolution projectors, participant interactive tracking system (PITS), computerized voting system and multi-media LCD SMART board interactive whiteboard.
2. Relay setting of live surgery. Trainees can observe the live surgery with high quality audio-visual transmission via the optical fibre connected to the operating theatre.
3. Supply of appropriate human cadaveric models from various anatomical regions, such as the knee, shoulder, ankle, wrist and hip.

Apart from cadaveric model training, there are emerging technologies in virtual training centre without the use of cadaver. Virtual training is user-friendly and overcomes the limitation of cadaveric model supply. This learning setting simulates lab setting with cadaveric models and provides students more opportunities to practise and speed up their acquisition of arthroscopic skills. Trainings have been undergone through virtual simulation modules in Orthopedic Learning Center (OLC) in Chicago. The Arthroscopy Association of North America (AANA) also organizes many arthroscopic courses in OLC Education & Conference Center, such as "Advanced Comprehensive Knee Course" and "Elbow: Arthroscopy, Reconstruction & Arthroplasty Course".

Example of virtual training can also be found in courses provided by various industries. An illustration of the spectrum of training capacity is illustrated as follows (Fig. 3.1).

3.2 Standardization of Training Centres

As the learning procedure is complicated and involves extensive equipment, expertise and provision of human tissues, it is recommended to observe the regulations accredited by the International Organisation for Standardisation (ISO). Reference

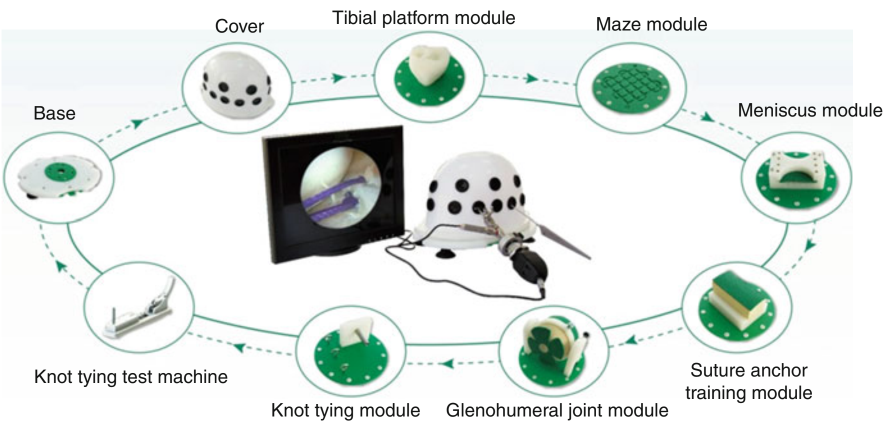

Fig. 3.1 An illustration adapted from Arthrotrain arthroscopic training module

can be made to the documents as enlisted in the appendant of the Orthopaedics Learning Centre, The Chinese University of Hong Kong (OLC). OLC has obtained the ISO9001 Certification, that the centre fulfils the requirements of a quality management system, which ensures that the centre can demonstrate the abilities to provide the products that meet the needs of customers consistently and to enhance customer satisfaction through an effective application of the system.

The ISO 9001 certification would ensure that the centre has done the right job, for the right person, in an effective manner.

Since human tissues are involved, it is important to pay attention to the procedures of procurement of the tissues, the regulations regarding handling of the tissues and the final dissemination of the remains to authorized centres. These are all outlined in the documents, *Notes to participants: Precautions for Handling Workshop Cadavers* (OLC) and *Precautions for Handling and Disposal of Dead Bodies* (Hospital Authority)

3.3 Design of a Training Programme

An arthroscopic training course should include five major sections:

1. Basic didactic lectures of video to highlight specific clinical problems and arthroscopic anatomy setup of the operating theatre.
2. Hands-on cadaveric demonstration and practice with preferably a 1:1 or 1:2 tutor–trainee ratio.
3. Live surgery to illustrate key operating procedures to provide trainee surgeons real operating room experience.
4. A full clinical round up with problem case discussion, round table quiz and a question and answer session. This will give a comprehensive approach to learning of skills, which is applicable to specific anatomical regions with clear illustration of major clinical problems.
5. Feedback from trainees regarding the programme and tutors to improve the course.

Special anatomical regions may entail specific requirements pertaining to the unique clinical condition and skill training that matches the need to handle these conditions. Examples are illustrated as follows:

3.3.1 Knee

Knee arthroscopy technique has been widely applied in various areas including meniscal surgeries, ligament reconstructions, patellofemoral realignment surgeries, chondroplasty/microfracture surgeries and loose body removals.

A well-planned and thorough diagnostic arthroscopic examination should be conducted with visual feedback of the suprapatellar pouch, patellafemoral joint, medial and lateral gutters, medial and lateral compartments and the intercondylar

Fig. 3.2 An illustration showing a knee cadaveric training station at work

notch region as well. Through workshop cadaveric training, participants would be allowed with the opportunities of mastering the three-dimensional fundamental technique of "triangulation" with one hand holding the arthroscope camera and other hand holding the instruments (Fig. 3.2).

The state of art of knee arthroscopy should focus on the establishment of portals and their trajectories to enhance subsequent instrumentations without causing hindrance. Needle technique gives surgeons and workshop participants a better sense of orientation prior portal establishment. The needle technique is even more crucial in establishment of posteromedial and posterolateral portals for difficult situations such as meniscal root tear surgeries and transtibial posterior cruciate ligament (PCL) reconstruction surgeries. Special precautions should be addressed on protection of vital structures particularly the popliteal neurovascular bundle.

The practice of knee arthroscopy should further include practice of meniscus procedures of various techniques in meniscal repair with regard to the meniscal tear configuration and the anatomical location. For ligament reconstructions, tunnel positioning and preparations with regard to the anatomical landmarks are to be demonstrated and practiced amongst surgeons.

3.3.2 Shoulder

The advancement of shoulder arthroscopic techniques enables surgeons to tackle simple procedures such as removal of loose bodies, bone spur removal, biceps tenotomy or tenodesis to more complex procedures such as rotator cuff repair, labral repair and acromio-clavicular joint excision or reconstruction.

The pros and cons of the beach-chair positioning versus lateral decubitus positioning and also the particulars with respect to traction should be reinforced.

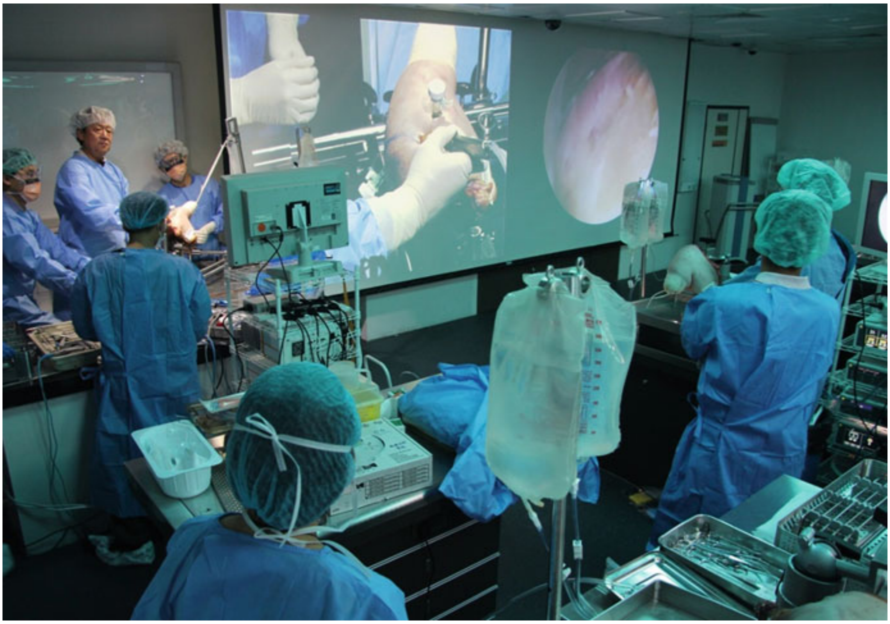

Fig. 3.3 An illustration showing how a teaching session on cadaveric model of the shoulder can be done in a lab setting with amplification to teach a bigger group of surgeons in training. This will give a "near-operating-room" experience followed by immediate practice on the cadaveric model with supervision of the mentor

The orientation in each of the shoulder position should be clearly demonstrated with room allowed for practice. Skills in suture management, knot-typing and suture-passing techniques are essence of arthroscopic labral repair and rotator cuff repair (Fig. 3.3).

3.3.3 Ankle

New techniques are emerging to deal with diverse ankle pathology. Those include deformity correction of hallux valgus, endoscopic superior peroneal retinaculum reconstruction, endoscopic calcaneofibular and anterior talofibular ligament reconstruction etc.

Since the first descriptions of tendoscopy in 1995 by Wertheimer et al. and in 1997 by Niek van Dijk et al., foot and ankle surgeons have expanded the use of tendoscopy to other tendons of the foot and ankle including the tibialis anterior, Achilles, EHL, EDL, FHL and FDL. An understanding of the surface and intra-articular anatomy of the ankle region is critical to the successful performance of arthroscopy of the ankle. Standard portals include anteromedial, anterolateral and posterolateral portals. The risk of neurovascular injury associated with these portals should be repeatedly observed.

3.3.4 Setup and Instrumentation

Arthroscopy of the ankle may be performed with general, regional or local anaesthesia. The position of the patient may also vary, depending on the surgeon's preference. Supine placement of the patient is preferred, with ankle joint maximal dorsiflexion in order to gain more work space. Ankle distraction may assist visualisation when ankle stiffness restricts the views in narrow joint. A resterilizable noninvasive distraction device permits the surgeon to move the ankle quickly from the dorsiflexed position to the distracted position and vice versa. Before portal placement, the ankle joint should be distended with 10–15 ml of lactated Ringer's solution or normal saline injected into the ankle joint medial to the tibialis anterior tendon with the use of an 18- to 20-gauge needle (Fig. 3.4).

There are potential complications with ankle arthroscopy. Careful preoperative planning and the use of appropriate distraction and instrumentation techniques also help in avoiding complications. Foot and ankle arthroscopy workshop and practice on cadaver model has the advantage of shortening the learning curve and make the surgeons familiarised with the anatomy and hence reduce the potential complications.

3.3.5 Wrist

At arthroscopy, we can understand better the patho-anatomy and the pathomechanics of many disease conditions previously unknown or impossible to be mastered without an unnecessary disruption to the normal enveloping structures on

Fig. 3.4 An ankle cadaveric training session with the mentor showing handling of the arthroscopy and manual control of the joint as the fundamental skill of ankle arthroscopy

this most complex joint in human body. It enables us to tackle directly the culprit, making wrist surgery much more logical and effective. In many clinical conditions, wrist arthroscopy has opened up a new horizon or standard for evaluation and treatment.

With the development of portal site local anaesthesia (PSLA) to allow wrist arthroscopy to be performed under local anaesthetic setting without tourniquet and sedation, the risk and cost associated with arthroscopy has markedly diminished and the acceptance of the surgery both by the patients and the surgeons is escalated.

On the resection aspect, common procedures include lavage, joint debridement, synovectomy, ganglionectomy, removal of loose bodies, capsular contracture release and various forms of osteotomy. Reparative surgery includes ligament repair, arthroscopic assisted reduction and internal fixation of fracture dislocation and chondroplasty for small chondral lesions. In osseous reconstruction, scaphoid non-union can be treated by arthroscopic bone grafting and percutaneous fixation with union rate of over 90 %. Partial wrist fusion can be achieved arthroscopically to maximize motion and to enhance union by preserving soft tissue and vascularity. In soft tissue reconstruction, arthroscopic assisted reconstruction of the radio-ulnar ligaments with tendon graft can be performed to treat chronic distal radioulnar joint instability through bone tunnels in sigmoid notch and ulnar fovea. In chronic scapholunate (SL) instability, the dorsal and palmar portion of the SL interosseous ligament is reconstituted anatomically through arthroscopically assisted reconstruction with tendon graft in a box-like structure. SL gaps can be reduced satisfactorily and stability maintained with good long-term outcome. In cartilage reconstruction, post-traumatic chondral lesion can be treated with arthroscopic osteochondral transplant.

Wrist arthroscopy is not merely a technique. The successful application of wrist arthroscopy in clinical practice also relies on a solid foundation of broad knowledge and updated concept, particularly on the indications for surgery. Arthroscopic discoveries need to be correlated with clinical findings (Fig. 3.5).

3.3.6 Elbow

The clinical use of elbow arthroscopies includes loose bodies removal, synovectomy, debridement, osteochondritis dissecans debridement/microfracture drilling and elbow release. In 2002, there was report of arthroscopic assisted capitellum fracture fixation. Arthroscopic assisted bone grafting for osteochondritis dissecans of the capitellum was reported in 2003, arthroscopic radial head fracture fixation in 2004, endoscopic distal biceps tendon repair in 2005, tennis elbow release in 2006, coronoid fracture fixation in 2007, triceps tendon repair in 2010 and collateral ligament repair in 2013. The clinical application of elbow arthroscopy is still advancing. Practising in and dissection of cadaveric specimens help to master the skills and refine the techniques while understanding more about the safety zones for the establishment of portals, which further extend the indications for elbow arthroscopy (Fig. 3.6).

Fig. 3.5 Wrist arthroscopy is a relatively new sub-specialty which requires a comprehensive spectrum of conditions to be delineated with good correlation of the pathology and arthroscopic findings and surgical procedures

Fig. 3.6 An elbow arthroscopy training session with cadaveric model in a lab setting

3.4 Comparison Between Different Natures of Training Programmes

A. *Arthroscopic surgery vs. open surgery training*

There may be a misconception that an arthroscopist is a new breed of orthopaedic surgeon. The application of arthroscopic procedures to handle a great majority of joint diseases and injuries has been well-illustrated over the past 30 years. Yet it is still important to consider that the surgeons are trained to be orthopaedic surgeons well conversant with the anatomy of the region both from the conventional approach and the arthroscopic approach. This is because surgeons can decide which approach to employ depending on the condition of patients. We shall train all-rounded orthopaedic surgeons instead of arthroscopists alone, by teaching them clinical problem-solving skills.

For example, the American Academy of Orthopaedic Surgeons (AAOS) is going to organize an open and arthroscopic technique in shoulder surgery course to enhance surgeons' open and arthroscopic surgical skills and clinical decision-making abilities. Furthermore, the course updates surgeons with the latest indications and surgical techniques for reverse shoulder arthroplasty and covers controversial topics on shoulder instability.

B. Industry-sponsored vs. academic centre/professional society-sponsored training programmes

The debate between an industry-sponsored training programme and an academic centre/professional society-sponsored training programme is one of our key considerations. The enormous financial and logistic input from various industries is much appreciated. However, this is a part of their marketing strategy to train orthopaedic surgeons to use the equipment and the appropriate implants from their company. They play a vital role around the world, but we are also concerned about the possible over-expectation on the specific use of a certain set of equipment and implant through these marketing strategies. Therefore, a balance should be achieved. We believe that this is the role of the programme director who should preferably be the director of arthroscopic surgery in sports medicine in a well-established orthopaedic centre/hospital.

Professional bodies in local, regional and international settings play an important role to ensure that such programmes will have the accreditation of academic or professional sectors, as well as a balanced approach in the utilization of sponsorship from various industries.

Arthroscopy Association of North America (AANA) has recently sent out a questionnaire *2014 Education Needs Assessment*. Part of the survey investigates factors that participants should consider when joining trainings provided by industry or professional societies. Possible factors are the cost, location, faculty, instrumentation, quality of course content and the quality of instructors. Industry-sponsored trainings may offer more specific instrumentation, while professional societies may introduce various approaches to treat orthopaedic injuries. Continuing medical education (CME) credits cannot be obtained by attending industry-sponsored trainings, so this is one of the considerations of participants.

Table 3.1 Teach the teachers course

First year	Second year	Third year	Fourth year
Teach-the-teacher Participants will be qualified to be local trainers at future basic courses	*Teach-the-teacher* Participants will be qualified to be local trainers at future basic courses	*Teach-the-teacher* Participants will be qualified to be local trainers at future basic courses	*Master class* For T-t-T participants in all previous T-t-T programmes to update the skills
	Basic course Teachers of this course will be chosen from first and second year T-t-T participants	*Basic course* Teachers of this course will be chosen from first and second year T-t-T participants	
	Advanced course For global participants	*Advanced course* For global participants	

This questionnaire demonstrates that professional associations such as AANA are also aware of the strengths and weaknesses of their courses compared to those organized by industries. This understanding could help professional societies to improve their education programmes.

3.5 Mentorship of Arthroscopic Surgery

Arthroscopic skills are an essential approach to solving clinical problems. There should be a continuous monitor of such skills being applied in a clinical setting. With the example of a “Teach-the-Teachers” course, continuum of observation can be introduced over a 2–3 years period with a close monitor system. The foot and ankle course jointly organized by The Chinese University of Hong Kong and Academic Medical Center (AMC) is an excellent example to share (Table 3.1).

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4 Setting Up a Curriculum

David Pitts

> **Key Messages**
> - Develop a clear understanding of what your curriculum should contain and who it is aimed at
> - Work with the right people
> - Do not underestimate the work involved

4.1 Introduction

Some disciplines in surgery and medicine have been established for 500 years or more, sports medicine and sports surgery are new arrivals on the clinical scene. Despite having been around for several centuries, most of the clinical specialties have only recently paid major attention to the writing of curricula. The first complete curriculum for a surgical specialty was published in 2005 [9], little more than 10 years ago. So, like sports surgery itself, curriculum writing in surgery and medicine is still a "work in progress".

As a consequence anyone wishing to write a curriculum might be overwhelmed by the amount of literature exploring different aspects of curriculum development. They will nevertheless have to search very hard for simple guidelines on how to actually write one or find accessible, mature examples of good practice.

In this chapter, we will attempt to provide a simple plan for the curriculum novice in how to pursue the task of writing a curriculum for the first time. We will first define what a curriculum is and what benefits it can give. Second we will describe some of the steps that have to be taken and the work that is involved in creating one. Third we will look at some of the common problems and obstacles curriculum writers face.

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4.2 What Is a Curriculum and Why Do You Need One?

4.2.1 What Is a Curriculum?

According to the UK's General Medical Council standards a curriculum is:

> "A statement of the intended aims and objectives, content, experiences, outcomes and processes of an educational programme including:
>
> - A description of the training structure (entry requirements, length and organisation of the programme including its flexibilities, and assessment system)
> - A description of expected methods of learning, teaching, feedback and supervision

The curriculum should cover both generic professional and specialty specific areas." [4].

In essence a curriculum is a map of an educational project; it articulates where you intend to go, how you will get there, how you know you are heading in the right direction and how you know when you have arrived.

One component of a curriculum is a syllabus, and these two are often confused. A syllabus is a description of what has to be learned during the programme, it is only one of the required components of a curriculum. Sometimes the confusion has serious consequences. It is not unknown to hear an invited speaker at a clinical meeting give a presentation on 'The new curriculum in my country/specialty' presenting only the details of a syllabus. It has been known for quite substantial communities of clinicians to rest comfortably in the belief that they have completed their "curriculum" only to find when their work is presented in public that the work they thought was complete is in fact hardly begun. Adding a couple of paragraphs on how the training programme is structured may enhance a syllabus but it does not transform it into a curriculum.

4.2.2 Why Is a Curriculum Necessary?

Recent interest in curriculum development has stemmed from the need to plan postgraduate medical education in detail. *Resources* of all types are scarce and need to be managed effectively whether that is the investment of public money that funds the programme or the time available for training. An overtly planned programme is a key requirement of *governance*; patients not only wish to know that their taxes are well spent but also that they are receiving treatment from appropriately trained and experienced clinicians. In orthopaedic sports medicine in particular the curriculum gives very necessary support to inter-specialty *collaboration*. The majority of sports medicine practitioners in general begin their professional life in another specialty such as general medicine or orthopaedic surgery. Any curriculum in sports medicine has to define the appropriate pathways and entry requirements at the early career stages and also to facilitate ongoing collaboration between the qualified sports medicine practitioner and other specialties later on. As a newer specialty, and one whose practitioners vary greatly in their professional focus, it is vital that all those engaged in the patient pathway are fully aware of what the sports medicine specialist contributes. The curriculum defines that contribution through its articulation of the training programme. In orthopaedic sports medicine in particular the curriculum must define the differences between the orthopaedic sports surgery professional and an orthopaedic surgeon who is treating a sporting injury.

4.3 Understanding Fundamental Concepts

Most orthopaedic surgeons do not undertake a Ph.D. in Tribology before fixing a fracture with a plate and screw for the first time. Similarly most clinicians who wish to help in the curriculum writing task are unlikely to undergo a thorough education in all aspects and issues of curriculum development before they start. There are however some key concepts that must be grasped by every member of the team before beginning the journey.

4.3.1 Curriculum

Everyone on the writing team must have a shared understanding of what a curriculum is and is not and why it is necessary or desirable (and possibly urgent) to write one.

4.3.2 Consensus

There will be many occasions in the writing process where team members disagree. These are important points where the battle for quality can be won or lost. The greatest temptation is for the chairperson to make the choice or possibly take a democratic vote. Much more can be gained and learned by pursuing consensus. Everyone must agree to some extent that the solution chosen is the best one, and they are prepared to back it wholeheartedly. Taking the easy way out can lead to decisions that have not been thoroughly thought through and eventually lead to disaster when exposed to the real world of training.

4.3.3 Collaboration

Not having the wrong people on the writing team is at least as important as getting the right people. Just because someone is an excellent clinician, a member of an important committee, a genuinely nice person (or all of the above) does not necessarily give them the competence for curriculum development. For most clinicians it is a new area, one they have never encountered before and one in which they must be learners, not experts in order to get the job done. Inviting the “most important” people in the specialty will probably be counterproductive if they are already committed to so many committees and conferences that they have no time to be part of the curriculum team. This is not an activity to be conducted by email or conference calls; it needs large quantities of face-to-face discussion if the right quality is to be achieved.

The size of the curriculum writing group is also important. Most of the work will need to be done by a small executive group of four or five people. There may be a larger, extended group who are consulted regularly and review the work, but this group will need to be disciplined in the ways in which they contribute. An effective curriculum cannot be written by a large committee. The executive group pursue consensus together but in the larger group they must listen carefully, be prepared to go away and think again but also exercise authority on occasions.

4.3.4 Purpose

All curricula do not serve the same purpose and are not written for the same people. It is important to debate and agree at the start who this curriculum is written for, what it seeks to achieve for those people and most importantly what its boundaries are. Writing a curriculum for orthopaedic sports surgery in a particular country, linking into all of the existing structures for training and healthcare governance of that country will produce a radically different end product to one that is produced for a single institution or medical school.

4.3.5 Understanding the Specialty

At the heart of very specialty there must be something that makes that specialty unique, otherwise it cannot be a specialty. This uniqueness must be captured at the start. If it is not then the curriculum writing team will fail keep it at the centre and drift into creating a curriculum that reflects only generalities. At worst the result might be that the orthopaedic sports surgery curriculum cannot be differentiated from the other clinical disciplines it might draw on such as orthopaedics or accident and emergency medicine. Every clinical specialty that already trains its own members is working to a “hidden curriculum”. Once assembled and having agreed on basic concepts, the writing team’s next task is to map that curriculum. The team needs to create a document that will become the specialty overview. It has two purposes; the first is to assemble all of the detailed information needed to underpin the new curriculum e.g., How many specialists do we have at the moment? Where are they based? How many of them are able to train others….? This is a detailed review of all aspects of the specialty at present and hopefully as much information as can be gathered on what the future needs will be. This information informs the curriculum. Any proposals contained within the new curriculum must either fit into the present situation or contain within them a plan for transition and change. The second purpose of this mapping exercise is the education and development of the writing team and their skills. In conducting the mapping exercise the team will be forced to engage with other specialties, stakeholder groups and organisations, government and statutory bodies. In so doing, they will extend their awareness of how their own specialty works. This will be vital in enabling them to write the new curriculum realistically.

In the case of orthopaedic sports surgery there are numerous interfaces with other specialties and specialist groups within and beyond orthopaedics. The mapping exercise should also be conducted for those groups. Future proofing the curriculum will only be possible with an awareness of what changes are likely to occur on the boundaries of the specialty.

4.4 Developing a Curriculum Template

Every journey needs a map, especially if more than one person and multiple possible destinations are involved. A template or series of headings for the curriculum must be drawn up and agreed at the start. The headings can be adapted as the project continues but a basic list is required at the beginning. These headings will, to some extent, determine the structure of the curriculum and may provoke substantial discussion about the way in which the actual curriculum (i.e., what really happens) is reflected and summarized in the curriculum document.

There are many ways of structuring such a template. An example of one possible design is shown in the mindmap below.

Figure 4.1 shows the template for a curriculum that might contain a number of specialty modules. Such a curriculum might cover all surgical specialties with a module for each specialty or perhaps a single specialty such as orthopaedic sports medicine but with modules relating to different aspects of the specialty.

For any single specialty module, a subset of the template shown in Fig. 4.1 could be used as the whole curriculum but some of the items from the larger version might need to be added.

A major advantage of taking a modular approach to the curriculum document is that it provides an obvious series of smaller, more achievable writing tasks. Such tasks might be delegated to individual writing group members to lead in their development.

4.5 Designing Key Curriculum Elements

Considerable work must be undertaken in the development of some aspects of the curriculum. The usual reason for writing a curriculum for the first time is some sort of dissatisfaction with the way things are currently being done. That dissatisfaction needs to be articulated and alternative pathways defined for the future if change is to be effected.

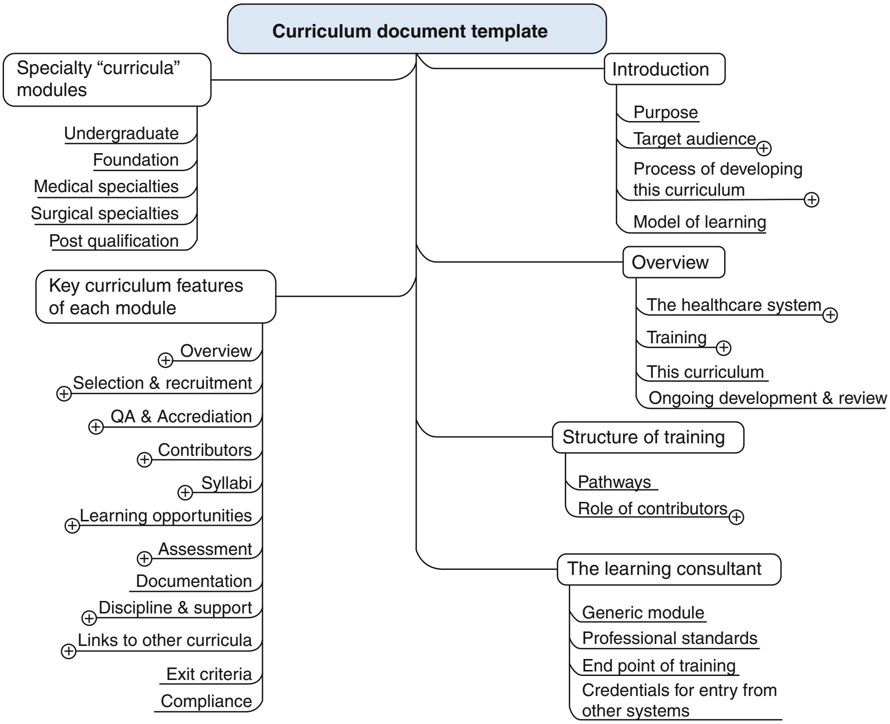

Fig. 4.1 Template for a multi-specialty curriculum

4.5.1 Selecting Syllabus Models

How will you describe what must be learned? The 1956 publication of the first handbook of "*Bloom's Taxonomy*" [1] is the tip of a vast iceberg of debate on the subject of how to define and classify educational objectives. Most curricula follow themes laid down in Bloom and colleagues' texts and create a series of syllabi that look in some way at knowledge, skills and attitudes or values. Even the simplest of these needs careful thought. The most obvious way to define knowledge might seem to be to list a series of topics. Even with this simple approach care must be taken in describing the depth or breadth to which any topic must be explored at any particular level of progress through the programme. A first year medical student might be expected to know what an anterior cruciate ligament is. However, they might at that stage have a limited understanding of its function, and it will be much later in their training that they have an understanding of how a defective ACL can be diagnosed and even later still before they have acquired the skill to make an effective repair. In deciding how to construct a syllabus it is necessary to refer back to the purpose of the curriculum and its boundaries. What stages of training does this curriculum cover, what is expected of trainees entering this stage and what evidence will be acceptable as proof that they have met those expectations? Similar problems exist with a skills syllabus and even more difficulties arise in trying to define attitudes or values.

Many syllabi at present are "competence focused". They seek to define the programme in terms of what the trainee must be able to *do* rather than just what they *know*. Other options exist, such as defining the syllabus in terms of the "Entrustable Professional Activities" concept developed by Ten Cate [10]. Training is necessarily a dynamic field, and by the time this chapter is published there will no doubt be others.

One of the most challenging aspects of any syllabus is the definition of attitudes and values. Such things are more often caught than taught and so can be difficult to define. They are also some of the most important items, having the most major impact on the future effectiveness of any clinician. The difficulty is sometimes overcome by the creation of a professional skills syllabus. The World Federation for Medical Education defines professionalism as follows:

> "Professionalism describes the knowledge, skills, attitudes and behaviours expected by patients and society from individuals during the practice of their profession and includes concepts such as skills of lifelong learning and maintenance of competence, information literacy, ethical behaviour, integrity, honesty, altruism, service to others, adherence to professional codes, justice and respect for others" [11].

If this is your first attempt at curriculum writing begin by developing a knowledge syllabus and build up from there. The understanding you gain from this exercise will help you in tackling the rest.

4.5.2 Identifying Assessments

There are two main types of assessments: summative (assessments *of* learning) and formative (assessments *for* learning), and a curriculum should contain both. Summative assessments are used for decisions on progress (e.g., a formal examination). Formative assessments are used to give feedback to the trainee on their performance and for trainers or tutors to understand how well the trainee is progressing in response to their efforts. Most people are familiar with formal examination type assessments but not the field of workplace assessment, where the trainee's performance is reviewed, is a real-time clinical task. Designing or selecting workplace assessments may seem simple at first but not all assessment tools are suitable for all situations. If used incorrectly they not only provide misleading results but also add substantial costs to the training programme in terms of the time they take to complete. There does not appear to be a reliable, comprehensive guide to workplace assessment tools at present but a thorough description of the procedure-based assessment tool that is used throughout surgical training in the UK can be found in "*Competence Evaluation in Orthopaedics – A 'Bottom-up' approach*" [8].

No element of the curriculum is completely independent of any other. In terms of the assessment strategy it is vital that any assessments chosen can be mapped clearly to the syllabus. In other words, you cannot assess whether a trainee has learned something if you have not first said that it must be learned by including it in the syllabus.

4.5.3 Specifying Stages and Transitions

Your curriculum must have a starting point. In order to enter your programme a trainee may need to have certain experience, qualifications or other attributes. These must be specified in the curriculum together with a description of any evidence that is acceptable as proof of experience or qualification. Such evidence might include qualification certificates, logbooks, references or even reflective records. Part of the success of your own education programme will depend on identifying the appropriate trainees to join it so it is important to identify these clearly. If you have thoroughly completed the specialty overview then you will be able to identify any agencies or institutions who might be providing candidates for your programme and consult them to establish that both your criteria for admission and evidence requirements are realistic and effective.

If your programme has several sections, then you will need to articulate what the evidence of successful completion of each part is and also the mechanism by which a trainee moves on to the next part of the programme.

4.5.4 Training Trainers

The quality of training will stand or fall on the quality the trainers. In most of surgery and medicine training has been an intuitive activity with the trainer often emulating the behaviour of those who trained them until quite recently. The clinical specialties that have a long history of actually providing any sort of formalized training programme for their trainers have been in the minority. Nevertheless, it is essential in the curriculum to specify what skills the trainer should have and what evidence should be provided that they possess them. Many curricula in recent days have specified that a trainer must have, as a minimum, attended a training trainers course or programme. In the UK, the General Medical Council will in the immediate future be accrediting all clinical trainers against a set of standards that they have produced and specialties have been invited to adapt these standards for their own community. The surgical version of these standards, produced by the Royal College of Surgeons of Edinburgh, has received much acclaim for its clarity in this respect and can be found online at the website of the Edinburgh College [7] or the General Medical Council.

The curriculum development process can be a long one and it is worthwhile considering some multi-tasking in this respect. A project to develop training the trainers programme has an immediate relevance to improving the quality of the training programme. It can also provide a means of educating the specialty community and identifying a valuable community of potential pilot testers for the new curriculum.

4.5.5 Accrediting Training Centres

Is the centre where the trainee is to be located fit for training? This is an important question. If the centre does not have appropriate training facilities or adequately skilled trainers then delivering the curriculum may be impossible. If the curriculum specifies certain levels or amounts of experience then the training centre (hospital, local clinical practice) must have this experience readily available. The curriculum must specify the standards and facilities of the local centre and specify what evidence is acceptable to prove that they have been reached.

4.6 Reality Testing

Much of the work of curriculum writing will be done in offices and meeting rooms by a group of individuals who have become extremely familiar with the material being written and developed. Three tests must be applied to the material as it develops on a regular basis.

4.6.1 Realistic

Will it actually work in practice? Do you have enough suitably experienced trainers to deliver the programme? Is there too much/ too little material to be covered in the time available? Are the hospitals or medical schools that supply your trainees willing and able to provide the standard of individuals you need?

4.6.2 Readable

Does the style of the document, its page layout and writing style help or hinder the reader? The use of lengthy tables or excel spreadsheets may be extremely helpful to some readers but unless you are training accountants they are in the minority. Most clinicians want the curriculum on a single page. Such a miracle is unlikely but that is the audience you are writing for.

4.6.3 Reviewable

Has your document been produced in such a way that it can be reviewed easily by any statutory authorities? Is it easy to find important materials? If yours is one of many specialty curricula does it fit comfortably alongside the others or even stand as an example for them?

4.7 Mapping and Blueprinting

4.7.1 Exams and Assessments

A curriculum needs to have internal consistency. The syllabus must be designed so that any assessment tool can be easily mapped to it. An examiner wishing to ask a question in a viva exam must be able to determine easily whether that question is fair. Is it based on something in the curriculum relevant to the trainee's stage of training?

How does your curriculum relate to other international curricula? It is unlikely and undesirable that you will wish to adopt another country's curriculum as your own but is there a way to support an international approach by mapping certain sections, in particular the syllabi or assessment strategy in order to facilitate a common examination resulting in a transferable qualification?

4.7.2 External Accreditation

Is there an institution or organisation that will wish to or need to accredit your curriculum? Any specialty wishing to publish a curriculum in the UK must first have it approved by the General Medical Council. Other countries such as the USA or Australia have similar accrediting structures. In most cases, they will have a core framework such as CANMEDS [2] or Good Medical Practice [3] against which your curriculum will need to be mapped

4.7.3 Other Curricula

Your curriculum will inevitably need to sit alongside those of other specialties. Sports medicine in general is a discipline which by its nature touches internal medicine, orthopaedics, physiotherapy, psychology and many others. Orthopaedic sports surgery similarly connects with the specialty or orthopaedics (and in particular its subspecialties), general medicine, physiotherapy and others. How does your curriculum relate to theirs? Are there identifiable exit points for example in the orthopaedic curriculum which might provide a convenient entry pint to the orthopaedic sports surgery curriculum? Are there areas of overlapping interest in which it might be valuable to take a common approach or a consistency of syllabus?

4.8 Common Problems and Obstacles

Writing a curriculum can be a difficult task even when everything goes well but as in most real world projects, success is dependent on how you overcome the obstacles you face along the way. Here are just a few:

4.8.1 Working with the Wrong People

Having the wrong people on the team is costly in every respect. The questions that follow might help in identifying such people at an early stage and (hopefully) helping them to identify themselves.

Insight
- Are your team members aware of their own shortcomings? Do they accept that there are subjects or skill areas in which they need help and are they willing to ask for or accept it when offered? Are they aware of their own strengths or do they see themselves as universally competent? Such competence is rare and best identified by others. Do they have an awareness of the strengths and weaknesses of others? Are they prepared to understand others or do they jump rapidly to dismissive conclusions?
- Values
- What is important to them? Do they see the value of collaborating? Are they prepared to pursue consensus for the sake of quality? Do they believe in sharing the credit for the team's achievements or are they waiting for the opportunity to take the credit for themselves? Do they understand the importance of not only achieving a goal but also getting the details right along the way? Do they value honesty to the extent that they will give honest feedback on the ideas of others and not merely express agreement to preserve their own popularity? Do they place improved patient care higher on their professional priorities than any gain for themselves or any institution they represent?
- Competence
- Can they write clearly and concisely in a way that others can read? Having authored scientific papers is not necessarily a guarantee of this. Are they able to understand the concepts of training and education and share them intelligibly with others? Are they able to work as a member of a team that they are not in charge of? Whatever their specialty, are they considered competent in it as both a teacher and practitioner?
- Experience
- Do they have experience of the training system? Are they able to reflect meaningfully on that experience? Do they have experience of working in an interspecialty context? Do they have sufficient experience of working in multidisciplinary teams to make an effective contribution to this one?

4.8.2 Borrowing

Once you discover that someone has already written a curriculum or syllabus for orthopaedic sports surgery or any related discipline you may be tempted (with or without their permission) to use it in your own. Whilst standing on the shoulders of giants is admirable, it can also be extremely foolish. Not doing the work to develop your own materials may mean that you do not understand those materials in sufficient depth and may be less able to develop other materials later on. Also are they really fit for your purpose? A specialty group once presented their curriculum for approval. They had clearly copied (with permission) most of the syllabi from several other nations and combined them into a massive whole. Any one of those nations would have 200–300 specialists who are experienced in teaching this material. The group in question had less than a dozen. There was no way that such a syllabus could ever be viable in that situation. Curricula should be designed to fit a specific situation. This makes them at best an interesting vocabulary to learn from, at worst useless or toxic in another. Be especially wary of any group offering to sell or rent their curriculum to you. You may spend large sums of money adapting it to your purpose only to find that because you do not own it you have to rent it in perpetuity.

4.8.3 Lack of Stamina

Writing a curriculum is a marathon, not a sprint. Whatever physical preparation can be done beforehand, there is still a massive difference in the mindset needed. If the chairperson of the new curriculum group proposes that the task can be achieved over four meetings with some email exchange in between find another committee to join as soon as possible. The easiest way to lose a marathon is to sprint at the start. Rushing into curriculum development, not doing the proper groundwork to develop an appropriate understanding of both the curriculum and your specialty will lay a faulty foundation that it will be difficult to build on effectively.

4.8.4 Inadequate Professional Support

The writing group will almost certainly need professional secretarial support. It will also need a facilitator of some sort to keep the project moving in the right direction, chase progress and provide advice on writing, structuring and many other curriculum issues. A busy clinician is unlikely to have the time or expertise for this, but facilitators with sufficient experience of clinicians and clinical issues, understanding of curriculum development and the ability to question the work of others persistently and positively are rare.

4.8.5 Writing by Committee

When someone presents a draft of their work to the committee what they need is feedback, constructive criticism and encouragement before they go away to produce a new version. Resist the temptation to write or rewrite during the committee. Committees are good for brainstorming, discussion and debating ideas and issues. They do not write intelligibly as a group activity.

4.8.6 Thinking Inside the Box

> "The past is another country, they do things differently there" [5].

Most of us are influenced by our own experience of training. We must not let that experience, good or bad, dictate how we write a curriculum. The only reason to write a curriculum is that you need one. If you need one now then why did you not need one before? The answer is that something has changed and we cannot do things exactly as they were done in the past. Learning from our experience is not the same as repeating it. The specialty overview is the place to articulate how things have been done up until now. The new curriculum will need creativity and innovative ideas if it is to have value. Thinking outside the box should be encouraged.

4.9 Implementation and Innovation

> "The innovator has for enemies those who did well under the old system and faint friends in those who may do well under the new" [6].

It is unusual for people to welcome change unless they perceive a very clear benefit. We view the past through rose-tinted spectacles and it always seems preferable to the hard work involved in doing things a new way. Part of the task of the curriculum team is to highlight these benefits. To do so the whole sports medicine community must be considered, not just as individuals but also within the context in which they live and work.

4.9.1 Structures

How will the structures in which individuals find themselves need to be changed as a result of the curriculum? Most doctors have structural responsibilities within a National Health Service of some sort, a hospital, a university, a private practice and a college or professional association. How will the curriculum benefit these structures? How can you show that the costs of change are outweighed by its benefits?

4.9.2 Systems

What are the systems that are already in place that affect your curriculum? How are trainees trained? What is the system for accreditation of that training? How is information circulated around your community? How will the new curriculum benefit those systems? Can any of those systems be used to your advantage in implementing the change?

4.9.3 Tasks

What new tasks does the curriculum generate for the clinical members of the sports medicine community and those who support them? Are there any existing tasks that will become obsolete? Where will the time come from to perform the new tasks?

4.9.4 People

Does the curriculum require the recruitment of new people into the community? If so how will they be trained, does the curriculum specify this? How will the individuals receive personal benefit from the curriculum? Will it increase their professional status? By completing it will they be more employable in some way? How will they be persuaded to participate in the new way of doing things?

4.9.5 Managing Transition

In any journey from A to B there is a significant period when we are neither at A or B but somewhere in between. This is transition, a point where people facing change might experience a wide range of conflicting emotions. They welcome the idea of change but now they are on the journey they are apprehensive, beginning to see the value of where they were and the costs of where they are going. The management of change and transition in particular has an extensive literature of its own. For the curriculum writers it is necessary to know that it must be managed and plans must be put into place to make the transition as brief and well-structured as possible.

4.10 Celebrating Your Success

4.10.1 Publishing

Even though you may not be writing a curriculum to promote yourself or your institution, it is helpful to have a publishing strategy. Naturally you will wish to publish the final curriculum document. The quality of that publication will affect how it is received. If at all possible your final document should be professionally laid out and at least some copies printed. As you move through the writing process, there will also be opportunities for publications in journals e.g., how you determined the unique features of sports medicine or the criteria by which you selected assessment tools. Such publications serve a triple purpose; they set down a marker to prove intellectual ownership of ideas or materials, they publicise your ongoing work to the sports medicine community and they force you to think thoroughly and rigorously about the aspect of your curriculum that you are publishing.

4.10.2 Parties

How you launch the new curriculum depends largely on your budget, but it must be launched. Provision should be made to inform the sports medicine community in appropriate ways that the long awaited curriculum is now complete. The curriculum team should be given the applause they deserve, not just for their own encouragement but to help recruit the next generation of curriculum writers who will take the work forward in the future.

Conclusion

The specialty of orthopaedic sports surgery is a new one, and the desire to simultaneously articulate its core, differenciate itself from other specialties and improve the quality of patient care through developing a curriculum is an admirable one. The achievement of these goals through the development of a curriculum is a task that will benefit the specialty as it increases the strength and depth of its educational skill set. It will similarly benefit the trainers and trainees who will use it to develop their skills. Most of all it will benefit those who engage in such an exercise, if they survive it they deserve to be the specialty's leaders of the future.

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Defining Essential Skills

5

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5.1 Introduction

Knee arthroscopy is the most common orthopedic procedure performed in the United States and consists of 30 % of all orthopedic procedures performed in Europe [1–3]. Arthroscopy has certain specific technical requirements with a notable initial learning curve where the inexperienced surgeon requires greater supervision during a period of higher risk of iatrogenic injury as minimal access surgery requires different skill sets to open surgery [4, 5]. A study of senior orthopedic residents in the United States revealed that 68 % felt that there was inadequate time dedicated to training in arthroscopy in their program and 66 % did not feel as prepared in

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arthroscopic techniques as they did in open techniques [6]. But what skills need to be trained then before a resident starts performing arthroscopy on a patient?

From an educational point of view, a key feature for a well-designed training program is that the learning objectives should be explicitly defined [7]. Applying this theory to training of arthroscopic skills, consensus is required which skills need to be trained and what competency level needs to be acquired in each training phase. Overall, surgeons specializing in arthroscopy should be (1) a good surgeon, (2) a good medical doctor, (3) a good team physician, and (4) a good researcher [8]. In this chapter, the first item "being a good surgeon" is addressed, for which we focus on the initial training phase for no experience at all to competent in basic arthroscopic surgical skills. First, the results of studies are given that have gathered information on the skills a trainee "ideally" should possess before arthroscopic training is continued in the operating room. Second, theory on human behavior is introduced as a means to translate these arthroscopic skills into measurable performance actions, and finally levels of competency are discussed in order to qualify as a "good surgeon."

5.2 What Skills Need to Be Trained?

Although many training programs exist for learning arthroscopy, few studies have focused on what skills could be trained in a simulated environment without placing the patient at risk of unnecessary errors. So far, members of the Canadian association of orthopedic surgeons have been questioned and recently the European Society of Sports traumatology, Knee surgery and Arthroscopy (ESSKA) has asked their members for their opinion on this topic both using online questionnaires [9–11]. The results are discussed. All together 363 surgeons and residents responded to questions regarding generic skills and specific skills, such as patient and tissue manipulation, knowledge of anatomy and pathology, entry of the joint and arthroscopic inspection of the anatomical structures (Tables 5.1, 5.2, and 5.3). The participants were asked to rank the importance of each arthroscopic task or skill on a five point scale ranging from least important [1] to most important [5].

In all three surveys, knowledge on anatomy of the knee joint is ranked as priority number one, with tactile sensation and manual dexterity less important skills to possess (Table 5.1). Analysis of more specific arthroscopic skills as presented in Table 5.2 and does indicate precise portal placement as one of the priority skills to possess which has tactile sensation as important cue as surgeons need to palpate the area where the portal is made. Table 5.2 also highlights triangulation and identification as important skills to possess, which can be very well trained in a simulated setting as is discussed in the chapters to come. Notice that the residents feel that they should also be trained in using the shaver. This can be explained by the fact that it requires additional complex instrument handling with activation of the shaver being combined with precise placement of the shaver tip, avoidance of damaging the arthroscope lense, and verification of correct tissue removal. This could be a typical example of experts being so used to this skill and perform it without thinking of all steps that need to be taken, that they have forgotten the initial complexity of this skill.

Table 5.1 Ranking of important general skills for a trainee to possess prior to performing in operating room

Rank	Surgeons [10] $n=101$	Mean score (1–5)	Residents [9] $n=67$	Mean score (1–5)	Surgeons-residents $n=195$ [11]	Mean score (1–5)
1	Anatomical knowledge	3.86[a]	Anatomical knowledge	4.4	Anatomical knowledge	4.63[b]
2	Triangulation/depth perception	3.34[a]	Spatial perception	4.3	Triangulation	4.43[b]
3	Spatial perception	2.77[a]	Triangulation/depth perception	4.2	Spatial perception	4.29[b]
4	Manual dexterity	2.86[a]	Manual dexterity	4.2	Tactile sensation	4.00[b]
5	Tactile sensation	2.05[a]	Tactile sensation	3.7	Manual dexterity	3.85[b]

[a]Significantly different ($p<0.001$) [10]
[b]Significantly different ($p<0.001$) [11]

Table 5.2 Ranking of important specific skills for a trainee to possess prior to performing in operating room

Rank	Surgeons [10] $n=101$	Mean score (1–5)	Residents [9] $n=67$	Mean score (1–5)	Surgeons-residents $n=195$ [11]	Mean score (1–5)
1	Precise portal placement	4.7[a]	Triangulating the tip of the probe with a 30° scope	4.6	Precise portal placement	4.56[b]
2	Triangulating the tip of the probe with a 30° scope	4.6[a]	Precise portal placement	4.5	Triangulating the tip of the probe with a 30° scope	4.41[b]
3	Identification of lateral and medial compartment	4.4[a]	Identification of lateral compartment	4.4	Insertion of the arthroscope	4.23[b]
4	Identification of notch, ACL, and PCL	4.3[a]	Identification of posterolateral compartment	4.4	Patient positioning	4.29[b]
5	Insertion of the arthroscope	4.2[a]	Shaving of synovium, cartilage, and meniscus	4.4	Entry of all compartments	4.24[b]

[a]Significantly different ($p<0.001$) [10]
[b]Significantly different ($p<0.001$) [11]

Also detailed results of the ESSKA survey are presented in Table 5.3, as they indicate the top five of equally important surgical skills with a preferred level of priority, which have a noticeable emphasis on knowledge, such as knowledge on sterility of pathology, and of equipment. Also these skills can be very well trained

Table 5.3 Results of the ESSKA survey

Specific skills	Priority level	Rank	Median	Mean
Sterility	Level 1[a]	1	5	4.6
Knowledge of pathology	Level 1[a]	2	5	4.37
Patient positioning	Level 1[a]	3	5	4.33
Preparation before the start of the operation	Level 1[a]	4	5	4.3
Knowledge of equipment	Level 1[a]	5	4	4.2

Level 1: high level priority
[a]Items with $p < 0.001$

in a simulated digital e-learning environment away from the patient with assessment of the trainees competency been taken place before continuation of training in the operating room (see Chap. 9).

5.3 Translating Skills in Measurable Learning Objectives

Some theories on human behavior can assist the translation of the general description of an arthroscopic skill (e.g., triangulation or shaving) into a learning objective or set of learning objectives that can be monitored and assessed objectively. Both the Rasmussen model of human behavior and the Fitts and Posner model of learning psychomotor skill are introduced [12, 13].

To start with the Rasmussen model, this model distinguishes three levels of behavior: skill-based, rule-based, and knowledge-based.

5.3.1 Skill-Based Behavior

Skill-based behavior represents behavior that takes place without conscious control. An example of such behavior in everyday life is cycling or tying your shoe laces. Analogous to this, basic psychomotor skills that are required to perform arthroscopy is triangulation or shaving. Since these actions take place without conscious control once mastered, it can be difficult for trainers to explain how to perform these actions as they “literally” do not need to think about that action. See for example the difference in priority ranking between experts and residents in Table 5.2, where shaving is ranked in the top five by the residents.

5.3.2 Rule-Based Behavior

Rule-based behavior is represented by task execution that is based on prescribed rules or procedures. An example of this behavior is stopping your car when the traffic light is red [12]. The red light is the sign that triggers the rule which is stopping the car. Applied to arthroscopy, an example of rule-based behavior is the recognition of the pathology. Once this task is executed, the next step is triggered, which in this case is the appropriate intervention.

5.3.3 Knowledge-Based Behavior

Knowledge-based behavior is the highest level of complexity of human behavior, which is seen in unfamiliar situations that require a complete analysis of the situation and for which prescribed rules do not apply. The overall goal is known, but several scenarios are mentally evaluated from which one is selected. Applied to arthroscopy, this type of behavior is triggered in case an uncommon complication is encountered or when standard equipment cannot be used to execute the intended intervention (e.g., the patient is a child).

Considering the Rasmussen model, skilled-based behavior targets actual instrument handling, which is best trained by actual performance of these actions in a standardized simulated environment [14, 15]. Some rule-based skills can be trained as well in simulated environments. This depends on the fidelity level and the extensiveness of exercises and pathology that are offered by the simulators (see Chaps. 6 and 7). Notice that quite some ruled based and knowledge-based behavior does not require actual instrument handling but rather correct decision-making. This could also be trained in an e-learning environment with patient cases that are illustrated by medical images and arthroscopic videos (see Chap. 9). Eventually, competency in knowledge-based behavior is what defines a “good surgeon,” and this requires the integration of cognitive skills with the actual instrument handling in real-life situations [8]. To assess this, a more holistic approach of assessment is needed for example by using Global rating Scales as is presented in Chap. 10.

5.3.4 Model of Learning Psychomotor Skills

To train the psychomotor skills that are specifically required for basic skills in arthroscopy, the model of learning psychomotor skills can be applied [13], which consists of three stages:

5.3.4.1 Cognitive Stage

In the cognitive stage, tasks are well-defined and appropriate consecutive actions are listed that are needed to accomplish the task goals. This stage usually interacts with the knowledge of the trainee. In other words, one must have enough theoretical information to complete the cognitive stage. Characteristic of this stage is that the trainee must think about the execution of each action before doing so, which results in slow and intermittent actions.

5.3.4.2 Associative Stage

Once the cognitive stage is accomplished, the trainee can focus on the details of the actions to achieve task completion. In this transient associative stage, the required actions are split into simple sensorimotor skills and smooth transition between these skills is exercised. This results in reducing the time consumed for thinking about the action, but actions are not fluent yet.

5.3.4.3 Autonomic Stage

The final stage is the autonomous stage, in which the trainee can perform the necessary sensorimotor skills fluently and completes predefined task goals in an optimal or efficient manner. Thus, the trainee does not need to spend time to think about the action and demonstrates a fluent skill.

A characteristic feature of this three stage model is that the initial stages have a rapid progression whereas the progress to the autonomic stage is slow. A concrete example in training basic arthroscopic skills is for example "visualizing the patellofemoral joint." This requires a number of specific actions to some extent in a consecutive order:

- Verify if arthroscope camera and light source are connected and functioning properly
- Insert the trocar in the correct portal
- Change and insert arthroscope
- Adjust proper orientation of the camera
- Adjust the view angle of the arthroscope
- Verify focus of the camera and lense
- Start irrigation
- Visualize the joint by repositioning the arthroscope if necessary

As these actions are very elementary and well-defined, they are apt to be monitored by objective measurable metrics. This is convenient as it offers the possibility to perform automated monitoring of skill progression by algorithms that are run on a computer.

5.3.4.4 Metrics for Objective Monitoring and Assessing

In general, the available metrics that can be measured are classified based on performance efficiency and performance safety [11]. Performance efficiency is defined as economic highly goal-oriented performance. Examples of these metrics are the numbers of repetition until a satisfactory level of completion is achieved [16], the number of task errors [17–19], task time [20–30], path length [22, 25–27, 30–32], and economy of motion [26, 33]. Task time and path length are being implemented quite extensively in arthroscopic simulated training settings, and also have consistently shown to actually indicate performance efficiency, as experts outperform novices. As with all new environments, there is always some training time required to get familiar with a simulator, as also experts show a learning curve when they first perform exercises on a simulator. This aspect needs to be taken into account when starting a training program.

Performance safety is defined as delicate tissue interaction and considerate instrument handling. Examples of these metrics are the number of unallowed instrument-tissue collisions [22–24, 27, 30], out of view time defined as the percentage of task time that the instrument tip is not visible in the arthroscopic view [34, 35], and motion speed and force magnitude. The force applied to surrounding tissue could lead to unintended damage of healthy tissue, which is especially true for tissues that have limited healing potential. Consequently, the force magnitude can qualify as a metric for monitoring performance safety. This suggests that calculation of the mean force exerted during a certain task might not sufficiently reflect safety performance. That is why the maximum peak force [32] as well as the standard deviation of forces [36, 37] and exceeding a certain threshold force [38, 39] have been suggested. For all three options, significant differences were found between novices and experts.

Continuing the example of "visualizing the patellofemoral joint," one could measure task completion, the number of errors, and task time as performance efficiency measures and measure the insertion force magnitude and direction of the trocar as performance safety measure.

5.4 What Competency Levels Are Required?

In literature, studies have been performed to document the number of operations a surgeon needs to have performed in order to become proficient by questioning faculty. Of course these are merely guidelines, as one resident shows a faster learning curve than others. O'Neill and coworkers [40] have presented quantitative numbers as a result of a questionnaire: on average 50 (standard deviation (SD) 46) repetitions for partial medial meniscectomy, 61 (SD 53) for ACL reconstruction, 48 (SD 44) for diagnostic shoulder scope, and 58 (SD 56) for subacromial decompression. Leonard and coworkers [41] stated that 41 diagnostic knee scopies (SD 18), 65 partial medial meniscectomy (SD 9), 88 partial lateral meniscectomy (SD 18), and 117 ACL reconstruction (SD 34) are required to achieve competency. A recent study by Koehler and coworkers indicated that more than 35 knee arthroscopies are required to demonstrate competency [42]. The number of cases to become competent in hip arthroscopy was determined to be 30, and for arthroscopic latarjet procedures was determined to be at least 15 cases [43, 44]. An interesting result was that the absolute minimum number of repetitions needed to achieve proficiency was indicated to be five to eight for any arthroscopic procedure [40].

5.5 Discussion

Patients are placing an additional demand of accountability on today's physicians, and a surgeon must be capable of performing specific procedures in a safe and efficient manner such that the patient will not experience adverse consequence. A young surgeon should acquire specific skills before continuing training in the operating theater.

First, data are available on type of skills and priority level of arthroscopic skills that should be trained before starting training in the operating room. Noticeable is that quite a percentage of these skills are cognitive skills. For example, knowledge on anatomy of the knee joint was ranked as the top one skill [9, 10]. These skills can very well be trained outside the operating room and easily implemented in training programs (Chap. 9).

The second aspect is that theories suggest to start training of the complex arthroscopic skills by adapting the strategies of other fields that require psychomotor skills training such as sports and playing a music instrument. The general approach in those fields has been to divide a complex task into basic path tasks. For example, when training basketball players, basic skills such as dribbling and passing are taught before full-court playing. In archery, one must exercise inspiration techniques and hand-eye coordination before shooting. In this chapter, some explicit examples were given for arthroscopic skills.

Third, a plea would be for arthroscopy faculty to team up and execute this strategy for the top ranked arthroscopic skills that are actually needed before continuation of training in the operating room. The first crucial step would be the unambiguous definition of the basic skills that is needed for the arthroscopic tasks. Implementing this strategy in residency training programs would contribute the safety of the first five to eight patients that are at sustaining unnecessary operative errors or damage due to the inexperience of the trainee. It would also contribute highly in efficient training of these skills, as simulator developers can truly focus on implementing these exercises in their simulators. Further research is required to determine the training time and number of repetitions that is actually needed to achieve the required level of competency in basic skills. Unalan and coworkers as well as Verdaasdonk and coworkers used ten repetitions on basic motor skill training instruments to achieve the plateau in the learning curve [30, 45].

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Arthroscopic Skills Training Modalities

6

Joe Tauro and Robert Pedowitz

6.1 Introduction: How We Learn Motor Skills

Arthroscopy is a challenging psychomotor task because it requires integration of multiple tools, using both hands (and often a foot) while visualizing on a two-dimensional video display, with constant vigilance to patient anatomy and general welfare. At the early stages of surgical training, management of these many simultaneous variables exceeds the capacity of the learner, and it increases the risk of iatrogenic injury. This situation is obviously frustrating for learner and the teacher, and it creates unnecessary risk in the operating room. It also introduces a substantial risk of formation of poor fundamental surgical habits.

Once firmly engrained, bad psychomotor habits are remarkably difficult to correct. This is analogous to the process of learning a golf swing from the ground up. Taught properly, the learner first understands and practices address, stance, and grip. This should happen *before* the student takes a rip at the golf ball. Sports are never taught by asking the learner to watch and then emulate an elite athlete in full action. Nor should we take a similar approach in arthroscopic training. Unfortunately, "see one – do one" is still the mantra of apprenticeship learning in the surgical fields [1].

There are factors that we cannot control such as prior experience, motivation, and the ability of the student. Luckily, there is much that can be done to help motivated surgeons perfect their arthroscopic skills. It is said that "Practice makes perfect" and that is true. Repetition is critical in learning a skill. However, the famous football coach Vince

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Lombardi put it better, "Practice does not make perfect. Only perfect practice makes perfect." "Perfect practice" should be our goal, not just observation and repetition [2].

A successful learning experience is facilitated by structured skills training from the ground up. This can be achieved by detailed task deconstruction, followed by fundamental skills training and rehearsal, leading to integrated tasks and finally surgical procedures. Learning can proceed at the pace of the learner, since some will naturally acquire skills quickly and others may struggle with a particular element. An often underestimated challenge in arthroscopic surgery specifically is the need to perform surgery with both hands. Arthroscopy is different than most other endoscopic specialties, because ambidextrous use of arthroscope and scope is an absolute requirement (unless the learner plans on operating on just one side of the body!). In most other endoscopic domains, the surgeon can rely upon his/her dominant hand for the most challenging elements. Not so in arthroscopy. Ambidextrous surgical skills are something that must be practiced and perfected, and some beginning surgeons have a particularly difficult time with this fundamental requirement.

Surgeons tend to overestimate their own skill levels and so an objective evaluation is helpful to determine their starting point. Prior experience and training can be a rough guide, as can written questionaires. Haptic computer simulators are becoming more important for more objectively evaluating basic skill levels (and for teaching them). But as we will see, basic skill learning does not require expensive equipment and can be accomplished using simple training devices.

Realism becomes more important when teaching more advanced skills. There are advanced models that can be very effective teaching aids for intermediate levels of learning. Availability, ease of use, and cost are important factors in this process. Dry labs with advanced models can reduce the need for wet labs with animal joints or human cadavers. Most importantly, practice on a model can significantly improve the quality, effectiveness, and efficiency of the time spent in the more realistic (but expensive, messy, and infrequent) wet lab.

"Pre-teaching" before any lab, basic or advanced, is another important adjunct to maximize the learning experience. In courses sponsored by AANA, the Arthroscopy Association of North America, we have developed online teaching "Modules" for participants to review prior to their attendance. These modules also set up a goals checklist that helps the student and instructor monitor and assess progress. It is important that pre-teaching "Modules" be specific to the model used and the procedure.

A well thought out curriculum for an arthroscopic skills lab is also critical for success. The curriculum provides the structure and content and also should define metrics and performance expectations for progression and completion of a module/course. One of the major pitfalls of prior simulation efforts has been emphasis upon the teaching "gizmo," with inadequate preliminary attention to the curriculum. If nothing else, solid definition of teaching objectives is a critical step, and when it comes to basic motor skills, this is best accomplished by careful task deconstruction (which is harder than it seems).

Finally, skills assessment after the lab experience is important. Objective assessment is actually quite challenging but is receiving more attention and will become more important in the future.

6.2 Basic Trainers

Basic skills trainers are best developed *after* task deconstruction and curriculum development. These steps lead to teaching objectives and concepts of performance metrics, which should be used to monitor proper skills acquisition. The Fundamentals of Arthroscopic Surgery Training (FAST) Program was created with this developmental pathway. The FAST Program is a collaborative project of the Arthroscopy Association of North America, the American Academy of Orthopaedic Surgeons, and the American Board of Orthopaedic Surgery. The objective was to create a set of education modules that could be used for training of basic arthroscopy skills, starting at the most basic skills levels. These modules, with accompanying video demonstrations, are available open-access on the AANA and ABOS websites (AANA.ORG and ABOS.ORG).

The FAST Program workstation and FAST Program knot tester were developed in collaboration with the Sawbones company (Vashon, WA). The workstation is modular and relatively inexpensive, with a base station that accommodates multiple snap-in elements for teaching of various motor skills. Basic arthroscopy skills are first rehearsed open, then under direct vision using a lucent shell that has multiple access portals that mimic knee and shoulder triangulation, and finally under video display using an opaque dome with portals (Fig. 6.1). The geometries mimic clinical arthroscopic ergonomics (for example, scope to target distance and separation of portals). This setup allows for sequential skills mastery, in a logical order, without time pressure and without any patient morbidity.

The FAST Program committee first deconstructed arthroscopy into its most basic elements (Table 6.1), which were then incorporated into the teaching curriculum.

Fig. 6.1 FAST program workstation

Table 6.1 Task deconstruction basic arthroscopy skills

Equipment tutorial
Basic image skills
Triangulation
Track and probe
Moving target
Switch hands
Shaver control
Scope tools
Manage multiple simultaneous variables

Table 6.2 Deconstruction of basic arthroscopy imaging

Center the image
Steady the camera
Control the horizon
Telescope (z-plane)
Track the target (x/y planes)
Periscope (with 30° offset)

For example, beginning arthroscopists must first learn about the instrumentation itself, including scope optics and fundamental concepts of periscoping and telescoping. It is important to provide a cognitive foundation that can be built upon. Then the learners go through a sequence of exercises to teach image centering, stability, and horizon control, before moving on to telescoping, periscoping, and target tracking (Table 6.2). All of this happens with just one hand (the one holding the scope). Once image control starts to become more natural, then probing, grasping, and biting elements are introduced. Each skill should be practiced with both hands. This logical progression is intended to encourage good skills that can be built upon, while motor elements become automated (which leaves more cognitive "room" for integration and complexity). Most important, the FAST Program is designed to catch and correct poor motor habits early. This approach should enhance educational efficiency and overall quality.

Once the learner achieves sufficient proficiency with basic triangulation skills, the FAST Program provides modules for suture anchor insertion into synthetic bone, suture passage and retrieval through synthetic soft tissue, and knot tying. These intermediate skills can be rolled up into the stereotypical steps of labral repair and rotator cuff repair, all performed on an abstract physical model (in other words, prior to practice on a dry model of a joint or a cadaver specimen). This is a much less expensive way to learn and rehearse the basic steps of the procedure, which are best mastered *before* rehearsal on complex and expensive joint simulators.

One of the most challenging aspects of skills training is the development of valid and reliable performance metrics that can be used by trainees and educators. At the time of writing of this chapter, this important step is still underway. At times, the best way to evaluation performance is with a check list and subjective assessment, for example with a visual analog scale (i.e., an OSATS). Another approach is to use a checklist to monitor for technical errors and critical errors. In the case of arthroscopic knot tying, we were able to incorporate direct and objective performance assessment with the FAST Program knot tester (Fig. 6.2). This device is used to apply fifteen pounds of tensile load for 10 s to a loop of #2 high strength suture created by arthroscopic knot tying using the FAST workstation (Fig. 6.1). Expansion of the loop is measured, with loop expansion ≥3 mm considered to be a knot "failure" (since high strength suture is relatively stiff, and ultimate load is much higher than 15 lb, loop expansion reflects the weakest link, which is the knot). This approach was then used to collect data for a cohort of arthroscopy experts (faculty arthroscopy educators at the AANA Orthopaedic Learning Center), which was then used to formulate an appropriate benchmark for learners (defined as no more than two knots "failed" out of five sequential knots tied and tested) [3].

Fig. 6.2 FAST program knot tester

Fig. 6.3 Alex shoulder model

6.3 Basic Dry Anatomic Models

Basic dry anatomic models allow practice in a more realistic setting and so are useful for the next step in arthroscopic learning after mastering core skills with nonanatomic trainers. These models have replaceable parts so they are partly reusable. This makes them relatively inexpensive to use and ideal for repetitive practice. Both labral repair and rotator cuff repair can be practiced, encompassing the basic skills of cannula insertion and use, anchor insertion, suture passage, and knot tying specifically for these procedures. The best known of these trainers is the "Alex" shoulder model. It can be placed in either the lateral or beach chair position and can be used with either a clear plastic or opaque cover. The first step in practice uses the clear cover and the student can practice with or without the need of an arthroscope (Fig. 6.3). With an opaque cover, an arthroscope is necessary. Now the student can develop arthroscopic skills in coordination with instruments and implants. Standard operating room arthroscopy systems can be used but much less expensive alternatives are available. Some of these systems use a simple video camera, which connects to a desktop or laptop computer via a USB port. Less expensive light sources are also available for use with these cameras.

There are limitations with these models anatomically, which is what makes them inexpensive, but their ease of use and availability are an advantage for training basic skills.

6.4 Advanced Dry Anatomic Models

For advanced training, more realistic anatomic training models have been developed. The hip, knee, and shoulder are the most commonly employed. These advanced SAAM models (Soft Anatomic Arthroscopic Models) have advantages over basic models, animals, and cadavers. They provide much better replication of arthroscopic techniques compared to basic models (although they are significantly more expensive). Compared to cadavers, they can be used in a more relaxed, dry environment, are less expensive, and avoid cultural restrictions. They can also enhance the consistency of the learning experience (in other words, avoiding terrible arthritic joints in the cadaver lab is a good thing). They can also be fine tuned for a multitude of surgical procedures, assuming the educators define what they want. Furthermore, these models can incorporate a wide range of materials with various properties (hard bone, soft bone, tough soft tissue, etc.). Newer materials are also available that closely mimic biologic material, and some are even hydrated. In the future, our "models" are likely to become more and more lifelike, at a fraction of the cost and logistical problems associated with cadavers.

For the knee, partial menisectomy, meniscal repair and cruciate ligament repair are all possible. For the shoulder, labral repair and rotator cuff repair are well simulated. Excellent hip SAAM models are also available and can be used to teach basic portals and labral surgery.

A significant limitation of both basic and SAAM models is that motorized shavers and burrs cannot be used, since they will seize in a dry environment. Therefore, procedures that relay fundamentally on burrs to remove bone (such as subacromial decompression, Mumford procedure, and contouring of the femoral neck) are not practical.

6.5 Animal Models

Animal models can be used to train surgeons and are less expensive and more readily available than human specimens [4–8]. Bovine and porcine knees are the most frequently used animal specimens due to their gross and arthroscopic similarity to the human knee. Bovine knee was proposed early in the early 1980s by Patel and Guhl [4] and later refined by Unalan and coworkers [8].

In the wet lab setting, trainees are able to perform basic arthroscopic procedures such as diagnostic arthroscopy, synovectomy, loose body extraction, meniscectomy, and microfracture (Fig. 6.4). Due to the anatomic discrepancies, bovine knees need to be prepared prior to utilization. The bovine knees have extensions of 20–25 cm to the proximal and distal parts; are stripped of all soft tissue, especially the Hoffa pad; and are covered with stretch film to allow fluid irrigation during training (Fig. 6.5).

Porcine joints need to be primed prior to exposure to the trainees. Bony parts should be left out proximal and distal to the joint required to permit proper positioning in holders and the soft tissue around the joint needs to be removed for easy

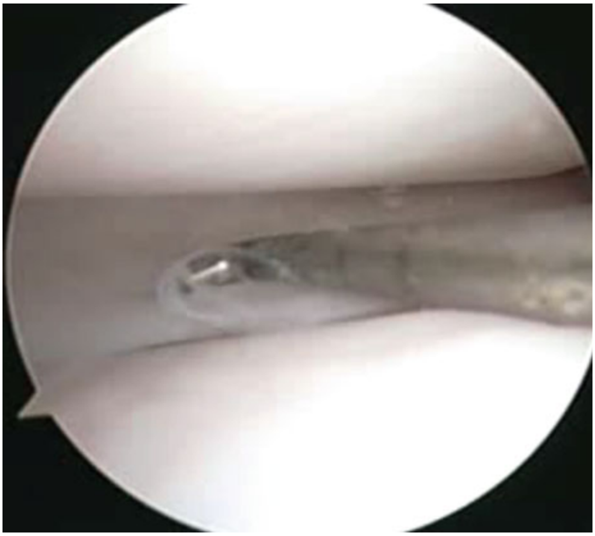

Fig. 6.4 Arthroscopic probing of the bovine meniscus

Fig. 6.5 Plastic coating of the prepared bovine knee

access into the joint [7, 8]. Regular arthroscopy equipment can be used to work in this setup which naturally requires additional sterilization procedures if used in humans. Voto and coworkers [7] have used canine knees and horse ankles for arthroscopy training.

6.6 Human Cadaveric Model

In the United States, human cadaveric practice has been utilized extensively and has been considered the "Gold Standard" for teaching and learning arthroscopic skills. Cadavers do provide the most realistic experience. They include skin, muscles, nerves, and blood vessels. They are one of the only models that work in a fluid environment (although some wet synthetic systems have been developed, they have not

Fig. 6.6 Learning center of AANA

been commonly used). Therefore, cadavers allow the student to practice procedures not possible on dry and less anatomically correct models such as meniscal shaving, synovectomy, subacromial decompression, Mumford procedure, suprascapular nerve decompression, Latarjet, and femoral neck contouring.

There are also significant disadvantages of the human cadaveric model. Specimens are expensive and although fluid makes the surgery more realistic, it also makes it messy, requiring more sophisticated learning center environments. There is much variability in cadaveric specimens, and sometimes specimens are unusable because of pre-existing pathology or degenerative changes. Although blood vessels are present, they of course will not bleed when cut. Disease transmission and proper disposal are additional issues. There are also cultural limitations on their use in many parts of the world, and their actual teaching effectiveness has never been measured until now [9].

At this time, human cadaveric specimens are best used as a final step in the learning process to hone the skills learned on the basic trainers and dry models and to allow performance of those procedures not really practical on a dry model. As with every other model, didactic "pre-teaching" is very important to maximize the effectiveness of training on the cadaver.

The newly constructed Arthroscopy Association of North America (AANA) learning center is an example of the latest generation of cadaveric practice laboratories (Fig. 6.6). Individual stations for each specimen include a full array of the necessary electronics and instruments. Prior to a basic motor skills course, online participant self-assessment and input into the course curriculum is important. This allows lab partners to be paired appropriately and instructors to be aware of the more specific needs and goals of the participant. A suggested simple set of questions is in Table 6.3.

For the knee, the human cadaveric specimen provides a realistic experience for meniscectomy, meniscal repair, chondral procedures, and ligament reconstruction. For the shoulder, both labral repair and rotator cuff repair (RCR) are well taught on

Table 6.3 Suggested simple set of questions for online participant self-assessment

1. Rate your skill level 1–4 (beginner, intermediate, advanced, expert)
(a) Basic skills: triangulation, portals, knot tying (if applicable)
(b) Procedure specific skills. For example: ACL reconstruction, rotator cuff repair, hip labral repair
2. For shoulder, do you prefer beach chair or lateral positioning?
3. What do you as the participant want to learn specifically? 1–4 (Very important, important, mildly important, not important)
(a) Provide list of proposed skills appropriate to the course for rating

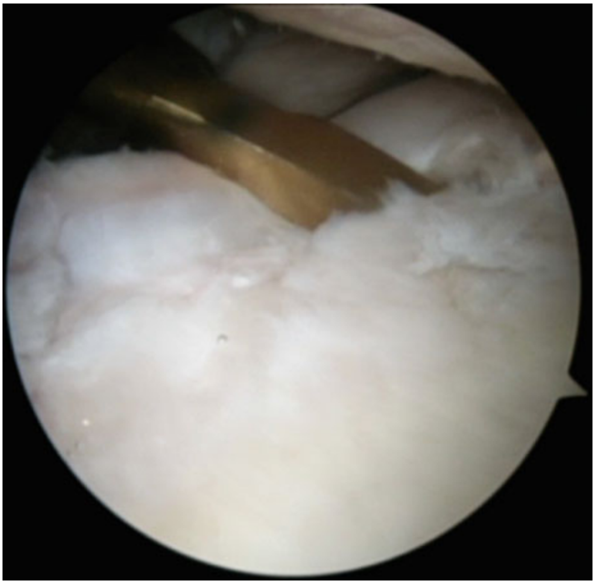

Fig. 6.7 Periosteal elevation of the glenoid labrum

the human cadaver. For both RCR and labral repair, making the pathologic lesion is as critical to success as repairing it. A common mistake is to resect, rather than elevate, labral tissue to reproduce a Bankart lesion. A sharp elevator, held tightly to the rim of the glenoid, is recommended (Fig. 6.7). The standard steps for portal placement, anchor insertion, suture passage, and knot tying can then be performed (Fig. 6.8).

To establish a rotator cuff tear, needle localization from lateral, parallel to the tuberosity surface (Fig. 6.9), followed by elevating the tendon off the tuberosity with a #11 blade will produce the best tear. Both crescent, L shaped, and longitudinal tears can be made using this technique. The standard steps for repairing both crescent and longitudinal tears can then be performed (Fig. 6.10).

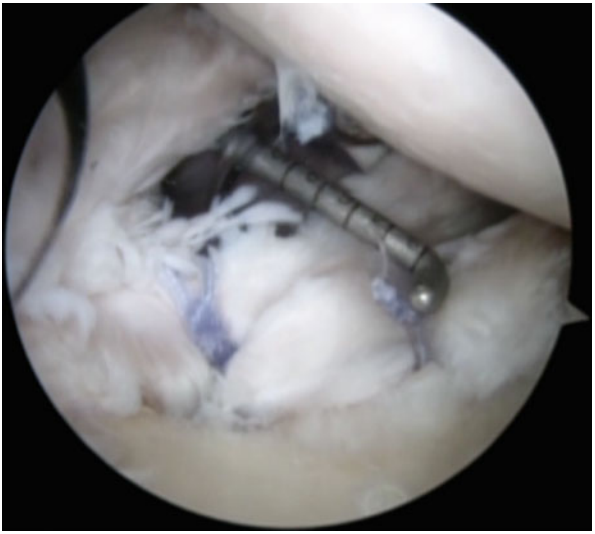

Fig. 6.8 After completion of the standard steps for portal placement, anchor insertion, suture passage, and knot tying can then be performed

Fig. 6.9 First the needle and then the knife are inserted for creating the cuff tear in a cadaver

The cadaveric model is very useful for teaching arthroscopic hip surgery. It facilitates the use of the c-arm for portal placement. Femoral neck contouring, which cannot be performed on dry models, can be practiced. Labral debridement and repair as well as extra articular procedures such as bursal debridement and ITB release can also be practiced.

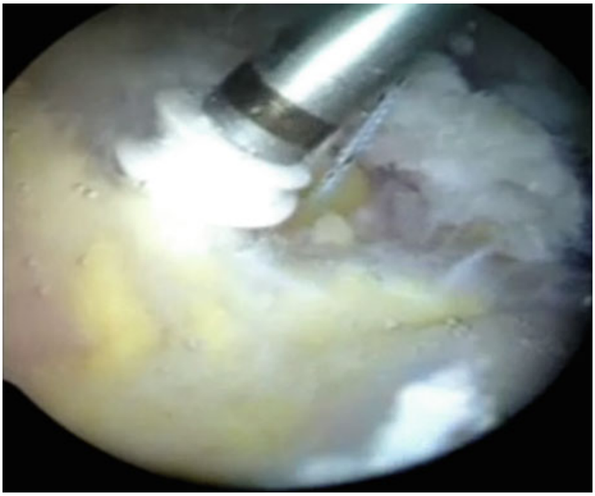

Fig. 6.10 The standard steps for repairing both crescent and longitudinal tears can then be performed

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7 Simulators in Surgical Skills Training

Gabriëlle J.M. Tuijthof and Tim Horeman

7.1 Introduction

Experts indicate that it takes considerable time to achieve proficiency in arthroscopic skills [1]. Studies show that these arthroscopic skills are optimally trained when performing actual instrument handling [2, 3], that is why traditionally residents are trained in the operating room. A major drawback is that patients are placed at risk to sustain unnecessary tissue damage or other complications, when orthopedic residents are in the beginning of their learning curve [4–11]. This requires a simulation environment that mimics the operative setting. The historical roots of simulation might be described with the broadest definition of medical simulation: "an imitation of some real thing, state of affairs, or process" for the practice of skills, problem solving, and judgment [12]. From the first "blue box" flight simulator to the military's impetus in the transfer of modeling and simulation technology to medicine, worldwide acceptance of simulation training is growing [12]. As the skills to be trained in arthroscopy require specific eye-hand coordination and instrument tissue handling, traditional primitive forms of anatomic bench models have not been implemented widely in curricula. That is why since the 1990s, initiatives have been taken by various groups around the world to develop training means for arthroscopic skills that do not place patients at risk [8, 11, 13–17]. Other reasons to use a simulated environment instead of traditional training in the operating room are improved

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educational experience and cost efficiency [2]. Crucial conditions for such training means include mimicking a real-life operation setting that provides (1) natural sensory feedback (e.g., vision and force feedback), (2) sufficient clinical variation, and (3) feedback on performance [2, 18–20].

This has led to basically two main design approaches to fulfill these criteria for simulated arthroscopic training: physical simulators with sensors and virtual reality simulators. Virtual reality simulators have developed as a result of the fact that during arthroscopy the surgeon already needs to look at a 2D computer screen to see the intra-articular joint. Furthermore, the rapid development in computer-processing power and quality of computer graphics, which is demanded by the computer game industry, has facilitated the realism of virtual reality simulators. For medical virtual reality simulators these have been crucial developments, since insufficient visual detail can lead to misidentification of anatomy and the increased likelihood of adverse events [21]. For each of the two design approaches, trainees can, once being introduced to the simulator, train in their own pace without the necessity of a supervisor being around continuously, as automated feedback is giving on training performance [7]. Each design approach will be introduced with concrete examples of simulators and discussed for available evidence on their suitability to use as training means.

7.2 Physical Simulators with Sensors

We can distinguish two types of physical simulators with sensors. The first category includes commercially available anatomic bench models representing a human joint (e.g.,www.sawbones.com, www.adamrouilly.co.uk, www.surgimodels.com, www.coburger-lehrmittelanstalt.de) which are combined with separate commercially available sensors (e.g., stopwatch, motion tracking system (www.ndigital.com or www.ascension-tech.com), force sensor (www.medishielddelft.com)). So, the sensors are not physically integrated with the anatomic bench models, and these composed simulators can be considered as "do it yourself" packages. In literature, several studies have been performed using such composed simulators, where the focus was not necessarily on the validation of the composed simulator itself, but results do show relevant results that indicate their usefulness as training means.

Instrument or hand motion have been measured with electromagnetic motion tracking systems, where electromagnetic markers were attached to the instruments or the dorsum of the hands during task training on the Alex Shoulder Professor anatomic bench model and on a knee joint bench model [5, 22–24]. All four studies showed a significant difference in performance between experts and novices and it was concluded that the motion analysis system could subsequently be used to track performance progression when practicing arthroscopic skills on bench top models. Furthermore, the studies by Howells and coworkers are one of the few that actually demonstrate transfer validity for training with arthroscopic simulators [5, 22].

Peak forces, average force, and "overall force over time" have been measured with a six degree of freedom sensor that was attached in between the fixation table and the knee joint bench model [24]. The results indicate that the three force metrics

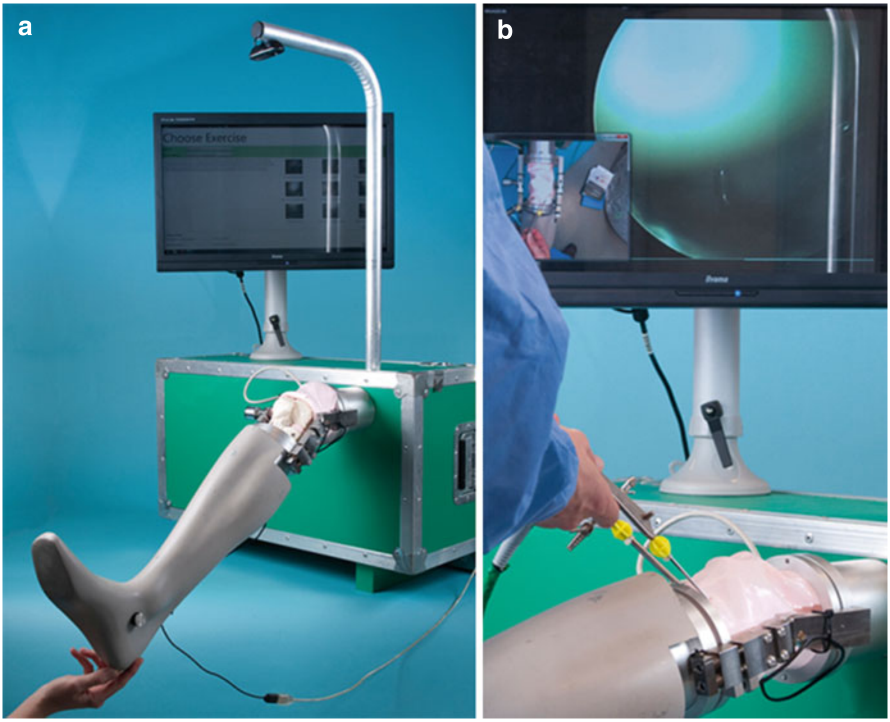

Fig. 7.1 (**a**) PASSPORT arthroscopic simulator showing the leg, a webcam that tracks instrument motions, and a user interface that provides selection of the exercises and offers real-time force and time feedback during training (© AJ Loeve 2012. Reprinted with permission). (**b**) Close-up showing the skin covering the joint, the instruments inserted in the joint, and the arthroscopic view (© AJ Loeve 2012. Reprinted with permission)

were also able to discriminate between experts and novices. Another affordable 3D force sensor has been designed by Horeman and coworkers [25] specifically for training of endoscopic skills. Its added value is that this sensor not only measures the forces but offers direct visual feedback when manipulation forces are exceeded.

The second category are physical simulators in which a sensory system is built in. So far, only two examples were found in literature. The PASSPORT is a co-development project between the Academic Medical Centre in Amsterdam and Delft University of Technology [10, 26] and will be commercially available in 2015 (Fig. 7.1). It can be used with any arthroscopic instrument set. The PASSPORT consists of an anatomic bench model containing patella, tibia, femur bones, the ACL, the PCL, and replaceable menisci that can be cut and sutured. The outer appearance is a dummy leg of a mannequin and the skin surrounding the joint is made from reinforced silicone and is connected watertight to the main frame. A special hinge allows natural joint stressing and flexion-extension motion of the knee joint. Various sensors are integrated in the anatomic bench model: a special version of the previously introduced 3D force sensor [25], which is positioned in the femur and tibia bone, a potentiometer that measures the angle of the lower leg relative to the upper leg, a light sensor that can detect bleedings, and task time and instrument motions are detected by a webcam and colored markers that are attached to the instruments. All sensors are connected to a computer that has a custom designed software program, which processes all data, gives real-time feedback, and offers digital instructions and videos. PASSPORT v2 demonstrates face and construct validity [26].

Escoto and coworkers also developed a high-fidelity knee joint bench model with performance tracking named Knee Arthroscopy Simulator [27]. The Knee Arthroscopy Simulator is composed of modular and replaceable plastic elements using quick release clamps that uncover the intra-articular joint space. The clamps also secure the skin watertight to allow joint irrigation. The lower leg is moveable and covered by a custom-made foam that holds hard plastic bones. Instrument motion is recorded by electromagnetic motion tracking system, and modified arthroscopic instruments that contain strain gauged allow the measurement of instrument tissue interactions. The Knee Arthroscopy Simulator shows the presence of a learning curve for trainees and was evaluated for face validity [27].

7.3 Virtual Reality Simulators

From the mid-1990s, computer scientists and (orthopedic) surgeons in various institutes teamed up to develop the first arthroscopic virtual reality simulators [11, 14, 16, 17, 28]. Virtual reality simulators comprise a computer and screen which present the virtual world including the intra-articular joint space, pathology, and instruments such as cameras, probes, punches, and shavers. For the computer scientists, the advantage of working in this medical area was the fact that bone is a solid tissue, which can be considered as an undeformable object in contrary to, for example, the soft tissues located in the abdominal area. Contrary, this also poses a huge engineering challenge as surgeons are used to haptic feedback during actual arthroscopy and demand this sensation as well in their arthroscopy simulators. In the early stages, the American Academy of Orthopaedic Surgeons (AAOS) evaluated virtual reality technology as a means of learning and maintaining surgical skills and felt that it was too early to commit the substantial resources required [8, 15]. But research groups continued development focusing primarily on the knee joint [4, 29–31] by application of volume rendering techniques [17], object deformation modeling techniques for collision detection [11, 20, 28], and computer graphics techniques to guide a trainer through exercises [29, 32, 33]. Also, Lu and coworkers have worked on algorithms that mimic tissue cutting [34].

The challenge of incorporating haptic feedback into the virtual environment has led to two different development strategies for virtual reality simulators. The first was started by Megali and coworkers who focused on the advantages of having a computer with specific software [29, 32]. The computer program offers unsupervised guidance for a trainee through different steps of a curriculum, which can be built of imaged-based instructions, videos, digital questionnaires, and basic navigation in a virtual environment. Assessment of performance is feasible using metrics

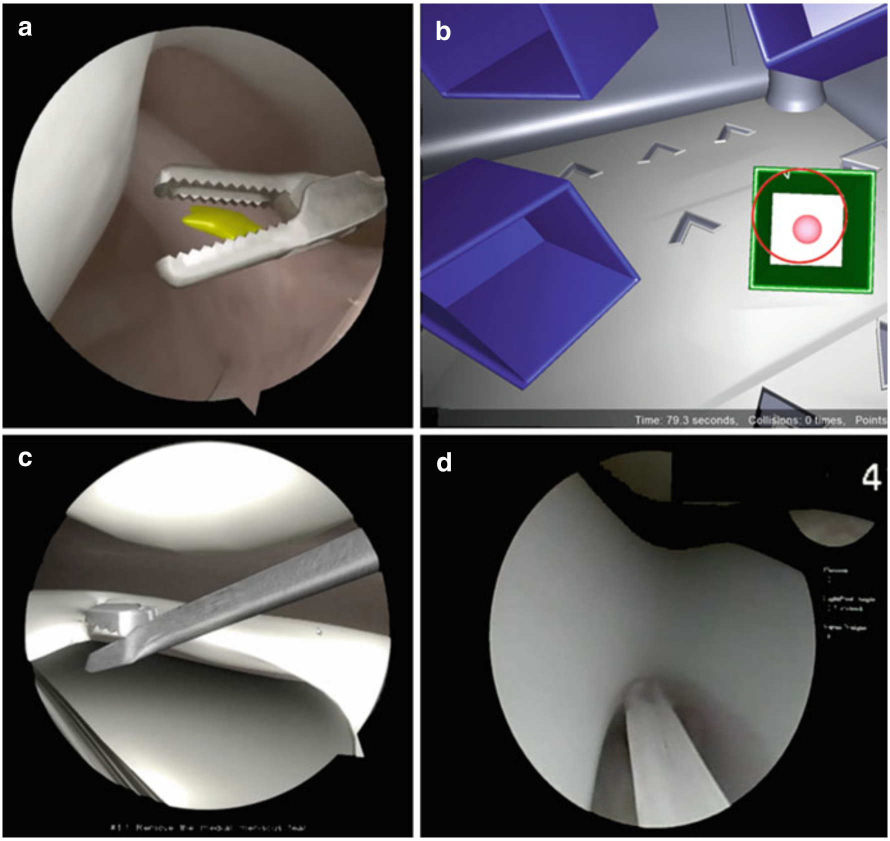

Fig. 7.2 (**a**) Screenshot of Virtamed ArthroS knee joint showing the ACL ligament and a grasper. (**b**) Screenshot from the virtual world of the *Boxes* exercises of the SIMENDO Arthroscopy™. The ball in a box needs to be touched with the camera tip (© Simendo 2014. Reprinted with permission from www.simendo.eu). (**c**) Screenshot of ARTHRO Mentor™ showing the lateral compartment and a punch. (**d**) Screenshot of ArthroSim™ showing the notch and the ACL of the virtual knee

that need to be defined anyway to build the interactive virtual environment, e.g., task time and path length. Within this strategy, specific basic skills that require high levels of haptic feedback (e.g., cutting) are less present or completely absent.

This strategy has been implemented in the SIMENDO Arthroscopy™ (Simendo, Rotterdam, The Netherlands, www.simendo.eu), a simulator that solely focuses on training of eye-hand coordination. The focus on eye-coordination training is prominently expressed in their exercises "4 Boxes" and "6 Boxes," which take place in an entirely virtual world that does not represent a human joint and focuses solely on correct camera orientation (Fig. 7.2a). Target users are residents that have no arthroscopic experience. The simulator can also be connected to the Internet, where training progress is document and can be viewed by supervising surgeons.

Another initiative that has embraced this strategy is the joint project between the Royal College of Surgeons of England and Primal Pictures, which focuses on a "cognitive" online trainer for arthroscopy leaving out the "haptic" part. The concept of the "cognitive" trainer called VATMAS was built on earlier work on the VE-KATS simulator [20]. Initial results show that it is possible to reproduce arthroscopic optics and a probe that can be independently manipulated, with indication of contact with hard and soft surfaces. As laid out, such a simulated environment can take the trainee through a series of tutorials using real arthroscopic images or videos, while providing automated feedback. Hurmusiadis and coworkers in their study showed that this type of simulator is a simple and cheap interface to address the cognitive ("non-haptic") components of arthroscopic knee surgery [35].

The second development strategy has been initiated by McCarthy and coworkers [6, 13], since they acknowledged that apart from realistic graphics, a key feature is the feeling of touch. It is for example important to know if the anatomic structure at the end of the probe is soft or hard. Their Sheffield Knee Arthroscopy Training System (SKATS) was initially designed as a cost-effective PC based knee arthroscopy simulator consisting of a hollow plastic leg, replica surgical instruments, and a monitor displaying the internal view of the knee joint [6, 13]. Evaluation of the SKATS simulator demonstrated severe acceptability issues due to the lack of realistic haptic feedback [36]. The SKATS simulator was updated by adding passive haptics in the form of a more realistic leg containing solid femur and tibia bones that gave resistance when navigating through the virtual environment [37]. The validation results obtained with this mixed reality environment provided construct, predictive, and face validity for navigation and triangulation training.

This strategy of combining virtual reality with passive haptic feedback using anatomic bench models or with active haptic devices has been applied in all other commercially available arthroscopic virtual reality simulators. These are shortly discussed. The ArthroSim™ Arthroscopy Simulator has been developed by the AAOS Virtual Reality Task Force in collaboration between the ABOS, the Arthroscopy Association of North America (AANA), and Touch of Life Technologies (ToLTech, Colorado, USA, www.toltech.net) (Fig. 7.2d). The ARTHRO Mentor™ (Simbionix, Cleveland, Ohio USA, www.simbionix.com) and the Virtamed ArthroS (Virtamed AG, Zurich, Switzerland, www.virtamed.com) are the two other high-fidelity virtual reality simulators (Fig. 7.2b, c). They all offer a knee and a shoulder module, a wide variety of pathologies, and basic skills to be trained, including the identification of anatomical structures, navigation skills, triangulation and depth perception and instrument handling skills. Where ArthroSim™ solely focuses on diagnostics, the other two also offer training of therapeutic interventions such as screw placement, shaving, and cutting. All three types of simulators make optimal use of the computer graphics by offering video tutorials and 3D visualization of the instruments relative to the anatomic structures and performance assessment with objective metrics derived from the virtual environment. Individual studies indicate face and construct validity for the ArthroSim™, ARTHRO Mentor™, and the Virtamed ArthroS [19, 38, 39].

7.4 Discussion and Future Perspective

The main conclusion is that currently simulators are available to train basic arthroscopic skills in the knee and shoulder joint in a highly standardized and repetitive manner. Simulators to train specific skills in other joints are virtually absent, although the "model with separate sensors"-concept can be easily applied in combination anatomic bench models of the wrist, hip, ankle, and elbow joint.

Training environments in which anatomic bench models are used allow for normal everyday life sensory feedback. This implies that the relevant human senses (vision and proprioception, and to a lesser extend sound and smell) can be used by the trainee to acquire feedback on their performance in a natural manner. A limitation is that the models are usually not sufficiently realistic for more complex skills training. Additionally, the combination with separate sensors often requires automated data processing software which is not readily available when purchasing the sensors. That is why anatomic bench models with sensors as of yet are not widely integrated in the training curricula. The work done by Tuijthof and Escoto and coworkers [10, 27] indicate that engineers are aware that improvements are needed. The challenge is to keep these models affordable, which is a big asset.

Virtual reality arthroscopy simulators offer highly realistic arthroscopic images, can be used repeatedly without consumable parts, and allow self-directed learning by practicing a large variety of different pathologies and exercises. Additionally, trainees can progress at their own pace and at a time of their choice without the need for a senior surgeon to be present [7]. Limitations of virtual reality are that they lack realistic tissue behavior [40], and they are expensive. A future perspective of the value of virtual reality simulators is that that they could be used for preparation of individual complex patient cases by loading their CT- or MRI- scans into the simulator. As to this date none of the simulators offers this option, but this approach can contribute to life-long learning strategies and involve more experienced surgeons in simulator training.

There is little published research on the current commercially available simulators and there has not been any evidence of the ability of simulator-based training to improve arthroscopic performance in the operating theatre [41–43]. One major drawback of all available simulators is that none allows repetitive training of portal placement, which has been indicated as one of the important skills residents should possess before they continue training in the operating room [9, 44].

Further crossover studies are needed with longitudinal follow up of trainees undergoing virtual reality simulation-based training to fully understand the benefits to patients [41]. It is accepted though that simulator training can shorten the time it takes for trainees to acquire basic skills in theatre and this has universal advantages, for trainees, trainers, institutions, and, most importantly, patients. Simulation-based training can cause a "right-shift" along the learning curve for more efficient training with real-world improvements [45–47]. In conclusion, for the training of basic skills, except portal placement, different types of simulators are available. The challenge is to implement this into training curricula.

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8 Aspects of a Course Design

Alasdair Thomas, Gregory Ian Bain, and Donald Bramwell

Teaching should be such that what is offered is perceived as a valuable gift and not as a hard duty. Albert Einstein, *New York Times*, Oct 5 1952

8.1 Introduction

The success of a course starts with getting the right people coming to learn something that they want to learn and are able to learn in the time available. It may be that you are designing a course for a known group of novices such as a local group of medical students that have approached you wanting to learn some basic skills or the initial intake of a residency programme. It could be that you are setting out to gain the interest of a group of experts in learning a new technique or using a new piece of equipment, the basic rules remain the same, know your audience and be realistic as to what you can achieve in the time available. This requires the insight of both the course designers and the potential participants. As discussed in other chapters, people's skill levels are best stratified into novice, beginner, intermediate, advanced and expert. It is important that people learn in appropriate groups, and we recommend that the skill level of the participants be gained prior to your course so that you can set up groups appropriately.

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8.2 Beginning at the End!

At some point this year you will have attended at least one course or conference and during or after you will have been asked to fill in one or more feedback forms. There would have most likely been an incentive to fill in the form (maybe the much needed CME accreditation certificate was linked to filling it out) and it would have probably had had a Likart Scale [1] and an ability to give some freehand comment. So before we begin setting out to design a course, let us look at what evidence there is on what is needed and what is wanted from a course teaching a practical skill and how these two sometimes-divergent things (a need vs. a want) can be met.

The majority of evidence comes from combining feedback received on such courses and tests of skills and knowledge [2, 3]. The evidence that there is shows that participants most valued the time undergoing the practical aspects of the course. It also shows that time repeating the practical aspects of the course led to better skill attainment and retention.

So, before you start to design your course imagine yourself at the end of it. The venue is being tidied and faculty meeting is going over the feedback forms that have been collated and the results are presented; the results are that for the first time in recorded history too much time has been spent on the practical aspects of the course! Whatever else occurs on your course, however you feel it should be presented and delivered you will achieve optimal learning by priming your participants and faculty, getting them to an appropriate state of arousal and then most importantly allowing for adequate deliberate practice (Fig. 8.1).

So with the above end in mind is it time to start designing your course? Pause and before committing a lot of your time and probably other people's time to the process ask yourself the simple question. Why?

Have you been asked to set up a course? Do you simply have a desire to set up a course to teach something that you believe is not being taught elsewhere? Have you been approached by a company or a specific group? The reason you need to ask

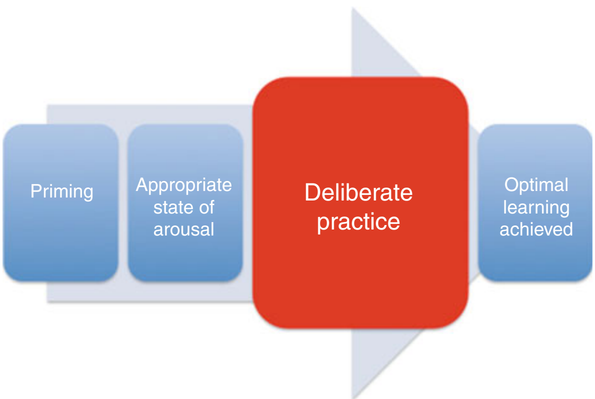

Fig. 8.1 Achievement of appropriate deliberate practice

these questions is because your motivation will be tested! There will be times both during the planning, running and wrap-up phase of any course, however well planned, however well designed and however well run that your motivation will be tested. In general you will have to deal with unfamiliar situations, repeated negotiations and divergent expectations. So as with any project, the reason why has to be a good one for yourself and for those around you.

We have designed this chapter so as to provide some general advice that has come from running many courses and conferences over the years; specifically ones concerning surgical skills and arthroscopy. The various sections can be used as a reference tool that follows the timeline that we recommend you follow. The final two sections of the chapter are Tips and Tricks and Do's and Don'ts. We recommend that you keep in mind a couple of acronyms. These have been popularised in the management world and will help you keep on track and keep your focus. SMART objectives, KISS, First things First and The Devil is in the Detail.

8.2.1 Using SMART Objectives

This refers to objectives that are *specific, measurable, achievable, relevant and time bound*. For example, the main objective of your course may be to deliver basic arthroscopy skills. With reference to the other chapters in this book you will be able to be *specific* as to what basic arthroscopy skills are and you will be able to know how best to teach them. You should set out to *measure* whether your course has taught these skills to your participants and that the goals you set on the course where *achievable*. You will seek feedback that the course was *relevant* to their day-to-day activities. Throughout that process you will ensure that you, your faculty and the participants are *time bound* by a published programme.

8.2.2 KISS

Keep it simple stupid refers to the fact that with every layer of complexity there is further potential for something to go wrong or a further level of potential misunderstanding. So whenever possible simplify, from the title of your course, to the slides in a presentation to the language used to describe a concept.

8.2.3 First Things First

W H Auden in his poem of the same said, 'Thousands have lived without love, not one without water'. You will have attended a course I am sure when 80 % of the time was spent doing other things apart from the practical aspect that you had come to learn. The many things that we will cover in this chapter have their place; however, the key will always be the practical aspect and it is vital that you consider that first thing first at all points along your planning and implementation of your course.

8.2.4 The Devil Is in the Detail

As in surgery it is aspects of course design. To illustrate this we will consider the timing and length of refreshment breaks.

Routinely we would recommend four refreshments breaks in a day-long course, one on arrival, mid-morning, lunch and mid-afternoon. So how long should these be? Your own experience of attending a course will tell you that refreshment breaks can be anything from 10 min up to 2 h. So when you are determining the length of your own breaks the detail is in what you and your faculty consider their purpose to be. The refreshment break on arrival should be considered an opportunity for people to mingle and a time to ensure that the administrative staff can deal with any last-minute housekeeping issues. The programme must show that this refreshment break is considered to be for that purpose i.e. (Registration (coffee and light breakfast)). The next refreshment break should be mid-morning and long enough that it can be shortened! It should take place close to rooms that your practical's are taking place in and you should ensure that there are enough toilets and that they are well signposted so that toilet breaks do not delay participants and faculty to making it back in time for the next session. The lunch break should be honestly planned with adequate time for visiting sponsors stands if that is required, whilst still having time to sit down and reflect on the course so far. The afternoon refreshment break should be just over an hour after lunch so as to coincide with the peak lethargy of everyone on the course brought about by digesting lunch.

So you can see that just taking into account the refreshment breaks, the detail can be quite significant and it is this detail that you and your working group must work through so as to get to right solution for your course.

8.2.4.1 Providing a Safe Space

A course provided to orthopaedic surgeons must follow an adult education approach [4]. It is vital that throughout the process of designing your course you focus on providing an educationally safe space as described by Malcolm Knowles and colleagues [5] (Fig. 8.2).

8.2.4.2 Course Cycle

Every course should proceed through the course cycle as illustrated in Fig. 8.3. The blue elements occur outside the period of time the course is taking place, the red elements during the course.

It is vital that as early as possible in the genesis of your course you set up a fully functioning working group (Fig. 8.4). This is the group of people that you need to bring together to develop your course and ensure that all the aspects of the course that you need and as many as possible of those you want are incorporated. Each person on the working group can take up one or more roles. The meeting of the working group should be realistically planned with the benefits of a face-to-face

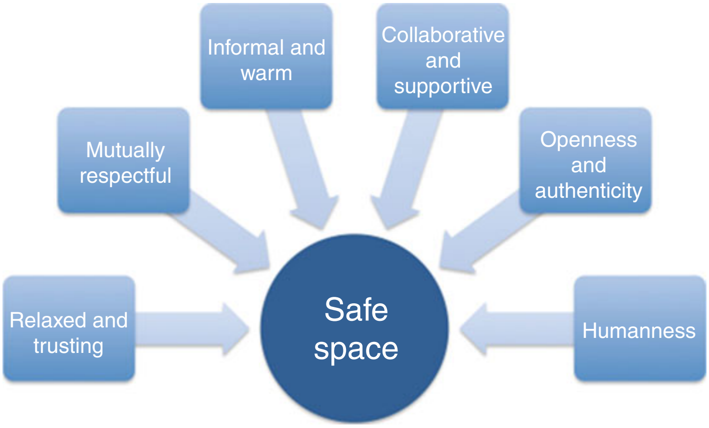

Fig. 8.2 Requirements for a safe learning space

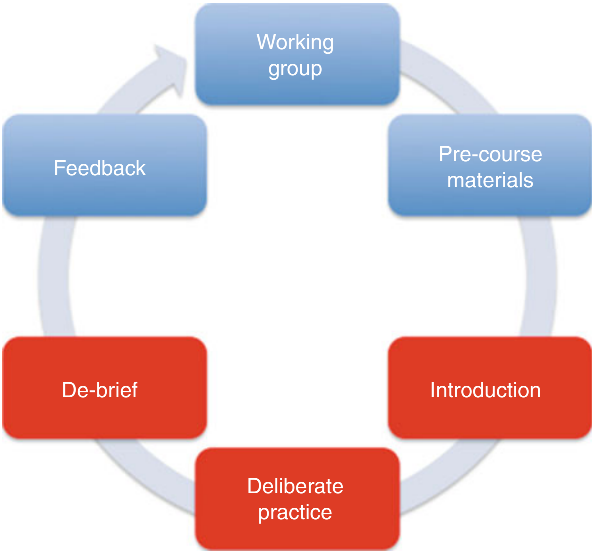

Fig. 8.3 Description of the course cycle

meeting being balanced with its feasibility. There are multiple options such as videoconference calling which are far more beneficial than an email trail for brainstorming ideas and preventing misunderstandings and delays in processing of ideas. We shall now cover each of the roles and at the same time cover the key aspects of their responsibilities.

Fig. 8.4 Working group elements

8.2.4.3 Chairperson

This is the leader of the working group and will be the person who is considered the most experienced in the field that is to be taught on the course. Ideally this person will have a recognisable name locally, nationally or internationally depending on the targeted audience. Ideally he or she will have taught on many courses beforehand will be able to bring their insights into how to provide the best course possible.

8.2.4.4 Course Organiser

Typically if the course organiser is not the chairperson then they will be someone who works closely with the chairperson and will be the engine that provides the main thrust for moving the course forward from concept to delivery. It is vital that this person has a firm grasp of the vision, which is provided by the chairperson. He or she must have good organisation, a firm grasp of the art of delegation and finely tuned negotiation skills.

8.2.4.5 Educational Advisor

During every stage of developing your course input regarding the educational principles that must be at the core.

8.2.4.6 Representative of Target Audience

'Know your audience'. The best way to gear a course appropriately for a target group of surgeons is to have one involved in setting it up and running it.

8.2.4.7 Administrator

This should be seen as far more than just secretarial support. As we all know meeting deadlines and keeping open lines of communication is vital to any project.

8.2.4.8 AV and IT Co-ordinator

The Audio-Visual and Information Technology that is used to facilitate the delivery of the course should be 'fit for purpose'. This will need coordination and on the day support.

8.2.4.9 Treasurer

This role is absolutely pivotal, as the next section on finances will explain. All financial decisions and payments should be co-ordinated by this person and explicit rules governing the financial arrangements of the course should be clear from the outset.

8.2.4.10 Finances

Without the appropriate financial arrangements in place the course cannot be run; therefore, it is paramount that a stepwise approach is applied to this part of the course, as it should be to the rest. Have an understanding of the market that is at work in the arena that you are setting up your course.

For the purposes of this section, of this chapter we shall be considering, an independent course that is being set up so as to be funded by a mixture of sponsorship and delegate contribution.

The financial planning of the course should start with some basic market research to look at the cost of courses directed at the same target audience as the course that you are planning. The main costs will then have to be factored in as listed below. The exact financial arrangements for managing the accounts of the course will depend on the country that the course is being run. We strongly recommend that these matters be clarified at the beginning, as it may be that a separate entity has to registered with the appropriate authorities so as to proceed without any financial liability falling onto the organiser's shoulders. There is often special recognition given to bodies that are providing education and there will definitely be a need to keep good financial records from the outset.

When you are first setting up a course there is going to be a list of things that you want, and one of the most important aspects of designing your course will be your ability to differentiate between what you want and what you actually need (Table 8.1). Sometimes the two will be the same however more often than not

Table 8.1 Financial Planning for a course

Venue
Catering
Faculty expenses
Administrative costs
Advertising
Website administration
Course disposables
Course non-disposables (this will be a one-off course cost for the first course run)
Insurance
Publicity
Pre-course material

constraints of time, money and expertise will mean that to be able to move forward you must focus on your needs.

An example of this is when you are considering your simulation materials, you may want to have a high fidelity model with video playback options and time to use a validated score to feedback to the participants on their performance. What you need is an appropriate model (which could just be a Black Box [6]) with sufficient numbers of experienced faculty to provide real-time practical feedback and instruction.

Please see Table 8.2 for further examples of needs and wants. An example of a course timetable is provided below (Table 8.3).

- Set up working group
- Research needs and wants of a defined group of delegates
- Define educational objectives of course
- Research market for the course via formal and informal means
- Explore financial viability
- Provisionally booked venue and faculty
- Advertise course in appropriate journals, websites, trainee groups and email distribution lists
- Confirm course venue and faculty

Table 8.2 The needs and the wants of a course

Component of course	Need	Want
Venue	Accessible and appealing to faculty and participants	5 star facilities and 3 star cost!
IT	Whiteboard with pens, projector and space in the lab for live demonstration	Smart board with linked in laptop and live feed from lab for demonstration
Teaching models	Validated model	Cadaveric joints
Space	Multifunctional rooms that have adequate space and materials	Purpose built simulation lab with on site lecture facilities and refreshment areas

Table 8.3 Example course itinary for a 2 day course

Evening before course	Course dinner/social gathering
Day 1	Registration with refreshment pastries and fruits
	Introduction overview of course objectives and methods review of pre-course materials and housekeeping
	First practical session familiarisation with equipment and basic techniques
	Debrief followed by refreshments
	Repeat first practical session with further specific goals
	Full group debrief and lunch (reset practical area for next practicum)
	Introduction to next session with clarification of specific sessional objectives and methods and further review of pre-course material
	Second practical session familiarisation with equipment and basics of techniques
	Small-group debrief with refreshments
	Repeat second practical session with concentration on fluidity and remembering steps
	Full group debrief
	Faculty meeting
	After course drinks in immediate environment and then course dinner
Day 2	Refreshments and second day registration
	Introduction to second day objectives and methods with tie into relevance of first day and inclusion of any feedback on running of practical is group dynamics and housekeeping
	Finish at 15:00
Post-course evaluation	Time Management
	Naming your course
	Pre-course materials
	Website
	Administrative support
	Sponsorship
	Accommodation
	Faculty to participant ratio
	Technical staff
	Set up and clear up time
	Feedback formal and informal

Tips and Tricks

- Put everything into context. For each activity have a specific case study as a reference point, preferably from the faculties clinical experience.
- Familiarise the faculty and yourself with the venue and the equipment in advance and make sure that there is an open dialogue between the technical staff and the rest of the course.
- If you are pushed for time and space then move the pre-practical lectures and demonstration into the practical area. When you do this make sure that you indicate to people when they should concentrating on the instructions and when they should be familiarising themselves with the models and equipment.
- Always explicitly set ground rules, politely, warmly and at times firmly. Be specific regarding expectations around behaviour and time keeping before, during and after activities.
- When there is a difference of experience levels within the group consider the potential pros and cons of matching skill levels or mismatching. It may be that you have a practical that is relatively basic that leads onto a more complex procedure when a mismatch can be beneficial. Most of the time matching experience provides for an educationally safer space.

Do's and Don'ts

- Do have good coffee, tea and plenty of water.
- Do keep things moving along and especially during the first running of the course be prepared to shorten some sections and lengthen others; remember to put buffers into your programme!
- Do have pictures and basic info of the candidates and the faculty so that each can be familiar with each other.
- Do make sure that refreshment breaks (which are invaluable extra discussion time) are long enough.
- Do stipulate a casual dress code for both the faculty and the participants.
- Don't forget to ask for any special dietary requirements.
- Don't skip the social event.
- Don't have too many lectures; emphasise the KISS principle to the instructors.
- Don't end up with too many participants and not enough instructors.
- Don't forget to have the correct instruments and check and recheck that they work.

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Establishing Validation Methods: Measuring Progress (Measuring Teaching Effectiveness) – Global Rating Scales

9

Moises Cohen, H. Kaya Akan, Lucio Ernlund, and Oğuz Poyanlı

Tell me and I forget, teach me and I may remember, involve me and I learn

—— Benjamin Franklin

9.1 Introduction

Examination of arthroscopic skill necessitates evaluation methods that are valid and reliable. They should also possess clarity, reproducibility, intra- and interobserver reliability. The identification of effective arthroscopic teaching methods and evaluation tools requires comprehensive assessment using true indicators of competence. Yet the definition of competence and quantification of arthroscopic proficiency has not been established [1].

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9.2 Global Rating Scales

The current teaching model in arthroscopic training relies on the apprenticeship model where residents are evaluated by a surgeon as their level of involvement increases over time. This assessment is not based on a predetermined level of performance, but rather on global evaluation by the participating surgeon. The surgeon's experience, theoretical knowledge and teaching abilities play all the role in this assessment. An evaluation tool should be practical and feasible while remaining as objective as possible [2]. In order to overcome the bias related to the assessment of the procedure by the experienced surgeon, rubrics which are called Global Rating Scales (GRS) have been developed in order to provide clear evaluation criteria and rightful levels of competence. The GRS suggested that arthroscopic skills will be elucidated as well as their validation and examples to assess learning curves.

There are various procedure-specific checklists [3–5] and global rating scales [6–8] in other surgical disciplines, and the objective structured assessment of technical skill (OSATS) is the most widely accepted tool for objective clinical assessment [9].

In orthopaedic surgery the objective evaluation techniques are limited (Table 9.1). The arthroscopic global rating scales have a similarity in terms of items to be checked on a 5 point scale. Items such as instrument handling, flow of procedure

Table 9.1 Current orthopaedic global rating scales

Study	Tool	Description	Conclusion
Howells et al. [10]	Modified orthopaedic competence assessment project (OCAP)	Intraoperative 14 point arthroscopic checklist and OSATS GRS	Tool demonstrated improved performance in operating room for simulator trained individuals compared to untrained control
Insell et al. [7]	The basic arthroscopic knee scoring system (BAKSS)	Combined task-specific checklist and GRS for diagnostic arthroscopy and partial meniscectomy	System able to discriminate people with different levels of arthroscopic experience
Elliott et al. [8]	Arthroscopic skill assessment form (Knee)	100 points score, 75 for structure identification, 25 for time completion and deductions for cartilage damage	Can distinguish between novice, experienced and expert surgeon in cadaveric knee
Schantz et al. [12]	The objective assessment of arthroscopic skills (OAAS)	Global skills domains with 5 skill level option combines with 13 point anatomical area checklist	Discriminates between various skill level of training, high level of consistency and test-retest reliability
Tuijthof [13]	Arthroscopic surgery skill evaluation tool (ASSET)	Global skills domain with 8 skill level option additional 1 domain for complexity using procedural video	Discriminates between novice, competent and expert level of training

Derived from various sources

and autonomy are almost similar in every scale. OCAP and BAKSSS are also recommended to be used with task-specific checklists, whereas ASA solely focuses on knee arthroscopy with such a checklist.

Analysing these GRS, one can conclude that a certain level of consensus exists on arthroscopic skills that a resident should be able to demonstrate in the operating theatre and the required level to qualify as competent. OCAP is not specifically tested, but its items are derived from the well-established OSATS GRS, which has been validated extensively. The four other GRS have been validated for construct, content and concurrent validity as well as internal consistency, interrater and test-retest reliability. These results are summarised in Table 9.2.

Table 9.2 All GRS that are suggested for rating of arthroscopic skills based on Hodgins and Veillette [14]

Acronyms of global rating scales	Description	Validation
OCAP	9 items, scored on a 1–5 point Likert scale	Based on OSATS validation protocols
BAKSSS	10 items, scored on a 1–5 point Likert scale	Construct validity level of experience ($p<0.05$)
		Concurrent validity with year of residency ($r=0.93$)
		Concurrent validity with motion analysis ($r=0.58$) (Alvand et al. [15])
		Internal consistency (Cronbach's $\alpha=0.88$) (Alvand et al. [15])
		Interrater reliability (kappa = 0.543) (Olson et al. [16])
ASA	100-point score, 75 for structure identification, 25 for time to completion and penalties for cartilage damage	Construct validity level of experience ($p<0.001$)
OAAS	7 items, scored on a 1–5 point Likert scale, complexity of procedure	Construct validity level of experience ($p<0.0001$)
		Internal consistency (Cronbach's $\alpha=0.97$)
		Level of agreement (ICC = 0.80)
		Test-retest reliability ($r=0.52$)
ASSET	8 items, scored on a 1–5 point Likert scale, complexity of procedure	Content validity: expert group
		Concurrent validity level of experience ($p<0.05$)
		Level of agreement (ICC = 0.90)
		Test-retest reliability ($r=0.79$)

The global rating scales are given in the following figures (Figs. 9.1, 9.2, 9.3, 9.4 and 9.5). As a summary one should keep in mind that these are all suitable to monitor overall arthroscopic skills progression in the operating room. These scales structure and objectify the feedback of the supervising surgeons but cannot be so illustrative as video feedback. Furthermore, it is recommended that assessors using the scales are trained to reach a uniform assessment. However, they are truly easy to implement in residency curricula, have been demonstrated to reflect the learning curve of residents and could also be used for self-assessment [12].

		Score				
	Skill	**1**	**2**	**3**	**4**	**5**
1	Follows protocol	Unsatisfactory		Adequate. Occasional need for guidance and help		Excellent adherence to agreed protocol. No prompts. No mistakes
2	Handles tissue well	Careless Potential to cause damage		Adequate. No tissue damage. Occasional need for increased care		Excellent tissue handling. Precise and delicate
3	Appropriate and safe use of instruments	Dangerous. Risk to patient and assistant. Potential for damage to equipment		Adequate use of instruments and scope. Occasional guidance to ensure instruments remain within field of vision		Excellent use of instruments. Good control of arthroscope. Instruments constantly within field of vision
4	Appropriate pace with economy of movement	Erratic pace and movements. Overly rushing or inappropriately slow		Adequate economy of movement. Majority of movements controlled and careful. Occasional erratic movement		Excellent fluidity and economy of movement. Procedure performed at appropriate pace without erratic movements
5	Act calmly and effectively with untoward events	Unable to deal with adverse events. Panic and inability to respond		Remains calm. Remains safe. Takes advice from supervisior. Unable to cope independently		Excellent ability to cope with adverse events. Remains calm. Deals with complication independently
6	Appropriate use of assistant	Fails to involve assistant appropriately. Resultant poor positioning. Poor rapport		Asks for appropriate joint position at appropriate times. Unable to suggest alternative positions to improve view/ access		Excellent use of assistant. Good rapport. Able to constantly modify input of assistant to best advantage throughout procedure
7	Communicates with scrub nurse	Inappropriate communication resulting in confusion or operative delay		Appropriate communication with scrub nurse. Occasional need for clarification form supervisor		Excellent rapport with scrub nurse. Clear and effective communication, maximising procedural efficiency
8	Clearly identifies common abnormalities	Unable to identify common abnormalities. Confusion over basic anatomy		Adequate identificaion of common pathology. Occasional mistake. Unsure of precise classifications		Excellent knowledge of pathology of common abnormalities. Clear understanding of classification of injuries
9	Protecting the articular surface	Inability to protect articular surface appropriately. Potential to cause damage		Awareness of need to protect articular surface. Adequate care taken. Occasional prompt from supervisor required		Excellent awarenes of articular surfaces. High degree of care maikntaikned throughout the procedure

Fig. 9.1 Modified orthopaedic competence assessment project (Howells)

Study Form	Bio-skills Lab: Knee Arthroscopy	Subject number:
	Global Rating Scale (GRS)	Test Dage: ______/______/______

Please circle the number (1-5) that best describes the subject

1. **Dissection**
   1- Appeared excessively hesitant, caused trauma to tissues, did not dissect into correct anatomical plane
   2-
   3- Controlled and safe dissection into correct anatomical plane, caused minimal trauma to tissues
   4-
   5- Superior and atraumatic dissection into the correct anatomical plane

2. **Instrument handling**
   1- Repeatedly makes tentative or awkward movements with instruments
   2-
   3- Competent use of instruments, although occasionally appeared stiff or awkward
   4-
   5- Fluid moves with instuments and no awkwardness

3. **Depth perception**
   1- Constantly overshoots target, slow to correct
   2-
   3- Some overshooting or missing of target
   4-
   5- Accurately directs instuments in the correct plane to target

4. **Bimanual dexterity**
   1- Noticeably awkward with non-dominant hand, poor coordination between hands
   2-
   3- Users both hands but does not maximize interaction between hands
   4-
   5- Expertly uses both hands in complementary manner to provide optimum performance

5. **Flow of operation and forward planning**
   1- Frequently stopped operating or needed to discuss next move
   2-
   3- Demonstrated ability for forward planning with steady progression of operative procedure
   4-
   5- Obviously planned course of operation with effortless flow from one move to the next

6. **Knowledge of instruments**
   1- Frequently asked for the wrong instrument or used inappropriate instrument
   2-
   3- Knew the names of most instruments and used appropriate instrument for the task
   4-
   5- Obviously familiar with the instruments required and their names

7. **Efficiency**
   1- Many unnecessary, inefficient movements. Constantly changing focus or persisting without progress
   2-
   3- Slow, but planned movements are reasonably organized with few unnecessary or repetitive movements
   4-
   5- Confident, clear economy of movement and maximum efficiency

8. **Knowledge of specific procedure**
   1- Deficient knowledge, needed specific instruction at most operative steps
   2-

Fig. 9.2 Basic arthroscopic skill scoring system (Insel [7])

Start time	**Stop time**	**Total time**
Landmark	To be visualised	Score
Suprapatellar pouch	View all areas of pouch	(3)
Patella	View medial facet	(3)
	View lateral facets	(3)
Trochlea	View trochlear surface	(4)
Medical recess	View medial gutter/assess meniscal synovial junction	(4)
Lateral recess	View lateral gutter/assess meniscal junction/popliteus	(4)
Medial compartment	Assess condyle for chondral lesions	(5)
	Meniscus/view anterior, middle, posterior	(5)
	Probe superior and inferior surface	(10)
Intercondylar notch	View and inspect ACL	(5)
	View and inspect PCL	(5)
Lateral compartment	Assess condyle for chondral lesions	(5)
	Meniscus/view anterior, middle, posterior	(5)
	Probe superior and inferior surface	(10)
	View popliteus tendon	(4)

Fig. 9.3 Arthroscopic skills assessment (Elliott)

Modified OAAS Global Assessment Form for Arthroscopy: Staff Surgeon Form

Your Staff Surgeon Number:

Procedure Number (File name written at top of screen): ______________________

Instructions: For each skill domain, please CIRCLE ONE STATEMENT in each row best describing how well the resident performed each aspect of this procedure.

Skill Domain					
Examining / Manipulating Joint	Did not examine joint or position to give improved visualization during procedure.	Examined joint without diagnostic abilities and lacked ability to facilitate view by positioning.	Positioned knee appropriately after some difficulty with visualization.	Used common positioning to facilitate view during athroscopy.	Used accepted and novel positioning to perform the arthroscopy effortlessly.
Triangulating Instruments	Could not insert instruments into ports and maintain them in vies. Unable to locate instrument tips without difficulty.	Unable to maintain instrument in field of view consistently.	Found instruments with delay. Field of view wandered form operative site but returned.	Found instruments quickly and began work. Occasionally delayed in orienting camera to afford better visualization.	Immediately located instruments and began work without delay. Kept instument in field of view at all times.
Controlling Fluid Flow and Joint Distension	Under/overdistended joint consistently due to inappropriate matching of suction and flow.	Achieved proper distension after delays. Some extravasation into tissue due to overdistension.	Distended joint adequately after initial loss of pressure during suction.	Joint distended appropriately through control of flow and suction.	Minimal fluid extravasated with constantly maintained field of view.
Maintaining Field of View	Often disoriented. Was unable to adjust scope to improve visualization.	Maintained field of view part of the time.	Maintained and adjusted arthroscope to provide maximal view with some difficulty.	Maintained field of view in same portal.	Changed portals quickly to improve visualization.
Controlling Instruments	Was unable to perform tasks with provided instuments. Caused cartilage damage.	Repeatedly made tentative or awkward moves with instruments.	Competently used instruments although occasionally appeared stiff or awkward.	Used instruments appropriately and efficiently.	Made fluid moves with instruments and used some instruments in novel ways to increase efficiency.
Economizing Time and Planning Forward	Was unable to complete any portion of the procedure.	Was able to complete components of the procedure, but needed to discuss next move.	Competed all components of the operation with some unnecessary moves.	Was efficient, but continued discovering new time saving motions.	Showed economy of movement and maximum efficiency.
Overall	Possessed rudimentary arthroscopic skills with only basic anatomical and mechanical understanding.	Knew basic steps of procedure and performed some independently	Performed the procedure independently.	Performed procedure with changes to improve efficiency.	Performed the procedure with minimal chance to improve efficiency.
Skill Level	Novice	Advanced Beginner	Competent	Proficient	Expert

Given the norms for this procedure, how *difficult* was performing the operation on this particular patient? (Check One)

☐ No Difficulties ☐ Slightly Difficult ☐ Moderately Difficult ☐ Considerable Difficulty ☐ Critical

Approximately how many times have you completed this form for this or any resident? ________ Times.

How skilled do you think this resident was at performing this procedure? (make a vertical mark on the line to indicate skill)

Has No Skill |——————————————| Extremely Skilled

Resident Evaluation Form

Fig. 9.4 Objective assessment of arthroscopic skills (Shantz)

Safety	**1 – Novice** Significant damage to articular cartilage or soft tissue	**2**	**3 - Competent** Insignificant damage to articular cartilage or soft tissue	**4**	**5 - Expert** No damage to articular cartilage or soft tissue
Field of view	**1 – Novice** Narrow field of view, inadequate arthroscope or light source positioning	**2**	**3 - Competent** Moderate field of view, adwquate arthroscope and light source positioning	**4**	**5 - Expert** Expansive field of view, optimal arthroscope and light source positioning
Camera dexterity	**1 – Novice** Awkward or graceless movements, fails to keep camera centered and correctly oriented	**2**	**3 - Competent** Appropriate use of camera, occasionally needs to reposition	**4**	**5 - Expert** Graceful and dexterous throughout procedure with camera always centered and correctly oriented
Instrument dexterity	**1 – Novice** Overly tentative or awkward with instruments, unable to consistently direct instruments to targets	**2**	**3 - Competent** Careful, controlled use of instruments, occasionally misses targets	**4**	**5 - Expert** Confident and accurate use of all instruments
Bi-manual dexterity	**1 – Novice** Unable to use both hands or no coordination between hands	**2**	**3 - Competent** Uses both hands but occasionally fails to coordinate movement of camera and instruments	**4**	**5 - Expert** Uses both hands to coordinate camera and instrument positioning for optimal performance
Flow of procedure	**1 – Novice** Frequently stops operating or persists without progress, multiple unsuccessful attempts prior to completing tasks	**2**	**3 - Competent** Steady progression of operative procedure with few unsuccessful attempts prior to completing tasks	**4**	**5 - Expert** Obviously planned course of procedure, fluid transition from one task to the next with no unsuccessful attempts
Quality of procedure	**1 – Novice** Inadequate or incomplete final product	**2**	**3 - Competent** Adequate final product with only minor flaws that do not require correciton	**4**	**5 - Expert** Optimal final product with no flaws
Autonomy	**1** Unable to complete procedure even with intervenion(s)		**2** Able to complete procedure but required intervenion(s)		**3** Able to complete procedure without intervenion

Added Complexity of Procedure

1	2	3
No difficulty	Moderate difficulty (mild inflammation or scarring)	Extreme difficulty (severe inflammation or scarring, abnormal anatomy)

Fig. 9.5 Arthroscopic surgical skill evaluation tool (Tuijthof)

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Certification of Surgical Skills

10

Jorge Mineiro

10.1 Introduction

Europe as a continent is a collection of countries with different backgrounds. The standards of medical education from undergraduate, through resident training, postgraduate training and to professional competence and independent practice are generally high but vary between different countries, and the standards of speciality training are also very demanding but different among European countries.

In 1958, with the foundation of the UEMS (Union Européenne des Médicins Spécialistes), the main concern was the study and promotion of the highest level of training of the medical specialists, medical practice and health care within the European Union in order to facilitate and promote the free movement of doctors as well as patients within the European Union. Harmonisation of the different training programmes around Europe has been one of its major tasks since the beginning although still not fully accomplished at this stage.

However, our main obligation is towards the public and therefore, as very specific medical professionals – surgeons, we must ensure the best quality health care is provided at all levels of clinical practice.

The experience from the Fellowship examination of the European Board of Orthopaedics and Traumatology over the last decade has shown that trainees and young specialists throughout Europe are exposed to different scenarios in their residency that explains the different outcomes at the end of training despite very standardised programmes of training in most European countries.

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10.2 Scope of Practice

The scope of practice for the trained orthopaedic surgeon in Europe involves the safe and effective application of all competencies obtained through an effective programme of training. This involves the development of expertise in the three domains recognised in all the medical specialties: a knowledge base, which involves exposure to and complete understanding of the whole of the orthopaedic syllabus; clinical skills, which includes all the practical aspects of patient care and the surgical skills appropriate for a specialist in independent practice and professional behaviour, which includes communication skills, organisation, ethics and probity. Most National Orthopaedic Authorities in Europe have developed syllabi, guidelines and curricula for orthopaedic practice, but these are not always consistent, reliable or integrated. UEMS and EFFORT are in the process of developing a European curriculum, which will be offered by UEMS to National Associations as a framework to allow consistency in training and practice throughout Europe, in line with the recommendations of the Professional Qualifications Directive of the European Commission.

10.3 Professional Role

Orthopaedic surgery is a demanding and sophisticated branch of surgery that like many other specialities has become very technical. The use of implants is common in all branches of orthopaedics and traumatology, and the specialty also lends itself to minimally invasive surgery.

The professional role of an orthopaedic surgeon may involve several domains, from simple clinical assessment to more sophisticated, involving modern minimally invasive surgical skills.

Besides the technical side of orthopaedics in general, speciality related cognitive skills is another area where professionals have to ensure the highest standards. Orthopaedic surgeons must have the cognitive skills appropriate to the speciality/subspeciality in which they will be providing care sufficient to satisfy the requirements of the profession, the government and the public at large.

10.4 Certification

In Europe most orthopaedic surgeons are board certified by their national boards although this is not rule across all different countries as it is closely linked to the health system in each country. Certification by an accredited body in a given area of a speciality denotes that candidates have successfully completed the assessment process designed to test their mastery of the minimum knowledge and skills contained in the core of competency (a core body of knowledge that defines an area of specialisation).

Core competencies are developed by literature review combined with review by medical experts in the field. The core knowledge and skills are compiled into a scheme of competencies that should be part of general training before final certification.

Certification of a qualification will ensure that surgeons have achieved the competencies required by the regulatory authority. Previously this was based on the timescale necessary to achieve these, but it is now recognised that competence rather than time in the specialty is the important factor in certification. Nevertheless, a certified orthopaedic surgeon in Europe will have accomplished at least 5 years of residency training following medical school and completed successfully the board (or equivalent) assessment at the end of training, usually by examination. These are the “basic” requirements for practising orthopaedic surgery in the European Union (EU).

It has been agreed that all orthopaedic surgeons should achieve the high standards required in “The generality of orthopaedics and traumatology” before proceeding to subspecialty training in the subspecialty of their choice, which is undertaken at fellowship level. To be certified as a specialist in one particular area of orthopaedics/trauma, by an accredited body such as a Speciality Society, the orthopaedic surgeon must meet the high standards established specifically for that particular area and it related subspecialities. It does mean that the surgeon has acquired expertise and advanced surgical skills in that particular field.

Subspecialist certification is likely to be a Postgraduate Diploma based on a curriculum developed by the Specialist Societies, endorsed by the National Regulatory Authority. The regulation of such diplomas will need to be integrated with general certification and will not be regarded as an alternative to general certification but rather an additional qualification. It is already recognised that a subspecialty diploma should not offer exclusive professional practice rights.

10.5 Education

We can separate the education into two domains – the general training accomplished at the recognised training centres within EU and the subsequent advanced training, at the centres that have Specialised Fellowship programmes recognised and accredited by the Speciality Societies in Europe.

In the first domain, the education process is defined by an accredited training programme in Europe, completing a residency in which knowledge and clinical skills are developed. Integration and application of theoretical knowledge and refinement of clinical and technical skills are applied, using good clinical judgement in assessment and treatment of individuals affected by the different pathologies of the musculo-skeletal system. These parameters are defined by the curriculum.

During their training, they must acquire extensive experience and broad knowledge of disease management and operative skills in the different areas of traumatology and orthopaedic surgery.

However, education and training of an orthopaedic surgeon involves much more than acquisition of factual knowledge and surgical skills. The development of professionalism, judgement and ethics are required by the end of residency in order to integrate with the technical side of our training, to guarantee quality assurance, as expectations of a professional like an orthopaedic surgeon are extremely high.

In the second domain, education goes beyond the general training and surgeons choose to complete an additional year or two of speciality training in a specific field of orthopaedic surgery, in an accredited department with a Fellowship programme. Most of these focus on the diagnosis and treatment of a particular area of the body and integrate a combined programme that covers four domains: applied clinical skills, advanced surgical skills and techniques, academic activities and research. Surgeons that complete successfully a Fellowship programme (1 or 2 years), either with continuous assessment by their mentor or head of Fellowship training or through some form of final assessment, do become sub-specialists and registered members of this subspeciality.

10.6 Examination

Final assessment at the end of training has been structured in many ways although the tendency today will be to have three main sections – written, oral and clinical.

The written part which is good for testing factual knowledge and can rapidly test over a wide range of subjects. An oral part will test their clinical judgement and decision-making and evaluate their ability to diagnose and treat diverse clinical scenarios.

However all around the world, in the twenty-first century the tendency for decision-making is moving away from the clinical judgement and patient assessment to be more and more purely based on investigations.

This "evolution" has shown that different qualities expected from an orthopaedic surgeon are left out and I would separate two main areas – the first should test professional behaviour, attitude and clinical skills and the second the expertise in surgical skills.

The first one can be assessed by a clinical exam with patient (or other) in a similar setup as for medical student where those clinical skills and attitude can be evaluated.

The second one I would separate it in two different phases. The phase 1 will have to be ensured by the head of training that the trainee has achieved the end of training and therefore has acquired enough clinical and operative experience as well as a broad knowledge basis required to apply for the final qualification (fellowship examination) as an orthopaedic surgeon. Phase 2 is the advanced phase of the expertise in surgical skills – this should be a voluntary exam, more technical, based on surgical problem solving and performing certain procedures and therefore requiring either a simulation or cadaver laboratory. This could be supplemented by careful examination of the European electronic logbook.

Certification of surgical skills is a new trend with a supportive background! The public does need the general orthopaedic surgeon, but we also need the expert surgeon. Complex pathology should be referred to specialised centres where those skills should be concentrated. The net work should exist and referrals should be enhanced, because this will be the best option to guarantee efficiency, patient safety and cost effectiveness.

10.7 Decision-Making

Orthopaedic surgeons must practice prudent and professional judgement consistent with their level of competency. Decision-making is a process that involves different areas of judgement. It does begin with the clinical assessment, interpretation and request of the appropriate investigations in order to achieve the correct diagnosis (level one). Then comes the next level which will be the decision on the best therapy for that particular condition and based on the data collected at level one. Once the treatment is chosen, if surgical, decision should be made on the best operation with all different details from the procedure, approach, positioning, material needed, etc. and consider the possible complications which may be encountered. The third level of this high order thinking process on decision-making is to decide on the best post-operative rehabilitation programme for that patient with that condition and all other comorbidities.

Certification of surgical skills will guarantee that the surgeon is not only an expert on those particular procedures (technical ability) but most of all he is qualified to make the appropriate and correct judgement all the way through until the patient resumes his/her normal activities.

Conclusion

Orthopaedic surgeons must maintain the skills, knowledge, attitude and judgement at the highest level and always endeavour to improve the profession to meet the many technological and procedural advances of the future.

Certification of surgical skills is a new trend that is required to qualify surgeons to the best of their ability. Surgery is not only a technical procedure but all that leads to it and follows it until patient is returned to society and therefore this qualification by an accredited speciality society should mean that a surgeon has acquired all the expertise in that field to become a safe, competent superspecialist.

Conclusion

João Espregueira-Mendes, Mustafa Karahan, H. Kaya Akan

Orthopedic sports medicine has been in constant development, and it is a conjunction of scientific knowledge, experience, and art. Still, before the "art of surgery" is acquired, the student has to master the scientific knowledge of basic concepts and the current state of art of several areas, such as anatomy, physiopathology, biomechanics, diagnostics, and treatment fields. In addition, conquering these surgical skills has a steep learning curve varying in personal qualities and learning opportunities. As soon as the basic concepts are learnt, the orthopedics sports surgeon should work on his surgical skills, from the most basic to the most specific and technical demanding ones.

Teaching becomes an important task of leading and qualified sports orthopedic surgeons to convey to the young and enthusiast orthopedic surgeon as many tools as possible, so the student is able to safely and effectively perform the surgery on their own. This is often accomplished through residency programs and surgical orthopedic-directed courses, designed to provide the student a set of orthopedic sports medicine skills, which are required to the "sports surgeon" succeed in the demanding tasks he/she will face in their career.

This book approached the multidisciplinarity and proficiency of designing and managing an orthopedic sports medicine motor skills course. To this end, it is explored the fundamentals and requirements of a sport orthopedic surgeon as well as the surgical motor skills essential to succeed and aim for excellency. Attention is then shifted to the teaching principles of any orthopedic sports medicine surgical course, going through the strategies of design and standardization of the course program, learning stages and the importance of mentorship within the arthroscopic surgery. Along these lines, it is depicted the key elements and concepts that should be included within an orthopedic sports medicine *curriculum* and, most importantly, how it should be structured and developed. The required arthroscopic surgical skills are then described, as also, how to translate these skills into measurable learning objectives and outcomes. The motor skills training modalities are then explored in detail, from anatomic, animal, and human models to the more up-to-date physical and virtual reality simulators that are currently available. Last but not least, several hints are provided in how to properly design a course based on surgical skills and arthroscopy, the validation methods of progression measurement are presented, and

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the certification of qualification of the surgical skills and correct judgement is portrayed.

This book provides the fundamentals and strategies to all the qualified orthopedic sports medicine surgeons that desire to develop and implement an orthopedic sports medicine motor skills course.

> Before you are a leader, success is all about growing yourself. When you become a leader, success is all about growing others. – Jack Welch