Needs and Wishes from the Arthroscopy Community

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Take-Home Messages

- Residents need to learn many skills before performing safely independent in the operating theatre.
- A quality training program should focus on skills that are considered more important for performing arthroscopy: anatomical knowledge, triangulation, and spatial perception.
- Online surveys can be useful to investigate the opinion and generate consensus from orthopedic surgeons about what should be trained and skills that are crucial for a resident to possess before continuing safe in the operating room.
- Training simulators should focus on skills considered more relevant by a large number of physicians:
  - Portal placement
  - Anatomical knowledge on identification of different compartments, intercondylar notch including ACL and PCL, and all important structures in the joint
  - Inspection with the arthroscope

2.1 Introduction

Surgical skills training plays an important role in medical education. In recent years, substantial progress has been made in the development of simulation programs and tools for the training and assessment of a trainee's performance. However, these devices have generated controversy about their validity for arthroscopic surgical training,

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and the bridge between technological development and educational needs has not yet been clearly established. From an educational point of view, a key feature for a well-designed training program is that the learning objectives should be explicitly defined (Biggs 2003). The aim of this chapter is to address the learning objectives in simulation training, and subsequently, we focus on the number of procedures that are required to become competent.

2.2 Learning Objectives for Simulation Training

Only few studies to date have tried to determine the relevance of skills that a simulator or training protocol should teach to residents. Concerning what skills are crucial for a resident to possess before continuing safe training in the operating room, results of a questionnaire submitted to the members of the Canadian association of orthopedic surgeon are available in the literature (Safir et al. 2008). The online survey outlining fundamental skills of arthroscopy and methods that a surgical trainee might use to develop such skills was composed of 35 questions. Surgeons were asked to rank the importance of each arthroscopic task or usefulness of a learning method on a five-point scale ranging from least important to most important. Overall, 101 orthopedic surgeons responded to survey. Anatomy identification and navigation skills were deemed to be the most important for a trainee to possess prior to entering the operating room (Table 2.1). Furthermore, portal positioning and triangulation were elected as the most important specific skills.

Hui and coworkers (2013) reported results of 65 orthopedic residents that completed online a similar survey. Identification of structures and navigation of the arthroscope were ranked highly in terms of importance for trainee surgeons to possess before performing in the operating room (Table 2.1).

Supported by the Dutch Arthroscopy Society (NVA), a similar questionnaire was conducted in the Netherlands among the experienced arthroscopists and residents to determine the presence of cultural differences. The preliminary results of the Dutch survey are presented together with the results from Safir and coworkers (2008) and Hui and coworkers (2013) (Table 2.1). In all three surveys, knowledge on anatomy of the knee joint is ranked as priority number one.

In order to investigate the opinion of a large community of orthopedic surgeons, an online survey was distributed to surgeons that are members of the European Society of Sports Traumatology, Knee Surgery & Arthroscopy (ESSKA) and among the members of the Dutch Arthroscopy Society. The purpose of the project was to generate consensus from a group of experienced orthopedic surgeons about what should be trained and

Table 2.1 Ranking of importance for a trainee to possess ability prior to performing in the operating room

Rank	Surgeons (Safir et al. 2008) $n=101$	Score (1–5)	Residents (Hui et al. 2013) $n=67$	Score (1–5)	Surgeons-residents NVA $n=20$	Score (1–5)	Surgeons-residents $n=195$	Score (1–5)
1	Anatomical knowledge	3.86[a]	Anatomical knowledge	4.4	Anatomical knowledge	4.70	Anatomical knowledge	4.63[b]
2	Triangulation/depth perception	3.34[a]	Spatial perception	4.3	Spatial perception	4.15	Triangulation	4.43[b]
3	Spatial perception	2.77[a]	Triangulation/depth perception	4.2	Tactile sensation	4.15	Spatial perception	4.29[b]
4	Manual dexterity	2.86[a]	Manual dexterity	4.2	Manual dexterity	4.00	Tactile sensation	4.00[b]
5	Tactile sensation	2.05[a]	Tactile sensation	3.7	Triangulation	3.75	Manual dexterity	3.85[b]

[a]Significantly different ($p<0.001$) (Safir et al. 2008)
[b]Significantly different ($p<0.001$), this chapter

skills that are crucial for a resident to possess before continuing safe in the operating room.

An online survey was developed based upon the questions Safir and coworkers asked (Safir et al. 2008) and distributed using an open-source platform (www.limesurvey.org). An e-mail to present the research initiative and to invite to complete the online questionnaire was sent to about 1,000 members of ESSKA.

The survey on training knee arthroscopy encompassed 65 questions outlining fundamental skills of arthroscopy and methods that a surgical trainee might use to develop such skills. The survey consisted of 5 questions regarding generic skills and 10 regarding specific skills; 16 items about patient and tissue manipulation, 11 about knowledge of pathology, and 6 about inspection of the anatomical structures; 5 questions concerning practice methods to prepare residents; 3 items about global exercises; and 9 about detailed exercises that residents have to be trained for (Tables 2.2, 2.3, 2.4, 2.5, and 2.6).

Surgeons were asked to indicate the importance of each arthroscopic task on a six-point ordinal scale with explicit anchors at the extremes ranging from *not important at all* (score 1) to *very important* (score 6) in order to increase response variance while better discriminating central tendency bias. The results were later down sampled to a 5-point scale to guarantee comparability to other studies (the univariate analysis of the information lost in the down sampling would be out of the scope of the chapter) (Hui et al. 2013; Safir et al. 2008). Average completion time was 10.5 min and half (mean = 10.7 min, standard deviation = 7.1 min). The survey was kept open for 21 days, from the 5th of December 2013 to the 26th of the same month.

Statistical analyses were carried out using SPSS software. Results were considered statistically significant at the confidence level of 95 %, when P values were below the 5 % threshold. In order to verify whether the proposed items were considered significantly important for a novice resident, all responses were recodified in dichotomic variables considering scores of 1 and 2 as *not important* and scores of 4 and 5 as *important*. A chi-square test was conducted on the equality of response proportions *important* vs. *not important*. The 3 s in the middle were not included in this analysis for the down sampling process mentioned above; however, since those responses represented the opinion of the uncertain respondents, the verification of any polarization in the response distribution was not undermined by this discard. The rejection of the null hypothesis of

Table 2.2 Results of general skills

General skills	Priority level	Rank	Median	Mean
Anatomical knowledge	Level 1[a]	1	5	4.63
Triangulation	Level 1[a]	2	5	4.43
Spatial perception	Level 1[a]	3	4	4.29
Tissue manipulation	Level 1[a]	4	4	4
Manual dexterity	Level 1[a]	5	4	3.85

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

Table 2.3 Results of specific skills

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
Workup	Level 1[b]	6	4	4.09
Contact with patient	Level 1, ns	7	4	4.13
Tissue manipulation	Level 1, ns	8	4	4.05
Hand positions	Level 2, ns	9	4	3.95
Overall control in the OR	Level 2, ns	9	4	3.95

ns not significant
Level 1: high-level priority. Level 2: low-level priority
[a]Items with $p < 0.001$
[b]Items with $p < 0.05$

Table 2.4 Detailed results on patient and tissue manipulation, knowledge and pathology, and inspection of anatomical structures

Patient and tissue manipulation	Priority level	Rank	Median	Mean
Precise portal placement	Level 1[a]	1	5	4.56
Triangulating the tip of the probe with a 30° scope	Level 1[a]	2	5	4.41
Insertion of the arthroscope	Level 1[a]	3	4	4.23
Patient positioning	Level 1[a]	4	4	4.29
Entry of all compartments (medial/lateral/posteromedial, suprapatellar/intercondylar)	Level 1[a]	5	4	4.24
Judgment ligament stability (VKB, AKB, MCB, LCB)	Level 1[b]	6	4	3.74
Removal of loose bodies with grasping forceps	Level 1, ns	7	4	4.02
Joint stressing and holding of the leg	Level 2, ns	8	4	4.03
Palpation of articular surfaces with probe	Level 2, ns	9	4	3.98
How to find insertion needle	Level 2, ns	10	4	3.95
Shaving of synovium, cartilage, and meniscus	Level 2, ns	11	4	3.88
Placement of tourniquet	Level 2[b]	12	4	3.77
Exiting the joint and site closure	Level 2[a]	13	4	4.14
Use of vaporisator	Level 2[a]	14	3	3.21
Triangulating the tip of the probe with a 70° scope	Level 2[a]	15	3	3.1
Triangulating the tip of the probe with a 0° scope	Level 2[a]	16	3	2.95
Knowledge				
Knowledge of knee anatomy	Level 1[a]	1	5	4.73
Knowledge of sterility	Level 1[a]	2	5	4.48
Knowledge of ACL/PCL ruptures	Level 1[a]	3	4	4.26
Knowledge of sequence of inspection round in the knee	Level 1[a]	4	5	4.34
Knowledge of different types of meniscal tears	Level 1[a]	5	4	4.25
Knowledge of chondropathy (Outerbridge classification)	Level 1[a]	6	4	4.09
Knowledge of osteochondral defects	Level 1, ns	7	4	4.04
Knowledge of arthroscopy tower and instruments	Level 1, ns	8	4	4.04
Knowledge of corpus liberum	Level 2, ns	9	4	3.81
Knowledge of plica synovialis	Level 2[c]	10	4	3.79
Knowledge of Hoffa impingement	Level 2[a]	11	4	3.56
Navigation				
Inspection/identification of medial compartment: MFC, MTP, MM	Level 1[a]	1	5	4.4
Inspection/identification of intercondylar notch, including ACL and PCL	Level 1[a]	2	5	4.41
Inspection/identification of lateral compartment: LFC, LTP, LM	Level 1[a]	3	5	4.41
Inspection/identification of suprapatellar pouch and patellofemoral joint	Level 1[a]	4	4	4.27
Inspection/identification of lateral gutter	Level 1[a]	5	4	4.16
Inspection/identification of medial gutter	Level 1[a]	6	4	4.12

ns not significant
Level 1: high-level priority. Level 2: low-level priority
[a]Items with $p < 0.001$
[b]Items with $p < 0.05$
[c]Items with $p < 0.01$

equal proportions means that the respondents significantly assigned a high (or low) importance to the proposed items.

A qualitative ranking method was developed to identify the top-ranked items for a trainee to possess before entering an operating room. We performed the ranking of the features not by calculating the arithmetic mean of the single evaluations collected for each feature, which is a sort of conventional method for similar purposes. Indeed, this operation would be of little interest for ordinal values because

Table 2.5 Simulator preference

Simulator	Priority level	Rank	Median	Mean
Cadaveric specimen	Level 1[a]	1	5	4.27
Virtual reality simulator	Level 1[a]	2	4	3.67
Physical knee phantom equipped with sensors to track performance	Level 1[a]	3	3	3.56
Physical knee phantom (e.g., Sawbones model)	Level 1[a]	4	3	3.32
Box trainer model without specific knee characteristics	Level 1, ns	5	3	2.88

ns not significant
Level 1: high-level priority
[a]Items with $p < 0.001$

the assumption of uniformity along the whole scale would be untenable (i.e., the distance between 1 and 2 is not as great as the distance between 4 and 5), as well as the assumption that different raters could agree on what single values really mean (i.e., 5 for rater A is not 5 for rater B).

In light of these considerations, we rather proceeded in the following way: (1) we counted the number of times each feature was ranked first, second, third, and so forth according to the *standard competition ranking* strategy; this is a strategy by which features that compare equal receive the same ranking number, and a gap is left in the ranking numbers (or *1224* strategy); (2) we normalized the sum of all rankings thus associated with each feature by the number of times that feature was actually evaluated; (3) finally, we created the final ranking of features by putting them in decreasing order from the feature with the lowest normalized rank sum to the feature with the highest sum.

Even with this method (let alone with arithmetic means), differences in ranking between single features are often negligible: this means that we cannot assert whether differences between features are due to chance (or to selection bias) or not, instead of being related to real differences in the perceived importance of respondents.

Table 2.6 Results of ranking exercises to train basic arthroscopic skills

Global exercises	Priority level	Rank	Median	Mean
Identification of structures and navigation with the arthroscope	Level 1[a]	1	5	4.46
Instrument handling	Level 1[a]	2	5	4.33
Preparation of patient and equipment	Level 1[a]	3	4	4.22
Detailed exercises				
Portal placement	Level 1[a]	1	5	4.66
Anatomical knowledge: Identification of different compartments, intercondylar notch including ACL and PCL, all important structures in the joint	Level 1[a]	2	5	4.6
Inspection with the arthroscope	Level 1[a]	3	5	4.54
Navigation by visualization of structures and probing them	Level 1[a]	4	5	4.41
Insertion arthroscope in anterolateral portal	Level 1[a]	5	5	4.37
Triangulation such as pick up a ball with a grasper, place the probe through a ring, and remove corpus liberum	Level 1[a]	6	5	4.26
Meniscectomy	Level 1[a]	7	4	4.22
Tissue manipulation	Level 1, ns	8	4	3.98
Meniscal suturing	Level 1, ns	9	4	3.76

ns not significant
Level 1: high-level priority
[a]Items with $p < 0.001$

Thus, we also proceeded with a prioritization process and grouped the features in priority levels. To this aim, we counted the number of times each feature ranked in the first three positions for each respondent (n) and the number of times the same feature came in any other position (m). Then, we assigned each feature to the *high priority level* if n was greater than m and to the *low priority level* otherwise. Then, we also performed a chi-square test to evaluate the statistical significance of the difference between *n* and *m*, which in its turn could have been due to chance.

This created a feature prioritization process through which we assigned each feature to either two priority levels: higher priority (Level 1) and lower priority (Level 2). The reader should not consider features in Level 2 irrelevant, but only less relevant than those at Level 1 (on the other hand, absolute relevance is estimated with chi-square tests as reported above). However, some features could not be assigned to a priority level with statistical significance, as the repetition of this survey or involving different raters could lead to different assignment (no generalizability of results). Thus, we distinguish between Level 1 and Level 2 but we also indicate whether the assignment is significant, that is, independent of the specific sampling and consequently generalizable, or, conversely, likely due to chance. To this aim, we indicate if the assignment is significant (features with an asterisk *) or not (indicated with *ns*).

We believe that this way to proceed to analyses responses makes more sense than traditional mean-based ranking, as it allows interested researchers to detect what features should be really considered more important than the others, also in those surveys where most of the features were actually considered either relevant or very relevant, as it is in our case. Consequently, as a recommendation for decision-making, we consider priority levels first, in order to understand where to focus the main teaching efforts (high-level features first, then low level ones), and then take the single feature ranking to articulate more fine-grained interventions and teaching loads with respect to specific features that junior surgeons have to master.

2.3 Results of ESSKA Survey

A total of 195 orthopedic surgeons responded to the survey (response rate 19.5 %). Sixty-seven percent of the respondents had more than 10 years of personal experience in doing knee arthroscopy. The number of knee arthroscopies performed by respondents in the last year was more than 400 for 11 % of the respondents, between 200 and 400 for 25 % of the respondents, between 50 and 200 for 46 % of the respondents, and less than 50 for the remaining 17 %.

A chi-square test of independence was performed to examine the difference in proportions between those who assigned a low importance to each item (response value 1 or 2) and those who assigned a high importance (response value 4 or 5). Except for triangulating the tip of the probe with a 0° scope, with a 70° scope, and box trainer model without specific knee characteristics ($p > 0.05$), the difference between these two proportions was significant for all variables ($p < 0.001$). This means that for these variables, the sample exhibited a strong polarization in their response considering the related skills "important to be mastered" in a statistically significant manner.

All general skills were considered important in equal manner by respondents as they were assigned to Level 1 of priority ($p < 0.001$) (Table 2.2).

The qualitative ranking method showed that anatomical knowledge was the most important skill, followed by triangulation and spatial perception (Table 2.2).

Even if sterility, knowledge of pathology, patient positioning, preparation before the operation, knowledge of equipment, and workup were ranked from 1 to 6, these specific skills were assigned to same level of priority (Level 1) ($p < 0.001$ and $p < 0.05$) (Table 2.3). Similarly, contact with patient and tissue manipulation (ranked from 7 to 8) were allocated to Level 1, but this result did not achieve the statistical significance (Table 2.3). Finally, the least important skills including hand positions and overall control in the operating room were allocated to an inferior priority level (Level 2) (Table 2.3).

Although precise portal placement was the most important feature investigating patient and tissue manipulation, features that were ranked from 1 to 7 were all assigned to high priority level (Level 1) (Table 2.4) whereas an inferior importance was observed for features ranked from 8 to 16 (Level 2) (Table 2.4).

In regard to the knowledge section, features ranked from 1 to 6 were perceived relevant in equal manner (Level 1, $p<0.001$) (Table 2.4). Features from 7 to 8 achieved the same level of importance without statistical significance (Level 1, ns). Knowledge of corpus liberum, of plica synovialis, and of Hoffa impingement (ranked from 9 to 11) was considered less relevant as they were assigned to Level 2 (Table 2.4). All features of navigation section were considered important in equal manner by respondents as they were allocated to same level of priority (Level 1) (Table 2.3).

2.4 Preferred Training Means

Vitale and coworkers (2007) created a survey to evaluate the methods by which orthopedic surgeons are trained in the skill of all-arthroscopic rotator cuff repair. When ranking the relative importance of resources in the training for all-arthroscopic repair, the overall Likert scale scores were highest for a sports medicine fellowship (3.49), hands-on instructional courses (3.33), and practice in an arthroscopy laboratory on cadaver specimens (3.22). Likert scores were lowest for residency training (2.02), practice on artificial shoulder models (2.13), and Internet resources (2.25). Safir and coworkers (2008) also suggested that high-fidelity simulation is preferred for training over low-fidelity benchtop models. Hui and coworkers (2013) found that higher-fidelity simulation models such as cadaveric specimens or the use of synthetic knees were preferred over lower-fidelity simulation models such as virtual reality simulators or benchtop models.

In the ESSKA survey, although cadaveric specimen was the top-ranked practice method to prepare a trainee before performing in the operating room, all practice methods were allocated to Level 1, and except for the box trainer model without specific knee characteristics, all items achieved the significance (Table 2.5).

All global exercises were considered relevant in equal manner by respondents as they were assigned to the highest level of priority (Level 1) (Table 2.6). Focusing on specific exercises, although portal placement, identification of joint structures, and inspection with the arthroscope were ranked as the top three, all features achieved the same level of importance (Level 1) (Table 2.6).

2.5 Training to Become Competent

Arthroscopy is a core orthopedic skill and knee arthroscopy is the most common orthopedic procedure performed in the United States (Cullen et al. 2009). It is also the most common procedure recorded on case lists at the time of certification by the American Board of Orthopaedic Surgery (ABOS), with the numbers performed seen to be more than twice that of the second most common operation (Garrett et al. 2006). Review of the logbooks of candidates undertaking the oral component of the American Board exam also showed that five of the top eleven procedures involved arthroscopy. Knee arthroscopy has also been shown to constitute 30 % of all orthopedic procedures performed in Europe (Grechenig et al. 1999). 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 skills sets to open surgery (Allum 2002; Hanna et al. 1998). 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 arthroscopic techniques as they did in open techniques (Hall et al. 2010).

The opinion of faculty was documented on how many repetitions an average resident needs in the operating room to become proficient in arthroscopic procedures. O'Neill and coworkers (2002) 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 (2007) stated that 41 diagnostic knee scopes (SD 18), 65 partial medial meniscectomies (SD 9), 88 partial lateral meniscectomies (SD 18), and 117 ACL reconstructions (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 (Koehler and Nicandri 2013). 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 (Castricini et al. 2013; Hoppe et al. 2014). An interesting result was that the absolute minimum number of repetitions needed to achieve proficiency was indicated to be 5–8 for any arthroscopic procedure (O'Neill et al. 2002).

2.6 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 theatre. Even if this is a matter of concern, only few studies to date have tried to determine the relevance of skills that a simulator or training protocol should teach to young orthopedic surgeons.

2.7 Learning Objectives for Simulation Training

Knowledge on anatomy of the knee joint was ranked as the top one (Hui et al. 2013; Safir et al. 2008). This skill does not require actual instrument handling during training. As performing arthroscopy is largely dependent on visual cues received from the monitor, arthroscopic anatomy is suited to be taught outside the operating room, for example, using interactive e-learning modules that incorporate arthroscopic movies, pictures, and animated joint structures or using virtual reality simulators which also provide movies and sometimes specific exercises focused on anatomy in combination with spatial perception (Obdeijn et al. 2013; Tuijthof et al. 2011). One other solution being explored is to use online simulators, where the program is held on a central server and where the simulator addresses those aspects of a surgical task that do not require a complex end-user controller that is expensive and fixed in one geographical location (Hurmusiadis et al. 2011). The other general skills do require actual instrument handling (Chami et al. 2008).

In general, the top five specific skills to be trained reflect the basic steps required to gain access and navigate into the joint. This seems straightforward as knowing your way in the joint will contribute to safe performance of the therapy.

2.8 Preferred Training Means

Questioning experts and residents what training means they prefer, cadaver courses are ranked number one followed by high-fidelity simulators (e.g., synthetic knee), virtual reality simulators, and box trainers.

Although arthroscopic simulators have the potential to enable residents and surgeons to further develop their skills in a safe environment, definitive conclusions on whether simulator training correlates to an improved arthroscopic skill set in the operating room are still not available (Frank et al. 2014). Moreover, as of now, none of the available trainers allows repetitive training of the most important skill: portal placement.

2.9 Training to Become Competent

Results of surveys have shown that at least up to eight patients are at risk at the start of each resident training program. An ideal situation is that before residents continue their training in the operating room, they should have achieved a competency level that guarantees safe arthroscopic treatment on their first patient. Logically, this should be one of the primary learning objectives for training arthroscopic skills in a simulated environment.

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