How to Create an Arthroscopy Training Laboratory Using a Bovine Knee Model

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Abstract: Orthopaedic surgeries by video arthroscopy have become increasingly popular, as they allow joint treatment through small incisions and minimal tissue damage. However, their execution requires specific skills from the surgeon, different from open surgery, which can only be achieved through practical training. These skills would be ideally performed on human cadaveric anatomical pieces which, however, can be difficult to access for different reasons. Animal anatomical models for surgical skills training have been used for years in medicine, and we observed that the bovine knee has anatomical characteristics quite similar to that of the human knee. In this study, we explain, step by step, the installation and creation of an arthroscopy laboratory with a bovine model, in an effort to contribute to several training centers in arthroscopic surgery around the world, assisting and guiding such centers to install arthroscopy laboratories and facilitating the improvement of more surgeons.

The ideal training to improve the arthroscopic skills of trained surgeons and specialist surgeons is on human cadaver parts.[1] However, there are several difficulties in obtaining human anatomical pieces, such as their high cost (which can reach \$500.00 for each piece), storage requirements, and ethical issues.[2-4] Alternatives to the use of human cadavers are training with artificial models, 3-dimensional simulators, and animal anatomical models, such as porcine and bovine knee.[4-7] Simulators and artificial models have the advantage of easy repetition of training,[8,9] but they do not replicate the exact reality of the procedure, such as contact with the texture and resistance offered by human and animal tissue, for example.[7]

Several studies have already shown that some anatomical animal models are very close to humans and therefore apply well to the training of open and arthroscopic surgical skills.[1,9,10] The bovine model has already been used in several studies and shown itself to be an adequate animal model for arthroscopic training, mainly for arthroscopic triangulation training.[1,6,11] In this article, we describe, step by step, how to set up an arthroscopy laboratory with an anatomical animal model.

Technical Note (With Video Illustration)

Obtaining and Preparing the Anatomical Piece

The anatomical bovine piece can be obtained in commercial establishments that sell bovine meats, such as slaughterhouses and butcher shops. We request a bovine knee (left or right) already without the skin (Fig 1A), and we ask the employee of the commercial establishment to

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The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Filming was performed in the arthroscopy laboratory of National Institute of Traumatology and Orthopedics of Brazil with bovine cadaver knee.

Received February 16, 2021; accepted April 2, 2021.

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2212-6287/21188
https://doi.org/10.1016/j.eats.2021.04.007

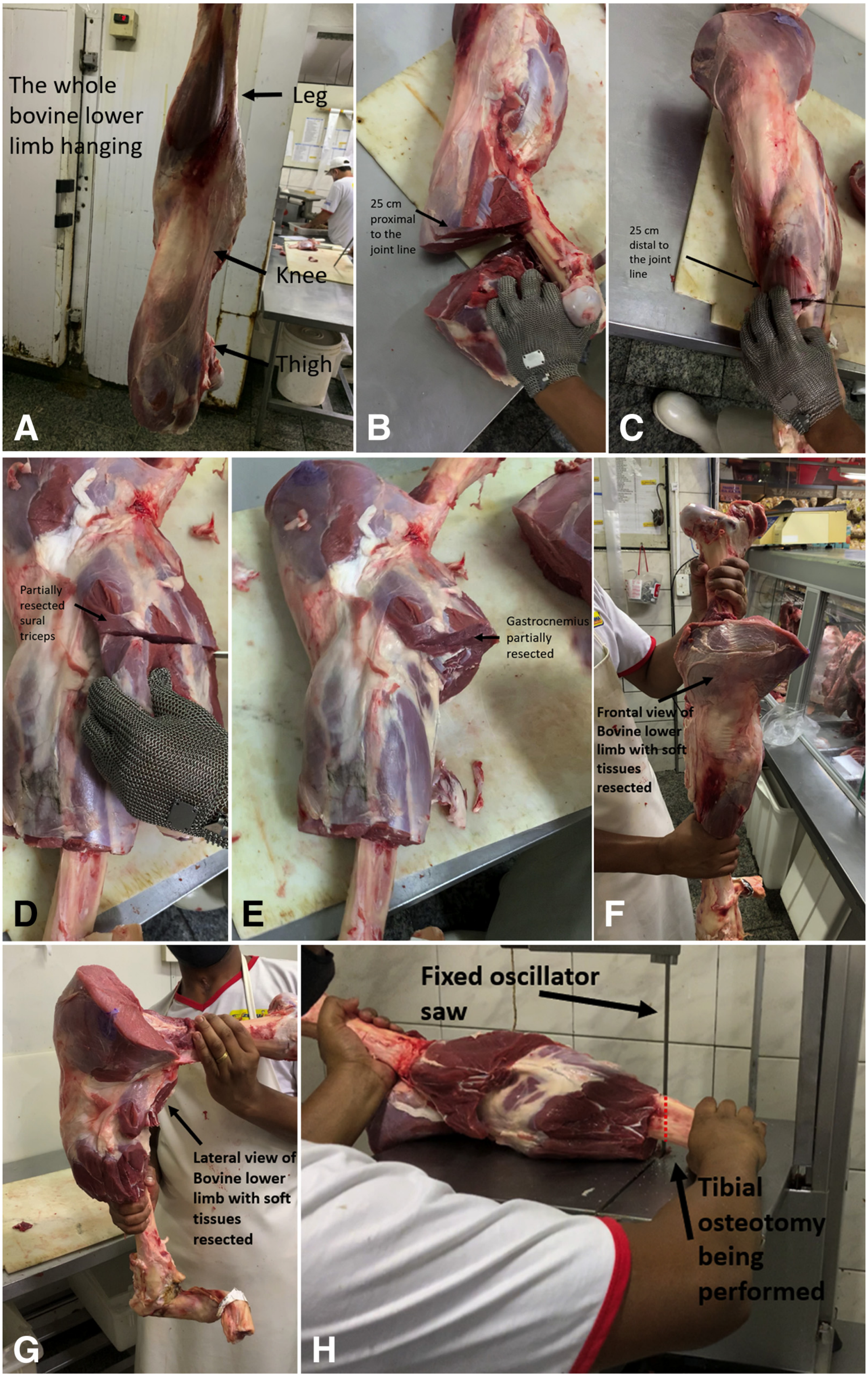

Fig 1. (A) The whole bovine lower limb, hanging in the commercial establishment. (B) Soft-tissue resection 25 cm proximal to the joint line. (C) Soft-tissue resection 25 cm distal to the joint line. (D) Partially resection of the sural triceps. (E) Gastrocnemius partially resected. (F) Frontal view of bovine lower limb with soft tissues resected. (G) Lateral view of flexed bovine lower limb with soft tissues resected. (H) Tibial osteotomy being performed with a fixed oscillatory saw.

remove the soft tissues 25 cm proximal to the joint line in the femur (Fig 1B) and 25 cm distal to the joint line in the tibia (Fig 1C). Myotendinous tissues at the joint level must be kept intact. In bovine models, the muscular thickness of the sural triceps is too thick, considerably increasing the weight of the anatomical piece and, therefore, to facilitate handling, this tissue can be sectioned, facilitating its use (Fig 1 D and E). In this way, the frontal and lateral views of the knee with the femur and tibia are still intact (Fig 1 F and G). Then, transverse

Fig 2. (A) The room chosen to be an arthroscopy laboratory, equipped with a tap with running water, drain in the ground, adequate lighting, and sockets for 110 and 220 volts. (B) A large bucket used to capture the arthroscopy water, and the pleasure pliers fused to a vise. (C) Water tap with its original tip. (D) Adapters are necessary to be able to attach the arthroscopy serum set to the water tap. (E) Water tap without its original tip. (F) Water tap with the first adapter that will allow the attachment of the serum. (G) Arthroscope serum equipment attached to running water tap with all adapters. (H) The arthroscopy serum attached to the water tap working. (I) The bovine coupled to the pressure pliers, a large bucket used to capture the arthroscopy water, and the surgical instrumental table water tap being prepared to couple the arthroscopy serum equipment. (J) Pressure pliers fused to a vise.

tibial and femoral osteotomy are performed approximately 20 to 25 cm distal to the joint line (Fig 1H).

Physical Aspects of the Arthroscopy Laboratory

For installation of this type of laboratory, we need a room that measures at least 20 m^2. It must be equipped with a tap with running water, a drain in the ground, adequate lighting, and plugs for 110 and 220 volts (Fig 2 A and B). In this room, we adapt a tap of running water to couple a path of the arthroscopic 4-way equipment in this tap (Fig 2 C-H). A container similar to a large bucket is also needed to capture the water that leaks out during the surgery (Fig 2I). We use a fixed bench (or other similar surface), with pressure pliers welded to a vise attached to fix the anatomical model, supported by a resistant metallic cube used to wash one's hands (Fig 2J).

Arthroscopy Equipment

We need an optic (Stryker, Kalamazoo, MI), a fiberoptic cable (Stryker), an appropriate serum set with trochar and arthroscopic camera (Stryker), in addition to a shaver handpiece loaded with a 3.5- to 4.5-mm blade (Stryker). They will be connected to an arthroscopy tower with monitor (Stryker), camera controller (Stryker), light source (Stryker), and shaver console (Stryker) at about 1 m distance from the surgeon and within his or her field of vision, next to the anatomical piece (Fig 3A).

Basic surgical instruments with straight and curved duckbill arthroscopy forceps, scalpel with blade, Kelly forceps, and Metzenbaum scissors are also required (Fig 3B). It is important to note that all of these materials available to the laboratory must remain in this location and are no longer used in patients.

Performing Arthroscopy in the Bovine Anatomical Model

The anatomical piece is stored frozen in a traditional freezer at about −15 to −18°C. We leave the anatomical piece outside the freezer for about 24 hours to thaw before training. If it still feels stiff at surgical time, we immerse the part in warm water until entirely defrosted.

The proximal third of the bovine femur is secured by means of pressure pliers welded to the support base previously fixed to the metal bench through the pressure vise. We test the fixation, observing whether it is adequate, and thus avoid possible accidents. We test the knee flexion extension. We identify the patella and patellar tendon (Fig 4A) and create standardized medial, lateral, and transpatellar portals.

We introduce the arthroscopic trochar through the anteromedial portal, through the optics enter, allowing us to view the interior of the joint and where the knee is irrigated. Once inside the joint and with clear visualization, we enter with the shaver blade through the opposite portal and begin the debridement and cleaning of the synovial and "Hoffa" fat, that is usually hypertrophied in this animal model (Fig 4, B and C). The arthroscopy laboratory is finally ready for training on various surgical techniques and skills (Video 1).

Discussion

Training is essential for the development of surgical skills, especially for arthroscopic procedures, both for doctors in training and for the improvement and development of new surgical techniques in more-experienced surgeons.[1,9,11-14] Included in this article is a detailed description of how to set up a laboratory of arthroscopy that will facilitate orthopaedic training centers around the world in setting up training stations in their respective services. Advantages, disadvantages, risks, and limitations of an animal model arthroscopy laboratory are shown in Table 1.

Unalan et al.[11] conducted a study evaluating arthroscopic training in bovine knees with 64 participants who were submitted to theoretical classes followed by hands-on practical classes in animal models. The

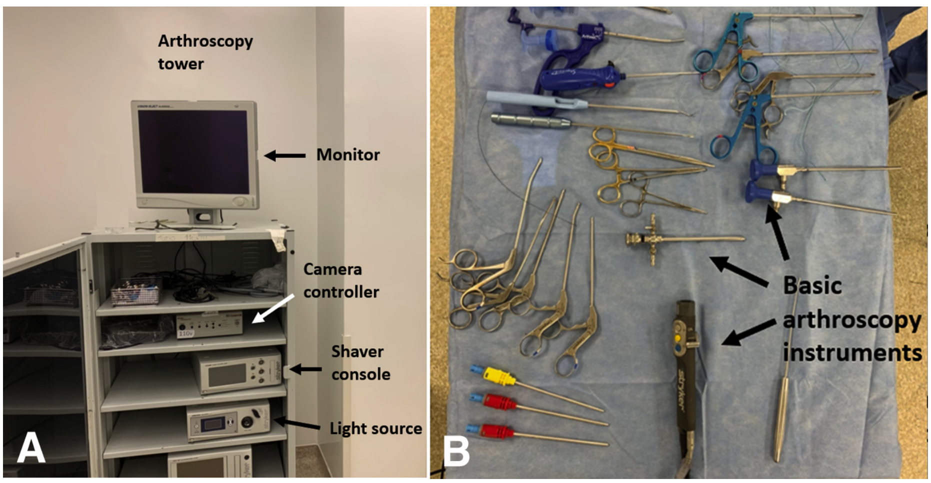

Fig 3. (A) Arthroscopy tower with camera controller, shaver console, light source, and the monitor. (B) The basic arthroscopy instruments on the surgical table, like trochar, shaver and shaver blades, and curved duckbill arthroscopy forceps.

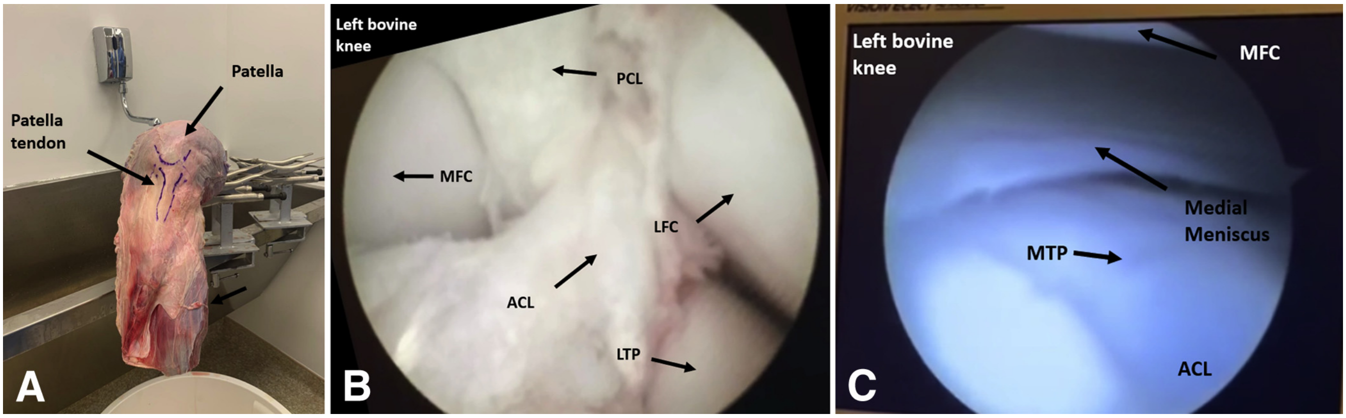

Fig 4. (A) The bovine knee fixed to the pressure pliers, with the patella and patellar tendon marked with dermographic pen. (B) Arthroscopy view of a left bovine knee, with posterior cruciate ligament (PCL) anterior cruciate ligament (ACL), medial femoral condyle (MFC), lateral femoral condyle (LFC), and lateral tibial plateau (LTP). (C) Arthroscopy view of a left bovine knee viewing the medial meniscus, medial femoral condyle, and medial tibial plateau (MTP).

training was carried out on 2 consecutive days with a daily load of 8 hours. At the end of the course, the participants were asked about their satisfaction in carrying out the training on a scale of 1 to 5, with 1 being very dissatisfied and 5 very satisfied, and most of them were very satisfied (4.36 ± 0.47). Before the research was started, the participants made a self assessment of their arthroscopic skills. They answered on a scale of 0 to 10, where 0 meant the participant declared him or herself incompetent to perform an arthroscopy alone and where 10 meant he or she declared themselves competent to perform an arthroscopy alone. In the pre-course, the average result was 4.2 and at the end of the course the average was 7.7. The authors concluded that arthroscopic training with bovine knee is accessible, inexpensive, safe, and manages to improve the arthroscopic skills of surgeons.[11]

In 2017, Kim et al.[15] published a study evaluating the feasibility of arthroscopic training in porcine knees. They studied 14 participants (5 residents in orthopaedics and traumatology in the first and second years; 5 in the third year; and 4 fellows in orthopaedics), who underwent 3 training sessions, one per week, for 3 weeks. The authors use the Arthroscopy Surgery Skill

Table 1. Advantages, Disadvantages, and Risks Associated of an Arthroscopy Laboratory With an Animal Model

Advantages	Disadvantages	Risks	Limitations
Great ease in obtaining an animal anatomical model	There is no bleeding as in a real arthroscopic procedure	The training participant may be injured by a surgical instrument	A room is required that is exclusive for the installation of this laboratory
The bovine knee has a very similar anatomy to that of the human knee	Bovine menisci is a slightly more rigid than human menisci	Chondral or meniscal injuries can be found in the bovine model, hindering the possible planned training	A conventional freezer must be available to store the bovine knee after use. In general, we can reuse the animal model 3 to 4 times
Various arthroscopic surgical techniques can be trained	The medial compartment is a little bit tighter. Frequently, we perform a pie crust of a medial collateral ligament		The anatomical model must be defrosted 1 day before training
Low cost to set up and keep the laboratory running, because the laboratory can be assembled with used monitors and consoles purchased at a lower price	A small learning curve is necessary to get used to the bovine model		
Training of experienced surgeons with new techniques and new surgical devices			
Training of resident doctors and surgeons in training, learning, and improving arthroscopic skills			
Due to the anatomical model sold in a butcher shop, legal ethical barriers are lesser			

Evaluation Tool (ASSET) score. This score analyzes the following skills: safety; field of view; camera dexterity; instrument dexterity; bimanual dexterity; flow of procedure; and quality of procedure; autonomy. The ASSET score can range from 8 to 38. The researchers found an improvement in the average of the ASSET score from 21.8 to 24.9 and also an average time spent in the first training from 242 seconds to 207 seconds in the third training. They concluded that the porcine animal model provides adequate training for residents and young orthopaedic surgeons.[15]

Recently, Garfjeld Roberts et al.[8] conducted a randomized controlled trial in which the authors divided orthopaedic surgeons in specialization into 2 groups; one group, considered the intervention group, was subjected to regular weekly arthroscopic simulation training and in the other group, the control group, participants received standard training from the hospital without regular weekly training. The intervention group was composed of 15 participants and the control group was composed of 13 participants. Participants used a sensor attached to the elbow that measured hand movement during the performance of arthroscopic training in all stages of the study. In this training, participants were instructed follow a predetermined checklist of tasks, such as palpating the medial meniscus and medial femoral condyle. After completing 13 weeks of weekly training, participants entered the surgical field in a real arthroscopic procedure, with the elbow sensors attached, supervised by an experienced surgeon who did not know in which group the resident doctor participated. Participants performed the same tasks as the checklist used in the previous training. The authors observed that the intervention group obtained the best results. The participants in this group performed the tasks with fewer hand movements and with less execution time than the control group. The authors concluded that simulated surgical training improves technical skills and intraoperative performance.[8]

Another study published in 2020 showed, in a systematic review, that arthroscopic training in artificial models also can improve surgical skill. It is also an important arthroscopic training method for surgeons who are learning.[16]

However, the use of animal anatomical models such as porcine and bovine are facilitators of surgical skills and technique training, as they are easily accessible,[9,11] affordable (around $25.00 for a bovine knee),[11,14,17] easy to store, and easy to obtain.

The best surgical training laboratory model is undoubtedly the use of human cadavers because they faithfully represent what will be found by the surgeon in real life, but for the reasons set out throughout the text, we suggest services that provide education for doctors in orthopaedics use animal models such as bovine and porcine for the improvement of arthroscopic skills.

Our group recently published promising new surgical techniques in the treatment of meniscal injuries. It is a line of research that involves a type of meniscal suture called continuous meniscal suture.[18-21] In the absence of a laboratory with human cadavers, training with animal models becomes an important method to assist in the training of these and other new arthroscopic surgical techniques.

We believe that this article will help and stimulate several centers around the world to set up their own arthroscopy laboratories, improving the surgical skill and the clinical outcomes of surgeries performed by surgeons trained in such laboratories.

Acknowledgments

The authors thank Alexandre Lima, owner of the Zequinha Supermarket, located in the city of Juiz de Fora (Minas Gerais, Brazil), for providing access to the refrigerator and being able to prepare the bovine models. We also thank João Marcelo Soares Dias da Costa and Marco Antonio Oliveira Frutuozo for logistical support. Filming was performed at Arthroscopy Laboratory of the National Institute of Traumatology and Orthopedics of Brazil.

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