A Knee Model for Arthrocentesis Simulation

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Abstract

Objectives : To produce a knee model for medical students and residents to practice knee aspiration and intra-articular injection.

Material and Method : The model was made of plastic, rubber and silicone that included the lower third of the femur, the upper third of the tibia and the patella. They were fixed on 2 plastic boxes in the anatomical position and the boxes were connected together with 2 small hinge joints. A rubber bag was made in the pattern of synovial space of the knee. Quadriceps, anterior muscles of the leg and patellar tendon were also presented. The model was covered with silicon sheet, representing the skin. Water was used to fill up the synovial bag to simulate joint aspiration *via* supero-lateral approach with the knee in extension. The model was appraised by 30 medical students, 26 orthopedic residents and 10 orthopedic staff in terms of size, anatomy, physical examination, feeling during aspiration, need of the model in education and commercial use.

Results : Most of the medical students, residents and staff (80-90%) were satisfied with the model and rated it as good to very good teaching media. However, the model should come out in different sizes and the synovial bag should be modified to improve the ballotment test. Mass production of the model should be done.

Conclusion : The knee model is an acceptable teaching model for arthrocentesis simulation with affordable cost.

Key word : Medical Education, Arthrocentesis, Knee Model

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According to the curriculum of doctors of medicine, Faculty of Medicine, Siriraj Hospital, Mahidol University, arthrocentesis or synovial joint aspiration is one of the clinical procedures that all medical students must learn and should have the competency to perform knee joint aspiration[1]. During the clinical years, not every medical student has the chance to perform arthrocentesis under the supervision of their teachers. Furthermore, it is not a good step for a student to start to practice arthrocentesis on a patient. There are a few knee models for practicing knee joint aspiration on the market. They are very expensive and no model demonstrates the anatomy outside the knee. Furthermore, the rubber bag in the model, representing synovial space, can not be repaired. After a certain number of aspiration the rubber bag has to be replaced. It was the aim of the authors to produce a model of the knee for arthrocentesis simulation that can demonstrate the anatomy of the knee and also be repairable. It must also be marketable in affordable price.

MATERIAL AND METHOD

A cadaveric right lower third femur, right upper third tibia and right patella of an adult female were used as the initial template. The femur and tibia were placed in the anatomical position to form the right knee joint. They were fixed together with a block of clay. The clay was crafted to be the posterior part of the right knee. The clay block was separated transversely into two blocks at the joint line. Plaster of Paris was used to make the molds of these two initial templates and the patella. Then, hard plastic was used to make the knee model from the molds. The two parts were fixed together by two small copper hinges. The hinges allowed some degree of flexion from zero degree to 15 degrees. The quadriceps muscle and the muscles of the anterior compartment of the leg were built up on the plastic model with clay. The synovial space and articular cartilage were also outlined by the clay. The clay models were crafted and shaped to the anatomical configuration of those structures. They were used for producing the plaster of Paris mold for the muscles and synovial bag. Soft rubber was used to make the quadriceps and the muscles of the leg models from the molds. The synovial space and joint capsule were made of two thin rubber sheets, like a bag, from the molds that could be fixed in the anatomical position between the femoral and tibial condyles (Fig. 1). The synovial bag was placed under the patella

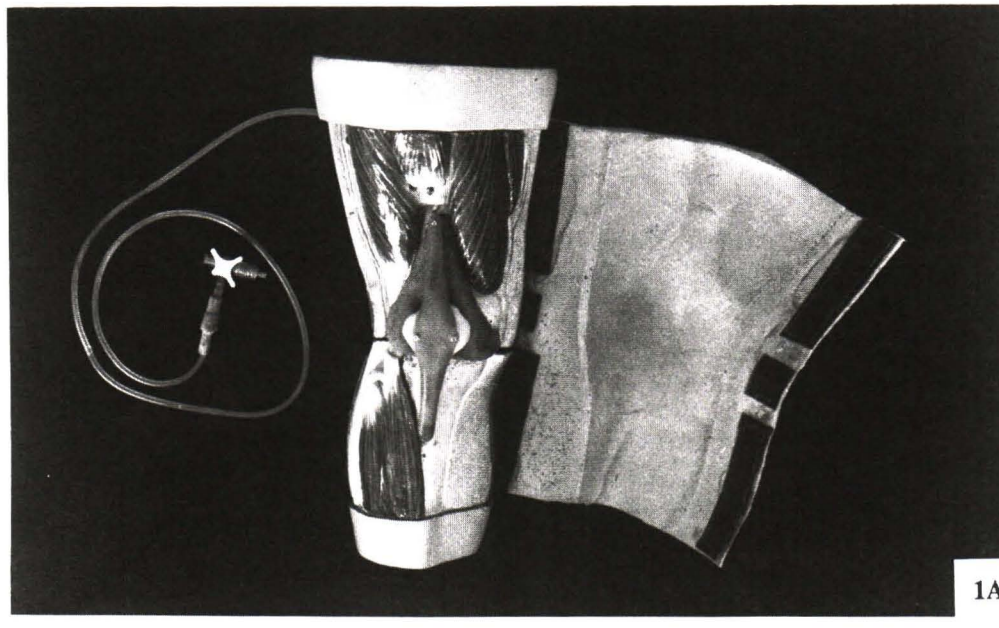

Fig. 1A. The model consists of femoral and tibia components, connected together with springs and rubber tubes. The normal anatomy around the joint is also demonstrated.

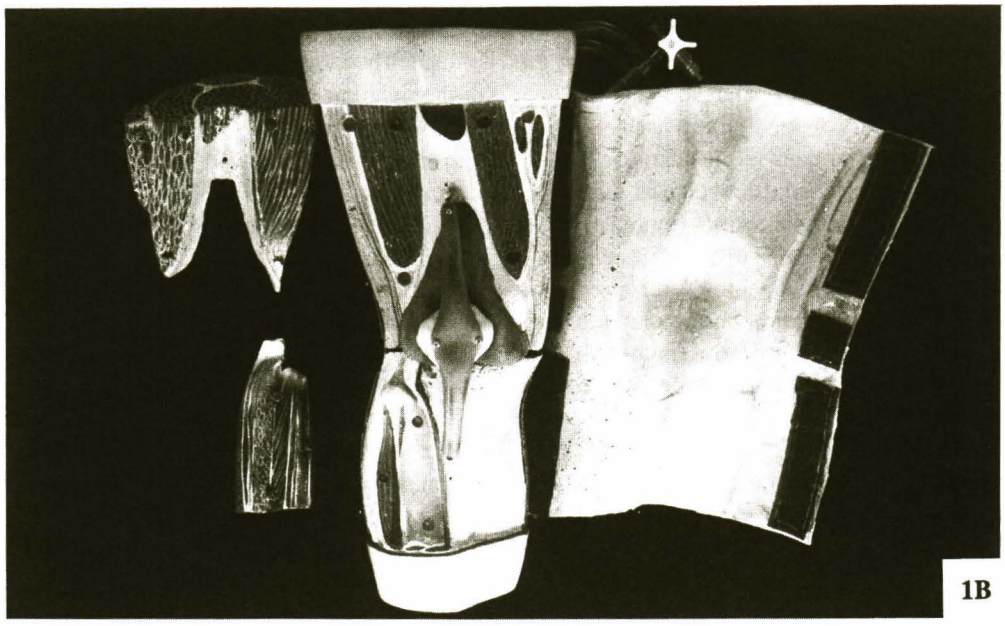

Fig. 1B. Quadriceps and anterior muscles of the leg can be removed and the synovial space is represented by a rubber bag.

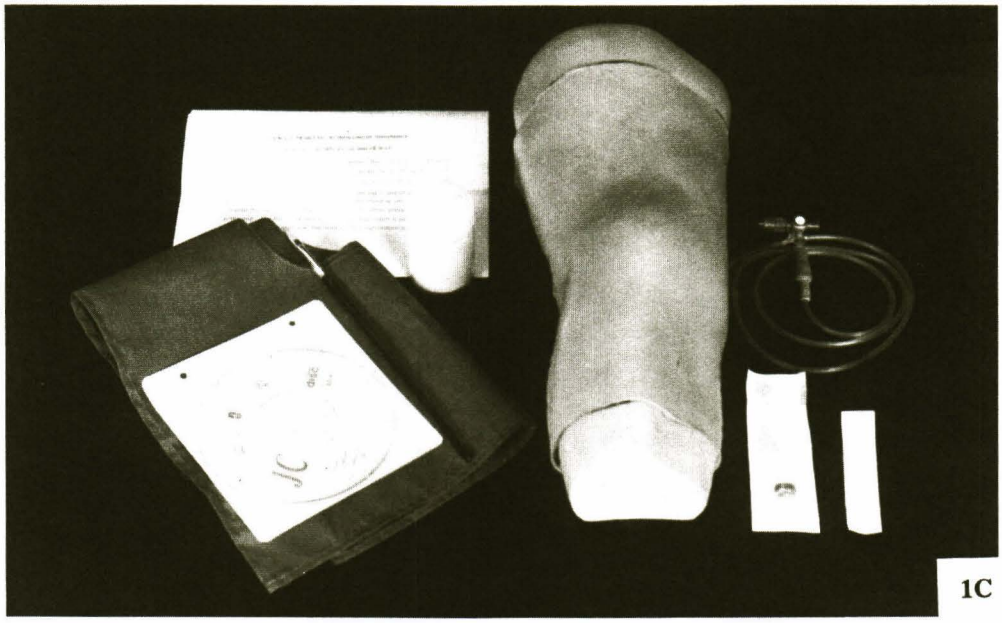

Fig. 1C. A set of knee model consisting of the model, a bottle of rubber latex and a brush, needle and syringe, surgical drape cloth and a instruction manual CD.

and extended up to form the supra-patellar pouch. At the infero-posterior aspect of the rubber bag, a small tube was connected to the bag and the other end of the tube was connected to a three-way stopcock. The tube was used for filling up the synovial bag with water, to simulate synovial fluid. The patella was fixed to the femur and tibia by small coiled springs and screws. The springs were covered with 1 cm in diameter rubber tube to represent the patellar tendon. Then, a well-crafted thin silicone sheet was made for covering the model and represented the skin and subcutaneous tissue around the knee. The model was evaluated by 10 orthopedic staff, 26 orthopedic residents and 30 medical students about the anatomy of the knee, size, ability to perform the ballotment test and feeling during aspiration at the supero-lateral aspect of the knee model with the knee lying in full extension. Their suggestions were recorded and used for further development.

The steps of evaluation of the model were similar to the steps of knee aspiration under sterile technique. The model was placed on a table similar to the patient's knee at full extension. The coverage of the model or the skin was prepared and scrubbed with liquid soap. Then, the model was painted with antiseptic solution. The model was draped with a piece of surgical cloth with a central hole, 8 cm in diameter. The hole allowed the one who evaluated the model to expose the anterior part of the knee and the patella. The supra-patellar pouch was identified by palpation and a 21 G, long needle with 5 ml syringe was passed deep to the patella into the supra-patellar pouch. Successful aspiration was indicated when water in the rubber bag was taken and the needle did not strike the femur or the patella.

RESULTS

Concerning the size of the knee model, most of the medical students (29/30 or 96%), residents (23/26 or 88%) and staff (8/10 or 80%) felt that the model was very good and good (Table 1). However, larger models, representing an average Thai male, and degenerated knee model were requested. The model was also rated as very good and good in terms of anatomy by most of the medical students (28/30 or 93%), residents (20/26 or 76%) and staff (9/10 or 90%). Rating of feeling during aspiration by most of the evaluators was still high (Table 1). All except two medical students and one resident could not obtain water from the rubber bag while practicing arthrocentesis. Re-orientation and demonstration of the

Table 1. Results of evaluation of the knee model by the orthopedic staff, residents and medical students.

	Size			Anatomy			Physical examination			Feeling during aspiration			Need			Marketing		
	Staff	Residents	Medical student	Staff	Residents	Medical student	Staff	Residents	Medical student	Staff	Residents	Medical student	Staff	Residents	Medical student	Staff	Residents	Medical student
Very good ; Very much	7	9	25	4	8	24	2	5	18	6	17	20	7	20	20	7	18	15
Good ; Must be	1	14	4	4	12	4	5	14	8	4	5	7	3	6	10	3	6	14
Fair	2	3	1	2	5	2	2	5	2	-	4	3	-	-	-	-	2	1
Poor	-	-	-	-	1	-	1	2	2	-	-	-	-	-	-	-	-	-
Unacceptable ; Not at all	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

anatomy of the model by removing the coverage was needed. All achieved successful aspiration later. The model has limitation in terms of physical examination because only 26 medical students (86%), 19 residents (73%) and 7 staff (70%) rated the model as very good and good. However, all felt that this model should be included in the skill lab for psychomotor training of medical students (Table 1). Mass production for commercialization was also suggested by most of the evaluators.

DISCUSSION

Knee arthrocentesis is one of the clinical skills that doctors of medicine must have competency in[1-3]. To lessen the risk of patients whom will undergo knee aspiration by medical students various subjects such as cadaveric knee, knee model and computer assisting programs have been used[4-6]. However, because of the limitation in preserving, a cadaveric knee is not commonly used. An animal knee has been used but it was much different from a human knee. A computer-assisting program is still being developed and can not provide the proper feeling of joint aspiration. Knee models, which are now available in some teaching centers, are very expensive and cost of maintenance is also high.

The presented knee model was made locally in the faculty and could be purchased at the price of one-eighth of the imported model. Furthermore, the rubber bag can be easily repaired by applying rubber latex on the bag after 50 to 70 aspirations. The leakage at the bag can be sealed promptly.

Even though the results of evaluation of the knee model concerning most of the indicators revealed very good to good in rating and the model should be used in the skill training of medical students, to obtain better rating in terms of physical examination, the soft rubber bag, representing the synovial space, must be re-designed. The problem is how to fix the soft rubber bag to the patella and the femoral condyle directly and include them as part of the synovial space. So, the surface of these two bones could directly contact each other during the ballotment test, which may provide better feeling.

The model has limitations in motion because it could be flexed from zero degree to 15 degrees only. The rubber bag was not flexible enough to allow free motion along the joint line, so, it might resist the motion. Furthermore, the model needs a stable and large enough support for practicing skin preparation and draping and the two small hinge joints, connecting the femoral part to the tibial part, had to be fixed in the eccentric position. These two factors caused limitation in the motion of the model. The silicone sheet, which was representing skin and subcutaneous tissues was not flexible enough to allow knee flexion beyond 20 degrees. Re-shaping of the silicone sheet is being further developed.

SUMMARY

The presented knee model is an interesting learning media, which should be used in the skill lab. It allows the medical students to practice arthrocentesis and provides them with better understanding and skill before they practice on the patients.

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หุ่นจำลองข้อเข่าเพื่อการฝึกเจาะและฉีดยาเข้าข้อ

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เพื่อพัฒนาการฝึกหัตถการการเจาะข้อเข่าและฉีดยาเข้าข้อเข่าสำหรับทำศึกษา แพทย์เวชปฏิบัติทั่วไป และแพทย์-เฉพาะทาง และผู้รายงานจึงได้ผลิตหุ่นจำลองข้อเข่าด้านขวา ซึ่งมีขนาดเท่าข้อเข่าหญิงไทย หุ่นจำลองมีถุงยางภายในที่มีขนาดเท่ากับช่องในข้อเข่า ขยายขนาดได้และซ่อมแซมได้ง่ายหลังการฝึกเจาะ หุ่นจำลองมีส่วนแสดงกายวิภาคภายนอกใต้ผิวหนังของข้อเข่าเพื่อประกอบการเรียนการสอน ได้แก่ กล้ามเนื้อ เอ็น และกระดูกสะบ้า ได้ประเมินหุ่นจำลองโดยอาจารย์แพทย์ 10 คน แพทย์ประจำบ้านออร์โธปิดิคส์ 26 คน และนักศึกษาแพทย์ชั้นปีที่ 5 จำนวน 30 คน ร้อยละ 80-90 รายงานว่าหุ่นจำลองมีขนาด ลักษณะทางกายวิภาค และให้ความรู้สึกระหว่างการเจาะที่ดีมากและร้อยละ 95 เห็นสมควรมีไว้ใช้ในห้องฝึกทักษะ หุ่นจำลองมีลักษณะต่างจากหุ่นจำลองข้อเข่าที่มีจำหน่ายคือ มีส่วนแสดงกายวิภาคภายนอกข้อเข่าใต้ผิวหนัง ซึ่งหุ่นจำลองข้อเข่าที่มีจำหน่ายไม่มี และถุงยางที่บรรจุน้ำสามารถซ่อมแซมได้ง่ายด้วยน้ำยางพารา โดยไม่ต้องเปลี่ยนใหม่ ในขณะที่หุ่นจำลองที่มีจำหน่ายไม่สามารถซ่อมแซมได้ ต้องเปลี่ยนส่วนถุงยางใหม่เมื่อใช้ไประยะหนึ่ง หุ่นจำลองที่คณะผู้วิจัยผลิตทุกชิ้นส่วนขึ้นเองและมีราคาถูกกว่าหุ่นที่นำเข้ามาประมาณ 8 เท่า

คำสำคัญ : แพทยศาสตร์ศึกษา, การเจาะข้อ, หุ่นจำลองข้อเข่า

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