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Shoulder Arthroscopy – Creating an Affordable Training Model*

Artroscopia do ombro – Criação de um modelo de treinamento acessível

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Abstract

The present study created a cheap (below US$ 100) shoulder arthroscopy training model, affordable for the practical education of medical students and residents. The model was created using a polyvinyl chloride (PVC) knee joint pipe (150 mm in diameter and 90 degrees in inclination) and a synthetic shoulder model. The parts were arranged to simulate a lateral recumbency with the upper limb in traction, which is the frequent positioning during arthroscopies. Colored dots on the glenoid and a partial rotator cuff model on the upper portion of the scapula were placed to assist training. This inexpensive, easy-to-make model for shoulder arthroscopy can aid surgical training.

Keywords

- arthroscopy
- simulation
- shoulder
- low-cost
- education, medical

Resumo

O objetivo do presente trabalho é criar um modelo de treinamento em artroscopia de ombro de baixo custo abaixo de 100 dólares, tornando-o acessível à capacitação prática de estudantes de medicina e residentes. O modelo foi criado utilizando um cano de PVC de 150 mm de diâmetro em 90 graus e um modelo de ombro sintético. O posicionamento das peças foi disposto de forma a simular a posição de decúbito lateral com membro superior em tração, frequente nas artroscopias. Para auxiliar no treinamento, foram demarcados pontos coloridos na glenóide e foi confeccionado um modelo de parte do manguito rotador na porção superior da escápula. Foi possível confeccionar um modelo para treinamento de artroscopia do ombro com um valor abaixo de 100 dólares, de fácil manufatura, que pode ser um auxiliar no treinamento de cirurgiões.

Palavras-chave

- artroscopia
- simulação
- ombro
- baixo custo
- educação médica

* *Study developed at the Orthopedic Skills Laboratory of the Health Sciences Department, Universidade Federal do Paraná, Curitiba, PR, Brazil.*

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Introduction

Shoulder arthroscopy can be used in a wide range of procedures, from simple ones, such as bursectomy, to complex ones, such as labral reinsertion.[1] Up to now, most of an arthroscopic surgeon training is carried out in a traditional way, in which the apprentice watches the procedure and then progresses to supervised practice. In addition to ethical and legal issues, this teaching model results in longer surgeries and increased operative complications. There is a universal search for quality improvement concomitant to a decrease in healthcare costs.[2]

Simulators provide a safe, efficient opportunity to develop and sustain arthroscopic surgery skills. Studies have shown improved training performance and better transfer of simulator-acquired skills to the operating room.[2] However, their cost may be prohibitive.[3]

The present study aimed to create a training model for shoulder arthroscopic surgery under US$ 100, affordable to the practical education of medical students and residents.

Materials and Methods

Research project developed at the Orthopedic Skills Laboratory of the Health Sciences Department of our university. Low-cost, easily obtained materials were used to assemble the training model (►**Table 1**).

The project was submitted to the Human Research Ethics Committee of our institution and was approved on April 1, 2017 under the number 1.994.655.

Table 1 Cost of materials. All materials were purchased in electronic commerce

MATERIAL	COST
Knee joint pipe 90°, 150 mm, Tigre	R$ 26.00 (US$ 4.83)
Polyvinyl chloride (PVC) extender for siphon box, 150 × 200 mm, Tigre	R$ 15.00 (US$ 2.79)
2 Caps, 150 mm, Tigre	R$ 43.00 (US$ 7.99)
1 Left shoulder model Edutec (EB3007)	R$ 119.00 (US$ 22.12)
4 chipboard screws, 3.5 × 14 mm, Bemfixa	R$ 6.81 (US$ 1.27)
2 chipboard screws, 2 × 6 mm, Maxmix	R$ 5.50 (US$ 1.02)
1 angle plate, 30 mm, Bemfixa	R$ 8.01 (US$ 1.49)
Flat elastic for sewing, 16 cm x 25 mm	R$ 16.00 (US$ 2.97)
Superglue Loctite 60sec	R$ 17.00 (US$ 3.16)
TOTAL COST	**R$ 256.32 (US$ 47.64)**

At the time of translation (November 2020), US$ 1 = BRL$ 5.38.

External Structure

This assembly used a polyvinyl chloride (PVC) knee joint pipe with 90° in inclination and 150 mm in diameter (►**Figure 1a**). The upper (proximal) end was closed with a 150 mm PVC connection tube, sectioned at 125 mm, and inserted at the knee end (►**Figure 1b**). Next, a 150 mm PVC cap was placed (►**Figure 1c**). The bottom end was closed with a 150-mm plug (►**Figure 1d**).

Assembly

Humerus: the 130 mm proximal segment of a synthetic humerus model was sectioned. This model was fixed to the lower cap with a 3.5 × 14-mm chipboard screw (Bemfixa, Juquitiba, São Paulo, Brazil) eccentrically positioned at 15 mm from the center of the cap (►**Figure 2a**).

Scapula: the upper angle of the scapula was sectioned, 30 mm from the scapular notch, with a 60° angle. It was fixed to the PVC knee joint with a 10-mm metal bracket with 2 holes. The first scapular hole was 80 mm from the lateral margin, and the second one was 20 mm from the sectioned end. These scapular holes were fixated with screws in the PVC knee joint, in holes 45 mm from the lower end and 35 mm from the midline of the pipe (►**Figure 2b**).

Clavicle: the distal 65 mm were used. This segment was attached to the PVC knee joint through a hole 200 mm from the distal end of the model and 30 mm lateral to the scapular attachment point. The humerus assumes anatomical position when the caps are assembled (►**Figures 2c** and **2d**).

Preparation of Training Items

Rotator cuff: a flat elastic tape, 25 mm wide and 160 mm long was used, folded, and superglued in its center. It was fixated to the model with two chipboard screws (2 × 6 mm, Maxmix, São Paulo, Brazil), one on the scapular spine and the other on the bottom of the acromion (►**Figures 3a** and **b**).

Glenoid: five landmarks were painted with different colors, one at the center of the cavity and the other four at the edges, as in the 3, 6, 9, and 12 o'clock positions from the side angle (►**Figure 3c**)

Arthroscopic Portals

Three 15-mm diameter perforations were made to represent the anterior, lateral, and posterior portals. The posterior portal was located at the posterior region of the model, 40 mm from the distal end of the pipe. The anterior portal was made at the anterior region, 45 mm from the distal end. Last, the lateral portal was placed on the lateral edge of the model, 100 mm from the distal end (►**Figure 4**). Additional portals can be placed as required.

After the final assembly, the model assumes an "L" appearance, and it can be used both in lateral recumbency and in the beach chair position; these different positions are achieved just turning the model over. Thus, it is used for visualization

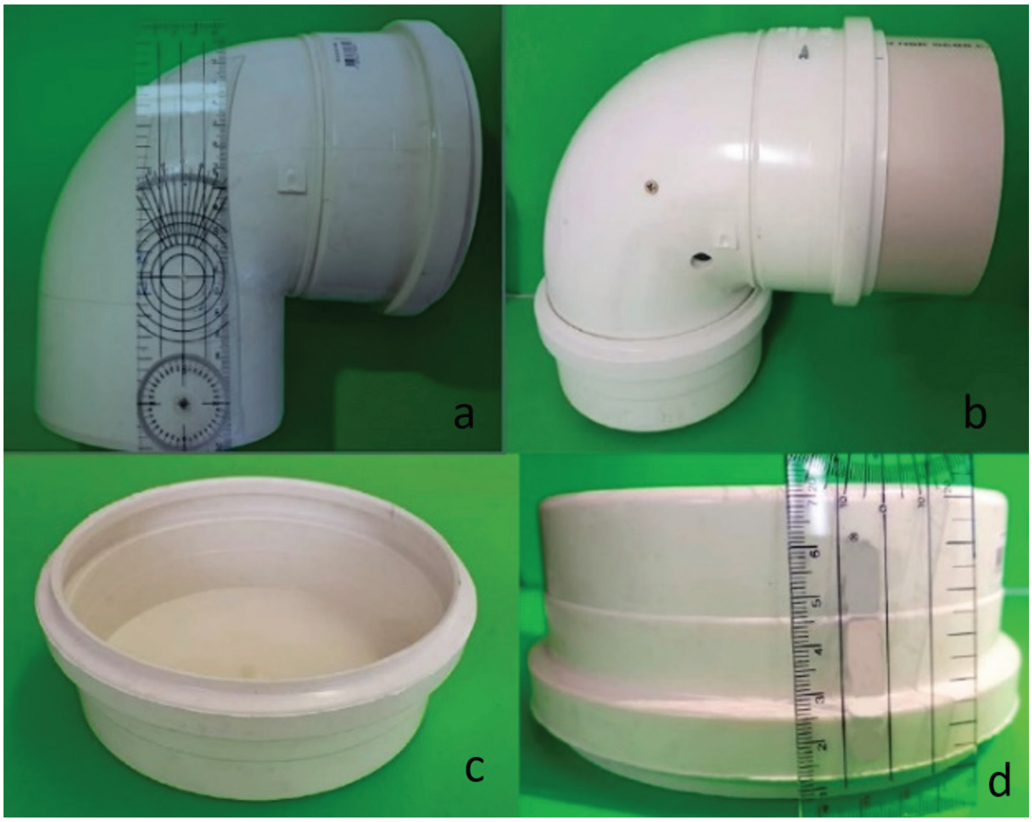

Fig. 1 Polyvinyl chloride (PVC) knee joint pipe; (**B**) connecting tube; (**C**) and (**D**) closing cap.

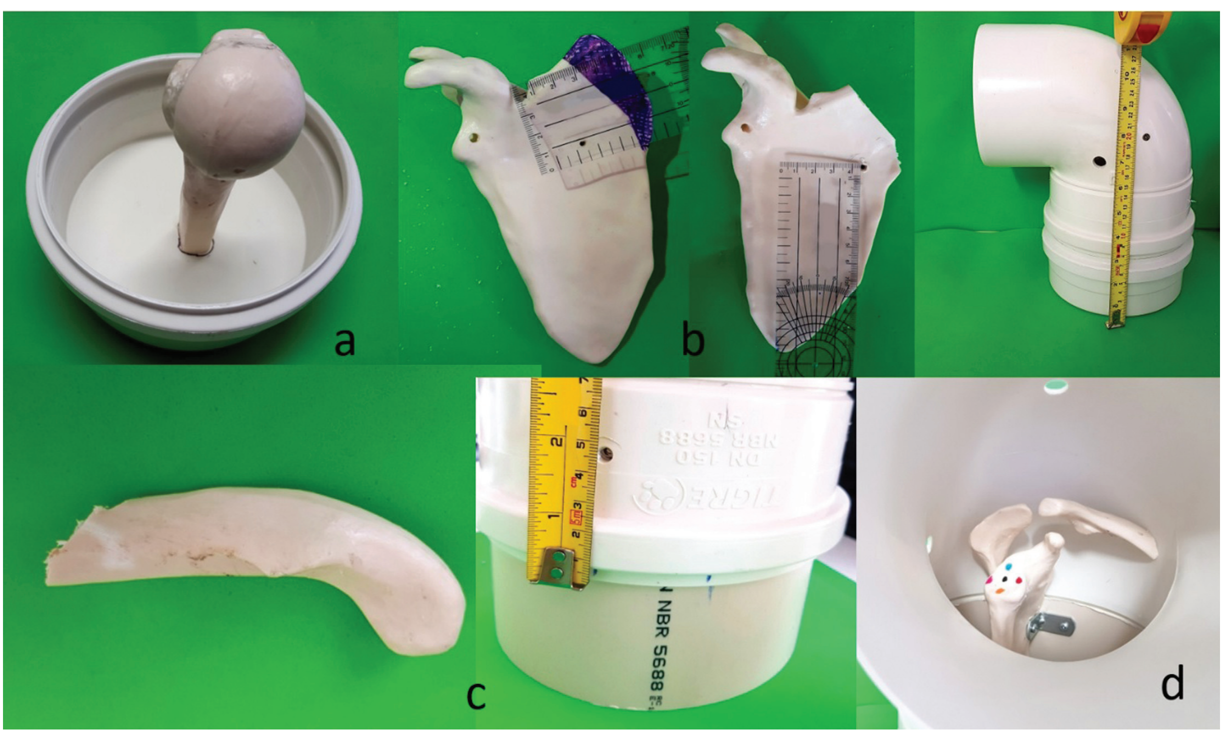

Fig. 2 (**A**) Humeral fixation at the cap; (**B**) section of the scapula, hole for fixation and fixation point at the external structure; (**C**) clavicle section; (**D**) internal assembly.

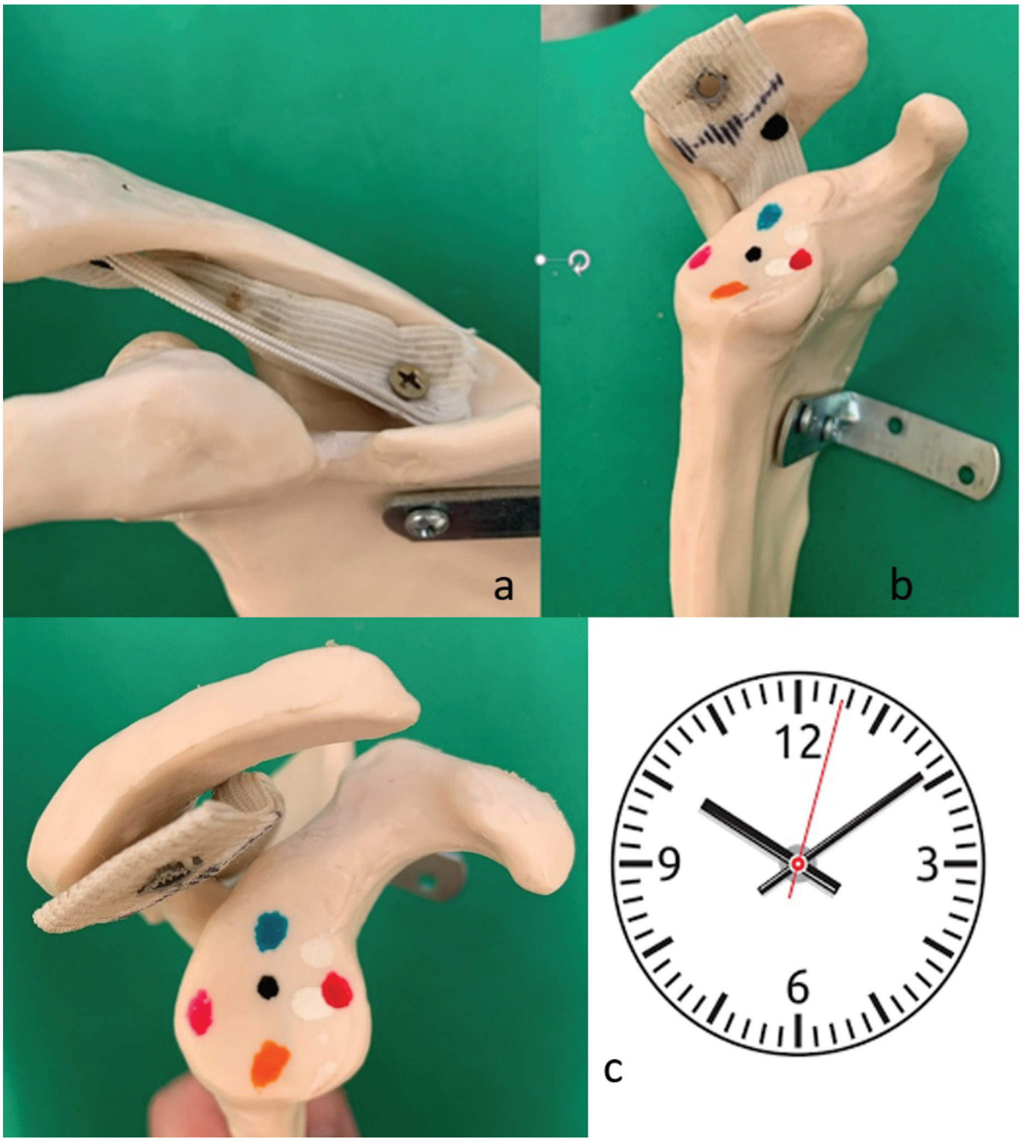

Fig. 3 (**A**) Folded tape fixated at the scapula (simulating the supraspinatus tendon); (**B**) cuff handling hole and tape reference line; (**C**) glenoid landmarks for triangulation.

and triangulation of the basic structures of the shoulder with an arthroscope (►**Figure 5**).

Discussion

Arthroscopy can be used to treat shoulder conditions ranging from cuff injury to nerve release. Surgical training can take years. Inadequate training can result in high complication rates, unsatisfactory results, and low productivity rates. Simulation can improve skills and shorten surgical time.[4]

The simulator must provide an environment similar to the one in which the task will be performed, visually and spatially imitating procedural features in real-time; in addition, it must deliver realistic tactile feedback.[1,2]

Cadaveric models are the gold standard for simulated training, but their disadvantages include costs, availability, and a high logistical demand for storage.[5]

Physical models, including high-tech devices such as tactile virtual reality, have numerous resources as advantages, but their availability is limited by cost (more than U$ 50,000). Dry anatomical models have been tested and validated for training; although they provide surgical skills gain equivalent to virtual models, they are expensive, costing more than US$ 3,000 (www.gtsimulators.com).[1,3]

Since our simulator was built within a US$ 100 budget and readily available materials, it is affordable to any teaching center. Dal Molin et al.[1] demonstrated that this type of simulator is competent for triangulation training, depth perception, reduction of the number of movements to perform a task and surgical time control. This type of model can also be made for other joints.[6,7]

This model allows observing the anatomical relationships between the humeral head and the glenoid, identifying the coracoid process, the distal clavicle and a

Fig. 4 Arthroscopic portals: posterior (for visualization), lateral and anterior (for tissue manipulation and triangulation).

Fig. 5 (**A**) Complete shoulder arthroscopy training model; (**B**) model in use with arthroscope; (**C**) triangulation exercise with a probe in lateral recumbency position; (**D**) tissue manipulation exercise by elastic (supraspinatus) traction in the beach chair position.

supraspinatus tendon analogue, locating the acromion and subacromial region, learning triangulation with a probe to touch different joint parts and the simulated supraspinatus tendon, and to traction the supraspinatus tendon with a probe or with another available instrument.

Since this model was created from prefabricated pieces, its limitations include the lack of soft parts, bleeding, and anatomical structures for repair. This project focuses on the development of training models, and our simulation model can be built according to the surgeon's needs, including tissue to simulate labrum, ligaments, and other cuff tendons, in addition to devices for suturing. Moreover, although the model consists of low-cost materials, an arthroscope is required.

Conclusion

The shoulder arthroscopy simulator met the following criteria: low-cost, below US$ 100; all assembly pieces are easily obtained; potential assembly by the professional who is going to use it.

Conflict of Interests
The authors have no conflict of interests to declare.

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