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HEAD AND NECK

"Barbed snore surgery" simulator: a low-cost surgical model

Vittorio Rinaldi[1] · Andrea Costantino[1] · Antonio Moffa[2] · Peter Baptista[3] · Lorenzo Sabatino[1] · Manuele Casale[1]

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Abstract

Background "Barbed snore surgery" (BSS) represents one of the last innovation for obstructive sleep apnea syndrome (OSAS) surgical management. Although this technique represents an effective and minimally invasive surgery, it is not still widespread in many ENT centers. The aim of our study was to develop an inexpensive surgical simulator useful to expedite the surgical learning curve for BSS in untrained ENT surgeons.

Model assembly The simulator is a simple model composed of a manually shaped silicone palate (3 × 4 × 1 cm) fixed on a resin skeleton (21 × 16 × 12 cm) using a transparent silicon rubber. The mandible is fixed bilaterally with the aid of two screws allowing for modular inter-incisive distance.

Simulation Barbed anterior pharyngoplasty (BAPh) was readily performed on the simulator to show the feasibility of this BSS model. All surgical steps were carried out determining a lift and a shortening of the palate as in real surgery.

Conclusions This is the first surgical model that provides a realistic, easily repeatable training in the performance of BSS. Our BSS surgical model is very inexpensive with a cost of approximately 19.25$ dollars and it is manufactured to facilitate a worldwide diffusion of this promising palatal surgery for OSAS.

Keywords Simulator · Surgical model · Surgery · Barbed · Sleep apnea

Introduction

Palatal surgery is a cornerstone of obstructive sleep apnea syndrome (OSAS) operative management. Over recent decades numerous surgical techniques have been proposed to implement the surgical outcome to obtain a better clinical efficacy and a reduced invasiveness. In this context, the "barbed snore surgery" (BSS) represents one of the last surgical innovation: a velo-uvulo-pharyngeal lift is performed using fibro-osseous structures as anchoring points [1, 2]. Through the application of specific direction vectors, using barbed sutures, the surgeon is able to lift, shorten and advance the soft palate, customizing its structure on the basis of the drug-induced sleep endoscopy (DISE) previously performed [3]. Although this technique represents an effective and minimally invasive surgery, it is not still widespread in many ENT centers.

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✉ Andrea Costantino
andrea.costantino94@libero.it

Vittorio Rinaldi
v.rinaldi@unicampus.it

Antonio Moffa
moffa.antonio1@gmail.com

Peter Baptista
pmbaptista@unav.es

Lorenzo Sabatino
l.sabatino@unicampus.it

Manuele Casale
m.casale@unicampus.it

[1] Department of Otolaryngology, Integrated Therapies in Otolaryngology, School of Medicine, Campus Bio-Medico University, Via Alvaro del Portillo 21, 00128 Rome, Italy

[2] Department of Otolaryngology, University of Foggia, Foggia, Italy

[3] Department of Otolaryngology, Clínica Universidad de Navarra, Pamplona, Spain

The use of surgical simulators has been able to train several surgeons from almost all specialties at a time when cadaver dissections are not always available. In this context, numerous manufactured devices have become increasingly used in several otolaryngology settings improving students', residents' and fellows' surgical expertise [4]. A significant number of these is represented by devices simulating anatomical structures which can be used to practice technical skills [5].

The aim of our study was to develop a surgical simulator useful for expedite the surgical learning curve for BSS in untrained ENT surgeons. In addition, our purpose was to develop an inexpensive and easy-to-build model to simplify BSS spreading.

Model characteristic and assembly

Our simulator represents a very simple model according to the presence of only two components: the skeleton and the palate. Both simulator parts were easily found at online retailers with an extremely low cost: 14.42$ for the skeleton and 19.32$ for a silicone tablet able to provide at least four palates (4.83$ each). The skeleton is made from high-quality eco-friendly resin material. The mandible is fixed bilaterally with the aid of two screws allowing for modular inter-incisive distance. In addition, a dimension of $21 \times 16 \times 12$ cm is comparable to that of an adult male skull. The palate was manually shaped from a three layers (simulating mucosal, sub-mucosal, and muscular layers) silicone model (approximately $3 \times 4 \times 1$ cm). The palatal shape was pre-treated with an abrasive paper to gain adherence. Subsequently, it was glued on the resin-made skeleton using a transparent silicon rubber (Elastosil E43®).

Barbed anterior pharyngoplasty on the model

The following surgical procedure is the barbed anterior pharyngoplasty (BAPh) previously described [2] (see Electronic Supplementary Material).

Main surgical steps are shown in Fig. 1. Surgical landmarks (posterior nasal spine, PNS; the pterygoid hamulus, PH; and the pterygomandibular raphe, PR) are marked to guide the procedure (Fig. 1a). The PR was marked only for anatomical orientation purpose. After the resection of a mucosal semilunar strip using cold blade (Fig. 1b), the needle of a barbed thread (size 3-0, mounted on 26 mm semi-circular needle; V-Loc™ 180, Medtronic®) is used to create a central pivotal loop anchored to the PNS (Fig. 1c). The same needle is reinserted (in front of the PNS) and driven downwards through the muscles until it perforates the mucosa adjacent to the ipsilateral base of the uvula. (Fig. 1d). It is directed sideways along the palatopharyngeal muscle to reach the PH, and then driven back (from lateral to medial) towards the ipsilateral base of the uvula through the mucosal gap (Fig. 1e). At this point, the same needle is reinserted through the same mucosal hole and driven to encircle the palatopharyngeal muscle (along the semi-lunar mucosal gap) once or twice to close the gap. Finally, the needle is reinserted to reach the PNS and definitely stiffen the palate with a "back stitch".

The same manoeuvres are repeated specularly on the opposite side using another barbed thread (Fig. 1f).

Discussion

To our knowledge, we have developed the first surgical model that provides a realistic, easily repeatable training in the performance of BSS.

First, the decision to use a simple skeleton rather than a mannequin with mucous membrane throughout the oral cavity is due to the importance of surgical bony landmarks, such as the possibility to reduce the model manufacturing cost. During the real surgical procedure these landmarks could not be directly seen, but only searched through palpation. The opportunity to directly see these structures (posterior nasal spine, pterygoid hamulus, and pterygomandibular raphe) during the procedure leads, indeed, to a greater comprehension of surgical anatomy to easily reproduce it on patients.

Second, our simulator could be considered realistic according to one of the main surgical complexities: the small surgical field. Subtle maneuvering of the hands is required to perform these surgical steps, requiring plenty of practice to obtain a more accurate result. Although the absence of the tongue could simplify surgical maneuvering, the narrow surgical access (maximal inter-incisor distance of 5 cm) is absolutely comparable to the majority of adult OSAS patients undergoing BSS. In addition, the modular mandible position could improve surgical difficulty narrowing the surgical access.

Third, our palate could produce a proper resistance to tissue manipulation. In a BSS simulator, the palatal tissue texture must be close to reality, given that the strength applied to the muscle at the end of each suture step is extremely important to achieve the shortening and stiffening desired. Although silicone could not be absolutely comparable to real palatal muscle, it was already used to develop several simulators for cleft palate surgery [6].

Finally, our BSS surgical model is very inexpensive with a cost of approximately 19.25$ dollars. This should not be underestimated given that a great amount of surgical ENT simulators are complex technologies with costs not always affordable. In addition, a simple substitution

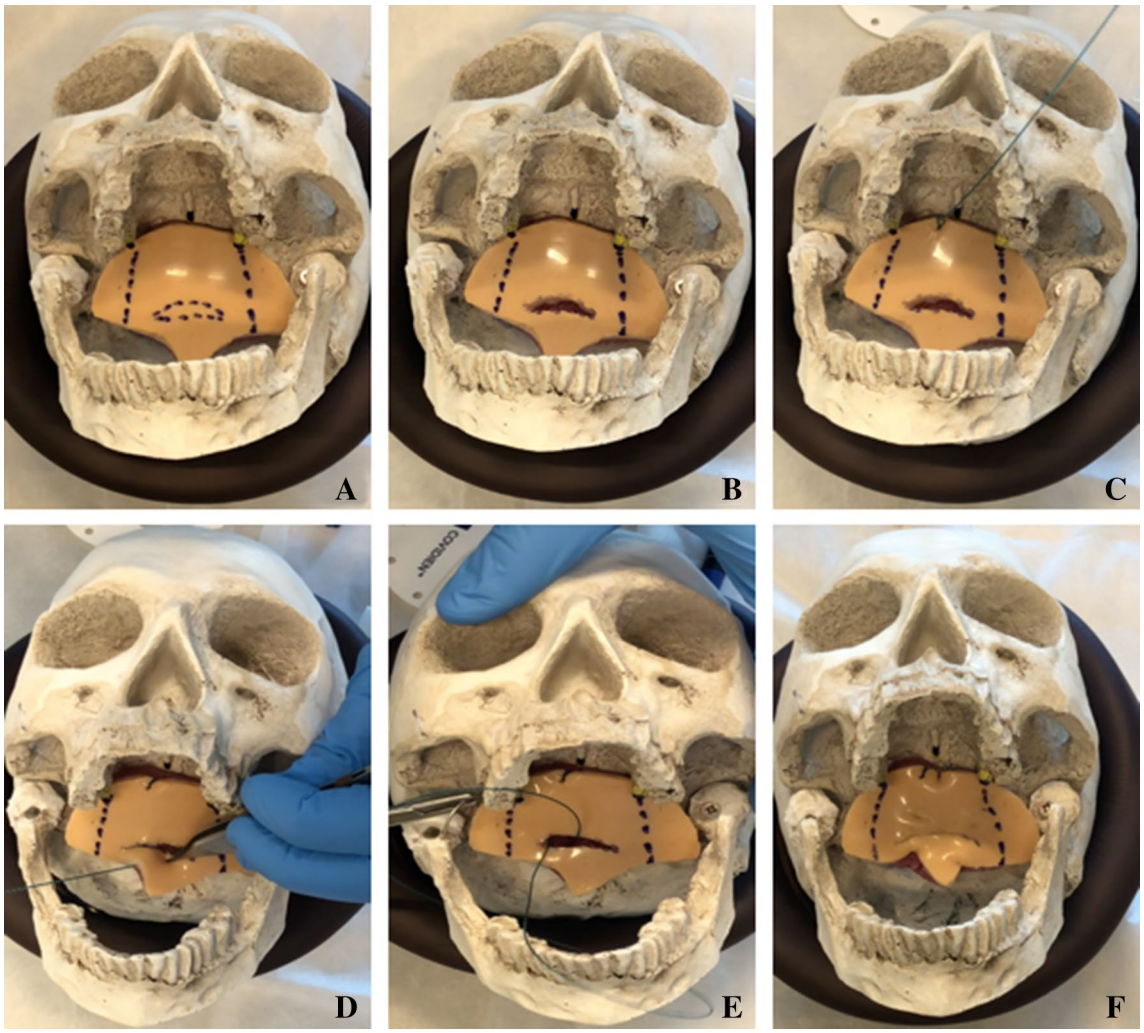

Fig. 1 Main surgical steps of barbed anterior pharyngoplasty on the simulator. **a** Baseline with surgical landmarks (PNS, PH, PR and semilunar mucosal strip) marked with blue ink. **b** After the resection of a mucosal semilunar strip using cold blade. **c** Creation of a central pivotal loop anchored to the PNS. **d** The needle is driven downwards to reach the ipsilateral base of the uvula. **e** The needle is directed sideways along the palatopharyngeal muscle to reach the PH. **f** The palate is lifted and shortened bilaterally at the end of the procedure

of the palatal component could allow to easily perform the procedure repeatedly. For these reasons, our model features are shaped to facilitate a worldwide diffusion of this promising palatal surgery for OSAS.

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Compliance with ethical standards

Conflict of interest All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

Ethical approval Due to the nature of this project, no institutional review board approval was necessary.

Informed consent This article does not contain any studies with human participants or animal performed by any of the authors.

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