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A model for foramen ovale puncture training: Technical note

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Summary

Background. Trigeminal neuralgia is a common cause of facial pain, characterized by shock-like pain affecting one or more branches of the trigeminal nerve. When conservative treatment fails and microdecompression is not indicated, percutaneous procedures are helpful. This percutaneous approach is done by a puncture up to the Gasserian ganglion, through the foramen ovale.

Although simple and safe, this puncture demands some expertise from neurosurgeons. For that, a partnership between neurosurgeons and bioengineers has developed a model for foramen ovale puncture, allowing practice for residents and young neurosurgeons.

Method. A model for foramen ovale puncture has been created by interposition of synthetic materials over a skull, simulating the human face.

Findings. This model has shown great similarity with that found in conventional surgeries, even upon repeated testing by experienced functional neurosurgeons and young residents.

Conclusion. This model for foramen ovale puncture training has demonstrated valuable help for initial practicing of this common neurosurgical procedure, particularly in centers where there are not many cadavers available for training.

Keywords: Foramen ovale; trigeminal neuralgia; surgery; model; percutaneous procedures.

Introduction

Trigeminal neuralgia is a common cause of facial pain, typically presenting with paroxysmal, ultra-short, shock-like pain, affecting one or more divisions of the trigeminal nerve. Although it can occur at any age, it is more common in advanced age. Conservative clinical treatment is usually effective in the short-term, but a significant number of patients will need further treatment, including surgery. A compression of the trigeminal nerve can exist, most commonly by a vascular conflict [3, 9].

For young and healthy individuals, microvascular decompression is usually the treatment of choice, causing a lesser degree of hypoesthesia [11, 14]. In older people, however, less invasive techniques are preferred and have shown significant and persistent pain relief. It is performed by a foramen ovale puncture up to the Gasserian ganglion, followed by destruction, either using radiofrequency, microcompression with a Fogarty catheter, or by neurotoxic substances (e.g. glycerol) [12, 15].

Even though simple and safe, the foramen ovale puncture procedure demands an serious practice from residents and young neurosurgeons. In ideal circumstances a cadaver should be used for initial training, but this is not always feasible in many places, especially due to legal objections.

The authors created a synthetic model similar to facial soft tissue, overlapping a natural or artificial cranial skeleton and propose it as a choice for training.

Methods and materials

A skull in good condition should be used. The mandible is coupled to the cranium, maintaining the joint movable through a system of springs attached to screws at the temporal bone and the coronoid process bilaterally. Whether the patient is edentulous, dentists should make an appropriate dental prosthesis, bringing a more natural relationship between anatomical structures of the face.

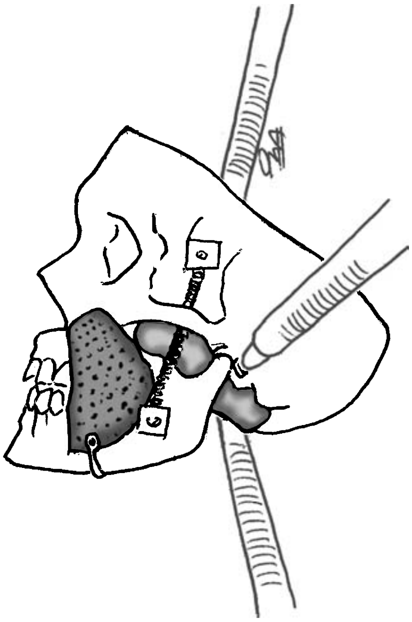

Fig. 1. Deep structures filled with silicone rubber and flexible silicone

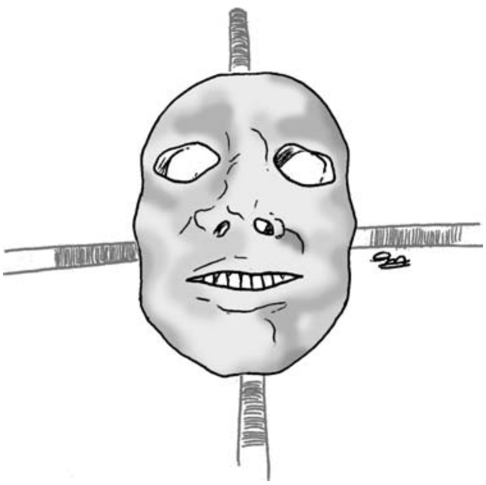

Fig. 2. Silicone rubber mimicking human superficial structures

Deep muscles space is filled with flexible silicone, which is shaped after injection, hardening afterwards. This material has shown elasticity similar to that found in vivo, as well as allowing a relocation of the needle, whenever needed (Fig. 1). Fixation is obtained using either further compression from a more superficial layer, or from elastic strips attached.

Superficial soft tissue space is filled with silicone rubber (Siqmol®), overlapping the former layer, giving a shape similar to human maxillar and mandibular region (Fig. 2). Finally, a latex mask is put on it, providing a realistic appearance (Fig. 3).

Under ideal circumstances, this model should be kept immovable, keeping the reference points steady. In our model, it has been done by a system of screw fixation in skull points to a tray as routinely used in anatomical dissections.

Fig. 3. A latex mask is superimposed, giving a realistic appearance

Results

This model has been tested by five experienced functional neurosurgeons, who concluded that it mimicked perfectly the characteristics of the human face, allowing a correct training for young neurosurgeons.

It has also been used in an invasive pain treatment course, and been shown to be very appropriate, with no change in its characteristics even after repeated punctures.

Discussion

The technique for percutaneous foramen ovale puncture is a well-defined method of approach to the Gasserian ganglion, especially for the surgical treatment of trigeminal neuralgia [4].

The most common parameters have been based on descriptions by Härtel [6], in 1914, with a puncture sited 2.5 cm lateral to the angle of the mouth, directed to a confluence point of the medial aspect of the ipsilateral pupil and a point 3.0 cm anterior to the tragus [5]. Before the foramen ovale is reached, skin, subcutaneous tissue, and muscles are traversed.

Although it can be usually done with fluoroscopic guidance, the advent of new technologies, such as guidance devices, frameless stereotaxy and CT may ease the puncture in complex cases [5, 7, 8]. Sweet and Wespic described selective thermocoagulation of trigeminal divisions [13].

For a safe procedure, correct training is needed. Therefore, many strategies can be valuable, including virtual reality simulators [10]. Preferentially, if available, corpses should be used. Otherwise, synthetic models can provide a good option for surgical training for residents and young neurosurgeons. A synthetic model can be especially useful for hands-on training courses, when many heads are simultaneously needed.

A group of bio-engineers (Biodesign Ind) started to test different materials. Special concern was directed to preserve important properties of the human face, such as elasticity and viscosity. High quality at low-cost was also considered. The use of subsequent different layers allowed a needle repositioning, in case the foramen ovale was not reached at the first attempt, which is quite common in real situations. Silicone has been found suitable with these properties, as well as for its capacity to return to the previous state after each puncture.

Indeed, in a training workshop, our model demonstrated its original properties even after hundreds of punctures. In the future, a model for training selective puncture of divisions V1, V2 and V3 could be constructed.

Another advantage is the use of radiotransparent materials, allowing the possibility of puncture under C-arm visualization, as usually done under real trigeminal operations. It has been tested by students and neurosurgeons, providing an adequate method for training.

According to all points observed, we can conclude that this model can help residents and young neurosurgeons to practice this important and usual neurosurgical procedure.

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Comment

The Percutaneous approach to the foramen ovale has appeal as an invasive procedure but carries a risk of injuring important structures at the base of the skull. These include hematoma as a result of puncturing branch(es) of the maxillary artery at the pterygo-maxillary fossa and penetration of the Eustachian tube at its membranous portion. Injury to important neural and vascular structures result from errors in trajectory – too anteriorly into the apex of the orbit through the inferior orbital fissure, too posteriorly internal into carotid artery at its subpetrosal segment if needle is directed to foramen jugularis, and too medially, into the carotid artery at its paratrigeminal portion through penetration of the foramen lacerum.

The Percutaneous approach to the foramen ovale, is very much "operator-dependant". The proposal for a model to shorten the learning-curve phenomenon appears to have a potential for important benefits

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