The Comprehensive Anatomy of the Foramen Ovale as it relates to Percutaneous Stereotactic Radiofrequency Rhizotomy: A Cadaveric Study of Dry Skulls

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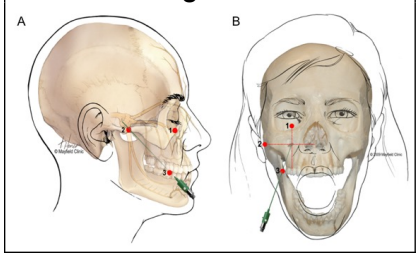
Introduction

Percutaneous stereotactic radiofrequency rhizotomy (Figure 1) is often used to treat trigeminal neuralgia, a serious condition that results in lancinating, episodic facial pain. Thorough understanding of the microsurgical anatomy of the foramen ovale (FO) and its surrounding structures is required for efficient, effective, and safe use of this technique. The goal of this morphometric study is to compare anatomical and surgical orientations to identify the variations of the foramen ovale and assess cannulation difficulty.

Methods

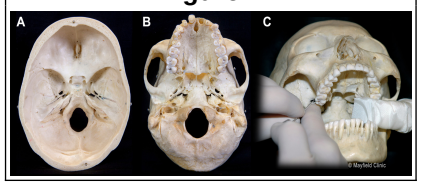
Bilateral foramina from 174 adult human dry skulls (348 foramina) were analyzed in both an anatomic and surgical orientation (Figure 2) using photographs obtained from standardized projections. Measurements were obtained of multiple variables including shape, size, presence of adjacent structures, and the morphometric variability effect on cannulation.

Figure 1



An illustration of the three skin (Hartel's) landmarks made on the patient's face to help the surgeon guide the needle into the foramen ovale: (1) beneath the medial aspect of the pupil on the lower eye lid; (2) 3 cm anterior to external auditory meatus; and (3) 2.5 cm lateral to the oral commissure. The surgeon inserts his gloved index finger into the patient's mouth along the side of the molars to rest against the lateral pterygoid. This finger position helps guide the cannula toward the foramen ovale and prevents penetration of the oral mucosa. (Printed with the Permission of the Mayfield Clinic)

Figure 2



The foramen ovale was examined from anatomic views intracranial (A), exocranial (B) and also from surgical view (C). (Printed with permission of the Mayfield Clinic).

Results

From the anatomic exocranial view, 6 distinct anatomical shapes of the foramen ovale (Figure 3) were identified as well as 5 anomalous variants (Figure 4).

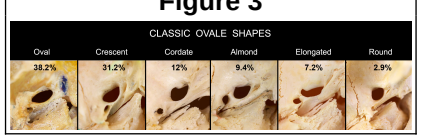
From the surgical view, 6 distinct procedural shapes were identified (Figure 5).

When the surface area (SA) of the FO was measured in the surgical view, there was a significant loss of SA compared to the anatomic exocranial view (Figure 6). On average, the SA lost was 18.5 5.7%.

Morphometrically, we found significant variability in foramen size, and obstruction of the foramen in up to 7.8% from a calcified pterygoalar ligament (Figure 7).

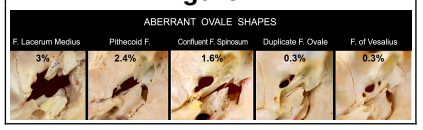
Importantly, we found that 8% of foramina were very difficult to cannulate and the risk of inadvertent cannulation of the foramen lacerum was 12% (Figure 8).

Figure 3



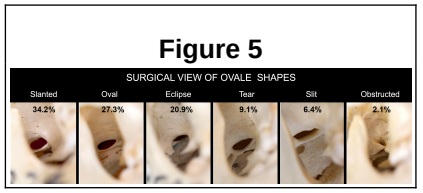
The six classic foramen ovale shapes viewed from an anatomic view and arranged left to right according to frequency include: oval, crescent, almond, elongated, round, and cordate.

Figure 4



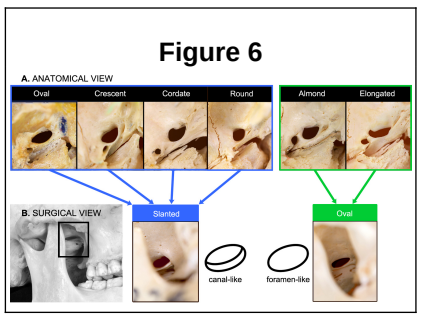
Aberrant variants of the foramen ovale shape viewed from an anatomic view and arranged left to right according to frequency.

Figure 5



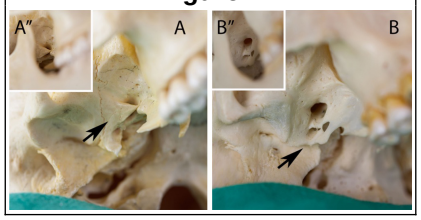
Six distinct foramen ovale shapes in the surgical view arranged left to right according to frequency.

Figure 6



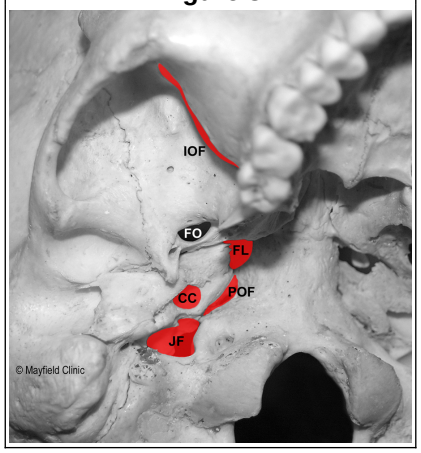
Correlation of anatomical shapes of the foramen ovale to surgical perspective. The oval, crescent and cordate anatomic shapes most commonly appeared as a slanted shaped FO in the surgical view (A). Almond and elongated shapes when examined from the anatomic view most commonly appeared as an oval shaped FO in the surgical view (B). (printed with permission Mayfield Clinic.)

Figure 7



In the surgical view, bony spicules were associated with the anterior and posterior borders of the FO in 27% and 15.5% of the foramina studied, respectively; 7.5% of specimens had both types.

Figure 8



Skull base foraminae may be punctured with a cannula when targeting the foramen ovale. The inferior orbital fissure (IOF) can be hit by a cannula aimed too anterior and superior to the foramen ovale (FO). The jugular foramen (JF) or the petro-occipital fissure (POF) can be hit by a cannula aimed too posterior and inferior. The internal carotid artery can be hit at the foramen lacerum (FL) or the carotid canal (CC) (printed with permission of the Mayfield Clinic).

Conclusions

We determined that there is significant variability in the shape and size of the FO, which we believe impacts the ability to safely and effectively cannulate this structure. Preoperative imaging with a 3D head CT may be of value in predicting difficulty of cannulation and guide treatment decisions when considering the use of a percutaneous approach over microvascular decompression or radiosurgery.

Learning Objectives

By the conclusion of this session, participants should be able to:

1) Recognize that there are variables sizes and shapes of the foramen ovale that must be recognized as not all patients may be good candidates for PSR based on variable anatomy;

2) Understand that there are multiple danger/high risk zones of injury during PSR or balloon rhizotomy and that anatomic variations of surrounding neurovascular structures are important to recognize when cannulating the foramen ovale to prevent complications

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