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Anatomoclinical Relevance of the Foramen Lacerum: a Brief Review

Vanessa Santos de Araújo[1], Dayanna Ferreira Gomes[1], Andrei Rannieri D'Ávila Pedrosa Ferreira[1], Priscilla Gadelha Braga[1], Filipe Victor Soares Barbosa[1], Danyelle da Silva Diniz[1], Ana Beatriz Camilo Leal de Amorim[1], Lucas David Amorim Stock[2], José Jailson Costa do Nascimento[3]

[1]University Center of João Pessoa, Academic of Medicine, João Pessoa, PB, Brazil
[2]Federal University of Paraiba, Academic of Odontology, João Pessoa, PB, Brazil
[3]Federal University of Paraiba, Department of Morphology, João Pessoa, PB, Brazil

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ABSTRACT

Introduction: anatomy lessons on the foramen lacerum (FL) highlight that this opening only exists in macerated skulls, which may undervalue its anatomoclinical relevance during the basic training of health and medicine academics.

Revision: the present review aimed to synthesize data from the literature on the anatomoclinical relevance of the FL to verify the clinical, surgical, and diagnostic contexts in which FL could gain prominence. After reviewing the PubMed and Science Direct databases, 34 papers published between 1975 and 2021 were selected, of which 21 between 2011 and 2021. This review verified two general thematic axes: surgical procedures of the skull base (n=24) and radiological diagnosis (n=17). In the thematic analysis, endoscopic endonasal approaches of the skull base 50% (n=17), transoral approaches for craniovertebral junction surgeries 5,88% (n=2), percutaneous procedures translacerum 2.94% (n=1), osteotomy Le Fort I 5,88% (n=2), preauricular surgical approach 2.94% (n=1), craniotomies for treatment of cavernous sinus meningiomas 2.94% (n=1) and stereotaxy 2.94% (n=1) were identified.

Conclusion: the FL study in anatomy lessons requires an understanding of the anatomical relationships that this region presents. This should provide a better understanding of clinical contexts and radiological evaluation, as well as surgical safety for being landmark anatomical for skull base procedures.

Keywords: Foramen lacerum; Skull Base; Diagosis; Skull base surgery.

Introduction

The foramen lacerum (FL) is a triangular opening seen in the middle cranial fossa, located between the sphenoid bone, petrous part of the temporal and basioccipital bone. Usually present in macerated skulls, this foramen is delimited by three cranial fissures: the petroclival, sphenopetrosal and pterygoid sphenoid[1,2,3], and establishes a close relationship with the internal carotid artery, which has part of its medial course (lacerated segment) located superior to the FL[1,4].

In specimens of anatomical heads, it can be observed that the FL is filled by cartilaginous tissue[2,5]. Important structures may be located in this region, such as the deep and greater petrosal nerves, which contribute to the formation of the pterygoid canal nerve[1,3,4], the meningeal branches of the ascending meningeal artery and emissary veins of the cavernous sinus[2].

The topographical relationships that the FL presents with the adjacent structures mentioned above[1-5] give it potential pathophysiological and surgical relevance. Possible gaps in the literature regarding the relevance of the FL may be a factor of neglect for the study of this foramen during academic training in medicine. The objective of the present study is to synthesize data from the literature related to the anatomoclinical importance of the FL.

Methods

Study Design

This is a literature review addressed to anatomoclinical relevance of the FL, which followed the steps: elaboration of the problem question; search in the literature (location and study selections), data extraction, synthesis, and presentation of the review. The problem question was: what is the anatomoclinical relevance of the FL?

Search in Database

The article search for the present review was conducted in the following databases: PubMed and Science Direct. The combination of keywords used was (foramen lacerum) OR (lacerated foramen) using the search field "title/abstract".

Selection Process and Eligibility Criteria

The search, selection and inclusion of the articles were carried out by two examiners (blinded), which used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[6]. A third examiner was consulted to obtain a consensus in case of selection discrepancy. The initial screening was through reading the titles and abstracts. The

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agreement analysis between the two examiners was assessed by KAPPA index at 95% confidence interval.

Original articles that addressed the anatomoclinical relevance of the FL in humans were searched in the English language, without restriction for publication year. Studies that were not available in full were excluded from the present study. When duplicated in more than one database, only 1 document was considered.

Results

The independent search of articles by the two examiners retrieved 45 potentially eligible studies up to the eligibility criteria stage and showed a Kappa agreement of 81.3 (P = 0.001). After the consensus meeting, 34 articles that met the eligibility criteria were selected, making up the final study sample. The flowchart, which shows this process in detail, follows the PRISMA model[6] (Figure 1).

The sample of articles selected for this review were published between 1975 and 2021, with 61.76% (n=21) of them published between 2011 and 2021. This review covered two general thematic axes related to the anatomoclinical relevance of FL, which were: surgical procedures of the skull base (n=24) and radiological diagnosis (n=17), within a broad clinical field of application.

In the literature analysis, endoscopic endonasal approaches of the skull base 50% (n=17), transoral approaches for craniovertebral junction surgeries 5,88% (n=2), percutaneous procedures translacerum 2.94% (n=1), osteotomy Le Fort I 5,88% (n=2), preauricular surgical approach 2.94% (n=1), craniotomies for treatment of cavernous sinus meningiomas 2.94% (n=1) and stereotaxy 2.94% (n=1) were identified.

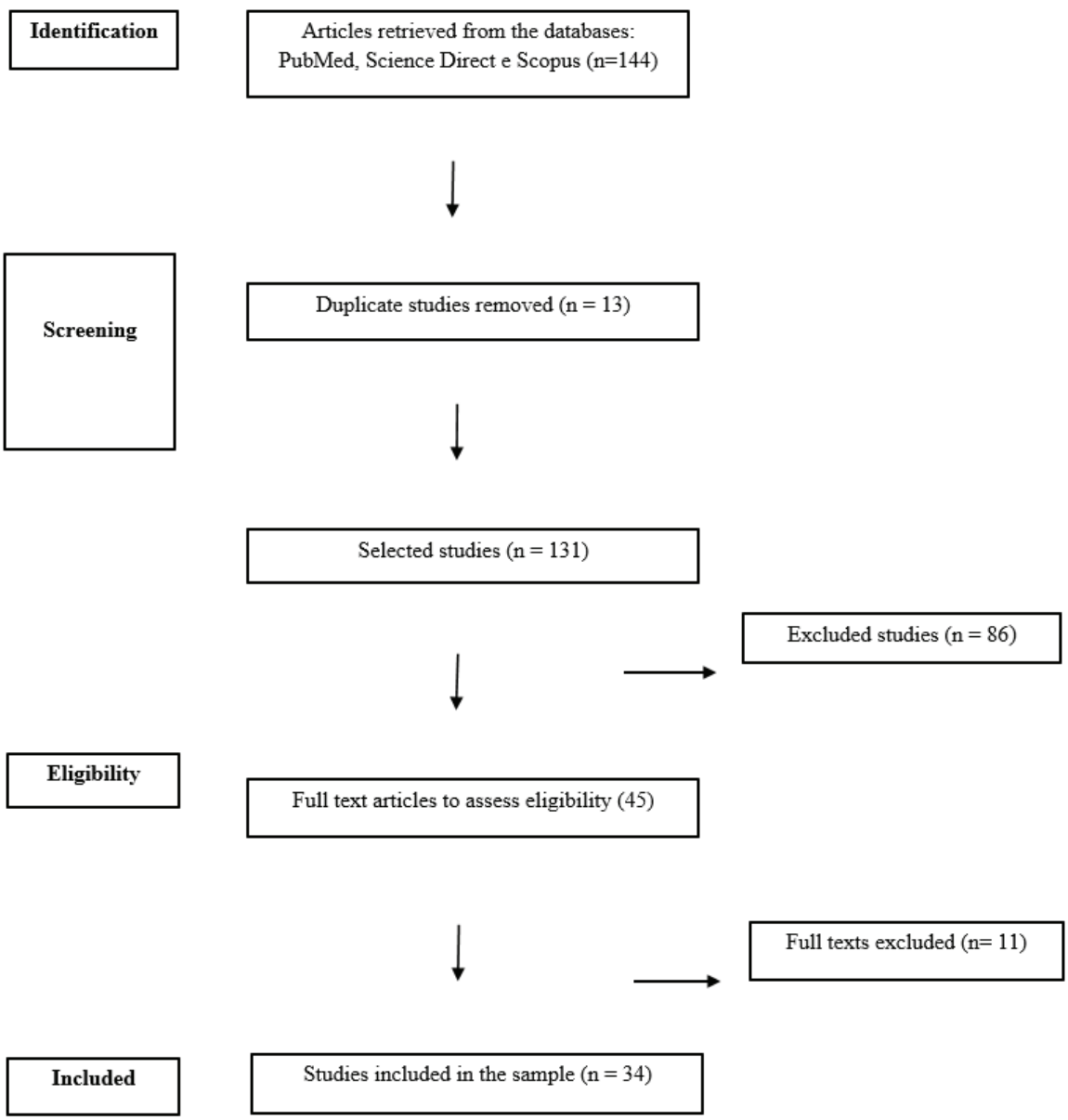

Figure 1. Database sampling, results of papers selection by independent researchers based on PRISMA Search Strategy Diagram.

Discussion

The present study synthesized data on the anatomoclinical relevance of the FL to fill possible gaps in the literature on the subject, thus contributing to the availability of scientific knowledge to academics and health professionals. In a complementary way, this study also provides a compilation of studies that can be useful for updating relevant anatomy books and atlases, especially those that seek to perform clinical correlations in their contents.

Regarding radiological diagnosis, the literature showed the relationship of extracranial tumors originating in the proximity of the FL, such as those originating from the nasopharynx, addressing the FL as a possible route for tumoral dissemination to important regions of the middle cranial fossa, with involvement of cavernous sinus, petrous part of the temporal bone, and pterygoid nerve[7-19].

The endoscopic endonasal approaches are procedures applied in several clinical contexts. The FL is a landmark for this type of procedure, since it is allowing a safe approach for tumor resection, reducing the risks of lesions in the petrous segment of the internal carotid artery, the pterygoid canal nerve, and the auditory tube, as well as establishing movement limits inside the cranial fossa, where the knowledge and proper handling of the FL fibrocartilage becomes important for a safe approach in these areas. In addition, the FL can be related to other important structures of the skull base to ensure better access and endoscopic approaches, such as for the hypoglossal canal to allow better exposure of the foramen magnum and occipital condyles, allowing lateral resection of the basioccipital[18,20-35].

The transoral approaches for craniovertebral junction are surgeries widely used to solve several problems such as lesions near the craniovertebral junction, fracture of atlas and tumors in the head, presenting themselves as an excellent procedure, being considered a less invasive and as the shortest route with less tissue destruction. In these procedures the FL and the pharyngeal tubercle were reported as an important surgical landmark[28,36].

Regarding the percutaneous translaceric access to reach the internal carotid artery (ICA), it is inferred that the method provides relatively safe intracranial guidance through the FL[37]. As for possible complications, hemorrhages, cervical hematomas, and ischemic events were reported. The greatest risk of access to the region is intracranial bleeding, mainly due to epidural bleeding secondary to dehiscence of the temporal petrous bone over the ICA. Bone exposure can also affect the acoustic or vestibular system and the facial nerve. Due to these complications, this intervention should be restricted to patients with restrictive and tortuous anatomy and intended only when it is impossible to choose another method[37].

Safe Le Fort I Maxillary Osteotomy requires that complete pterygomaxillary separation anteriorly occurs so that adjacent anatomical structures are preserved. A study carried out in 129 adult and 10 pediatric cadavers showed the presence, in 71% of the adult skulls and 60% of the pediatric ones, of a bony protrusion at the sphenoid base that projected inferiorly to the FL. The bony protrusions influenced the shape of the FL, being essential that the pterygomaxillary separation and the inferior fracture of the maxilla be performed cautiously to avoid an imminent risk to the portion of the carotid artery that runs in this region[12,38]. In addition, the FL allows for an operative exposure that provides access to the lateral wall of the sphenoid sinus, medial pterygoid buttress, and medial wall of the maxillary sinus, this being 24.4 mm in the Le Fort I Osteotomy and 25.1 mm in the expanded endonasal endoscopic approach[12,38].

Depicting craniotomy for treating cavernous sinus meningiomas, the literature showed that by opening the intrapetrous portion of the carotid canal, the ICA is exposed at the posterior edge of the FL, with the objective of identifying its proximal segment before its entry into the parasellar region and allow fixation, if necessary, to avoid injury to the ICA and cranial nerves. Regarding stereotaxis, there is no significant difference regarding surgical freedom in the FL and basilar sulcus of the midpoint, regarding the type of approach to any nostril. According to the article, 4 points were found out of 135 for approach, being points L1 (maximum cranial extension), L2 (maximum caudal extension), L3 (maximum lateral extension) and L4 (medial extension towards the nasal septum), the points recorded[15,38], as well as surgical approaches to the middle cranial fossa and relationships to ICA lesions[39,40].

Conclusion

Although it is described as an opening present only in macerated skulls, the FL study in anatomy lessons requires an understanding of the anatomical relationships that this region presents, since different clinical and surgical contexts can gain relevance in the FL, either as a surgical reference for various skull base procedures, or for evaluation radiological that can identify a probable tumor migration to the cranial cavity trough the FL.

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Mini Curriculum and Author's Contribution

1. Vanessa Santos de Araújo – Academic of medicine: Scientific meetings; planning; literature search; data interpretation; edition; critical review; final approval

2. Dayanna Ferreira Gomes - Academic of medicine: Scientific meetings; planning; data interpretation; edition; critical review, final approval.

3. Andrei Rannieri D'Ávila Pedrosa Ferreira - Academic of medicine: Scientific meetings; planning; literature search; data interpretation; edition; critical review, final approval

4. Priscilla Gadelha Braga - Academic of medicine: Scientific meetings, planning; data interpretation; edition; critical review, final approval

5. Filipe Victor Soares Barbosa - Academic of medicine: Scientific meetings, planning; data interpretation; edition; critical review, final approval

6. Danyelle da Silva Diniz - Academic of medicine: Scientific meetings, planning; data interpretation; edition; critical review, final approval

7. Ana Beatriz Camilo Leal de Amorim - Academic of medicine: Scientific meetings, planning; data interpretation; edition; critical review, final approval

8. Lucas David Amorim Stock - Academic of odontology: Scientific meetings, planning; edition; critical review, final approval

9. José Jailson Costa do Nascimento – PhD: Scientific meetings, planning; data interpretation; edition; critical review, final approval. ORCID: 0000-0002-0365-665X

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Corresponding author
José J. C. Nascimento
E-mail: josejailson64@gmail.com