ORIGINAL RESEARCH

DOI: 10.62838/ASMJ.2024.1.02

Assessment of lingula and foramen mandibulae morphology and their implications for inferior alveolar nerve block: a comparative study of contemporary and medieval individuals.

Veress Szidonia Krisztina[1], Péter Elődi Attila[1], Bojin Helga[1], Száva Dániel Tamás[1], Bögözi Bálint Botond[1], Gál Szilárd Sándor[2], Muresan Mircea Gabriel[1]
[1] George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Târgu-Mureș, Romania
[2] Mures County Museum, Târgu Mureș, Romania

Abstract
In this study, we conducted a detailed morphological analysis of the lingula and foramen mandibulae, aiming to examine their anatomical characteristics and relationships within contemporary and medieval individuals.
Our primary objective was to provide valuable insights to assist clinicians in minimizing potential intraoperative complications during anesthesia procedures targeting the inferior alveolar nerve.
To accomplish this, we examined the mandibular structures of 22 adults, 11 children aged 6-12 from archaeological findings in the Târgu Mureș area, and 14 contemporary adults. Our observations encompassed the size, shape, and spatial relationships of the lingula and foramen mandibulae concerning various points along the ascending branch of the mandible.
The study revealed a distinct order of lingula shapes among medieval children and adults, with the triangle, trapezoid, nodular, and assimilated shapes being most prevalent. In modern adults, the order of nodular and assimilated shapes was reversed. Additionally, oval foramina were more common in adults, while round foramina predominated in children. Notably, there was no statistically significant difference between children and adults in the distance from the most prominent point of the lingula to the anterior edge of the ascending branch.
Our findings imply that the depth at which the inferior alveolar nerve can be accessed remains relatively consistent between children and adults. Furthermore, we identified a correlation between the relationship of the shape of the lingula and the position of the mandibular foramen, providing valuable insights for clinical practice.
Keywords: lingula, foramen mandibulae, morphology, inferior alveolar nerve block.

Introduction

The front edge of the foramen mandibulae is covered by a bony formula, the lingula, which was described by Johannes-Baptist Spix in 1815, and is therefore also called Spix's process [1,2]. On the medial surface of the ascending branch is the foramen mandibulae, and sometimes an additional opening (foramina accesoria) can be found [3].

The above-mentioned structures are located in the medial surface of the mandibular ramus, approximately in its central part, and the lingula, if present, is located in front of the foramen mandibulae, which provides passage for the lower alveolar neurovascular bundle to the mandibular canal [4].

Inferior alveolar nerve block is the main technique for anesthesia of the mandible, it is the most important method for hemilateral anesthesia of the jaw [5,6]. The first succesful use of the conventional inferior alveolar nerve block was reported in literature in 1885 and it is also referred as the Halsted approach [7]. During the anesthesia of the inferior alveolar nerve it is necessary to deliver the anesthetic solution into the pterigomandibular area. In order for the anesthesia to be succesful, it is required to place the anesthetic solution as close as possibile to the foramen mandibulae [6,8].

The succes rate of the inferior alveolar nerve block is around 60-80%, due to the great variation of the position of the mandibular foramen and the position and form of the lingula, on which the sphenomandibular ligament attaches causing further difficulties in the lower nerve block [8,9].

The morphology and the position of the foramen mandibulae and lingula is influenced by genethics, the type of the growth, age, sex, the activity of the muscles, tendons and ligaments attached to it, mastication type [10,11,12].

The shape, length, thickness, and nature of attachment of the sphenomandibular ligament varies considerably between individuals. It can be ranged in shape from a thin band that descended for a short distance from the spine of the sphenoid to a broad bi-concave ligament with prominent insertions. Some sphenomandibular ligaments can attach to the medial surface of the mandibular ramus anterior and posterior to the lingula, in addition to their direct attachment to this structure [13,14].

Several authors have tried to classify the form of lingula. For the first time in India [8] the lingula was classified in the case of adult, dried jawbones into four groups: triangular, trapezoidal, nodular, the absence of the lingula is defined as assimilated [12,15]. According to another classification, the lingula can be divided into 5 main groups based on its size and shape: large nodular, small nodular, large triangular, small triangular, and small bony spinous types, which are located in front or behind the mandibular foramen [16].

The mandibular foramen moves anteriorly with age concomitantly with the decreasing size of the gonial angle (GA) and it is hypothesized that the change in the mandibular foramen position with age results from bone apposition in the posterior border of the ramus, and the decrease in the GA results from functional forces exerted from the masseter and medial pterygoid muscles [17]. The shape, size, and the morphology are highly influenced by the development of the person and is characteristic for certain communities [18].

The purpose of the study is to investigate the form and the position of the lingula and the foramen mandibulae in order to assess significant anatomical differences which might reduce the succes rate of this type of anesthesia and indicate the adoption of another inferioar alveolar nerve block tehnique with a higher succes rate. The aim of the study is to provide information about the detailed anatomical proprierties regarding the medial surface and size of the mandibular ascendent ramus in order to help the clinicians to avoid intraoperative injuries.

In this study, several measurements and investigations were made on contemporany human mandibles of different sex, age. In order to inspect a larger distribution of anatomical variations of these elements we studied medieval mandibles of different age and sex. It is known that the mastication type and consistency of food was much higher in medieval ages than nowadays, the abrasion of the occlusal surfaces of the investigated medieval mandibles sustain this fact also in our paper. Higher masticatory forces had a bigger impact on the growth of the anatomical surfaces.

Material and methods

During our study, we examined the anatomical formations and their morphology and location on the medial surface of the ascending branch of 47 dry mandibles. Of these, 14 originated from contemporary adults, which came from the anatomy department of George Emil Palade University of Medicine, Pharmacy, Science, and Technology of Targu Mures. Of the remaining 33, 22 belonged to medieval adults and 11 belonged to medieval children (aged between 6 and 12 years old), which came from the Muzeul Archeologic Târgu Mureș. The mentioned mandibles were unearthed during excavations in Fântânele, Teiuș, Micăsasa, Ghidfălău, Săvădisla, and Târgu Mureș. The approval of the ethics committee was not necesary because the study was not performed on living individuals.

The study took place between February and March 2023.

In the study, we only included mandibles whose ascending branch was preserved on both sides.

Photographs of the mandibles were taken using a 10 cm scale using a Canon 80D DSLR camera equipped with a 100 mm macro lens and RingFlash.

For the morphological classification, we used the classification described by Tuli, as this type of classification is the most frequently found in the literature, which is as follows: 1. triangle, 2. trapezoid, 3. nodular, 4. assimilated. We also took into account where the lingula was located in relation to the alveolar ridge level in horizontal plane and the occlusal plane.

We also classified the shape of the foramen mandibulae (round or oval) and examined the relationship between the foramen and the lingula.

Figure 1: Variations of lingula shapes: A. triangle, B. trapezoidal, C. nodular, D. assimilated

We also measured the distance of the most prominent point of the lingula to our various reference points using callipers with an LED display along imaginary lines drawn through the most prominent point. The distance was measured in the antero-posterior direction related to the anterior and posterior edges of the ascending branch, and in the caudo-cranial direction related to the base of the mandible and the deepest point of the incisura sigmoidea. We also measured how far this point was from the tip of the processius coronoideus and from the Gonion point.

With the help of Adobe Photoshop CC 2017 software, we measured the Gonion angle and the angle formed by the most prominent point of the lingula and the deepest point of the incisura sigmoidea, which we designated as the incisura angle of the mandible.

Figure 2 : The relation and the distance of the most prominent point of the lingula related to the various reference points: A. the relation with the occlusal surface and bone level, B. the distance from different ponts of the ascending branch of the mandible, C. the gonial and incisura angle

Afterwards, we introduced our results into a Microsoft Office Excel software sheet, dividing them into the groups of medieval children and adults and modern adults, and then we prepared descriptive statistics with the help of the software, according to each group. Analytical statistics were then performed using Graphpad InStat software. In the case of qualitative values, we used the Chi square test. In the case of quantitative values, outliers were excluded using the Grubbs test, and then the Kolmogorov-Smirnov test was used to examine the distribution of the data. In the case of numerical values with a normal distribution, parametric even and odd t tests were used, while in the case of values showing a non-normal distribution, nonparametric Wilcoxon, Mann Whitney U, and Spearman tests were performed. During all statistical analyses, the value of α was 0.05.

Results

Table 1. Average value in mm, standard deviation and p-value when comparing the two rami of the mandible in terms of the location of the tip of the lingula from the reference points

Parameters		Right side		Left side		*p*
		Average value	Standard deviation	Average value	Standard deviation	
Medieval children	ML-AM	11.09	2.50	11.90	2.46	*.0425**
	ML-PM	13.45	1.12	13.2	1.22	*.313169*
	ML-IM	23.90	6.84	25.45	5.10	*.30902*
	ML-MN	14.5	1.84	15	2.23	*.300002*
	ML- procc. CORONOIDEUS	24	10.28	33.58	4.50	*.342316*
	ML-GONION	22.7	5.27	22.6	5.58	*.483799*
Medieval adult	ML-AM	12.45	1.99	11.90	1.94	*.1559*
	ML-PM	16.09	2.44	15.5	2.22	*.19807*
	ML-IM	31.5	5.83	31.09	4.82	*.402558*
	ML-MN	16.76	2.82	16.95	2.57	*.410348*
	ML- procc. CORONOIDEUS	33	3.86	32.77	2.36	*.475334*
	ML-GONION	26.05	6.05	28.27	3.54	*.09231*
Contemporary adult	ML-AM	11.14	1.40	11.42	1.50	*.30194*
	ML-PM	14.28	1.54	15.57	0.93	*.00407**
	ML-IM	31.64	4.66	31.14	6.04	*.77022*
	ML-MN	19.46	3.40	17.64	3.99	*<.00001**
	ML- procc. CORONOIDEUS	34	3.19	33.58	4.50	*.808772*
	ML-GONION	27	4.73	27.92	4.95	*.625188*

ML-AM: Distance from the most prominent point of the lingula and the anterior margin.
ML-PM: Distance from the most prominent point of the lingula and the posterior margin.
ML-IM: Distance from the most prominent point of the lingula and the inferior margin.
ML-MN: Distance from the most prominent point of the lingula and the mandibular notch.
ML-procc. CORONOIDEUS: Distance from the most prominent point of the lingula and the proccessus coronoideus
ML-GONION: Distance from the most prominent point of the lingula and the gonial angle.

There is no statistically significant difference between medieval children and adults for the ML-AM distance (p=0.113811).

There is a statistically significant difference between medieval and modern adults for the ML-AM distance (p=0.041165).

We did not find any statistically significant differences between the right and left sides in the gonion and incisura angles for any of the examined groups.

Table 2. The p-value, which is created when the right and left sides of the mandible are compared, in terms of the incidence rate (in percentage) of the anatomical form of the mandibular foramen and lingula.

Parameters		Shape	Right side	Left side	*p*
Medieval children	Foramen mandibulae	Oval	36.4%	36.4%	*1.*
		Round	63.6%	63.6%	
	Lingula	Triangular	36.4%	36.4%	*.753004*
		Trapezoid	18.2%	36.4%	
		Nodular	27.3%	18.2%	
		Assimilated	18.2%	9.1%	
Medieval adult	Foramen mandibulae	Oval	72.7%	63.6%	*.517413*
		Round	27.3%	36.4%	
	Lingula	Triangular	40.9%	31.8%	*.585856*
		Trapezoid	27.3%	36.4%	
		Nodular	27.3%	18.2%	
		Assimilated	4.5%	13.6%	
Contemporary adult	Foramen mandibulae	Oval	66.7%	83.3%	*.345779*
		Round	33.3%	16.7%	
	Lingula	Triangular	35.7%	50%	*.801252*
		Trapezoid	28.6%	14.3%	
		Nodular	21.4%	21.4%	
		Assimilated	14.3%	14.3%	

In the case of medieval children and adults, there is a statistically significant difference in the shape of the foramen mandibulae, in the case of children the round shape is more common (p=0.01368), but we did not find a statistically significant difference in the shape of the lingula (p=0.943178).

The lingula covers the foramen to a statistically significant higher rate in medieval adults compared to medieval children (p=0.006647) and modern adults (p=0.003674).

Table 3. The p-value of the relation of the lingula to the alveolar ridge level in horizontal plane when comparing the right and left sides.

Parameters		Right side	Left side	p
Medieval children	Above bone level	83.3%	83.3%	1.
	At the same level as the bone level	8.3%	8.3%	
	Below bone level	8.3%	8.3%	
Medieval adult	Above bone level	91.3%	81.8%	.546308
	At the same level as the bone level	4.3%	13.6%	
	Below bone level	4.3%	4.5%	
Contemporary adult	Above bone level	78,6%	85,7%	.621705
	At the same level as the bone level	21,4%	14,3%	
	Below bone level	0%	0%	

There was no statistically significant difference in the relation of the lingula to the bone level between medieval children and adults (p=0.719472).

There is no statistically significant difference between the size of the lingula on the two sides for any of the examined groups.

The lingula was statistically significantly larger in the case of medieval adults than in the case of medieval children.

We did not find a statistically significant correlation between the value of the gonion angle and the location of the lingula in the antero-posterior direction, neither for medieval children (p=0.11029), nor for medieval adults (p=0.9339), nor for contemporary adults (p=0.80468).

Discussions

In our study, a total of 47 mandibles were examined, with particular attention to their ascending branch. Eleven of the examined jawbones (23.4%) were of medieval children, 22 pieces (46.8%) were medieval adults, and 14 pieces (29.8%) were a contemporary adults.

According to the present study, the shape of the lingula, both in children and in medieval adults, in order of frequency: 1). was a triangular, followed by 2). trapezoid, then 3). Nodular, and finally 4). assimilated form. In today's adults, the order of occurrence of the first two forms was unchanged, but the third most common was the assimilated form, followed only by the nodular form. To achieve successful anesthesia, it is necessary to reach the foramen mandibulae, which is more difficult to approach if the shape of the lingula is triangular or trapezoid; the size of the lingula and whether it covers the foramen or not also play an important role. A statistically significant correlation was found between the shape and size of the lingula in the medieval (p=0.0033) and modern adult (p=0.0224) groups, and the correlation was even more significant in the case of all adults ($p<0.0001$), but we did not find a correlation for medieval children (p=0.7037). The lingula covered the foramen in a statistically higher rate, if it was triangular or trapezoid in the medieval (p=0.001) and modern (p=0.0021) adults, as well as in the group of all adults ($p<0.0001$), but not for children (p=0.3547). In terms of shape, we found no statistically significant difference in the case of children and adults, but in terms of size, we did. This can be explained by the fact that the shape of the lingula may be genetically determined, but its size is influenced by the type of chewing and the adhesion of the ligamentum sphenomandibulare [12].

In a study carried out by the University College London Institute of Archeology which aimed to compare medieval mandibles with post-medieval mandible finds, a total of 279 finds (135 mediaeval, 144 post-mediaeval) were used, which were also grouped by gender. According to the results of the study, regarding the width of the ramus anteroposterior (AM-ML-PM), a significant difference can be detected between the two groups, both in the case of women ($p<0.05$) and men ($p<0.005$). Their research, in contrast to our present study, found that in addition to the ML-AM section, there are also significant differences in other sections. This allowed the researchers-archaeologists to conclude, knowing that the requisition of muscles and their strength affects the development of bones and is the result of a change in eating habits (uncooked food and a lot of chewing, which was required to cut it up, were replaced by soft, cooked and fried foods and therefore less chewing was necessary) is that the larger and more robust mandible was replaced by a smaller posteriorly rotated mandible. These changes were mostly observed in the region related to the muscles of mastication and the most striking changes observed were: a decrease in the width and in the height of the ramus of the mandible and an increase in the value of the gonion angle [19].

Ligaments mediate bone to bone attachments to transfer the strength and make structures as a whole in the musculoskeletal system. Heterotopic ossification commonly happens at all sites of the body. In pathology of heterotopic ossification of tendons and ligaments mechanical factors, such as overload, may be an essential factor. Besides the role of mechanical stimulus in inducing injury, it was reported to contribute to chondrogenic/ osteogenic differentiation, which may be an essential factor for heterotopic ossification of the ligaments. Pronounced masticatory forces can trigger ossification of the sphenomandibular ligament attached to the lingula, thereby increasing the size of the lingula. This fact may explain why we found statistically significantly larger lingulae in medieval adults. At the same time, based on this, individuals with stronger chewing forces like masseter chewing type are more likely to encounter a large lingula, which can make anesthesia difficult [20].

When comparing the right and left side, we found no statistically significant differences regarding the location of the lingula and foramen mandibulae from the different reference points or compared to the bone level (except for the ML-AM distance in medieval children and the ML-PM and ML-MN distances in modern adults) regarding the gonion and incisura angles or the shape and size of the lingula and foramen. According to this, if there are no problems during anesthesia on one side, there will probably be no problems with anesthesia on the other side either.

We did not find a statistically significant correlation between the most prominent point of the lingula and the value of the gonion angle. Based on the result, we can assume that the inferior alveolar nerve can be reached at a similar depth, regardless of age or skeletal type (we find an increased value of the gonion angle in children, the elderly and hyperdivergent growth type patterns) [21,22]. A study conducted on CBCT of 407 Chinese adults, in contrast to our study, found a correlation between the gonion angle and the foramen mandibulae, with the foramen being more posterior and inferior in individuals with higher gonion angle values [23].

Conclusions

Comparing the distance of the most prominent point of the lingula to different reference points between children and medieval adults, we found statistically significant differences at all stages except for the anterior edge of the ascending branch. Based on this, the inferior alveolar nerve can be reached at a similar depth in children during anesthesia of the lower jaw.

We found a correlation between the shape of the lingula and the foramen-lingula relationship, triangular and trapezoid processes more often cover the foramen mandible. At the same time, significantly less often in the case of medieval children and contemporary adults, the lingula, regardless of its shape, blocked the entry of the nerve into the mandible than in medieval adults.

Since pronounced masticatory forces can cause the ossification of the sphenomandibular ligament and, as a consequence, the growth of the lingula, it is more likely that patients with stronger masticatory forces have a larger lingula, so it will be more difficult to perform anesthesia of the lower jaw.

Conflict of interest: None declared.

References

1. Zhao K, Zhang B, Hou Y, Miao L, Wang R, Yuan H. Imaging study on relationship between the location of lingula and the Gonial angle in a Chinese population. Surg Radiol Anat. 2019; 41:455–460.
2. Hsu KJ, Tseng YC, Liang SW, Hsiao SY, Chen CM, Dimension and Location of the Mandibular Lingula: Comparisons of Gender and Skeletal Patterns Using Cone-Beam Computed Tomography. Biomed Res Int. 2020; 2020:2571534.
3. Lipski M, Tomaszewska IM, Lipska W, Lis GJ, Tomaszewski KA. The mandible and its foramen: anatomy, anthropology, embryology and resulting clinical implications, Folia Morphol (Warsz). 2013; 72(4):285-92.
4. Lima FJC, Oliveira-Neto OB, Barbosa FT, Sousa-Rodrigues CF. Location, shape, and anatomic relations of the mandibular foramen and the mandibular lingula: a contribution to surgical procedures in the ramus of the mandible. Oral Maxillofac Surg. 2016; 20(2):177-82.
5. Kharma MY, Kousa B, Alghamdi A, Alsenani A, Alhamed A, Quandeel R et al. Prevalence of inferior alveolar nerve block failure among undergraduate dental students: susceptible reasons and how to avoid them? Azerbaijan Medical Journal. 2022; 62. 4729-4740.
6. Truong MK, He P, Adeeb N, Oskouian RJ, Tubbs RS, Iwanaga J. Clinical Anatomy and Significance of the Retromolar Foramina and Their Canals: A Literature Review, Cureus. 2017; 9(10):e1781.
7. Jorgensen NB, Hayden J. Sedation, Local and General Anesthesia in Dentistry. 2nd ed. Philadelphia. Lea and Febiger. 1973; p.146.
8. Tuli A, Choudhry R, Choudhry S, Raheja S, Agarwal S. Variation in shape of the lingula in the adult human mandible. J Anat. 2000; 8:197 (Pt 2)(Pt 2):313-7.
9. AlHindi M, Rashed B, AlOtaibi N. Failure rate of inferior alveolar nerve block among dental students and interns. Saudi Med J. 2016; 37(1):84-9.
10. Hatcher DC. Anatomy of the Mandible, Temporomandibular Joint, and Dentition. Neuroimaging Clin N Am. 2022; 32(4):749-761.
11. Damera A, Mohanalakhsmi J, Yellarthi P, Rezwana B. Radiographic evaluation of mandibular ramus for gender estimation: Retrospective study. J Forensic Dent Sci. 2016; 8(2):74-8.
12. Chen CM, Lee HN, Liang SW, Hsu KJ. Morphological Study of the Mandibular Lingula and Antilingula by

Cone-Beam Computed Tomography. Bioengineering. 2023; 10(2):170.
13. Khoury JN, Mihailidis S, Ghabriel M, Townsend G. Applied anatomy of the pterygomandibular space: improving the success of inferior alveolar nerve blocks. Aust Dent J. 2011; 56(2):112-21.
14. Simonds E, J. Iwanaga J, Oskouian RJ, Tubbs RS. Duplication of the Sphenomandibular Ligament. Cureus. 2017; 9(10):e1783.
15. Upadhyay R, Upadhyay J, Agrawal P, Rao N. Analysis of gonial angle in relation to age, gender, and dentition status by radiological and anthropometric methods. J Forensic Dent Sci. 2012; 4(1):29-33.
16. Fabian FM. Observation of the position of the lingula in relation to the mandibular foramen and the mylohyoid groove. Ital J Anat Embryol. 2006; 111(3):151-8.
17. Ashkenazi M, Taubman L, Gavish A. Age-Associated Changes of the Mandibular Foramen Position in Anteroposterior Dimension and of the Mandibular Angle in Dry Human Mandibles. The Anatomical Record. 2011; 294(8):1319-25.
18. Gal SZS, Dudas CS, Gabor MH, Flesicher GJ, Kerekes B. Dental morphometric analysis of Medieval and Early Modern artefacts from Mureş County. Bibliotheca Musei Marisiensis. Seria Arhaelogica. 2019; 43-51.
19. Rando C, Hillson S, Antoine D. Changes in mandibular dimensions during the mediaeval to post-mediaeval transition in London: A possible response to decreased masticatory load. Arch Oral Biol. 2014; 59(1):73-81.
20. Zhang Q, Zhou D, Wang H, Tan J. Heterotopic ossification of tendon and ligament. J Cell Mol Med. 2020; 24(10):5428-5437.
21. Bajracharya M, Rajbhandari A, Pradhan R, Manandhar P, Maharjan S, Pant BD. Gonial Angle by Lateral Cephalogram in Orthodontic Patients of a Tertiary Care Hospital: A Descriptive Cross-sectional Study. JNMA J Nepal Med Assoc. 2021; 59(237):482-485.
22. Leversha J, McKeough G, Myrteza A, Skjellrup-Wakefiled H, Welsh J, Sholapurkar A. Age and gender correlation of gonial angle, ramus height and bigonial width in dentate subjects in a dental school in Far North Queensland. J Clin Exp Dent. 2016; 8(1):e49-54.
23. Chen CM, Lee HN, Chen YT, Hsu KJ. Locating the Mandibular Lingula Using Cone-Beam Computed Tomography: A Literature Review. J Clin Med. 2023; 12(3):881.

Corresponding author:
Veress Szidonia Krisztina
George Emil Palade University of Medicine, Pharmacy, Science and Technology of Târgu Mureș, 38 Gheorghe Marinescu street, Târgu Mureș, 540139, Romania
Email: szidonia-krisztina.veress@umfst.ro

Received: November 9, 2023 / Accepted: January 19, 2024