ONLINE FIRST

This is a provisional PDF only. Copyedited and fully formatted version will be made available soon.

ISSN: 0015-5659

e-ISSN: 1644-3284

The complete anatomy of the mandibular lingula: a meta-analysis with clinical implications

Authors: Kinga Glądys, Patryk Ostrowski, Michał Bonczar, Maria Kwiecińska, Jakub Gliwa, Ameen Nasser, Kamil Możdżeń, Mateusz Trzeciak, Iwona Gregorczyk-Maga, Agata Musiał, Marcin Lipski, Jerzy Walocha, Mateusz Koziej

DOI: 10.5603/fm.96992

Article type: Original article

Submitted: 2023-08-16

Accepted: 2023-10-23

Published online: 2023-11-08

The complete anatomy of the mandibular lingula: a meta-analysis with clinical implications

Kinga Glądys et al., The complete anatomy of the mandibular lingula

Kinga Glądys[1], Patryk Ostrowski[1, 2], Michał Bonczar[1, 2], Maria Kwiecińska[1], Jakub Gliwa[1], Ameen Nasser[1], Kamil Możdżeń[1], Mateusz Trzeciak[1], Iwona Gregorczyk-Maga[3], Agata Musiał[1], Marcin Lipski[1], Jerzy Walocha[1, 2], Mateusz Koziej[1, 2]

[1]Department of Anatomy, Jagiellonian University Medical College, Kraków, Poland

[2]Youthoria, Youth Research Organization, Krakow, Poland

[3]Faculty of Medicine, Institute of Dentistry, Jagiellonian University Medical College, Krakow, Poland

Address for correspondence: Mateusz Koziej, Department of Anatomy, Jagiellonian University Medical College, ul. Mikołaja Kopernika 12, 33-332 Kraków, Poland, e-mail: mateusz.koziej@gmail.com

ABSTRACT

Background: The objective of this meta-analysis was to investigate the anatomical variations of the mandibular lingula (ML) and its relationship to surrounding anatomical structures. Understanding such variations is crucial to help determine the site and depth of a successful inferior alveolar nerve (IAN) anesthetic block as well as a safe area for oral and maxillofacial invasive procedures in order to minimize the risk of neurological or hematological damage to the inferior alveolar nerve.

Materials and methods: A systematic search was conducted in which all studies were searched on the anatomy of ML. Major medical databases such as PubMed, Scopus, Embase, Web of Science, Google Scholar, Cochrane Library were searched.

Results: All of the results were based on a total of 4694 subjects. The overall height of the ML was found to be 8.17 mm (SE =0.22). The Triangular Type of the ML was found to be the most common one. The pooled prevalence of this variation was found to be 29.33% (LCI = 23.57% ; HCI = 35.24%). The pooled prevalence of the Nodular Type was set to be 27.99% (LCI = 22.64% ; HCI = 33.67%).

Conclusions: The present meta-analysis provides clinically relevant information regarding the shape, location, and height variations of the ML. Understanding such variations of the ML is crucial when performing malocclusion corrections procedures that require the ML as a landmark, namely sagittal split ramus osteotomy, and intraoral vertical ramus osteotomy. Furthermore, effective anesthetic blocks during oral and maxillofacial procedures can be accomplished with a higher success rate if the correct site of injection is identified. The possible locations of the ML should be considered in order to determine the location of the mandibular foramen and, therefore, inferior alveolar bundle in order to prevent motor, sensory, or perfusion pathology during maxillofacial and oral procedures of the lower jaw.

Keywords: mandibular lingula, mandibula, inferior alveolar nerve, anatomy, surgery

INTRODUCTION

The mandibular lingula (ML) (Figures 1-3) is a tongue-like shaped projection from the mandible located on the medial side of the ramus near the posterior border of the mandibular foramen (MF) [1]. The sphenomandibular ligament is palpable through the mucosa, which the ML serves as an attachment point [2]. Previous reports have observed that in more than 50% of adults, the ML participates in forming half to two-thirds of the wall of the MF, while also serving as the origin of the mylohyoid line from the posterior border [3]. A previous study [4] observed four shape variations of the ML; triangular, truncated, nodular, and assimilated.

Relevant to the ML is the inferior alveolar nerve (IAN) that goes through the MF. The IAN is a branch of the mandibular nerve that subdivides into the mylohyoid, dental, incisive, and mental branches [5]. The IAN is responsible for sensory innervation of the mandibular teeth, the gingiva of the mandible, and the lower lip, providing a target for anesthesia in certain oral and maxillofacial procedures [6].

The ML serves as an anatomical landmark for anesthetic and oral and maxillofacial orthognathic procedures [5]. Due to the variations of anatomical landmarks such as the ML or MF, IAN block procedures display a challenging and low success rate, with 29-35% of failure [5]. Specific caution should be taken during sagittal split ramus osteotomy (SSRO) procedures, a technique related to the invasive correction of mandibular deformities [2]. In the SSRO procedure, the ML provides an anatomical landmark for a safe split, ideally for the horizontal osteotomy to be done superior to the ML and extend posteriorly in order to prevent IAN injury [7]. Another procedure that utilizes the ML and anti lingula (AL) as landmarks are the intraoral vertical ramus osteotomy (IVRO) [8], in which the bone must be cut superior and posterior to the apex of the ML. This is primarily done to avoid damaging the inferior alveolar bundle (IAB) in order to prevent hemorrhage, neurological damage, or anesthetic toxicity [5]. Slight compression of the IAN can result in neurapraxia [9], and overall damage to the IAN presents as an abnormal sensation of the lower teeth and jaw area with possible speech and chewing difficulty.

The objective of this meta-analysis was to investigate the anatomical variations of the ML and its relationship to surrounding anatomical structures. Understanding such variations is crucial to help determine the site and depth of a successful IAN anesthetic block as well as a safe area for oral and maxillofacial invasive procedures in order to minimize the risk of neurological or hematological damage to the IAN.

MATERIALS AND METHODS

Search strategy

A systematic search was conducted in which all studies were searched on the anatomy of ML. Major medical databases such as PubMed, Scopus, Embase, Web of Science, Google Scholar, Cochrane Library were searched. The overall search process was conducted in 2 stages. (1) In the first step, all mentioned medical databases were searched using the following search terms: mandibular lingula. Neither the date, language, article type, nor text availability conditions were applied. (2) Furthermore, an additional manual search was also performed on all references from the initial submitted studies. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed. In addition, The Critical Appraisal Tool for Anatomical Meta-analysis (CATAM) and Anatomical Quality assessment Tool (AQUA) were used to provide the highest quality findings [10, 11].

Eligibility assessment and data extraction

The inclusion criteria were established as follows: original articles with extractable data on the anatomy, morphology, topography, and/or variance of the ML. Exclusion criteria included conference reports, case reports, case series, reviews, letters to the editor, patients with a noticeable pathology that could potentially distort the anatomy of ML and studies with no relevant or incompatible data. The systematic search was carried out by two independent reviewers. A total of 1862 articles were initially evaluated by two independent reviewers. Eventually, 48 articles met the required criteria and were used in this meta-analysis [2, 4–9, 12–52]. The overall data collection process can be found in Figure 4. The characteristics of the studies submitted can be found in Table 1. Data from qualified studies were extracted by two independent reviewers. Qualitative and qualitative data were extracted from the studies and gathered for statistical analysis. Any discrepancies between the studies identified by the two reviewers were resolved by contacting the authors of the original studies wherever possible or by consensus with a third reviewer.

Statistical analysis

To perform this meta-analysis, STATISTICA version 13.1 software (StatSoft Inc., Tulsa, OK, USA), MetaXL version 5.3 software (EpiGear International Pty Ltd,Wilston, Queensland, Australia), and Comprehensive Meta-analysis version 4.0 software (Biostat Inc., Englewood, NJ, USA) were applied. A random effects model was used. The Chi-square test and the I-squared statistic were chosen to assess the heterogeneity among the studies [53, 54]. P-values and confidence intervals were used to determine the statistical significance between the studies. A p-value lower than 0.05 was considered statistically significant. In the event of overlapping confidence intervals, the differences were considered statistically insignificant. I-squared statistics were interpreted as follows: values of 0–40% were considered as “might not be important”, values of 30–60% were considered as “might indicate moderate heterogeneity”, values of 50–90% were considered as “may indicate substantial heterogeneity”, and values of 75–100% were considered as “may indicate substantial heterogeneity.” The results obtained using different methods did not differ statistically significantly from one another ($p > 0.05$). Therefore, an overall analysis could be performed.

RESULTS

All of the results were based on a total of 4694 subjects. The overall height of the ML was found to be 8.17 mm (SE =0.22). The overall height based on the cadaveric studies was set to be 8.26 mm (SE=0.39). The overall height based on the imaging studies was found to be 7.84 mm (SE=0.10). The height of the ML occuring on the right side was found to be 8.42 mm (SE = 0.30), whereas on the left side was found to be 8.16 mm (SE = 0.81). All the results mentioned above and more deatiled ones are gathered in Table 2.

The types of the ML were established by Tuli et al. [4]. The Triangular Type of the ML was found to be the most common one. The pooled prevalence of this variation was found to be 29.33% (LCI = 23.57% ; HCI = 35.24%). The pooled prevalence of the Nodular Type was set to be 27.99% (LCI = 22.64% ; HCI = 33.67%). The pooled prevalence of the Truncated Type was established at 27.62% (LCI = 24.72% ; HCI = 30.61%). The pooled prevalence of the Assimilated Type was set to be 10.49% (LCI = 7.60% ; HCI = 13.77%). All the results mentioned above and more detailed ones are gathered in Table 3.

The mean distance from the ML to the mandibular notch was set to be 16.16 mm (SE = 0.33). The mean distance from ML to the anterior border of ramus was found to be 16.81 mm (SE = 0.64). The mean distance from ML to the posterior border of ramus was set to be 15.35 mm (SE = 0.33). The mean distance from ML to the retrolingular fossa was found to be 31.39 mm (SE = 1.52). All the results mentioned above and more detailed ones are gathered in Table 4.

DISCUSSION

The objective of this meta-analysis was to determine the anatomical variations of the ML with respect to surrounding structures. In regards to the heights of the ML, Sekerci and Sisman [23] identified the right side to be more pronounced in males than in females. This is similar to a study performed by Hsu et al. [55], where the ML height was identified to be bigger in males than females, however, with no relation to the side. Moreover, Jansisyanont et al. [42] identified an overall mean height of 8.2 mm. The present meta-analysis demonstrates similar findings, namely a mean height of 8.17 mm. Furthermore, our results show that the right ML is slightly higher (8.42 mm) than the left one (8.10 mm). A previous study conducted by Senel et al. [22], also supports this difference, with an observed ML height of approximately 8.3 mm on the right side and 7.4 mm on the left side.

A previous study performed by Tuli et al. [4] reported four shape variations of the ML; 68.5% of triangular shaped ML, 15.8% of truncated shape, 10.9% of nodular, and 4.8% of assimilated shape. Somewhat similarly, Hsu et al. [56] observed variation of shape predominance based on the method of study, namely dry mandible and CBCT; in the dry mandibular study, the predominant shape of the ML was found to be 39% triangular, while in CBCT the most frequent shape found was nodular in 50.6% of studied cases. Both studies, however, concluded that the least common shape variation of the ML was the assimilated type. The performed meta-analysis analyzed the prevalences of said morphological variations of the ML, with comparable findings of the assimilated type being the least common shape (10.49%). Moreover, the most commonly observed shape was triangular, with a prevalence rate of 29.23%; 27.99% of subjects had a nodular type, and 27.62% had truncated type. Among the triangular type, 74.99% of the studied subjects displayed bilateral symmetry. The second most common bilateral shape was found to be truncated, with a prevalence rate of 68.58%, followed by nodular (64.79%) and assimilated (62.11%). Hsu et al. [56] also reported a predominance of bilateral symmetry among both the investigated dry mandible and CBCT study groups. With respect to gender-determining factors, Alves and Deana [7] claimed that the truncated type was found more commonly in women, while triangular was found more commonly in men. Unfortunately, due to a lack of sufficient data in the literature, we could not perform a statistical analysis of the variable anatomy of the ML with respect to the gender of the subjects.

Knowledge about the morphometric relationships between the ML and the surrounding landmarks of the mandible may help to localize this structure effectively. Hsu et al. [55] reported a mean distance of 18-20 mm from the anterior ramus border to the mandibular lingula (ARLD). Interestingly, Findik et al. [46] concluded a lower mean ARLD of approximately 15-16 mm. However, the variation of reference points and planes could have led to possible dissimilarity among the different studies. This meta-analysis identified an ARLD of 16.81 mm; this closely relates to previously mentioned studies.

Senel et al. [22] observed a distance of 38.3 mm between the ML and the inferior ramus border. A mean distance from the lingula to the mandibular notch was observed to be approximately 16.6 mm, as found by Jansisyanot et al. [42] in a previous study, while Sekerci et al. [23] observed the mean distance to be 15.32 mm. The overall mean distance from the ML to the mandibular notch found in this meta-analysis was most similar to that of Jansisyanot et al., with a distance of approximately 16.16 mm. Moreover, the meta-analysis found the mean distance from the ML to the occlusal plane to be 9.60 mm. Similar distances were observed in previous studies conducted by Lupi et al. [34] and Ackay et al. [2], where the reported mean distances between the ML and occlusal plane were 10-12 mm and 8-10 mm respectively.

The ML serves as a crucial point of identification of the MF (located infero-posteriorly with respect to the ML) as well as IAN prior to its entry into the mandible [57]. The results of this meta-analysis can be useful to determine variations, which are crucial to keep in mind when performing an IAN anesthetic block in regard to the site and depth of injection in relation to the ML. This is primarily due to the low success rate of the anesthetic procedure, as previously mentioned, which was found to be approximately 29-35% [7]. Choi and Hur [58] claim that the maximal value from the occlusal plane can prevent injecting too deeply, thus preventing IAN block, in contrast to using the mean value as a point of reference. Nevertheless, preoperative scanning is a crucial step for the evaluation of the structure of the mandible prior to any invasive procedures [59]. With respect to the SSRO dentofacial correction procedure, the ML provides a convenient landmark for a safe horizontal osteotomy [7]. Smith et al. [60] observed that the fusion is approximately between 7.5 mm to 13.3 mm above the localization of the ML, serving as a point of reference for the cortical merge during the SSRO procedure. In addition to this, the IVRO [8] procedures require the utilization of the ML and AL as a landmark, in which the bone must be cut superoposteriorly to the apex of the ML. Furthermore, accurate identification of the anatomic variations of ML and MF is critical for other various oral and maxillofacial procedures, including but not limited to trauma management, tumor resections, cyst removals, and temporomandibular joint (TMJ) reconstruction [38]. Contrastingly, the ML can also serve as a landmark to identify the location of the IAN for intended excision procedures, such as in some cases of facial neuralgia [61].

The present study is not without limitations. It may be burdened with potential bias, as the accuracy of the data taken from various publications limits the results of this meta-analysis. Additionally, most of the evaluated studies come from Asia and therefore the overall results may eflect the anatomical features of Asian people rather than the global population. Some analysis were not performed due to insufficient amount of data in the literature. Although not without limitations, our meta-analysis attempts to estimate ML anatomy based on the data from the literature that meet the requirements of evidence-based anatomy.

CONCLUSIONS

The present meta-analysis provides clinically relevant information regarding the shape, location, and height variations of the ML. Understanding such variations of the ML is crucial when performing malocclusion corrections procedures that require the ML as a landmark, namely SSRO, and IVRO. Furthermore, effective anesthetic blocks during oral and maxillofacial procedures can be accomplished with a higher success rate if the correct site of injection is identified. The possible locations of the ML should be considered in order to determine the location of the MF and, therefore, IAB in order to prevent motor, sensory, or perfusion pathology during maxillofacial and oral procedures of the lower jaw.

Abberviations List: ML – Mandibular Lingua; IAN – Inferior Alveolar Nerve; MF – Mandibular Foramen; SSRO - Sagittal Split Ramus Osteotomy; AL – Anti Lingula; IVRO - Intraoral Vertical Ramus Osteotomy; IAB - Inferior Alveolar Bundle; ARLD - Anterior Ramus Border to the Mandibular Lingula; TMJ - Temporomandibular Joint

DECLARATIONS

Conflicting interests: The author(s) declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding: The author(s) received no financial support for the research, authorship, and/or publication of this article. Dr. Mateusz Koziej was supported by the Foundation for Polish Science (FNP). The funders had no role in the study's design, data collection, analysis, decision to publish, or preparation of the manuscript.

Informed consent: Not applicable

Ethical approval: Not applicable

REFERENCES

1. Devi R, Arna N, Manjunath KY, Balasubramanyam (2003) Incidence of morphological variants of mandibular lingula. Indian J Dent Res 14:210–3
2. Akcay H, Kalabalık F, Tatar B, Ulu M (2019) Location of the mandibular lingula: Comparison of skeletal Class I and Class III patients in relation to ramus osteotomy using cone-beam computed tomography. J Stomatol Oral Maxillofac Surg 120:504–508. https://doi.org/10.1016/j.jormas.2019.07.013
3. Fabian FM (2006) Observation of the position of the lingula in relation to the mandibular foramen and the mylohyoid groove. Ital J Anat Embryol 111:151–8
4. Tuli A, Choudhry R, Choudhry S, et al (2000) Variation in shape of the lingula in the adult human mandible. J Anat 197:313–317. https://doi.org/10.1046/j.1469-7580.2000.19720313.x
5. Ahn B-S, Oh SH, Heo C-K, et al (2020) Cone-beam computed tomography of mandibular foramen and lingula for mandibular anesthesia. Imaging Sci Dent 50:125. https://doi.org/10.5624/isd.2020.50.2.125
6. Jang H-Y, Han S-J (2019) Measurement of mandibular lingula location using cone-beam computed tomography and internal oblique ridge-guided inferior alveolar nerve block. J Korean Assoc Oral Maxillofac Surg 45:158. https://doi.org/10.5125/jkaoms.2019.45.3.158

7. Alves N, Deana NF (2015) Morphological Study of the Lingula in Adult Human Mandibles of Brazilians Individuals and Clinical Implications. Biomed Res Int 2015:1–7. https://doi.org/10.1155/2015/873751
8. Apinhasmit W, Chompoopong S, Jansisyanont P, et al (2011) The study of position of antilingula, midwaist of mandibular ramus and midpoint between coronoid process and gonion in relation to lingula of 92 Thai dried mandibles as potential surgical landmarks for vertical ramus osteotomy. Surgical and Radiologic Anatomy 33:337–343. https://doi.org/10.1007/s00276-010-0700-y
9. Apinhasmit W, Chompoopong S, Jansisyanont P (2015) Alternative Landmarks of the Mandibular Foramen to Prevent Nerve Injury during Ramus Surgery. J Med Assoc Thai 98:574–81
10. Henry BM, Tomaszewski KA, Ramakrishnan PK, et al (2017) Development of the Anatomical Quality Assessment (AQUA) Tool for the quality assessment of anatomical studies included in meta-analyses and systematic reviews. Clinical Anatomy 30:6–13. https://doi.org/10.1002/ca.22799
11. D’Antoni A V., Tubbs RS, Patti AC, et al (2022) The Critical Appraisal Tool for Anatomical Meta-analysis: A framework for critically appraising anatomical meta-analyses. Clinical Anatomy 35:323–331. https://doi.org/10.1002/ca.23833
12. Gupta S, Pandey K (2014) Morphological analysis of the lingula in dry mandibles of individuals in North India. IOSR Journal of Dental and Medical Sciences 1:04–06
13. Zhou C, Jeon T-H, Jun S-H, Kwon J-J (2017) Evaluation of mandibular lingula and foramen location using 3-dimensional mandible models reconstructed by cone-beam computed tomography. Maxillofac Plast Reconstr Surg 39:30. https://doi.org/10.1186/s40902-017-0128-y
14. Zhao K, Zhang B, Hou Y, et al (2019) Imaging study on relationship between the location of lingula and the Gonial angle in a Chinese population. Surgical and Radiologic Anatomy 41:455–460. https://doi.org/10.1007/s00276-019-02195-x
15. Yeh AYE, Finn BP, Jones RHB, Goss AN (2018) The variable position of the inferior alveolar nerve (IAN) in the mandibular ramus: a computed tomography (CT) study. Surgical and Radiologic Anatomy 40:653–665. https://doi.org/10.1007/s00276-018-1973-9
16. Varma CL, Sameer P (2013) Morphological Variations of Lingula in South Indian Mandibles. Research and Reviews: Journal of Medical and Health Sciences 2:31–34

17. Stipo AR, Bertoglio B, Biehler-Gomez L, et al (2022) Morphological analysis of lingula shape in a modern Italian cemeterial population: Clinical and forensic considerations. Leg Med 55:102027. https://doi.org/10.1016/j.legalmed.2022.102027
18. Srimani P, Goswami B, Mazumdar S (2017) Morphologic and Morphometric Analysis of Lingula in Localizing Mandibular Foramen with its Surgical Importance. International Journal of Anatomy, Radiology and Surgery 6:A001–A006
19. Sophia M, Alagesan A, Ramchandran K (2015) A Morphometric and Morphological Study of mandibular lingula and its Clinical Significance. International Journal of Medical Research and Review 3:141–148
20. Woo S-S, Cho J-Y, Park W-H, et al (2002) A Study of Mandibular Anatomy For Orthognathic Surgery In Koreans. J Korean Assoc Oral Maxillofac Surg 28:126–131
21. Sinanoglu A, Seki U, Tokuc B (2023) A detailed radiomorphometric analysis of the mandibular foramen, lingula and anti-lingula with a special emphasis on mandibular prognathism. J Stomatol Oral Maxillofac Surg 124:101260. https://doi.org/10.1016/j.jormas.2022.08.003
22. Senel B, Ozkan A, Altug HA (2015) Morphological evaluation of the mandibular lingula using cone-beam computed tomography. Folia Morphol (Warsz) 74:497–502. https://doi.org/10.5603/FM.2015.0114
23. Sekerci AE, Sisman Y (2014) Cone-beam computed tomography analysis of the shape, height, and location of the mandibular lingula. Surgical and Radiologic Anatomy 36:155–162. https://doi.org/10.1007/s00276-013-1150-0
24. Samanta P, Kharb P (2012) Morphological analysis of the lingula in dry adult human mandibles of north Indian population. Journal of Cranio-Maxillary Diseases 1:7. https://doi.org/10.4103/2278-9588.102467
25. Rikhotso R, Munsamy C (2017) A morphological study of the lingula in South Africans in relation to sagittal split osteotomy. South African Dental Journal 72:. https://doi.org/10.17159/2519-0105/2017/v72no9a2
26. Park JH, Jung H-D, Kim HJ, Jung Y-S (2018) Anatomical study of the location of the antilingula, lingula, and mandibular foramen for vertical ramus osteotomy. Maxillofac Plast Reconstr Surg 40:15. https://doi.org/10.1186/s40902-018-0155-3
27. Padmavathi G, Varalakshmi K, Suman T, Roopashree K (2014) A Morphological and Morphometric Study of the Lingula in Dry Adult Human Mandibles of South Indian Origin and Its Clinical Significance. Int J Health Sci Res 4:56–61

28. Özalp Ö, Salım H, Bilgin B, et al (2020) Morphologic and morphometric analysis of mandibular lingula. Anatomy 14:16–221. https://doi.org/10.2399/ana.20.003
29. Nirmale V, Mane U, Sukre S, Diwan C (2012) Morphological Features of Human Mandible. International Journal of Recent Trends in Science and Technology 3:38–43
30. Murlimanju BV, Prabhu LV, Pai MM, et al (2012) Morphological study of lingula of the mandibles in South Indian population. Morphologie 96:16–20. https://doi.org/10.1016/j.morpho.2012.01.001
31. Monnazzi MS, Passeri LA, Gabrielli MFR, et al (2012) Anatomic study of the mandibular foramen, lingula and antilingula in dry mandibles, and its statistical relationship between the true lingula and the antilingula. Int J Oral Maxillofac Surg 41:74–78. https://doi.org/10.1016/j.ijom.2011.08.009
32. Modasiya UP, D Kanani S (2018) Study of The Lingula In Dry Human Mandibles and Its Clinical Significance. International Journal of Anatomy and Research 6:5218–5221
33. Madiraju GS, Mohan R (2023) Morphological Analysis of the Mandibular Lingula and Its Relation to Antilingula Using Cone-Beam Computed Tomography in the Saudi Population. Diagnostics 13:419. https://doi.org/10.3390/diagnostics13030419
34. Lupi SM, Landini J, Olivieri G, et al (2021) Correlation between the Mandibular Lingula Position and Some Anatomical Landmarks in Cone Beam CT. Healthcare 9:1747. https://doi.org/10.3390/healthcare9121747
35. Lopes PTC, Pereira GAM, Santos AMPV (2010) Morphological analysis of the lingula in dry mandibles of individuals in Southern Brazil. Journal of Morphological Sciences 27:136–138
36. Lima FJC, Oliveira Neto OB, Barbosa FT, Sousa-Rodrigues CF (2016) 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 20:177–182. https://doi.org/10.1007/s10006-016-0547-4
37. Kronseder K, Runte C, Kleinheinz J, et al (2020) Distribution of bone thickness in the human mandibular ramus – a CBCT-based study. Head Face Med 16:13. https://doi.org/10.1186/s13005-020-00228-0
38. Kositbowornchai S, Siritapetawee M, Damrongrungruang T, et al (2007) Shape of the lingula and its localization by panoramic radiograph versus dry mandibular measurement. Surgical and Radiologic Anatomy 29:689–694. https://doi.org/10.1007/s00276-007-0270-9
39. Sanmugam K (2015) A Study of Morphological Variation of Lingula and Coronoid Process of Adult Human Dry Mandibles. Journal of Pharmaceutical Sciences and Research 7:1017–1020

40. Kim HJ, Lee HY, Chung IH, et al (1997) Mandibular anatomy related to sagittal split ramus osteotomy in Koreans. Yonsei Med J 38:19. https://doi.org/10.3349/ymj.1997.38.1.19
41. Jung Y-H, Cho B-H, Hwang JJ (2018) Location and shape of the mandibular lingula: Comparison of skeletal class I and class III patients using panoramic radiography and cone-beam computed tomography. Imaging Sci Dent 48:185. https://doi.org/10.5624/isd.2018.48.3.185
42. Jansisyanont P, Apinhasmit W, Chompoopong S (2009) Shape, height, and location of the lingula for sagittal ramus osteotomy in Thais. Clinical Anatomy 22:787–793. https://doi.org/10.1002/ca.20849
43. Huang C-Y, Liao Y-F (2016) Anatomical position of the mandibular canal in relation to the buccal cortical bone in Chinese patients with different dentofacial relationships. Journal of the Formosan Medical Association 115:981–990. https://doi.org/10.1016/j.jfma.2015.10.004
44. Hsiao S-Y, Hsu K-J, Liang S-W, et al (2020) The presence probability of mandibular lingla and antilingula. J Stomatol Oral Maxillofac Surg 121:621–625. https://doi.org/10.1016/j.jormas.2020.03.014
45. Hosapatna M, Ankolekar VH, D'Souza AS, et al (2015) The Study of Antilingula and Its Relation to the Lingula and Mandibular Foramen, the Presence of Mylohyoid Bridging in Dry Mandibles of South Indian Population. J Maxillofac Oral Surg 14:308–311. https://doi.org/10.1007/s12663-014-0663-3
46. Findik Y, Yildirim D, Baykul T (2014) Three-Dimensional Anatomic Analysis of the Lingula and Mandibular Foramen. Journal of Craniofacial Surgery 25:607–610. https://doi.org/10.1097/SCS.0b013e3182a30ec3
47. V Durgesh, Rani.Ch R (2016) A Study of the Shapes of Mandibular Lingula in North Coastal Andhra Pradesh. IOSR Journal of Dental and Medical Sciences 15:96–98. https://doi.org/10.9790/0853-1509079698
48. Direk F, Uysal II, Kivrak AS, et al (2018) Reevaluation of Mandibular Morphometry According to Age, Gender, and Side. Journal of Craniofacial Surgery 29:1054–1059. https://doi.org/10.1097/SCS.0000000000004293
49. Chenna D, Hosapatna M, Sylvan D'Souza A, et al (2014) Lingula and Antilingula as Anatomic Reference Points for Ramus Osteotomies. International Journal of Dental Sciences and Research 3:1–3. https://doi.org/10.12691/ijdsr-3-1-1
50. P Assis F, Sheela Sudhakar A, C R, K.G P (2019) Varying shapes of lingula and its prevalence in dry adult human mandible. Indian J Clin Anat Physiol 6:224–228. https://doi.org/10.18231/j.ijcap.2019.050

51. Asdullah M, Ansari A, Khan M, et al (2018) Morphological variations of lingula and prevalence of accessory mandibular foramina in mandibles: A study. Natl J Maxillofac Surg 9:129. https://doi.org/10.4103/njms.NJMS_13_16
52. ArunKumar G, Chinagudi M, Bhagyashree MP, Iqbal S (2016) The morphology and location of the mandibular lingula in south indian population using cone-beam computed tomography-a retro-sectional study. Int J Curr Res 8:28466–28469
53. Henry BM, Tomaszewski KA, Walocha JA (2016) Methods of Evidence-Based Anatomy: a guide to conducting systematic reviews and meta-analysis of anatomical studies. Annals of Anatomy - Anatomischer Anzeiger 205:16–21. https://doi.org/10.1016/j.aanat.2015.12.002
54. Higgins JPT, Thomas J, Chandler J, et al (2019) Cochrane Handbook for Systematic Reviews of Interventions. Wiley
55. Hsu K-J, Tseng Y-C, Liang S-W, et al (2020) Dimension and Location of the Mandibular Lingula: Comparisons of Gender and Skeletal Patterns Using Cone-Beam Computed Tomography. Biomed Res Int 2020:1–6. https://doi.org/10.1155/2020/2571534
56. Hsu K-J, Lee H-N, Chen C-M (2022) Morphological Investigation of Mandibular Lingula: A Literature Review. J Pers Med 12:1015. https://doi.org/10.3390/jpm12061015
57. Sekerci AE, Sahman H (2014) Cone Beam Computed Tomographic Analyses of the Position and Course of the Mandibular Canal: Relevance to the Sagittal Split Ramus Osteotomy. Biomed Res Int 2014:1–11. https://doi.org/10.1155/2014/945671
58. Choi D-Y, Hur M-S (2021) Anatomical review of the mandibular lingula for inferior alveolar nerve block. Folia Morphol (Warsz) 80:786–791. https://doi.org/10.5603/FM.a2020.0135
59. Jung S, Yun H, Chung CH, et al (2022) A computed tomography-based analysis of the structure of the mandible according to age and sex. Arch Craniofac Surg 23:103–110. https://doi.org/10.7181/acfs.2022.00150
60. Smith BR, Rajchel JL, Waite DE, Read L (1991) Mandibular ramus anatomy as it relates to the medial osteotomy of the sagittal split ramus osteotomy. Journal of Oral and Maxillofacial Surgery 49:112–116. https://doi.org/10.1016/0278-2391(91)90095-4
61. Aljamani S, Youngson C, Jarad F, O’Neill F (2020) Development of a method to clinically identify the position of the lingual nerve relative to the third molar region. Translational Research in Anatomy 19:100069. https://doi.org/10.1016/j.tria.2020.100069

Table 1. Characteristics of the studies included in this meta-analysis.

First Author	Year	Continent	Country	Method
Guna Shekhar Madiraju	2023	Asia	Saudi Arabia	CBCT
Sinanoglu	2022	Asia	Turkey	CBCT
Andrea Rosario Stipo	2022	Europe	Italy	Cadavers
Saturnino Marco Lupi	2021	Europe	Italy	CBCT
Byeong-Seob Ahn	2020	Asia	South Korea	CBCT
S.-Y. Hsiao	2020	Asia	Taiwan	CBCT
K. Kronseder	2020	Europe	Germany	CBCT
Öznur Özalp	2020	Asia	Turkey	Cadavers
H. Akcay	2019	Asia	Turkey	CBCT
Fasila P Assis	2019	Asia	India	Cadavers
Ho-Yeol Jang	2019	Asia	South Korea	CBCT
Keke Zhao	2019	Asia	China	CBCT
Mohammed Asdullah	2018	Asia	India	Cadavers
Filiz Direk	2018	Asia	Turkey	MDCT
Yun-Hoa Jung	2018	Asia	South Korea	CBCT, Radiography
Umesh P Modasiya	2018	Asia	India	Cadavers
Jin Hoo Park	2018	Asia	South Korea	Cadavers
Andrew Y.E. Yeh	2018	Australia	Australia	CT
RE Rikhotso	2017	Africa	South Africa	Cadavers
Phalguni Srimani	2017	Asia	India	Cadavers
Cong Zhou	2017	Asia	South Korea	CBCT
ArunKumar, G.	2016	Asia	India	CBCT
Durgesh.V	2016	Asia	India	Cadavers
Nilton Alves	2015	South America	Chile	Cadavers
Wandee Apinhasmit	2015	Asia	Thailand	Cadavers
Deepika Chenna	2015	Asia	India	Cadavers
Chun-Yuan Huang	2015	Asia	Taiwan	CBCT, Cephalograms
Kayalvili Sanmugam	2015	Asia	India	Cadavers
F. J. C. Lima	2015	South America	Brasil	Cadavers
B. Senel	2015	Asia	Turkey	CBCT
Sophia MM	2015	Asia	India	Cadavers
Yavuz Findik	2014	Asia	Turkey	CBCT
Mamatha Hosapatna	2014	Asia	India	Cadavers
Padmavathi	2014	Asia	India	Cadavers
Smrity Gupta	2014	Asia	india	Cadavers
Prajna Samanta	2013	Asia	India	Cadavers
Ahmet Ercan Sekerci	2013	Asia	Turkey	CBCT
C Lavanya Varma	2013	Asia	India	Cadavers
M. S. Monnazzi	2012	South America	Brasil	Cadavers
B.V. Murlimanju	2012	Asia	India	Cadavers
V.K. Nirmale	2012	Asia	India	Cadavers
Wandee Apinhasmit	2010	Asia	Thailand	Cadavers
Lopes, PTC	2010	South America	Brasil	Cadavers
P. Jansisyanont	2009	Asia	Thailand	Cadavers
Suwadee	2007	Asia	Thailand	Radiography

Kositboworchai				
Soon-Seop Woo	2002	Asia	South Korea	Cadavers
A. Tuli	2000	Asia	India	Cadavers
Hee-Jin Kim	1997	Asia	South Korea	Cadavers

CBCT - Cone Beam Computed Tomography; CT – Computed Tomography.

Category	Mean	Standard Error	Variance	Lower Limit	Upper Limit	Z-Value	p-Value
Overall Height							
Overall Height	8.17	0.22	0.05	7.74	8.59	37.88	0.00
Overall Height based on Cadavers	8.26	0.39	0.15	7.50	9.02	21.42	0.00
Overall Height based on Imaging Studies	7.84	0.10	0.01	7.64	8.03	77.21	0.00
Right ML							
Height of the Right ML	8.42	0.30	0.09	7.83	9.01	28.17	0.00
Height of the Right ML based on Cadavers	8.16	0.81	0.65	6.58	9.74	10.10	0.00
Height of the Right ML based on Imaging Studies	8.72	0.31	0.09	8.12	9.32	28.53	0.00
Left ML							
Height of the Left ML	8.10	0.36	0.13	7.39	8.80	22.59	0.00
Height of the Left ML based on Cadavers	7.99	1.04	1.07	5.96	10.02	7.71	0.00
Height of the Left ML based on Imaging Studies	8.23	0.30	0.09	7.64	8.82	27.41	0.00
Height according to the ML Type							
Height of the ML in Truncated Lingulas	8.04	0.30	0.09	7.45	8.62	27.00	0.00
Height of the ML in Triangular Lingulas	7.81	0.36	0.13	7.10	8.51	21.68	0.00
Height of the ML in Nodular Lingulas	8.29	0.57	0.32	7.18	9.41	14.57	0.00

Table 2. Statistical results of this meta-analysis regarding height of the Mandibular Lingula (ML). Some of the Authors referred to this parameter as ‘length of the MA’. All of the results mentioned in this table are in millimeters [mm]. The types were established according to Tyli et al. classification

Table 3. Statistical results of this meta-analysis regarding the pooled prevalence of specific types of Mandibular Lingula (ML). The types were established according to Tyli et al. Classification

LCI – lower confidence interval. HCI – higher confidence interval. Q – Cochran's Q.

Category	**N**	**Pooled Prevalence**	**LCI**	**HCI**	**Q**	**I^2**
Triangular Type	6919	29.23%	23.57%	35.24%	908.92	96.48
Bilateral Triangular Type	1277	74.99%	65.45%	83.47%	258.34	92.65
Unilateral Triangular Type	1277	25.01%	16.53%	34.55%	258.34	92.65
Nodular Type	6919	27.99%	22.64%	33.67%	831.71	96.15
Bilateral Nodular Type	1166	64.79%	53.40%	75.41%	239.86	92.50
Unilateral Nodular Type	1166	31.22%	22.41%	40.75%	174.20	89.67
Truncated Type	6916	27.62%	24.72%	30.61%	230.95	86.14
Bilateral Truncated Type	1104	68.58%	59.23%	77.24%	176.78	89.82
Unilateral Truncated Type	1104	31.42%	22.76%	40.77%	176.78	89.82
Assimilated Type	6916	10.49%	7.60%	13.77%	549.43	94.18
Bilateral Assimilated Type	347	62.11%	48.74%	74.63%	108.95	83.48
Unilateral Assimilated Type	347	34.78%	22.84%	47.73%	104.18	82.72

Table 4. Statistical results of this meta-analysis regarding position of the Mandibular Lingula (ML). All of the results mentioned in this table are in millimeters [mm]

Category	Mean	Standard Error	Variance	Lower Limit	Upper Limit	Z-Value	p-Value
Distance from ML to Mandibular Notch							
Overall	16.16	0.33	0.11	15.52	16.81	49.16	0.00
Based on Cadavers	16.45	0.29	0.08	15.89	17.02	56.83	0.00
Based on Imaging Studies	15.25	0.84	0.70	13.61	16.89	18.24	0.00
Distance from ML to Anterior Border of Ramus							
Overall	16.81	0.64	0.41	15.56	18.06	26.34	0.00
Based on Cadavers	16.80	0.63	0.40	15.56	18.04	26.55	0.00
Based on Imaging Studies	16.83	1.66	2.77	13.57	20.10	10.11	0.00
Distance from ML to Posterior Border of Ramus							
Overall	15.35	0.33	0.11	14.69	16.00	45.82	0.00
Based on Cadavers	15.53	0.37	0.14	14.80	16.26	41.51	0.00
Based on Imaging Studies	14.91	0.64	0.41	13.65	16.16	23.22	0.00
Distance from ML to Retreolingular Fossa							
Overall	31.39	1.52	2.30	28.42	34.37	20.68	0.00
Based on Cadavers	32.39	0.64	0.41	31.13	33.65	50.46	0.00
Based on Imaging Studies	27.86	6.92	47.87	14.30	41.42	4.03	0.00
Distance from ML to Occlusal Plane							
Overall	9.60	0.34	0.12	8.92	10.27	27.93	0.00
Based on Cadavers	9.53	0.43	0.19	8.68	10.38	22.01	0.00
Based on Imaging Studies	9.69	0.64	0.41	8.43	10.94	15.13	0.00
Distance from ML to Internal Oblique Ridge							
Overall	14.53	0.19	0.04	14.16	14.90	76.73	0.00
Based on Cadavers	14.38	0.37	0.14	13.66	15.11	38.95	0.00

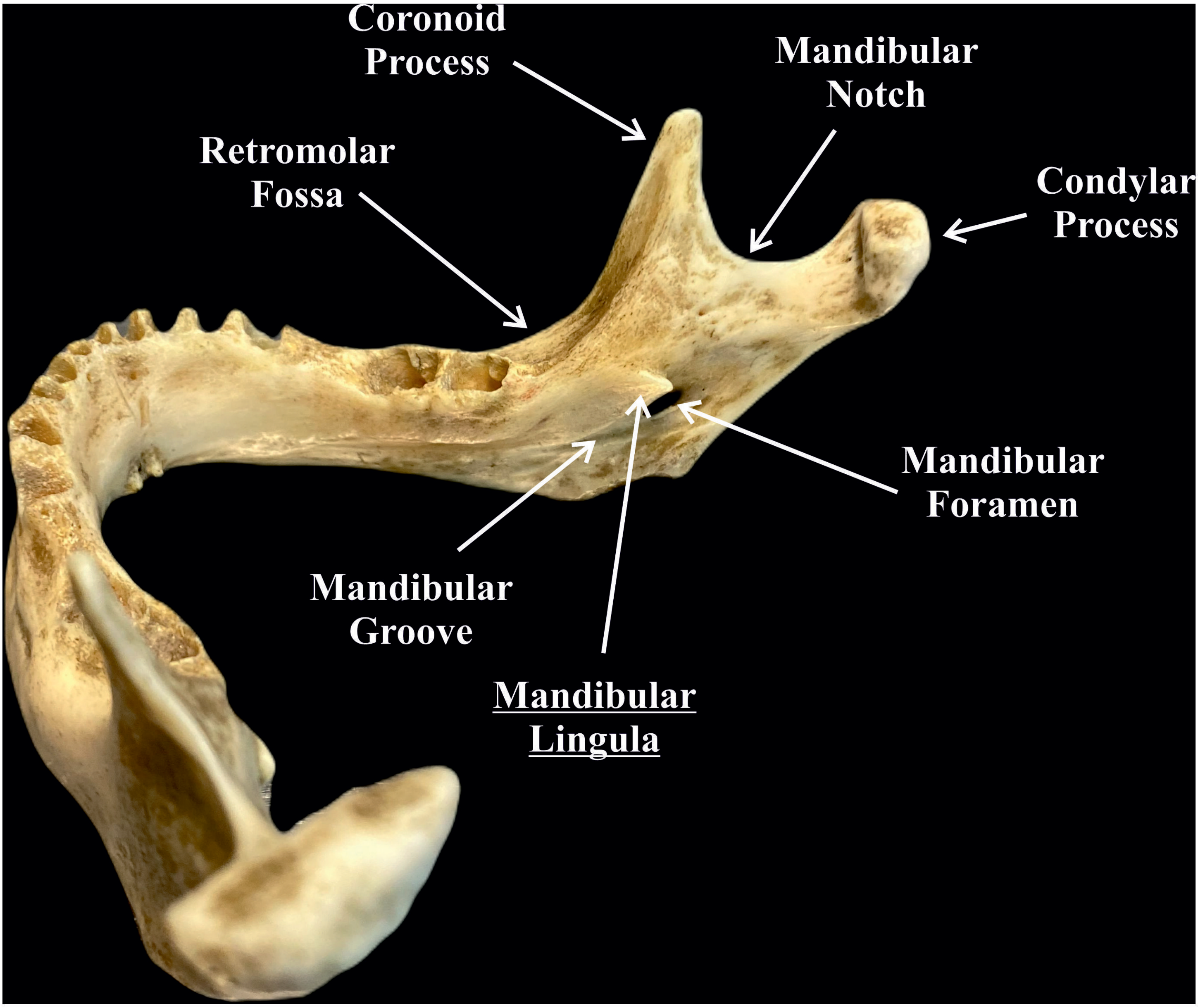
Based on Imaging Studies	14.68	0.06	0.00	14.55	14.81	227.95	0.00
Vertical Distance from ML to Antilingula							
Overall	6.08	0.27	0.07	5.55	6.60	22.62	0.00
Horizontal Distance from ML to Antilingula							
Overall	0.50	0.21	0.05	0.09	0.92	2.37	0.02

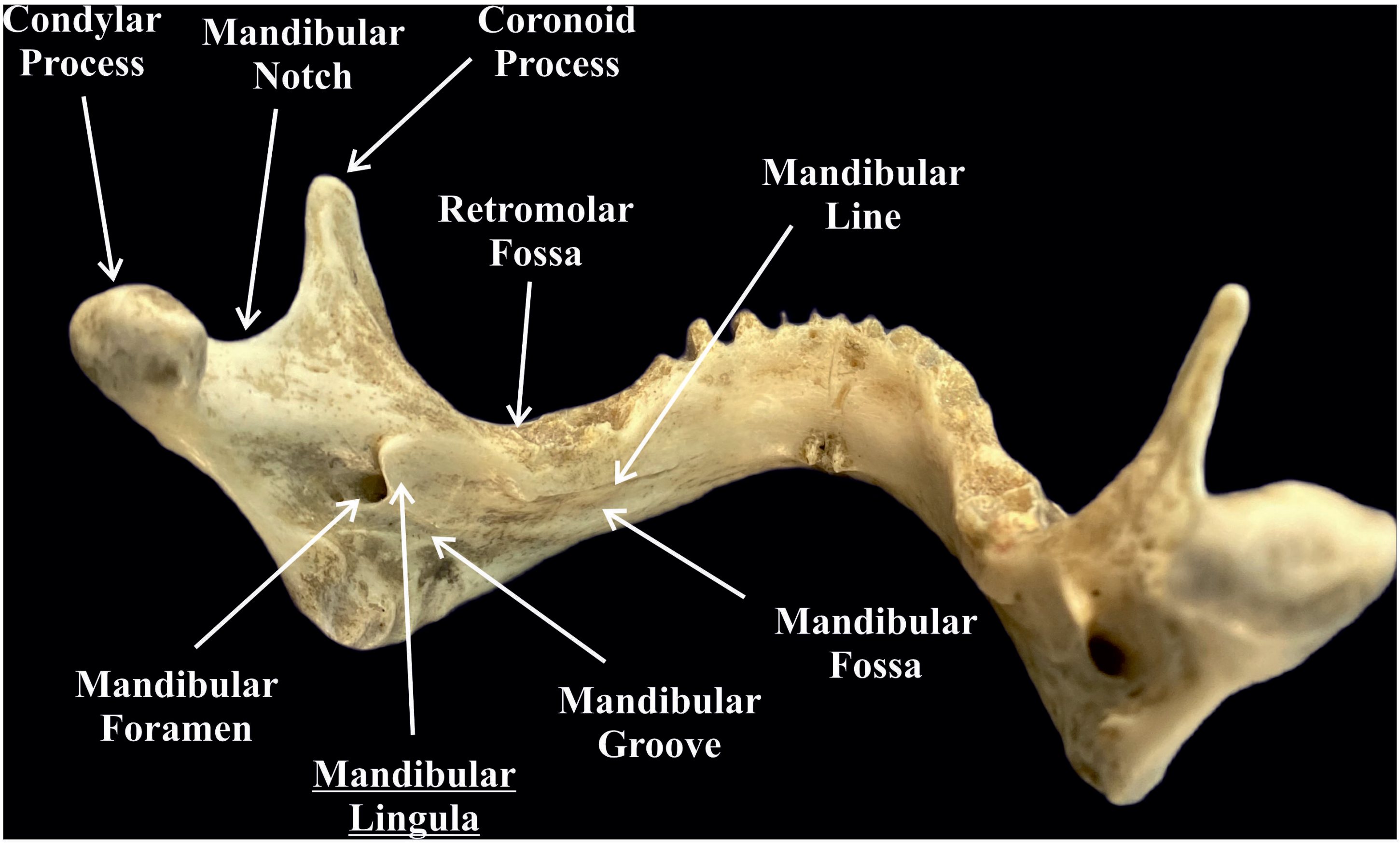
Figure 1. Mandibular Lingula (ML) and its close anatomical area.

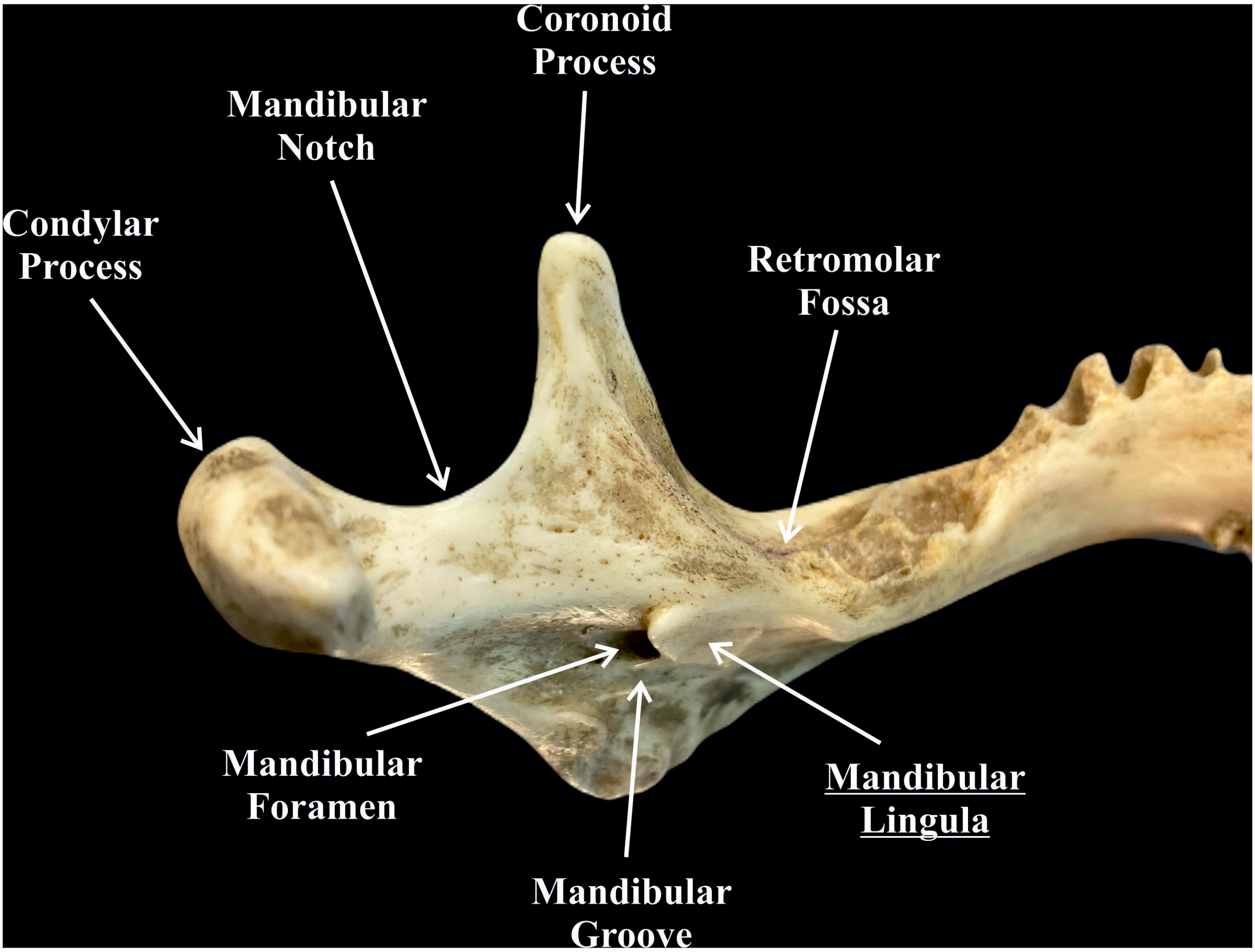
Figure 2. Mandibular Lingula (ML) and its close anatomical area.

Figure 3. Mandibular Lingula (ML) and its close anatomical area.

Figure 4. Flow diagram presenting process of collecting data included in this meta-analysis.


Coronoid
Process
Mandibular
Notch
Retromolar
Fossa
Condylar
Process
Mandibular
Foramen
Mandibular
Groove
Mandibular
Lingula


Condylar Process
Mandibular Notch
Coronoid Process
Retromolar Fossa
Mandibular Line
Mandibular Foramen
Mandibular Lingula
Mandibular Groove
Mandibular Fossa


Coronoid Process
Mandibular Notch
Condylar Process
Retromolar Fossa
Mandibular Foramen
Mandibular Lingula
Mandibular Groove

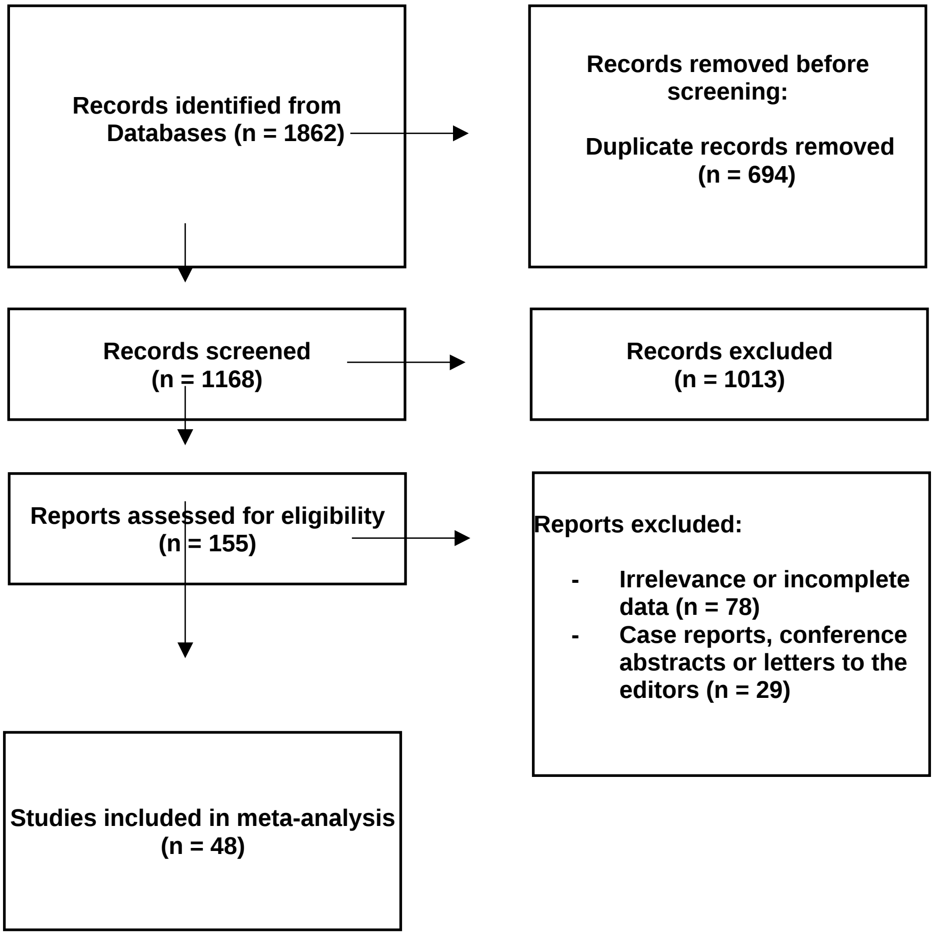


Figure 4 | Flow diagram presenting process of collecting data included in this meta-analysis.