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

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***Background:*** *The objective of this meta-analysis was to investigate the anatomical variations of the mandibular lingula (ML) and its relationship with surrounding anatomical structures. Understanding such variations is crucial to help determine the site and depth of a successful inferior alveolar nerve (IAN) anaesthetic block as well as a safe area for oral and maxillofacial invasive procedures to minimise the risk of neurological or haematological 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, and Cochrane Library were searched.*
***Results:*** *All 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 ML was found to be the most common. 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 found 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 correction procedures that require the ML as a landmark, namely sagittal split ramus osteotomy, and intraoral vertical ramus osteotomy. Furthermore, effective anaesthetic 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 to determine the location of the mandibular foramen and, therefore, the inferior alveolar bundle to prevent motor, sensory, or perfusion pathology during maxillofacial and oral procedures of the lower jaw.* (Folia Morphol 2024; 83, 3: 531–540)

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

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## INTRODUCTION

The mandibular lingula (ML) (Figs. 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) [13]. The sphenomandibular ligament is palpable through the mucosa, for 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 [16]. A previous study [56] observed 4 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 [1]. The IAN is responsible for sensory innervation of the mandibular teeth, the gingiva of the mandible, and the lower lip, providing a target for anaesthesia in certain oral and maxillofacial procedures [27].

The ML serves as an anatomical landmark for anaesthetic and oral and maxillofacial orthognathic procedures [1]. 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 [1]. 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 to prevent IAN injury [4]. Another procedure that utilises the ML and antilingula (AL) as landmarks is intraoral vertical ramus osteotomy (IVRO) [6], 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) to prevent haemorrhage, neurological damage, or anaesthetic toxicity [1]. Slight compression of the IAN can result in neurapraxia [6], 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 with surrounding anatomical structures. Understanding such variations is crucial to help determine the site and depth of a successful IAN anaesthetic block as well as a safe area for oral and maxillofacial invasive procedures in order to minimise the risk of neurological or haematological damage to the IAN.

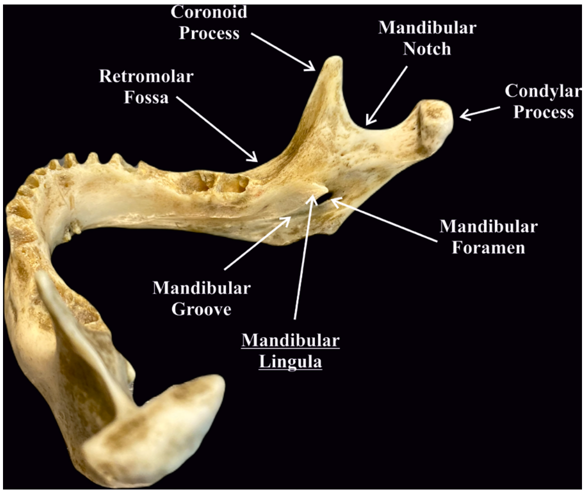


**Figure 1.** Mandibular lingula (ML) and its close anatomical area.

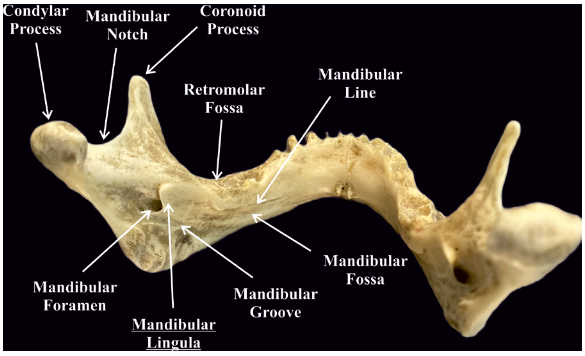


**Figure 2.** Mandibular lingula (ML) and its close anatomical area.

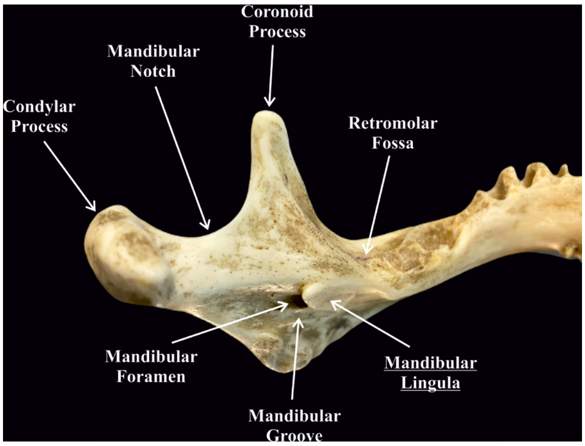


**Figure 3.** Mandibular lingula (ML) and its close anatomical area.

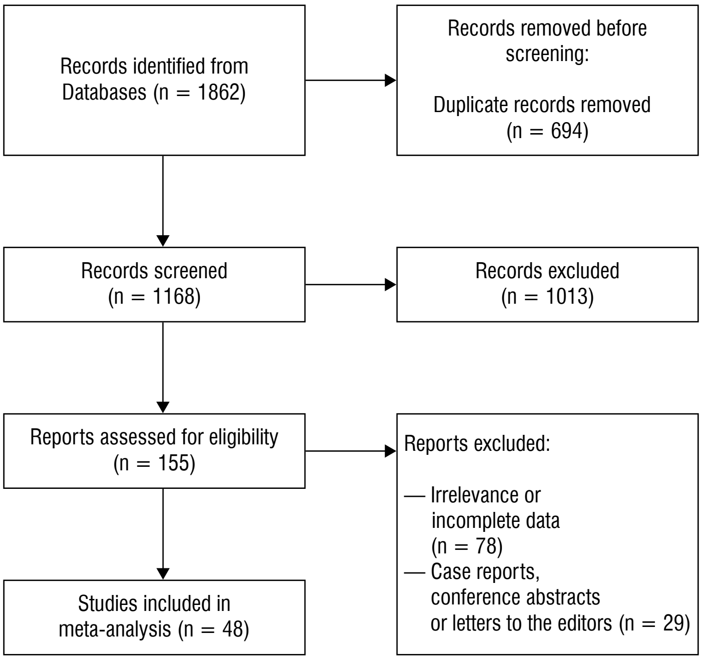


**Figure 4.** Flow diagram presenting process of collecting data included in this meta-analysis.

## 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, and Cochrane Library were searched. The overall search process was conducted in 2 stages. In the first step, all the mentioned medical databases were searched using the search term: mandibular lingula. Neither date, language, article type, nor text availability conditions were applied. In the next step, 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 the Anatomical Quality assessment Tool (AQUA) were used to provide the highest quality findings [12, 19].

### 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 2 independent reviewers. A total of 1862 articles were initially evaluated by the 2 independent reviewers. Eventually, 48 articles met the required criteria and were used in this meta-analysis [1, 2, 4–10, 14, 15, 17, 18, 22, 23, 26–28, 30–47, 49–51, 53–61]. 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 2 independent reviewers. Qualitative and qualitative data were extracted from the studies and gathered for statistical analysis. Any discrepancies between the studies identified by the 2 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 [20, 21]. P-values and confidence intervals were used to determine the statistical significance between the studies. A p-value lower than 0.05

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

| First Author | Year | Continent | Country | Method |
|---|---|---|---|---|
| Madiraju G.S. [37] | 2023 | Asia | Saudi Arabia | CBCT |
| Sinanoglu A. [51] | 2022 | Asia | Turkey | CBCT |
| Stipo A.R. [55] | 2022 | Europe | Italy | Cadavers |
| Lupi S.M. [36] | 2021 | Europe | Italy | CBCT |
| Ahn B.S. [1] | 2020 | Asia | South Korea | CBCT |
| Hsiao S.Y. [23] | 2020 | Asia | Taiwan | CBCT |
| Kronseder K. [33] | 2020 | Europe | Germany | CBCT |
| Özalp Ö. [42] | 2020 | Asia | Turkey | Cadavers |
| Akcay H. [2] | 2019 | Asia | Turkey | CBCT |
| Assis F.P. [9] | 2019 | Asia | India | Cadavers |
| Jang H.Y. [27] | 2019 | Asia | South Korea | CBCT |
| Zhao K. [60] | 2019 | Asia | China | CBCT |
| Asdullah M. [8] | 2018 | Asia | India | Cadavers |
| Direk F. [14] | 2018 | Asia | Turkey | MDCT |
| Jung Y.H. [30] | 2018 | Asia | South Korea | CBCT, radiography |
| Modasiya U.P. [38] | 2018 | Asia | India | Cadavers |
| Park J.H. [44] | 2018 | Asia | South Korea | Cadavers |
| Yeh A.Y.E. [59] | 2018 | Australia | Australia | CT |
| Rikhotso R.E. [45] | 2017 | Africa | South Africa | Cadavers |
| Srimani P. [54] | 2017 | Asia | India | Cadavers |
| Zhou C. [61] | 2017 | Asia | South Korea | CBCT |
| ArunKumar G. [7] | 2016 | Asia | India | CBCT |
| Durgesh V. [15] | 2016 | Asia | India | Cadavers |
| Alves N. [4] | 2015 | South America | Chile | Cadavers |
| Apinhasmit W. [6] | 2015 | Asia | Thailand | Cadavers |
| Chenna D. [10] | 2015 | Asia | India | Cadavers |
| Huang C.Y. [26] | 2015 | Asia | Taiwan | CBCT, cephalograms |
| Sanmugam K. [47] | 2015 | Asia | India | Cadavers |
| Lima F.J.C. [34] | 2015 | South America | Brazil | Cadavers |
| Senel B. [50] | 2015 | Asia | Turkey | CBCT |
| Sophia D. [53] | 2015 | Asia | India | Cadavers |
| Findik Y. [17] | 2014 | Asia | Turkey | CBCT |
| Hosapatna M. [22] | 2014 | Asia | India | Cadavers |
| Padmavathi G. [43] | 2014 | Asia | India | Cadavers |
| Gupta S. [18] | 2014 | Asia | India | Cadavers |
| Samanta P. [46] | 2013 | Asia | India | Cadavers |
| Sekerci A.E. [49] | 2013 | Asia | Turkey | CBCT |
| Varma C.L. [57] | 2013 | Asia | India | Cadavers |
| Monnazzi M.S. [39] | 2012 | South America | Brazil | Cadavers |
| Murlimanju B.V. [40] | 2012 | Asia | India | Cadavers |
| Nirmale V.K. [41] | 2012 | Asia | India | Cadavers |
| Apinhasmit W. [5] | 2010 | Asia | Thailand | Cadavers |
| Lopes P.T.C. [35] | 2010 | South America | Brazil | Cadavers |
| Jansisyanont P. [28] | 2009 | Asia | Thailand | Cadavers |
| Kositbowornchai S. [32] | 2007 | Asia | Thailand | Radiography |
| Woo S.S. [58] | 2002 | Asia | South Korea | Cadavers |
| Tuli A. [56] | 2000 | Asia | India | Cadavers |
| Kim H.J. [31] | 1997 | Asia | South Korea | Cadavers |

CBCT — cone beam computed tomography; CT — computed tomography.

**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 the results mentioned in this table are in millimetres [mm]. The types were established according to Tuli et al. classification [56].

| 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 |

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 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 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 occurring on the right side was found to be 8.42 mm (SE = 0.30), whereas on the left side it was 8.16 mm (SE = 0.81). All the results mentioned above and more detailed ones are gathered in Table 2.

The types of the ML were established by Tuli et al. [56]. The triangular type of ML was found to be the most common. 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 27.99% (LCI = 22.64%; HCI = 33.67%). The pooled prevalence of the truncated type was 27.62% (LCI = 24.72%; HCI = 30.61%). The pooled prevalence of the assimilated type was 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 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 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 regard to the height of the ML, Sekerci and Sisman [49] identified the right side to be more pronounced in males than in females. This is similar to a study performed by Hsu et al. [25], in which the ML height was identified to be bigger in

**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 Tuli et al. classification [56].

| 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 |

LCI — lower confidence interval; HCI — higher confidence interval; Q — Cochran's Q.

males than females, but with no relation to the side. Moreover, Jansisyanont et al. [28] 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 ML (8.10 mm). A previous study conducted by Senel et al. [50] 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. [56] reported 4 shape variations of the ML: 68.5% triangular shaped ML, 15.8% truncated shape, 10.9% nodular, and 4.8% assimilated shape. Similarly, Hsu et al. [24] observed variations 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 analysed 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. [24] 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 [4] 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 localise this structure effectively. Hsu et al. [25] reported a mean distance of 18–20 mm from the anterior ramus border to the mandibular lingula (ARLD). Interestingly, Findik et al. [17] concluded a lower mean ARLD of approximately 15–16 mm. However, the variation of reference points and planes could have led to dissimilarity among the different studies. This meta-analysis identified an ARLD of 16.81 mm, which closely relates to previously mentioned studies.

Senel et al. [50] observed a distance of 38.3 mm between the ML and the inferior ramus border. The mean distance from the lingula to the mandibular notch was observed to be approximately 16.6 mm, as found by Jansisyanot et al. [28] in a previous study, while Sekerci et al. [49] observed a mean distance of 15.32 mm. The overall mean distance from the ML to the mandibular notch found in this meta-analysis was

**Table 4.** Statistical results of this meta-analysis regarding position of the mandibular lingula (ML). All the results mentioned in this table are in millimetres [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 retrolingular 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 |

most similar to that of Jansisyanot et al., [28] 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. [36] 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 inferoposteriorly with respect to the ML) as well as IAN prior to its entry into the mandible [48]. The results of this meta-analysis can be useful to determine variations, which are crucial to keep in mind when performing an IAN anaesthetic 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 anaesthetic procedure, as previously mentioned, which was found to be approximately 29–35% [4]. Choi and Hur [11] 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 [29]. With respect to the SSRO dentofacial correction procedure, the ML provides a convenient landmark for a safe horizontal osteotomy [4]. Smith et al. [52] observed that the fusion is approximately between 7.5 mm to 13.3 mm above the localisation of the ML, serving as a point of reference for the cortical merge during the SSRO procedure. In addition to this, the IVRO [5] procedures require the utilisation 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 various other oral and maxillofacial procedures, including but not limited to trauma management, tumour resections, cyst removals, and temporomandibular joint (TMJ) reconstruction [32]. 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 [3].

The present study is not without limitations. It may be burdened with potential bias because 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 reflect the anatomical features of Asian people rather than the global population. Some analyses were not performed due to insufficient 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 anaesthetic 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 to determine the location of the MF and, therefore, IAB to prevent motor, sensory, or perfusion pathology during maxillofacial and oral procedures of the lower jaw.

## ARTICLE INFORMATION AND DECLARATIONS

### Ethics statement

Not applicable.

### Author contributions

**Kinga Glądys:** methodology, search, extraction, writing. **Patryk Ostrowski:** methodology, writing, literature, analysis, figures. **Michał Bonczar:** methodology, writing, statistical analysis, Tables. **Maria Kwiecińska:** writing, search. **Jakub Gliwa:** writing, extraction. **Ameen Nasser:** writing, search. **Kamil Możdżeń:** writing, extraction. **Mateusz Trzeciak:** writing, methodology. **Iwona Gregorczyk-Maga:** writing, methodology. **Agata Musiał:** methodology, writing. **Marcin Lipski:** writing, literature. **Jerzy Walocha:** writing, literature. **Mateusz Koziej:** methodology, writing, statistical analysis.

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### Conflict of interest

The authors declare no potential conflicts of interest with respect to the research, authorship, and/ /or publication of this article.

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