

Assessment of Emergence Patterns of the Mental Nerve through the Mental Foramen in Orthopantomograms: An Observational Study

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ABSTRACT

Introduction: The mental nerve is a terminal branch of inferior alveolar nerve that leaves mandibular canal via the mental foramen to supply skin of chin and lower lip. Variations in its emergence pattern are clinically significant, as failure to recognize these patterns may cause nerve injury during dental interventions. Therefore, the objective of this study was to determine proportion of mental nerve emergence patterns using orthopantomograms.

Methods: This retrospective observational study reviewed 381 archived orthopantomograms of patients aged ≥ 19 years from the database of department of dentistry. Ethical approval was taken from Institutional Review Committee (Reference number: bss2511282160). Mental nerve emergence patterns were noted in each radiograph. Point estimates with 95% confidence interval were calculated.

Results: The linear pattern was observed in 484 (63.52%) cases followed by anterior loop 197 (25.85%), and the perpendicular pattern 81 (10.63%). Among linear patterns, 234 (48.35%) were on right and 250 (51.65%) on left, with 212 (43.80%) in males and 272 (56.20%) in females. The anterior loop was identified in 110 (55.84%) right and 87 (44.16%) left sides, and in 108 (54.82%) males and 89 (45.18%) females. The perpendicular pattern occurred in 37 (45.68%) right and 44 (54.32%) left sides, and in 40 (49.38%) males and 41 (50.62%) females.

Conclusions: The linear pattern was most common; however, anterior loops, bilateral asymmetry, and sex-related variations emphasize the need for careful radiographic assessment to avoid mental nerve injury.



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INTRODUCTION

The mental nerve, a terminal branch of the inferior alveolar nerve, leaves the mandibular canal via mental foramen to supply the buccal vestibule in lower jaw and chin. In some individuals, a segment of the mental neurovascular bundle extends antero-inferiorly past the mental foramen, loop back and exit through it to form the “anterior loop”.¹ Inadequate knowledge of this variant may cause inadvertent injury during invasive dental procedures near mental foramen, resulting in post-operative neurosensory complications.²

Understanding these variations is essential for precise surgical planning and minimizing risk of iatrogenic injury during invasive dental procedures. Orthopantomogram (OPG), a widely available and low-radiation imaging modality, provides vital information on mental foramen position and mental nerve

emergence pattern.²⁻⁶

Understanding the mental nerve emergence pattern is essential to prevent postoperative neurological complications; however, data from the Nepali population are limited.^{7,8} Therefore, this study evaluated mental nerve emergence patterns through the mental foramen using OPG by sex and side of the mandible.

METHODS

A retrospective observational study was conducted in the Department of Anatomy in collaboration with the Department of Dentistry at Patan Academy of Health Sciences, Lagankhel, Lalitpur, Nepal from November 2025 to April 2026. Ethical approval was obtained from the IRC-PAHS (Reference number: bss2511282160) prior to data collection. Archived panoramic

radiographs of the patients who attended Dental Outpatient Department (OPD) between August 2022 and August 2025, as specified in the approved study protocol were retrieved from the institutional database.

High-quality digital OPGs of patients aged 19 years and above (By this age, all permanent mandibular teeth except for third molars are fully erupted with completely developed root apices, and mandibular morphology shows minimal age-related variations ensuring that the findings are applicable to adult dental procedures) with bilaterally visible mental foramina and well-defined cortical margins were selected, while images showing extensive mandibular bone loss.⁵ The sample size was calculated using the standard formula: $n = Z^2 \times p \times q / e^2$, where $Z = 1.96$ for a 95% confidence level, $p = 0.55$ (prevalence of the linear pattern reported in females in a previous study), $q = 1 - p = 0.45$, and $e = 0.05$ (margin of error).⁹

The prevalence values for different mental nerve loop patterns (anterior loop, straight pattern, and perpendicular or right-angled pattern) varied across previously published studies according to sex (male and female) and mandibular side (right and left). Therefore, sample size estimates were considered across these reported strata, and the largest calculated sample size was used to ensure adequate representation of all pattern categories.

Based on this calculation, the maximum required sample size was 381, and a total of 381 OPGs were included in the current study. Stratified random sampling was employed, with OPGs stratified by year. As OPG records are retained in the institutional database for only three years and older records are routinely deleted, the sampling frame was limited to the available three-year period. Accordingly, the total sample was equally distributed across three years ($381 \div 3 = 127$ per year), and 127 eligible radiographs were randomly selected from each year. Within each yearly stratum, each eligible radiograph was assigned a unique identification number, and a computer-generated random number sequence was used to select the required number of radiographs. The demographic data, such as age and sex were noted.

All OPG were acquired using a Planmeca ProMax Classic 2D

panoramic unit (Planmeca Oy, Helsinki, Finland) and were evaluated digitally using Planmeca Romexis imaging software to ensure accurate visualization of the mental foramen. To minimize interobserver variability, all images were assessed by a single observer. In each OPG, the mental foramen was identified bilaterally, and the pattern of mental nerve emergence (linear, anterior loop and perpendicular) was determined based on based on following criteria; **1. Linear/straight type:** The mental nerve emerges from the mental foramen following a straight course without forming any loop. **2. Anterior loop:** The nerve extends anteriorly and inferiorly beyond the mental foramen, then loops back to exit through the foramen. **3. Perpendicular type:** The mental nerve emerges almost perpendicular from the mandibular canal to exit the mental foramen.²

Statistical analysis was performed using the SPSS Statistics version 16.0 (SPSS Inc., Chicago, Ill., USA), where categorical variables (gender, mandible side and types of mental nerve emergence patterns) were summarized as frequencies and percentages, and continuous variables (age) were expressed as mean $\pm$ standard deviation. The distribution of mental nerve emergence patterns was calculated separately according for males and females, and for both the right and left sides of the mandible.

RESULTS

A total of 381 OPGs were included in the study. Of these, 180 (47.24%) belonged to male and 201 (52.76%) to female. The mean age of the study participants was 34.6 ± 11.2 years.

The linear pattern was observed in 484 (63.52%) mental nerves, 197 (25.85%) in anterior loop and the perpendicular pattern in 81 (10.63%). Among the linear patterns, 234 (48.35%) were identified on the right side and 250 (51.65%) on the left side. Of these, 212 (43.80%) were observed in males and 272 (56.20%) in females. For the anterior loop pattern, 110 (55.84%) were found on the right side and 87 (44.16%) on the left side, while 108 (54.82%) occurred in males and 89 (45.18%) in females. The perpendicular pattern was observed on the right side in 37 (45.68%) cases and on the left side in 44 (54.32%) cases, with 40 (49.38%) cases in males and 41 (50.62%) in females (Table 1).

Table 1. Distribution of mental nerve emergence patterns through the mental foramen according to the side of mandible and gender (N=762).

Emergence pattern of mental nerve	Overall n(%)	Right side n(%)	Left side n(%)	Male n(%)	Female n(%)
Linear	484(63.52)	234(48.35)	250(51.65)	212(43.80)	272(56.20)
Anterior loop	197(25.85)	110(55.84)	87(44.16)	108(54.82)	89(45.18)
Perpendicular	81(10.63)	37(45.68)	44(54.32)	40(49.38)	41(50.62)

DISCUSSION

The present study evaluated the distribution of mental nerve emergence patterns on OPGs and demonstrated that the linear pattern 484 (63.52%) was the most prevalent, followed by the anterior loop 197 (25.85%) and perpendicular patterns 81 (10.63%). Findings from both OPG and cone beam computed tomography (CBCT) studies consistently shows that the linear

pattern is most common followed by the anterior loop and then the perpendicular type.^{6,9,10} Krishnan et al., found straight pattern in 67.5%, anterior loop in 18.8%, and perpendicular in 13.7% on 300 OPGs, findings that closely align with distribution in the present study.² However, CBCT based studies from Indian populations demonstrate variation in the relative proportions

of these patterns. A CBCT evaluation of 400 mandibles reported a predominance of straight pattern (67.1%), with perpendicular emergence accounting for 26%, and anterior loops being relatively uncommon (6.9%).¹¹ Likewise, a CBCT study conducted in a North Indian population reported the linear patterns in 58–60% of cases, perpendicular patterns in ~32–33%, and anterior loops in only 7–9%.¹² Although the exact proportions vary probably due to differences in population characteristics and imaging modality (OPG vs. CBCT), the overall predominance of the straight or linear emergence pattern over non-linear configurations remains consistent across studies.

In this study, the linear pattern of mental nerve emergence was the most common, observed in 484 (63.52%) sides. This pattern distribution aligns with several previously published radiographic studies, suggesting that a straight or linear course is commonly observed across different populations.^{2,6,9,11} The linear pattern was observed in 234 (48.35%) cases on the right side and 250 cases (51.65%) on the left side, making it the dominant pattern bilaterally in the present study. A slightly higher prevalence of the linear pattern was noted on the left side, indicating mild bilateral asymmetry. Similar left-side predominance has been reported by Krishnan et al., who also observed a greater proportion of straight emergence on the left side.² In contrast, studies by Abidullah et al., Mohammad, and Iyengar et al., documented a right-side dominance of the straight pattern.^{6,9,13} Yosue and Brooks originally described linear emergence as the most frequent pattern on panoramic radiographs, attributing its prevalence to the fact that mostly the mental nerve has a relatively straight course as it exits the mental foramen.¹⁴ Similar findings have been reported by Ngeow and Yuzawati, reinforcing the notion that the linear pattern represents the typical anatomical configuration.¹⁵

In the present study, the anterior loop pattern was seen in 197 (25.85%) of evaluated sides. Previous studies have reported wide variability in the prevalence of the anterior loop, ranging from 7% to over 34%.^{11,13} Krishnan et al., documented an anterior loop prevalence of 18.8%, while Iyengar et al., reported loops in about 21% of examined sides, indicating a comparatively lower occurrence than that observed in the present population.^{2,6} In contrast, Shalash et al., in their retrospective CBCT study conducted on the Egyptian population, reported a higher frequency of anterior loop (55%) presence.¹⁶ With respect to laterality, the current study demonstrated a right-side predominance of the anterior loop (right side- 110 (55.84%) and left side- 87 (44.16%), a finding that has also been described in some previous investigations.^{11,17,18} However, other authors have reported either left-side dominance or no significant side preference, suggesting that anterior loop expression may not be bilaterally symmetrical.^{2,6,9}

The perpendicular type was the least frequently encountered pattern, present in 81 cases, accounting for 10.63% of total side examined in this study. This finding aligns with most previous reports that describe the perpendicular pattern as relatively uncommon.^{10,11,13} The predominance was slightly higher on

the left (right side- 37 (45.68%) and left side- 44 (54.32%), suggesting mild side asymmetry. Comparable low frequencies of the perpendicular pattern have been reported by Iyengar et al., and observed perpendicular emergence in approximately 6% of cases, without significant side dominance.⁶ Krishnan et al., reported perpendicular patterns in 13.7% of their study population and likewise noted minor side-to-side variation (right-13%, left-14.3%), comparable to the modest left-side predominance observed in the present study.² In contrast, Abidullah et al., documented a relatively higher prevalence of the perpendicular pattern, with a tendency toward right-side dominance.⁹

The substantial proportion of anterior loop and perpendicular patterns in the present study indicates that presuming a strictly linear course of the mental nerve may be unsafe, particularly during surgical procedures in the premolar and inter-foraminal regions.^{2,9,19,20} Moreover, panoramic radiography has been shown to have limited sensitivity in detecting anterior loops when compared with CBCT imaging and cadaveric studies,^{6,20-22} suggesting that the frequency of anterior loops identified here may underestimate their true prevalence. These findings highlight the importance of careful assessment of OPGs for non-linear mental nerve emergence patterns. The use of CBCT is recommended for implant placement and other high-risk surgical procedures in close proximity to the mental foramen.^{6,9,22} When only two-dimensional imaging is available, a safety margin of approximately 3–4 mm in front of the radiographic mental foramen should be maintained to minimize the risk of nerve injury.²³ The slight asymmetry in the emergence patterns of the mental nerve between the right and left sides may be attributed to developmental variations, functional loading differences, or asymmetric mandibular remodeling, and therefore, it is crucial to assess each side independently rather than assuming bilateral symmetry during radiographic evaluation.

The linear pattern of the mental nerve was the most prevalent configuration in both sexes, observed in 272 (56.20%) in female and 212 (43.80 %) in male, indicating a greater predominance of this pattern in females. The gender difference observed in our study was descriptive rather than inferential. In contrast, another study evaluating 120 CBCT images reported a statistically significant gender difference for the straight pattern, with males showing a higher occurrence than females.⁹ The anterior loop pattern in this study was more frequently observed in males 108 (54.82%) than in females 89 (45.18%), indicating a possible sex-related tendency toward anterior looping in males. In line with our observations, similar trends have been documented in panoramic radiograph-based studies, which found no significant correlation between gender and the presence of an anterior loop, despite its relatively higher prevalence in males.² Studies utilizing CBCT have likewise demonstrated variability in anterior loop prevalence between male and female patients, with anterior loops often reported more frequently in males, although this finding is not consistent across all populations.²⁴ In contrast, Abidullah et al., observed no significant gender association for the anterior loop pattern, despite a slightly higher frequency in

females, highlighting the influence of population characteristics and imaging modality on reported gender differences.⁹ Similarly, the perpendicular pattern was the least common configuration in both sexes in our study (males- 40, 49.38%; females- 41, 50.62%), showing minimal gender disparity. Supporting this observation, the comparative study also demonstrated no significant gender difference for the perpendicular pattern, indicating that this emergence type is relatively uncommon and largely independent of sex.⁹ These findings suggest that although gender may influence the distribution of mental nerve emergence patterns, individual anatomical variation remains the most critical factor, reinforcing the need for meticulous radiographic evaluation prior to surgical procedures in the interforaminal region.

The findings of the present study support the growing body of evidence that emphasizes the variability of mental nerve emergence patterns across individuals. Although advanced imaging modalities such as CBCT provide superior three-dimensional visualization, panoramic radiography remains a valuable and widely accessible diagnostic tool. Previous authors live, Neiva et al., and Apostolakis and Brown have noted that panoramic radiographs may either underestimate or overestimate the presence of the anterior loop due to factors such as image magnification and anatomical superimposition.^{25,26} Nevertheless, panoramic imaging remains a commonly used screening tool in routine clinical practice, particularly in resource-limited settings. Accordingly, the findings of the present study are especially relevant for clinical environments where CBCT is not routinely accessible.

This study was based exclusively on OPG images, which have inherent limitations including magnification, distortion, and overlapping of anatomical structures. As a result, certain emergence patterns, especially anterior loops, may not have been identified with complete accuracy. Future research using CBCT

could offer more precise visualization and allow for correlation with clinical outcomes.

CONCLUSION

The predominance of the linear pattern, followed by anterior loop and perpendicular patterns highlights the need for careful radiographic evaluation of the mental foramen region prior to surgical or implant procedures. Awareness of these anatomical variations is crucial to improving patient safety and minimizing the risk of iatrogenic nerve injury.

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