Research Article

Assessment of The Prevalence And Length of The Anterior Loop of The Mental Nerve Using Cone-Beam Computed Tomography: A Retrospective Study

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Abstract

Background

The anterior loop (AL) of the mental nerve is an important anatomical variation in the inter-foraminal region of the mandible. Accurate assessment of its presence, morphology and extent is essential during implant placement and other surgical procedures to minimize the risk of neurosensory complications. Cone-beam computed tomography (CBCT) provides three-dimensional visualization of mandibular neurovascular structures, enabling precise preoperative assessment.

Materials and methods

A retrospective cross-sectional radiographic study was conducted using 200 CBCT scans to evaluate the presence of the anterior loop of the mental nerve. The presence of the anterior loop was assessed in all scans. Statistical comparisons of anterior loop length were carried out in 71 males and 77 females. Statistical analysis was performed using SPSS version 24. Non-parametric tests were used for comparison of anterior loop length measurements between sides and genders, while the association between gender and anterior loop presence was assessed. Statistical significance was set at $p<0.05$.

Results

Among the 200 CBCT scans evaluated, the anterior loop was identified in 153 subjects, resulting in an overall prevalence of 76.5%. The prevalence was 78.8% in males and 75.8% in females, with no significant association between gender and anterior loop presence ($p>0.05$). Among subjects with an identifiable anterior loop, the median loop length ranged from 3.4 to 3.7 mm. No statistically significant differences in anterior loop length were observed between the right and left sides or between males and females ($p>0.05$).

Conclusion

The anterior loop of the mental nerve was present in more than three-fourths of the study population. Although its prevalence was high, anterior loop length did not differ significantly according to gender or side. These findings reinforce the importance of routine CBCT evaluation before implant placement and surgical procedures in the inter-foraminal region.

Keywords Anterior loop of mental nerve, Cone-beam computed tomography, Mental foramen, Implant dentistry

Introduction

The mental foramen is an important landmark of the mandible through which the inferior alveolar nerve (IAN) exits as the mental nerve. It is reported to play a crucial role in implant placement, oral surgical procedures, and prosthodontic rehabilitation[1]. IAN may extend anteriorly beyond the mental foramen before looping back to exit, forming the anterior loop (AL) of the mental nerve. This is an important anatomical variation relevant to surgical safety in the inter-foraminal region[2]. Hu et al[3] have emphasized the anatomical variability and clinical significance during surgical interventions by describing the branching pattern and intraosseous course of the mental nerve. Cone-beam computed tomography (CBCT) provides superior three-dimensional visualization of mandibular neurovascular structures, including the IAN, making it the preferred imaging technique compared to conventional imaging modalities for identifying such variations[4].

Sahman and Sisman have reported that the prevalence of this AL varies widely among populations, reflecting anatomical diversity and methodological differences in detection[5]. Kheir and Sheikhi reported that CBCT evaluation demonstrates significant variation in both prevalence and length of the AL across populations, indicating its ethnic and anatomical variability[6]. Siddiqui et al. reported that CBCT studies in Indian population have demonstrated intra-population differences in the prevalence and morphometric characteristics of the AL[7]. A systematic review and CBCT analysis by Apostolakis and Brown have reported a pooled prevalence of approximately fifty percent, highlighting the

clinical importance of AL in safe implant placement in the inter-foraminal region[8]. Furthermore, CBCT demonstrates significantly higher detection rates of AL compared to panoramic radiography, confirming its diagnostic superiority in anatomical assessment[9].

Despite the availability of multiple CBCT-based studies across different populations, significant variability persists in the detection and measurement of the AL, indicating the need for population-specific and region-specific evaluation[6,10]. Furthermore, data from specific regional populations remain limited, which may affect accurate pre-operative assessment during implant placement and surgical procedures in the inter-foraminal region. Therefore, the present study aims to assess the prevalence and length of the anterior loop of the mental nerve using CBCT and to evaluate gender-based variations, thereby providing anatomical data to support safer clinical decision-making.[7,10].

Materials and methods

A retrospective cross-sectional radiographic study was conducted to assess the prevalence and length of the AL of the mental nerve using cone-beam computed tomography (CBCT). The study was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies[11].

CBCT records of individuals belonging to the study population were retrospectively evaluated. A total of 200 CBCT scans were evaluated for the assessment of anterior loop prevalence. Among these, 153 scans demonstrated an identifiable anterior loop. Of these, 148 subjects (71 males and 77 females) with complete bilateral measurements were included for anterior loop length analysis. Sample size was estimated based on previous CBCT-based studies evaluating anterior loop measurements. Based on the findings of a study by Mathew and Mohan (2023)[9], an expected proportion of 75% was considered for sample size estimation. With a 95% confidence level and 10% allowable error, the minimum required sample size was estimated to be 73 subjects. CBCT images with adequate visualization of the mandibular arch, mental foramen, and mandibular canal were included. Images with inadequate `quality, artefacts, incomplete mandibular coverage, pathological lesions, fractures, or previous surgical alterations affecting the region of interest were excluded.

All CBCT datasets were analysed using Real Guide implant planning software. The inferior alveolar nerve canal and mental foramen were identified in axial, tangential, and cross-sectional views. The anterior loop was identified based on the anterior extension of the inferior alveolar nerve beyond the mental foramen, and its length was measured as the distance between the anterior border of the mental foramen and the most anterior point of nerve extension. Measurements were recorded on the available right and/or left sides in millimeters. CBCT acquisition parameters, including the imaging unit and voxel size, were recorded.

The primary outcome assessed was the prevalence and length of the anterior loop of the mental nerve in millimeters. Secondary analysis included comparison of anterior loop length according to gender and right-left side variation.

The data obtained was entered into a Microsoft Excel Spreadsheet and was subjected to statistical analysis. All analyses were conducted using the Statistical Package for the Social Sciences (version 24, IBM, Chicago, USA). The Shapiro-Wilk test was used to assess the normality of quantitative variables. Since the data were not normally distributed, non-parametric tests of significance were used. Mann–Whitney U test was used to compare the anterior loop length of the mental nerve between two independent groups. The level of significance was set at 5%.

Sample Size Calculation

Formula

$$n = \left\{ P_1(1-P_1) + P_2(1-P2) \right\} \left(\frac{Z}{E}\right)^2$$

n = Sample Size

P_1 = mean (1.22)

P_2 = mean (0.85)

Z = 95% confidence interval (1.96)

E = Difference between mean (0.37)

$$n = \left\{ 1.22(1-1.22) + 0.85(1-0.85) \right\} \left(\frac{1.96}{0.37}\right)^2$$

= 10.63

Each group required 11 samples

For the accuracy of the study the sample size can be increased.

Ratio = 1.1

Proposed Statistical Analysis:

→ Study data obtained will be entered to Microsoft Excel Software, which then will be exported to statistical package for social sciences (SPSS) version 20, IBM statistics, USA

→ Inter-group comparsion will be done using Chi-square test

→Level of significance will be set at 5% (P<0.05 = statistically significant)

Results

The anterior loop was identified in 153 of 200 CBCT scans, giving an overall prevalence of 76.5%. The prevalence was 78.8% among males and 75.8% among females, with no statistically significant association between gender and anterior loop presence (p>0.05). Age was classified into three categories with a reasonably even proportion of males and females. About 36% of men were between 31 and 35 years, 38.7% between 36 and 40 years and 25.3% between 41 and 45 years. Likewise, in women, 42.7% were in the 31-35 years, 36% between 36-40 years, and 21.3% in the 41-45 years category. The results indicate a good representation of the diverse age ranges for both genders.

The Mann–Whitney U test was used to compare the anterior loop length of the mental nerve between the right and left sides in males. Results showed no statistically significant difference, U = 2369, Z = –0.620, p = .53. Median values were 3.70 mm on the right side and 3.60 mm on the left side, and mean ranks were comparable (73.63 vs. 69.37) [Table 1]. For females, the comparison likewise revealed no statistically significant difference, U = 2927, Z = –0.136, p = .89. Median values were almost similar (3.40 mm vs. 3.60 mm), and mean ranks were nearly identical (77.01 vs. 77.99), supporting symmetry in anterior loop length across sides in male and female participants [Table 2].

Comparing genders, the median anterior loop length was 3.70 mm in males and 3.40 mm in females, with mean ranks of 76.95 and 72.24, respectively. The statistical comparison yielded U = 2559.5, Z = –0.552, p = .50, indicating no significant difference between males and females on the right side [Table 3]. Similarly, the median anterior loop length was 3.70 mm in males and 3.60 mm in females on the left side, with mean ranks of 74.21 and 74.77, respectively. The statistical comparison yielded U = 2713.0, Z = –0.079, p = .93, again indicating no significant difference between genders [Table 4].

Table 1

Groups	Median (IQR)	Mean Rank	U	Z	p-value
Right side	3.70	73.63	2369	-0.620	.53
Left side	3.60	69.37			

Table 2

Groups	Median (IQR)	Mean Rank	U	Z	p-value
Right side	3.40	77.01	2927	-0.136	.89
Left side	3.60	77.99			

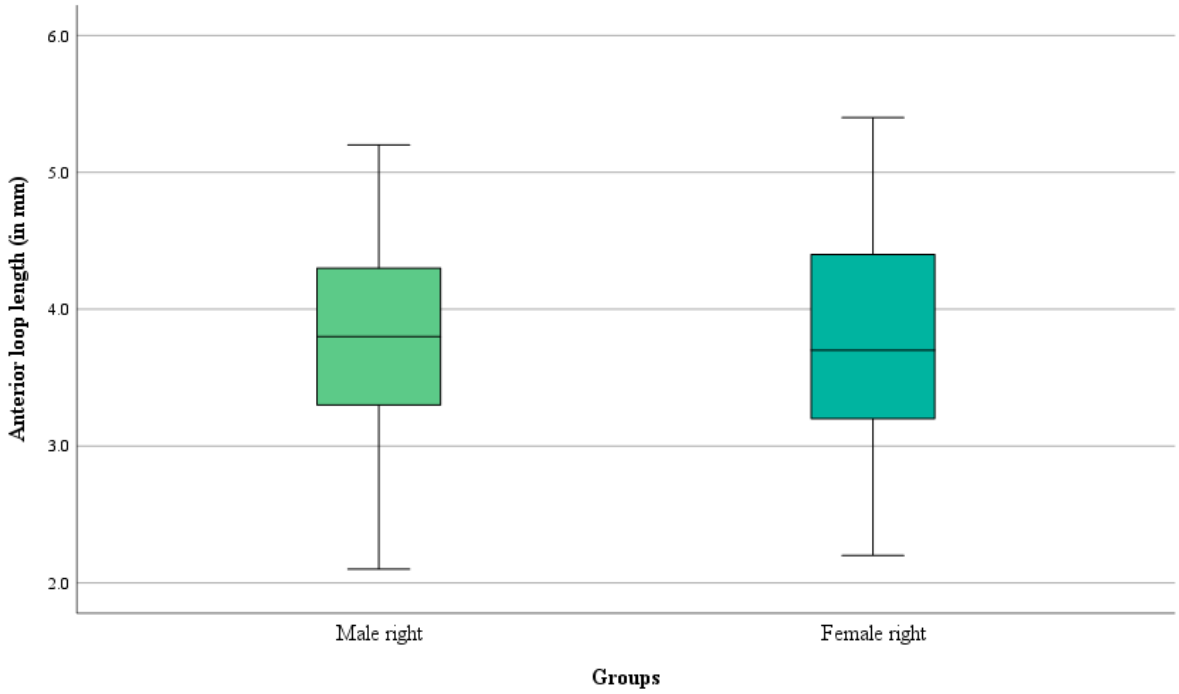
Table 3

Groups	Median (IQR)	Mean Rank	U	Z	p-value
Male	3.70	76.95	2559.5	-0.669	.50
Female	3.40	72.24			

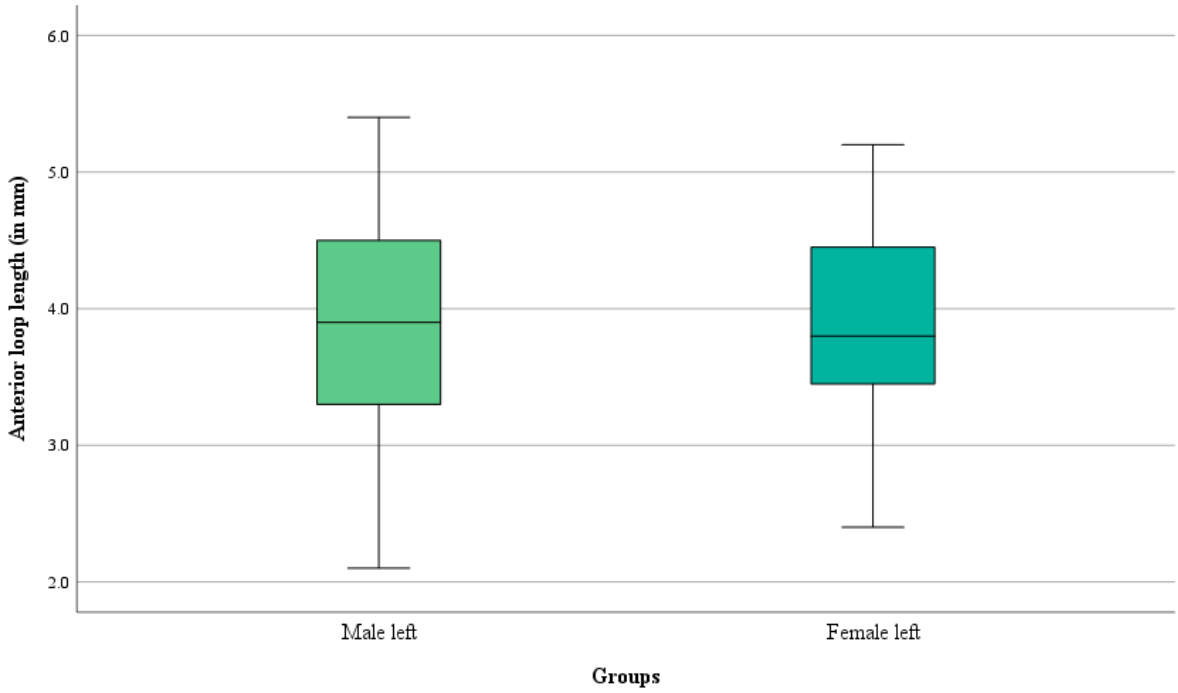
Table 4

Groups	Median (IQR)	Mean Rank	U	Z	p-value
Male	3.70	74.21	2713	-0.079	.93
Female	3.60	74.77			

Graph 1



Graph 2



These results confirm that the anterior loop length of the mental nerve on the right and left sides is also comparable across male and female participants, reinforcing the overall pattern of anatomical symmetry.

Discussion

The present study evaluated the prevalence and length of the anterior loop (AL) of the mental nerve using CBCT in the study population.The AL was identified in 76.5% of the study population, indicating that this anatomical variation is common in the mandibular inter-foraminal region. Although the prevalence was slightly higher among males than females, no statistically significant association with gender was observed. Similarly, AL length showed no significant variation between genders or between the right and left sides. These findings suggest that while the anterior loop is frequently encountered, its dimensions remain relatively consistent across demographic groups within this population.

The mental nerve anterior loop is of particular importance in implant dentistry because the mandibular inter-foraminal region is frequently selected for implant placement. Accidental involvement of an unrecognized anterior extension of the inferior alveolar nerve may result in altered sensation, pain, paraesthesia, or persistent neurosensory disturbances. Therefore, understanding the three-dimensional course of the nerve before implant osteotomy is essential for determining implant position, angulation, and surgical safety[1,8].

The prevalence of 76.5% observed in the present study is comparable with several CBCT-based investigations that have reported high detection rates of the anterior loop. Sahman and Sisman[5] reported a prevalence approaching 70% using CBCT, while Mathew and Mohan also demonstrated a similarly high prevalence among a South Indian population[9]. Conversely, systematic reviews have reported substantial heterogeneity in prevalence estimates, ranging from less than 30% to over 80%, reflecting differences in ethnicity, imaging protocols, observer criteria, and definitions used to identify the anterior loop[12].

Hui et al.[12] (2022), in their systematic review and meta-analysis, demonstrated heterogeneity in reported prevalence and anterior loop measurements, suggesting that ethnic variation, CBCT acquisition parameters, and differing diagnostic criteria influence reported values. Similarly, Suneetha et al.[13] (2022) reported variations in anterior loop dimensions using CBCT evaluation, reinforcing the importance of three-dimensional imaging for accurate visualization of mandibular neurovascular structures.

The prevalence and AL length observed in the present study showed similarity with findings reported in several Indian CBCT-based investigations. Siddiqui et al.[7] (2018) reported measurable anterior loop extension in a North Indian population, supporting the need for radiographic evaluation before implant placement. Recent studies have further highlighted the importance of regional assessment, with Srivastava et al.[14] (2024) demonstrating the usefulness of CBCT in evaluating anterior loop dimensions and surrounding anatomical structures. Suresh Kumar et al.[15] (2025) also reported variations in mental nerve loop characteristics among the Indian population, indicating that population-specific anatomical data may provide better clinical guidance than generalized assumptions.

In the present study, gender did not significantly influence anterior loop length. This finding suggests that sex-based assumptions cannot be used to predict the location or extent of the anterior loop during implant planning. Although comparable measurements were observed at the population level, individual anatomical variations may still occur and cannot be predicted solely based on side or gender. Individual CBCT evaluation therefore remains essential, particularly when implant placement is planned close to the mental foramen.

Because the anterior loop was identified in more than three-fourths of the study population, clinicians should anticipate its presence during treatment planning rather than assuming its absence. From a prosthodontic perspective, accurate identification of the anterior loop has direct clinical implications in implant planning, especially for determining the available safety zone, implant dimensions, and surgical approach. Recent CBCT-based evaluations have emphasized that three-dimensional imaging improves visualization of the mandibular canal and mental nerve pathway, thereby reducing uncertainty during implant placement procedures[16,17]. The measured anterior loop length may assist clinicians in determining an appropriate safety zone during implant placement; however, additional clearance should be considered due to possible imaging and anatomical variability. Clinically, the findings suggest that despite the observed population-level similarity, individual CBCT evaluation remains essential to determine an adequate safety margin around the mental foramen.

The major strength of this study lies in the evaluation of anterior loop morphology using CBCT, an area in which radiographic data remain limited. By assessing both prevalence and anterior loop length, the study provides anatomical information that may assist clinicians in implant planning and preoperative assessment. The findings contribute to a better understanding of anterior loop variations and may support safer clinical decision-making during implant placement and other surgical procedures in the interforaminal region. As a retrospective analysis, the evaluation was restricted to available CBCT records, and clinical outcomes such as implant placement accuracy and postoperative neurosensory changes were not assessed. Additionally, radiographic assessment was performed

by a single observer, and anatomical measurements may vary depending on observer experience and image quality. Future multicentric studies involving larger sample sizes, multiple observers, and automated nerve-tracing techniques may provide a more comprehensive understanding of anterior loop variations.

Overall, the present study demonstrated a high prevalence (76.5%) of the anterior loop in the study population, while anterior loop length remained comparable across genders and between sides. These findings emphasize that the anterior loop is a common anatomical structure that should be routinely identified using CBCT before implant placement rather than relying on generalized anatomical assumptions, thereby improving safety and predictability in implant and surgical procedures involving the mandibular inter-foraminal region. Future studies should aim to overcome these limitations by adopting prospective multicenter designs with larger and more ethnically diverse populations. Standardized CBCT acquisition protocols and the inclusion of multiple calibrated observers would improve measurement reliability and external validity. Further investigations should evaluate the influence of age, bone density, dentition status, and alveolar ridge resorption on anterior loop morphology.

Conclusion

The anterior loop of the mental nerve (ALMN) is an important anatomical variation of the inferior alveolar nerve (IAN) with significant clinical implications in implant dentistry, oral and maxillofacial surgery, endodontics, and prosthodontics. It represents the anterior extension of the inferior alveolar nerve beyond the mental foramen before curving posteriorly to exit through the mental foramen as the mental nerve. In the present study, the anterior loop was identified in 76.5% of the study population. Although anterior loop length showed no statistically significant differences between genders or sides, its high prevalence emphasizes the importance of routine three-dimensional assessment before implant placement and other surgical procedures involving the mandibular interforaminal region. The findings provide useful anatomical information that may support clinical assessment and treatment planning

List of Abbreviations:

Ab Abbreviation	Definition
CBCT	Cone Beam Computed Tomography
AL	Anterior loop
IAN	Inferior alveolar nerve
SPSS	Statistical Package for the Social Sciences
AI	Artificial Intelligence

Acknowledgements:

Name	Role
Real Guide Implant Planning Software	Used for measuring the length of anterior loop
AI tools	Assisted with language editing and refinement of portions of the Introduction and Discussion

Source(s) of support: None

Conflicting Interest (If present, give more details): No conflict of interes

Contribution Details:

Enter the role of contributors in the first column and names of the contributors in the columns 2, 3, and so on.

Role (Concepts, Design, Definition of intellectual content, investigation, manuscript writing, etc.)	Contributor 1 (Dr Allen Jim Hines)	Contributor 2 (Dr T C Giri)	Contributor 3 (Dr Aparna Mohan)	Contributor 4 (Dr Junu Henry)	Contributor 5 (Dr Keerthi)	Contributor 6 (Dr Johann immanuel)

Concepts	✓	✓	✓	✓	✓	✓
Design	✓	✓	✓	✓	✓	✓
Definition of intellectual content	✓	✓	✓	✓	✓	✓
Literature search	✓	✓	✓	✓	✓	✓
Experimental studies	✓	✓	✓	✓	✓	✓
Data acquisition	✓	✓	✓	✓	✓	✓
Data analysis	✓	✓	✓	✓	✓	✓
Statistical analysis	✓	✓	✓	✓	✓	✓
Manuscript preparation	✓	✓	✓	✓	✓	✓
Manuscript editing	✓	✓	✓	✓	✓	✓
Manuscript review	✓	✓	✓	✓	✓	✓

Ethical policy and Institutional Review board statement: SMIDS/IHEC No :05 /Protocol No :27/2024
Patient declaration of consent statement: Not applicable

Data Availability statement: The data set used in the current study is available (tick the appropriate option and fill the information)

- ❑ Repository name
  Dr. Keerthi P
- ❑ Name of the public domain resources
  Not required
- ❑ Data availability within the article or its supplementary materials
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- ❑ Data set can be made available after embargo period due to commercial restrictions
  Available

Reporting guidelines:

CRIS Guidelines (Checklist for Reporting In-vitro Studies) *

Section/Topic	Item No	Checklist item	Reported on Page No
Title and Abstract			
	1a	Identification as an in vitro/laboratory study in the title	1
	1b	Structured summary of trial design, methods, results, and conclusions	1
Introduction			

Backgrounds and Objectives	2a	Scientific background and explanation of rationale	2-3
	2b	Specific objective or hypothesis	3
Methods			
Interventions	3	The intervention for each group, including how and when they were actually administered, with sufficient detail to allow replication	3-4
Outcomes	4	Completely defined pre-specified primary and secondary outcome measures, including how and when they were assessed	4
Sample Size	5	How sample size was determined	4
Randomization: Sequence Generation	6	Method used to generate the random allocation sequence	4
Allocation concealment Implementation	7	Mechanism used to implement the random allocation sequence (such as sequentially numbered containers), describing any steps taken to conceal the sequence until interventions were assigned	4
	8	Who generated the random allocation sequence, who enrolled teeth, and who assigned teeth to intervention	4
Blinding	9	If done, who was blinded after assignment to interventions (for example, care providers, those assessing outcomes) and how	-
Statistical Methods	10	Statistical methods used to compare groups for primary and secondary outcomes	4
Results			
Numbers analyzed	11a	For each group, number of 'items' (tooth specimens) included in each analysis and whether the analysis was by original assigned groups	5
Outcomes and estimation	11b	For each primary and secondary outcome, results for each group, and the estimated effect size and its precision (such as 95% confidence interval)	6 (Tables 1-4)
Discussion			
Limitations	12a	Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses	10

Generalisability	12b	Generalisability (external validity, applicability) of the trial findings	9
Interpretation	12c	Interpretation consistent with results, balancing benefits and harms, and considering other relevant evidence	8-10
Other Information			
Protocol	13	Where the full trial protocol can be accessed, if available	-
Funding	14	Sources of funding and other support (such as supply of drugs), role of funders	-

Tables

Table 1: Comparison of Anterior loop length of the mental nerve between right and left sides in Males

Note. Each group comprised 71 male participants. The Mann–Whitney U test was conducted to compare the anterior loop length of the mental nerve between the right and left sides in male participants.

Table 2: Comparison of Anterior loop length of the mental nerve between right and left sides in Females

Note. Each group comprised 77 female participants. The Mann–Whitney U test was conducted to compare the anterior loop length of the mental nerve between the right and left sides in female participants.

Table 3: Comparison of Anterior loop length of the mental nerve on the right side between Male and Female participants

Note. Each group comprised 71 male and 77 female participants. The Mann–Whitney U test was conducted to compare the anterior loop length of the mental nerve on the right side between male and female participants.

Table 4: Comparison of Anterior loop length of the mental nerve on the left side between Male and Female participants

Note. Each group comprised 71 male and 77 female participants. The Mann–Whitney U test was conducted to compare the anterior loop length of the mental nerve on the left side between male and female participants.

Graphs

Graph 1: Anterior loop length of the mental nerve on the right side between Male and Female participants

Graph 2 : Anterior loop length of the mental nerve on the left side between Male and Female participants

Figures

Figure 1. Representative CBCT evaluation using RealGuide software for assessment of the anterior loop of the mental nerve.

Figure 2. Cone-beam computed tomography panoramic reconstruction using the curved planar reformation (CPR) technique.

Figure 3. Three-dimensional mandibular reconstruction, bilateral inferior alveolar nerve tracing, and corresponding multiplanar CBCT views.

Figure 4. Measurement of the anterior loop of the mental nerve using three-dimensional CBCT reconstruction in RealGuide software

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