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Original

A radiographic study on the visualization of the anterior loop in dentate subjects of different age groups

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Abstract: The anterior loop is defined as where the mental neurovascular bundle crosses anterior to the mental foramen then doubles back to exit the mental foramen. It cannot be seen clinically but can be detected in 11-60% of panoramic radiographs. As this anatomical structure is important in determining the placement position of endosseous implants in the mandibular premolar region, a pilot study was undertaken to determine its visibility on dental panoramic radiographs in dentate subjects of various age groups. One or more anterior loops were visible in 39 (40.2%) radiographs encompassing 66 sites (34.4%). Interestingly, anterior loops were most commonly observed bilaterally, followed by on the right side of the mandible only. An anterior loop on the left side only was observed in just 1 radiograph. Visibility of anterior loops reduced as the age of subjects increased. More than half (58.1%) of subjects aged 20-29 years exhibited at least one anterior loop; this gradually reduced to only 15 percent of subjects aged 50 and older. There was no association between visualization of the anterior loop and subject gender. (J Oral Sci 51, 231-237, 2009)

Keywords: anterior loop; mandible; dental panoramic radiographs; age; gender.

Introduction

Sicher's Oral Anatomy describes the anterior loop as "the mental canal which rises from the mandibular canal and runs outward, upward and backward to open at the mental foramen" (1). A more precise description is reported by Bavitz: "where the mental neurovascular bundle crosses anterior to the mental foramen then doubles back to exit the mental foramen" (2). Several studies have shown wide variations in anterior loop length (1,3-5). Because of this, it is not advisable to assume that a fixed distance mesially from the mental foramen will be safe for the placement of an endosseous implant, even with the current recommendation of a safety margin of 4-6 mm (3,6). The anterior loop cannot be seen clinically, but can be detected in radiographs, which include dental panoramic radiographs and magnetic resonance imaging (MRI) and (computed tomography) CT scans.

Dental panoramic radiographs are now widely used to locate anatomic landmarks in planning for the placement of endosseous implants in the jawbones. The mental foramen is commonly used as the boundary of the inferior alveolar nerve in the mandible when planning for the placement of dental implants in the anterior mandible (7,8). The mental nerve, however, may extend beyond the mental foramen boundary as an intraosseous anterior loop (Fig. 1). This structure has a high prevalence (61.5% - 96%) in cadaveric studies, with symmetric occurrence a common finding (76.2%) (1,4,9,10). Hence, its existence should not be underestimated even though its visualization on dental panoramic radiographs is not consistent.

Yosue and Brooks (11) noted that an anterior loop (termed continuous type mental foramen in their study) was present in 21% of the 297 radiographs studied, while Jacobs et al. (12) noted that it was present in 11% of panoramic radiographs, but was well visualized in only 3%. Similarly, Arzouman reported the structure in 12% of dental panoramic radiographs (1).

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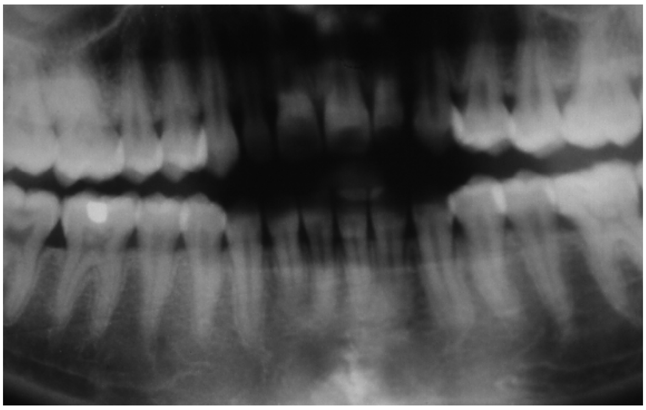

Fig. 1 The typical appearance of the anterior loops on a dental panoramic radiograph.

Investigations that compared radiographic and cadaveric dissection data with respect to identifying the anterior loop reported that radiographic assessments result in a high percentage of false-positive and -negative findings. Because of this variability, several authors have suggested that panoramic radiographs are limited with regards to the visualization of the anterior loop for implant treatment planning purposes (2,3,5). For instance, Kuzmanovic et al. (3) found that 62% of loops that were anatomically present in a cadaveric study were not visible on panoramic radiographs. In contrast, Mardinger found that, of radiographically diagnosed loops, 40% were not seen on anatomical examination (5). Bavitz et al. (2) postulated that the loop may represent a well-defined incisive canal or that it may be explained as a radiographic phenomena caused by a deep sublingual fovea and/or the mylohyoid line.

While several cadaveric and radiographic studies have looked into the correlations between cadaveric findings and the radiographic identification of the anterior loop, (1-3,5) none have investigated the visualization of the anterior loop in dental panoramic radiographs of dentate subjects of different age-groups and gender. Hence, the objective of this study was to look into the effect of aging and gender on the visualization of the anterior loop on dental panoramic radiographs. The null hypothesis was that age and gender do not influence the visualization of the anterior loop on dental panoramic radiographs of fully dentate patients.

Materials and Methods

Materials

Two hundred and forty panoramic radiographs of Malay patients of 4 different age groups, taken between 2003 and 2005, were obtained from the records kept in the Dental Faculty, University of Malaya. The age groups were as follows: 20 – 29 years, 30 – 39 years, 40 – 49 years, and 50 years and older.

All panoramic radiographs were taken using Siemen Orthophos® (Sirona, Bensheim, Germany) and Planmeca® (Planmeca, Helsinki, Finland) machines. The magnification factors reported by the manufacturers were 1.2 and 1.25, respectively. The radiographs were chosen according to the following criteria.

i. High quality with respect to geometric accuracy and contrast of the image.
ii. Teeth present between the lower right and lower left first molars.
iii. No deep caries, root canal treatment, or various large restorations in the lower teeth (because of possible associated periapical radiolucency).
iv. Free from any radiolucent or radiopaque lesion in the lower arch, and no evidence of jaw fracture around the mental foramen region.
v. No supernumerary or unerupted teeth (because the impacted/unerupted teeth might obscure the appearance of the mental foramen and anterior loop).
vi. Devoid of any radiographic exposure or processing artefacts.

Methods

Intra-observer as well as inter-observer calibration was performed using 10 randomly selected dental panoramic radiographs. The radiographs were placed on a well-illuminated radiograph view-box equipped with a magnifying glass. We first identified the mental foramen according to the description of Yosue and Brook (11), and then determined whether an anterior loop was present or absent. Anterior loop status was divided into four categories:

I. Present on both sides;
II. Present on the right side only;
III. Present on the left side only; and
IV. Absent.

Data and statistical analysis

All calculations were processed using Statistical Package for Social Science statistical software (Version 12.0; SPSS Inc, Chicago, Illinois, USA). Descriptive statistics were applied where appropriate. Cross tabulations followed by a chi-square test were performed to compare the significance of categorical findings with respect to age-groups and gender. A P-value of less than 0.05 was considered statistically significant.

Results

A total of 97 radiographs from the same number of subjects fulfilled the criteria and were examined. The breakdown of subjects according to age group is shown in Table 1. The male to female ratio was 1.06:1, and their distribution according to age group is shown in Fig. 2. The number of subjects (and hence radiographs) that fulfilled the criteria reduced as the age of subjects increased. This was because of the increasing frequency of subjects who were fully edentulous or partially edentulous beginning from the first premolar.

In terms of reproducibility of visualization of the anterior loop, close agreement was found between the two observers (DDD and HI).

Figure 3 shows the overall distribution of anterior loops. At least one anterior loop was visualized in 39 (40.2%) radiographs encompassing 66 sites (34.4%). Most of the anterior loops were observed bilaterally, followed by on the right side only; an anterior loop on the left side only was observed in just 1 radiograph. When bilateral anterior loops were present, the loop was more prominent on the right side of the mandible in 39.2% and on the left side in 28.9%.

The visibility of anterior loops reduced as the age of the subjects increased (Fig. 4). More than half (58.1%) of the subjects aged 20 – 29 years had at least one anterior loop identified; however, this gradually reduced to only 15 percent of subjects aged 50 and above (Fig. 4). Interestingly, all the anterior loops visualized in the oldest age-group were bilateral.

Table 2 shows the distribution of visible anterior loops according to subject gender. No association could be made between visibility of the anterior loop and gender.

In female subjects aged 20 – 29, the anterior loop was most commonly visible bilaterally (in 43% of radiographs). In contrast, for the male subjects of the same age, the anterior loop was most commonly visible on the right side (in 29% of radiographs). Another 24% of male subjects in this age group exhibited an anterior loop on both sides.

In the subjects aged 30 – 39, the anterior loop was more commonly identified in men than in women. Three-quarters

Table 1 Breakdown of the number of subjects according to age group

Age group	Number of subjects /radiographs [sites]
20-29	31 [62 sites]
30-39	24 [48 sites]
40-49	22 [44 sites]
$\geq$ 50	20 [40 sites]
Total	97 [194 sites]

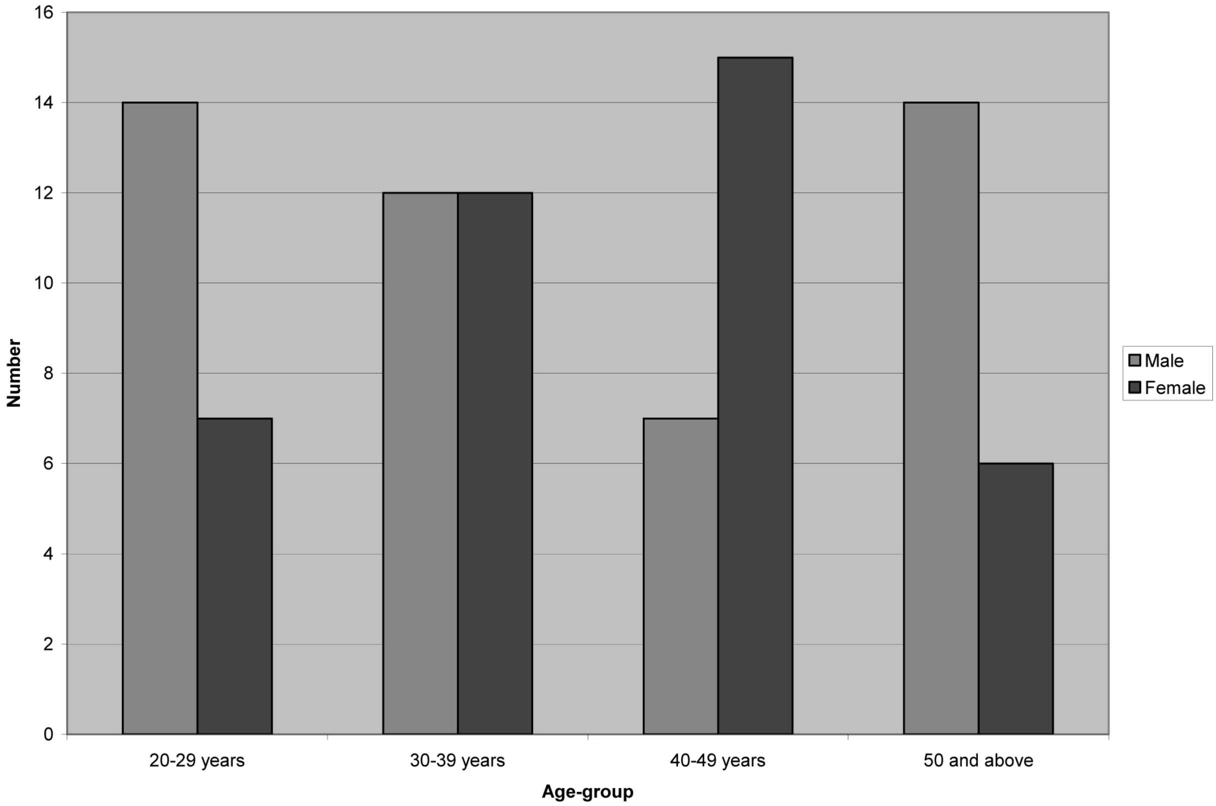

Fig. 2 Gender distribution of subjects according to age group. The total number of male and female subjects was 47 and 50, respectively.

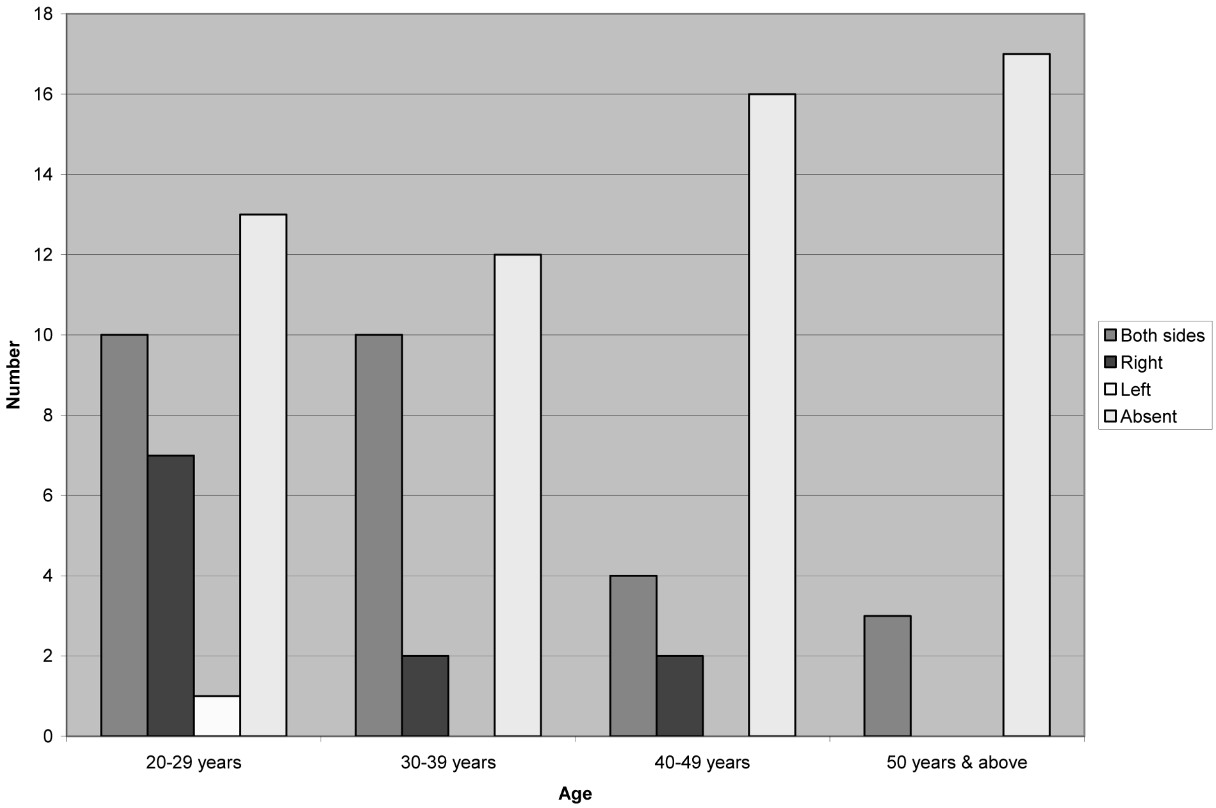

Fig. 3 Visualization of the anterior loop on 97 radiographs.

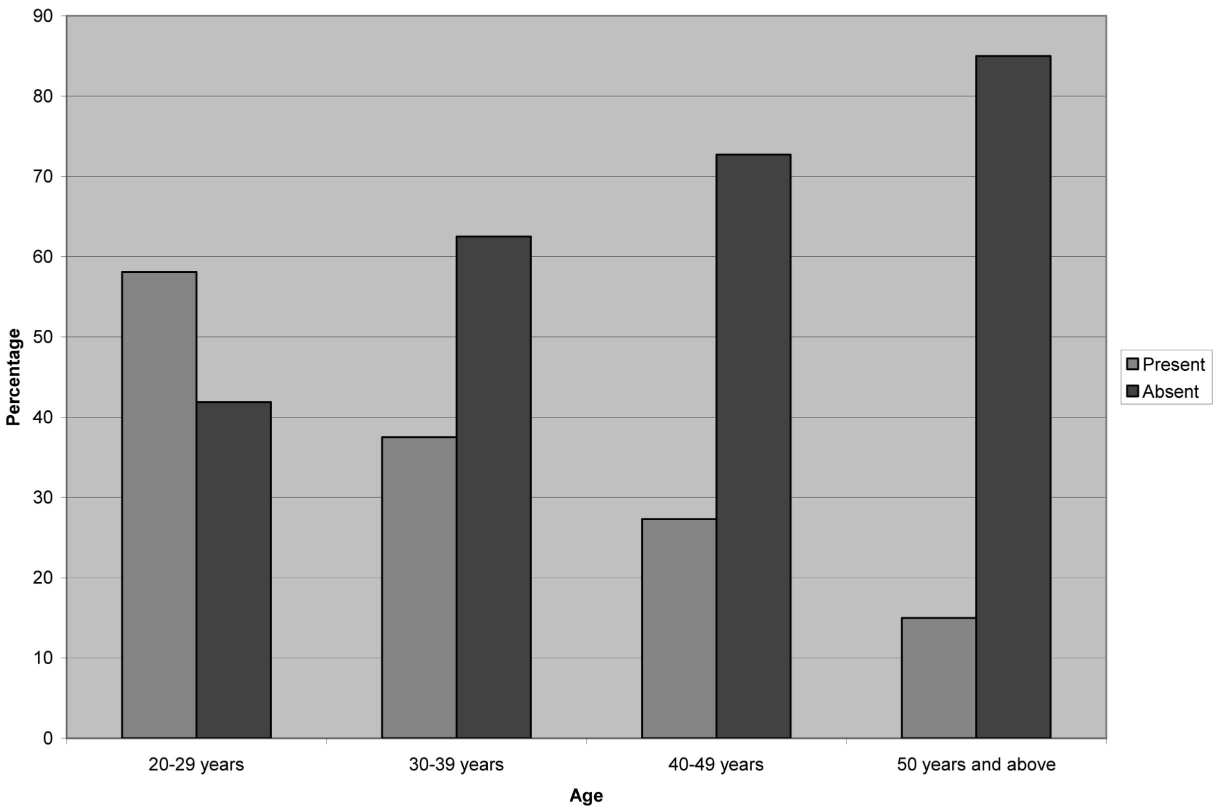

Fig. 4 The percentage of subjects with a visible anterior loop according to age.

Table 2 Distribution of visible anterior loops according to age and gender of the subjects

Age	Gender (n)	Present (frequency)			Absent (frequency)
		Both sides	Right side	Left side	
20-29 years	F (14)	6	2	1	5
	M (17)	4	5	0	8
30-39 years	F (12)	2	1	0	9
	M (12)	8	1	0	3
40-49 years	F (7)	1	1	0	5
	M (15)	3	1	0	11
≥ 50 years	F (14)	3	0	0	11
	M (6)	0	0	0	6

F = Female; M = Male.

(75%) of male subjects of this age group presented with an anterior loop on both sides. In comparison, only a quarter (25%) of female subjects showed an anterior loop; this was bilateral in 2 (16.7%) subjects, and confined to the right side in 1 (8.3%) subjects.

The percentage of subjects with at least one visible anterior loop was almost equal between genders in subjects aged 40 – 49 years. As the age of subjects increased, it became more difficult to identify an anterior loop in the radiographs. We were unable to determine the presence of an anterior loop in almost three-quarters of radiographs in both men and women aged 40 – 49 years. Similarly, no anterior loop was visible in the majority (79%) of female subjects aged ≥ 50, and in all male subjects aged ≥ 50.

We tried to apply chi-square tests to determine if there was any significant difference in the visualization of the anterior loop with regards to the gender and age of subjects. However, we later realized that this test was not applicable because of the small sample size and non-normal distribution of data. We also attempted to draw a relative (receiver) operating characteristic (ROC) curve in addition to calculating the sensitivity and specificity of visualizing the anterior loop according to gender and age-group. None of these statistical analyses yielded any significant finding.

Discussion

The anterior loop has been recognized for some time but has been regarded as of little consequence (7). However, of late, growing interest has been generated in this structure with the advent and increase in popularity of dental endosseous implants. Typically the implants are placed in the interforaminal region of the mandible. To maximize the distance between the implants, the most posterior implant is placed as close as possible to the mental foramen. The greater the distance between the interforminal implants, the better the anterior implants can counteract the forces generated on the distal cantilevers of the fixed prosthesis (2). However, the placement of implants in this region may impinge on the inferior alveolar nerve if it extends beyond the mental foramen and anterior loop (1).

Bavitz et al. recommended that an implant in the mental region is best positioned so that its distal aspect is 1 mm anterior to the anterior border of the mental foramen (2). They also recommended that it is safest if the mental nerve is identified in vivo during the placement of the implant itself. However, this recommendation did not take into consideration the presence of the anterior plexus of the nerve that can be of significant length (5,9,13). Some authors therefore recommended a minimum distance of 6 mm between the mental foramen and the most posterior implant in cases where the exact course and location of the mental canal and foramen are not identified (6,8). The reason behind this rather large safety margin is that the mental nerve has been documented to loop anteriorly for up to 5 mm (2,3,5,14).

Previous studies have shown variable results as to the radiographic visualization of the anterior loop. While Kuzmanovic et al. (3) suggested that panoramic radiographs are unreliable in identifying the anterior loop, we still decided to perform our study using this imaging modality as it is the most routinely used tool in implant treatment planning. Moreover, no similar study has been performed on a Malaysian population so far.

The incidence of the anterior loop was noted as 52% in males and 36.2% in females. Collectively, the loop was present in 40.2% of all subjects. This is higher than the incidence reported by Jacobs et al. (11%) (12), Arzourman et al. (12%) (1), Yosue and Brooks (21%) (11) and Kuzmanovic et al. (27%) (3). Our higher incidence of visualization may be related to the use of newer panoramic machines providing higher resolution radiographs. However, all these studies, including the present, suggest that panoramic radiographs are limited in their ability to visualize the anterior loop, as failure to view it does not mean it is absent.

The difficulty in identifying the mental foramen and anterior loop has been attributed to poor radiographs or bone quality, and the inability to distinguish these structures from the trabecular pattern (3,15). Patient position, technician errors, and processing errors affect the quality of the radiograph. Objects that are outside the section or plane of focus (in the focal trough) will result in distorted or obscured images (16). One possible explanation for the underestimation of the anterior loop is because it is an intermedullary structure that is located in an area with relatively thick cortical plates, hence making it difficult to distinguish in plain films (1).

The visibility of anterior loops reduced as the age of subjects increased. The difficulty in visualizing the anterior loop in older subjects may be a result of reduced calcification of the cortex that happens with age. Bone undergoes various quantitative and qualitative changes, but its remodelling appears to be slower with aging. After the age of 50, there is a marked increase in cortical porosity and the percentage of Haversian canals showing resorption (17). As a result of this resorption, the marrow space enlarges and disordered trabeculae are often seen, affecting the identification of the anterior loop (18). This may explain why the percentage of subjects in whom the anterior loop was not visualized was very high for those aged 50 and older, as the bony canals are likely to have become radiolucent.

We chose to study the presence of the anterior loop in dentate subjects only because the visualization and course of the anterior loop have been reported to become variable with the alveolar bone resorption that happens following the loss of posterior teeth (19). Resorption of the residual alveolar ridges in edentulous patients may progress to the extent that the mental canal is resorbed and the mental neurovascular bundle exposed (3). In addition, Kuzmanovic et al. reported that radiographic visualization of the anterior loop of the mental canal may be adversely affected by poor bone quality in edentulous patients (3).

Because of our preference for dentate subjects, the statistical analysis performed did not yield significant results due to the high number of subjects (radiographs) excluded. In fact, the tests used (chi-square and ROC curve analysis) were later found to be inappropriate because of the small sample size and non-normal data distribution. We combined the radiographs produced using the two machines in order to arrive at the current results. Ideally, we should therefore also investigate if there was any difference that may have resulted from the use of two different machines. However, the difficulty in obtaining adequate numbers of radiographs that fulfilled the criteria precluded this.

The high number of subjects excluded is related to the poor oral health status of the adult Malaysian population. Ninety-five percent of the adult population has caries experience, with a mean decayed, missing, and filled teeth (DMFT) index of 13.2. Approximately 72% of adults have some form of periodontal disease, with 29% having pockets deeper than the normal 3 mm (20). Periodontal disease among Malaysian adults is a problem of worrying magnitude as it leads to tooth loss (21). Many older adults excluded from the present study were fully or partially edentulous with the first or second premolar and/or first molar missing. We therefore hope to undertake a large full-scale study to validate the initial findings of this pilot study as well as determining if there is any significant difference in visualization with regard to the type of panoramic machines used.

Lastly, the successful placement of dental implants depends on proper diagnosis and pretreatment planning. While most dental practitioners believe that a dental panoramic radiograph is sufficient to visualize anatomical landmarks essential for implant planning, this study suggests that an alternative imaging technique may be needed when planning the placement of dental implants in the mental foramen region. This study, while unable to confirm the presence of the anterior loop in elderly subjects, cannot definitively show that these subjects do not have anterior loops. Only a larger study using a superior imaging modality such as CT may be able to improve on the findings of this study.

In conclusion, the anterior loop was visible in 39 (40.2%) dental panoramic radiographs encompassing 66 sites (34.4%). Anterior loops were most often observed bilaterally, followed by on the right side only. The visibility of anterior loops reduced as the age of the subjects increased. No relationship was found between subject gender and the pattern of visualization of the anterior loop. Panoramic radiography is not sufficient for presurgical implant planning in the mental region and may need to be supplemented with other modalities such as CT for better visualization of the area.

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