Panoramic Radiomorphometric Evaluation of Interforaminal Region Related with Age to Guide Dental Implant Planning

Yaşlara Göre Dental İmplant Planlamalarında Rehber Olması Amacıyla İnterforaminal Bölgenin Panoramik Radyomorfometrik Olarak Değerlendirilmesi

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ABSTRACT Objective: The aim of this study was to evaluate the variations of the height, width, appearance and position of the mental foramen (MF), according to age by using panoramic radiographs (PR) of large population, which are important for implant number and size selection in interforaminal region. **Material and Methods:** 514 younger (≤ 40 years) and 505 older (40 > years) dental implant cases interforaminal regions were evaluated by 9 radiomorphometric measurements in PR images. Distances of mental foramen to alveolar crest (MF-AC), mental foramen to lower cortex (MF-LC), between mental foramen and symphsis menti (MF-S), the height (HMF) and width of MF (WMF), anterior loop of mental foramen (ML), vertical and horizontal position of mental foramen and the radiographic appearance of mental foramen according to Yosue and Brook classification were determined by a experienced calibrated clinician. **Results:** Mental foramen was commonly located between and below the line passing from the apices of lower bicuspids. In PR images, MF-AC and MF-LC were significantly lower, WMF and HMF were significantly smaller, MF-S was significantly longer in older subjects. Slightly higher prevalence of ML was found (31%), with a mean length 3.70 mm, with no significant difference related to age. MF mostly showed continuity with mandibular canal in panoramic images (45%). **Conclusion:** Longer MF-S, smaller WMF and HMF and more prevalent continous radiographic appearance were advantages for older dental implant patients but there is prominence decrease in distance of between MF-AC and MF-LC, unfavorably effecting dental implant placement.

Key Words: Radiography, panoramic; dental implantation, endosseous; chin

ÖZET Amaç: Bu çalışmanın amacı, interforaminal bölgede implant sayısı ve boyutunun planlanmasının önemli olduğu geniş bir insan popülasyonunda, yaşlara göre panoramik radyografiler (PR) kullanılarak mental foramenin (MF) yükseklik, genişlik ve pozisyonundaki değişikliklerin değerlendirilmesidir. **Gereç ve Yöntemler:** 514 genç (≤40 yıl) ve 505 yaşlı (40> yıl) dental implant hastasının PR'leri üzerinde 9 radyomorfometrik ölçüm yapılarak interforaminal bölgelerinin değerlendirilmesi yapıldı. Mental foramen ile alveoler kret tepesi arası mesafe (MF-AK), mental foramen ile mandibulanın korteksinin en alt kenarı arasındaki mesafe (MF-MKAK), mental foramenden simfize olan uzaklık (MF-S), mental foramenin yüksekliği ve genişliği (MFY, MFG), mental foramenin anteriora doğru yapmış olduğu loop (MFL), mental foramenin vertikal ve horizontal pozisyonu gibi ölçümler deneyimli bir klinisyen tarafından Yosue ve Brook sınıflamasına göre yapılmıştır. **Bulgular:** Mental foramen genel olarak alt küçük azı dişlerinin arasında ve apekslerinden geçen hattın altında yer almaktaydı. Yaşlı bireylerin PR'lerinde MF-AK ve MF-MKAK değerlerinin sıklıkla daha düşük, MFY ve MFG değerlerinin genellikle daha küçük, MF-S mesafesinin de normalden daha uzun olduğu tespit edilmiştir. MFL bulunma sıklığı %31 olarak ölçüldü. Ortlama loop uzunluğu 3.70 mm olarak tespit edildi ve bu değerlerin istatistiksel olarak yaşla bir değişiklik göstermediği saptandı. MF çoğunlukla mandibular kanal ile devamlılık gösteriyordu (%45). **Sonuç:** Daha uzun MF-S mesafesi, daha küçük MFY ve MFG, ayrıca devamlılığı bozulmamış radyografik görünüm, yaşlı dental implant hastalarında implant başarısını arttıran etkenler olarak görülmektedir. Ancak aynı yaşlı bireylerde azalmış MF- AK ve MF-MKAK arası mesafesi implant yerleştirilmesi işlemini olumsuz olarak etkileyen bir faktör olarak kabul edilmektedir.

Anahtar Kelimeler: Panoramik radyografi; dental implantasyon, endosseoz; çene

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Reconstruction of form, function and health of the diseased tissue without damaging neighbouring tissues and anatomic landmarks is the primary goal of all surgical procedures.[1] Mental foramen (MF) is one of the significant anatomical landmarks in mandible from which branches of inferior alveolar nerve and vessels comes out.[1,2] Evaluating its localization, dimension, shape, quantity and detecting its probable loop has paramount importance during local anesthesia and not to violate during endodontic therapy, dental implant placement and maxillofacial surgeries.[1-3]

The inferior alveolar nerve comes out of the mental foramen to innervate lower lip, the skin of mental area and buccal gingiva of the cuspids and bicuspids.[1] Many studies investigate mental foramen in cadavers or clinical radiographs.[1-20] It is not in a constant localization, differing with age, gender, dental status and racial variety.[1-4,11,12,14-16,21] It is usually located between the apices of premolars or is apical to the second premolar in horizontal plane.[1] In children before tooth eruption, it is closer to alveolar crest, with advancing age it moves through the midway between the crestal bone and inferior border of mandible.[4] In older ages, some investigators stated that it is localized more coronally by the effect of atrophying alveolar crest and other researchers reported that mental foramen situated towards to lower cortex of mandible due to basal bone athrophy.[4,10-12] Its horizontal position changes depending upon race; among Chinese, Malay and Nigerian population it is usually located near the apices of second premolar whereas in Caucasian and Turkish population it is between the apices of lower premolars.[1,13,14]

Anterior loop is an extension genu of inferior alveolar nerve, prior to exiting from mental nerve.[1,17,22] Its detection and length varies among the studies, as like the location of mental foramen, according to their diagnostic methods including periapical radiography, panoramic radiography (PR), spiral computed tomography, direct measurement during the surgery or dissection in anatomic cadavers.[1,17,23,24]

Although computed tomography and cone beam are the gold standard for evaluation of anatomic structures, panoramic radiography is routinely used for radiodiagnostic method and for presurgical dental implant planning, showing all oral anatomic landmarks in one radiographic image.[1,17,22] It has been used in dental institutions for routine examinations and a source of data for retrospective studies.[25] Many studies have investigated the position of the mental foramen in different radiologic methods, dried skulls and during surgical procedures.[1-17] Although few studies have evaluated mental foramen with several parameters, interforaminal region has not yet been evaluated in detail at panoramic radiographs in terms of differences with age.[1] The aim of this study was therefore to investigate the quantity of surrounding bone, the position, shape and appearance of MF and the prevalence and the length of mental loop in panoramic radiographs of a large subject population at different ages, for to guide clinicians before immediate and conventional dental implant placement.

MATERIAL AND METHODS

700 younger subjects under the age of forty (mean 32.37 ± 6.41 years) and 700 of older subjects over the age of forty (mean 58.76 ± 9.98 years) were randomly selected from the patient pool of Department of Periodontology and Department of Oral and Maxillofacial Surgery, Gulhane Military Medical Academy, who are the dental implant therapy candidates during the period of 2006 to 2007. Of the 1400 subjects, 186 were excluded from the younger group and 195 were excluded from the older group due to various reasons such as having unerupted mandibular premolar, systemic diseases associated with bone such as osteoporosis, renal disease, thyroid disease, gross distortion of images of mandible, no horizontal space between mandibular and maxiller teeth in images and poor film quality.[12,15] Panoramic images of the remaining 514 younger (235 female and 279 male) and 505 older (241 female and 264 male) subjects were included in the study. All standart panoramic images were taken by the same Panovra 10-C (Toshiba Panoramic X-ray Unit) orthopantomograph with CEA OGA screen film (CEA OGA AB, Strangnas, Sweeden). The exposure factors were 55-65 kVp, 5-7mA, 15s time for all images. Special care was taken

to all patients, positioned in the focal trough accurately according to the manufacturer's directives, for to eliminate patient positioning errors.

RADIOGRAPHIC MEASUREMENT PROCEDURE

To ensure consistency, all radiographs were selected and measured by two authors (MS, SS) who are experienced in panoramic radiography interpretation and dental implant planning and treatment. A line was drawn tangential to the most inferior points at the mandibular angle and the lower border of the mandibular body. Horizontal and vertical lengths were measured parallel and perpendicular to this headstone tangential line, respectively.[12,15] The horizontal measurements were evaluated at interforaminal region in panoramic radiographs (Figure 1):

1- The most mesial point of mental foramen to the midline of symphsis menti (MF-S). If there was any loop, it was measured from the most mesial point of the mental genu.[2]

2- The most mesial and distal aspect of mental foramina was evaluated to measure its width (WMF).[2]

3- If an anterior loop was observed at panoramic radiograph, the shortest distance from the most anterior point of both the mental foramen and the mental canal (ML).[17]

4- If both bicuspids were present at the same side of the mandible (486 younger and 478 older patients), mental foramen examined horizontally and situated mesial to the apex of first mandibular premolar or between apices of mandibular premolars or distal to the apex of second mandibular premolar.

The vertical measurements were evaluated in interforaminal region in panoramic radiographs (Figure 1):

1- The distance from the most apical border of alveolar crest immediately superior to the mental foramen, to the superior border of the mental foramen (MF-AC).[2] In dentate areas, the most apical portion of the alveolar crest was identified as the proximal root surface, where the periodontal ligament starts to be of equal width.[26]

2- The distance from the most apical border of the mental foramen to the apical border of lower cortex of the mandible immediately inferior to mental foramen (MF-LC).[2,11,13,14]

3- The most coronal aspect to the most apical border of mental foramina was evaluated to measure its height (HMF).[2]

4- If both bicuspids were present at the same side of the mandible (486 younger and 478 older patients), mental foramen examined vertically and situated above, below or at the line that passes from apices of lower premolars.

After the lines and points were marked manually with acetate pencil, intervals between the abo-

FIGURE 1: The evaluation of mental foramen in panoramic image.

MF-AC: Mental foramen to alveolar crest, MF-LC: Mental foramen to lower cortex, MF-S: Between mental foramen and symphsis menti HMF: The height of mental foramen, WMF:Width of mental foramen, ML: Mental loop of mental nerve. Vertical and horizontal position of MF was also evaluated according to the apices of lower bicuspids. The foramen has continuous appearance with mandibular canal in both sides.

ve mentioned landmarks were measured to the nearest 0.5 mm with a transparent plastic ruler graded with a lens displaying 4x magnification. The values obtained from the panoramic measurements were corrected for their magnification (divided by the enlargement factor 1.3) as defined by the manufacturers. Clinic measurements were made by the same transparent plastic ruler to the nearest 0.5 mm.

The appearance of mental foramen in panoramic radiographs of the same subjects was also classified according to Yosue and Brooks classification in both contralateral mental regions, by the same examiner.[5,6] In each group 4 different MF appearance was classified:

- Continous: Foramen has continuity with the mandibular canal.
- Seperated: Foramen distinctly separated from the canal.
- Diffuse: Foramen has indistinct border.
- Unidentified: Foramen cannot be identified.

Before the observation period, the outlines for measurements were discussed and the observer was calibrated in radiographic system to recognize and agree on the anatomic landmarks. The border of measurements was well defined and the observers were also aware of misinterpretation by both verbal and written instructions. Duplicate recordings in the same ten panoramic images, approximately 2 week apart were performed for each examiner to calibrate (blinded from each other). Calibration was accepted if both measurements (inter- and intra-examiner measurements) were similar to the 0.5 mm at > 90% level and the appearances were classified as the same. In each patient, both contralateral regions were checked for these anatomic structures. All examinations were performed on a standard radiologic light box, under standardized viewing conditions.

STATISTICAL ANALYSES

The data were computerized and the statistical analysis was performed with a software programme (SPSS 9, SPSS Inc., Chicago, IL, USA). The measured values from right and left sides were pooled in the same column for statistical analyses, displaying mean, standard deviations and range for all parameters in each group. Two-tailed independent *t* test was carried out to establish possible differences between younger and older subjects. *P* value greater than 0.05 was not considered significant.

RESULTS

1- Distance between contralateral mental foramens (MF-S): The distance varied considerably, ranging from 20 to 33 mm, significantly longer in older subjects ($p< 0.001$) (Table 1).

2- Width of mental foramina (WMF): The values ranged from 2 to 6 mm, there was a significant difference according to age, significantly wider in younger subjects ($p< 0.05$) (Table 1).

3- Distance between superior border of the mental foramina and the most superior border of alveolar crest (MF-AC): The values ranged from 6 to 22 mm, being significantly higher in younger subjects ($p< 0.01$) (Table 1).

TABLE 1: Comparison of the average measurements (mm) in panoramic radiographs according to age.

Parameters	Younger subjects (n= 514) (Range)	Older subjects (n= 505) (Range)	Significance	Total subjects (n= 1019) (Range)
Horizontal measurements				
X MF-S (±SD)	24.67 ± 3.58 (20-32)	27.89 ± 3.94 (20-33)	p< 0.001	26.28± 3.76 (20-33)
X WMF (±SD)	3.46 ± 1.36 (2-6)	2.26± 1.57 (2-6)	p< 0.05	2.86± 1.49 (2-6)
Vertical measurements				
X MF-AC (±SD)	15.86 ± 2.55 (8.5-21)	11.34 ± 2.79 (6-22)	p< 0.01	13.60± 2.67 (6-22)
X MF-LC (±SD)	16.31 ± 2.31(10-20)	12.12 ± 2.62 (9-15.5)	p< 0.001	14.21± 2.46 (9-20)
X HMF (±SD)	3.42 ± 1.61 (2-6)	2.39 ± 1.42 (2-6)	p< 0.05	2.90± 1.49 (2-6)

SD: Standard Deviation.

4- Distance between the most apical border of the mental foramen to the outer lower cortex of the mandible (MF-LC): The values ranged from 9 to 20 mm, being significantly higher in younger subjects ($p< 0.001$) (Table 1).

5- Height of mental foramina (HMF): The values ranged from 2 to 6 mm, there was a significant difference between younger and older subjects, being higher in younger group ($p< 0.05$) (Table 1).

6- Vertical position of mental foramen: The vertical position of MF in relation to line between apices of bicuspids is shown in Table 2, the most frequent vertical position of the mental foramen below this line (49%). In both groups the most frequent position was below this line as well. With advancing age, there was a significant increase in the prevalence of more inferior location of the mental foramen ($p< 0.001$) (Table 2).

7- Horizontal position of mental foramen: The most frequent horizontal position of the mental foramen was between the apices of bicuspids (56%). With advancing age, there was a significant increase in the prevalence of more posterior location of the MF ($p< 0.01$) (Table 2).

8- The prevalence and the length of mental loop (ML): The prevalence and the length of mental loop are 31% and 3.70 ± 1.70 mm (range between 1 and 7 mm), respectively. The prevalences of mental loop in younger and older group were 32% and 30%, respectively, with no significant difference ($p> 0.05$). The lengths of mental loop in younger and older group were 3.58 ± 1.82 mm and 3.82 ± 1.58 mm, respectively. There was no significant difference between the groups ($p> 0.05$).

9- Radiographic appearance of mental foramen according to Yosue and Brook classification: The most common appearance of the mental foramen was continuous with prevalence of 40% and 51% in younger and older groups, respectively, significantly higher rate in older subjects ($p< 0.001$). Significantly higher rate of diffuse and unidentified mental foramen appearance was established in younger group ($p< 0.01$) (Table 3).

TABLE 2: Comparison of the position of mental foramen according to the apices of lower bicuspids in younger and older subjects.

Parameters	Younger subjects (n= 486) (%)	Older subjects (n= 478) (%)	Significance	Total subjects (n= 964) (%)
Vertical position				
Above the line between the apices	169 (35)	90 (19)	p< 0.001	259 (27)
At the line between the apices	104 (21)	125 (26)	p< 0.01	229 (24)
Below the line between the apices	213 (44)	263 (55)	p< 0.001	476 (49)
Horizontal position				
Mesial to the 1st premolar apice	123 (25)	92 (19)	p< 0.01	215 (22)
Between the premolar apices	285 (59)	258 (54)	p< 0.05	543 (56)
Distal to the 2nd premolar apice	78 (16)	128 (27)	p< 0.01	206 (22)

TABLE 3: Comparison of the younger and older patients by the appearance of mental foramen in panoramic radiographs according to Yosue and Brook classification (1989a,1989b).

Category	Younger subjects (n= 514) (%)	Older subjects (n= 505) (%)	Significance	Total subjects (n= 1019) (%)
Continuous	204 (40)	256 (51)	p< 0.001	460 (45)
Separated	141 (27)	145 (29)	NS	286 (28)
Diffuse	128 (25)	83 (16)	p< 0.01	211 (21)
Unidentified	41 (8)	21 (4)	p< 0.01	62 (6)

NS: Not Significant.

DISCUSSION

During the dental surgery at interforaminal region including dental implant placement, it is important to know the exact location of mental foramen and the quality and quantity of surrounding alveolar bone.[1,2] One of the purposes of this study is to determine the exact location of mental foramen and examine the surrounding available bone in selected large population, utilizing panoramic radiograph for to help pre-surgical dental implant planning.

Although distance between contralateral mental foramens (MF-S) has importance in order to determine the number and width of dental implants especially at edentulous interforaminal regions, it was evaluated scarcely in previous reports studied in dry skulls.[2,14] We have found MF-S top be averagely 26.28 mm, show accordance with Neiva et al who found this distance as 27.61 mm in Caucasian skulls.[2] Aktekin et al found no difference in MF-S, between younger and older dentate Turkish skulls, contrary to our findings.[14] We observed that interforaminal region is significantly longer in older patients. In previous reports it was observed that mental foramina moves distally in jaws continuing to atrophy, which is in keeping with the results of our study.[11,14,16] There is a wide range in MF-S can be related to age and herediter factors, effecting implant number and width especially in edentulous interforaminal region.

In previous reports, there were clear differences in width of mental foramina (WMF) and height of mental foramina (HMF), ranging from 0.75-6.5 mm.[1,4,5,7-9,13] In this study, the mean WMF and HMF was found to be 2.86 mm and 2.90 mm, respectively, with significant difference related to age, slightly wider and higher in younger group. As far as we know, the size of mental foramen has not yet been investigated related with age, only Gershenson et al examined the size of mental foramen according to age without any comparison in a dry skull study.[4] Our results are comparable with most of the studies that measured the size of mental foramen in panoramic radiograph, periapical radiographs and cadavers.[1,2,4,7-9,13]

In previous studies, there was significant variation in distance between superior border of the mental foramina and the most superior border of alveolar crest (MF-AC) level, ranging from 0 to 15.5 mm.[4,13,15] Some studies stated that in older ages with edentulous mandible, it is situated closer to the alveolar crest owing to physiologic alveolar atrophy, sometimes on top of the alveolar crest, causing difficulties in denture wearing.[1,4,11] Karaagaclıoglu and Ozkan stated that the mandibular ridge decreases in older age (> 60) with a significant difference and found that MF-AC can be affected by age, linearly decreasing with the elapsed period of edentulism, which is in agreement with the findings of our study.[10] In the study of Neiva et al, cemento-enamel junction (CEJ) superior to mental foramen was selected as a landmark, not allowing the comparison of edentelous patients with dentate ones.[2] Besides, alveolar crest around the extracted tooth is important to determine the length of immediate dental placement instead of CEJ especially in periodontitis patients, hence we used the most apical border of alveolar crest of the tooth instead of CEJ as a landmark.

The mean distance between the most apical border of the mental foramen to the outer lower cortex of the mandible (MF-LC) in our study was 14.21 mm, being significantly higher in younger subjects. Xie et al stated that the basal bone below the mental foramen was not affected by dental status and age in men but it was found to be significantly smaller in old edentulous women when compared with old dentate or young dentate women.[12] Soikkonen et al found that mental foramen was situated 3.8 mm lower in edentulous mandibles than in dentate ones and stated that the foramen moves through the lower cortex, which is in concordance with our study.[11]

In this study, the most frequent horizontal position of mental foramen was between the apices of bicuspids, which means that our results are in agreement with those of other studies on Caucasian populations, but in studies on Malay, Nigerian, Chinese and Korean populations, it was situated more posteriorly.[1,3] Some investigators stated that the age-related bone resorption begins at about for-

ties.[10] In accordance with these studies the age groups in this study were planned as younger (≤ 40) and older (> 40). Al-Khateeb et al found that the mental foramen was located more posteriorly and inferiorly with advancing age and stated that mental foramen is positioned below the apices of lower premolars in Jordanian population as in the Caucasians, which is in accordance with our study.[16] It can be concluded from the studies that mental foramen is located more inferiorly and anteriorly in Westerners.[1,3] The above location of mental foramen according to the apices of bicuspid, is important especially during immediate dental implant placement, in order not to damage mental nerve, causing paresthesia in lower lip and chin.[1]

The continuous appearance according to Yosue and Brook classification was seen more frequently than others in both age groups, which is in keeping with Al-Khateeb et al Unidentified appearance was more often seen in younger group and the continuous type was seen more frequently in older subjects (Table 3).[5,6,16] Kingsmill & Boyde found a significant bone density increase in mandible with age especially in dentate individuals.[27] In their other study, they found that the mineralization density of alveolar bone at the mental foramen site is greater after third molar region in dentate and partially dentate mandibles, especially in lingual and inferior cortex.[28] Several studies stated that better corticalization can improve visibility in radiographic images.[29,30] Further studies are required to answer the relation between the mineralization quantity and the radiographic appearance of mental foramen region in different dental status and ages.

Locating mental foramen and its genu is essential not to cause sensory dysfunction especially during dental implant placement at interforaminal region.[1] There are clear differences among studies related to the prevalence and the length of mental loop. In various studies, the prevalence varied between none to 94% and the length varied from 0.5 mm to 1cm.[1,17] We did not found any difference related to the age. In our previous report and present study we found the length of mental loop was longer than 3 mm, which is in concordance with other studies.[2,17,31]

Panoramic radiograph accuracy is limited owing to difficulty in controlling the distortion and magnification; however, it has been commonly used before implant surgery to estimate the quality and quantity of the alveolar bone so that appropriate implant length and width can be chosen, to prevent inflicting damage on anatomic structures during the surgery.[1,3,9,17,32] Jacobs et al found no difference related with age, gender or dental status, in the appearance quality of anatomical landmarks at interforaminal region in panoramic radiograph.[29] Philips et al stated that the size of MF was larger and shifted distally in comparison to its actual size and location in panoramic radiograph.[8] They stated that mental foramen displacements were seen in panoramic radiograph when compared with anatomical measurements, mainly because of the position of the patient's head.[8] Deficiencies related with patient position (projection geometry) and corticalization quantity can be seen but in a recent study the reproducibility and repeatability of radiomorphometric indices was found high in digital panoramic radiograph.[17,17,22,23,25,33]

Thanyakarn et al observed that the magnification in panoramic radiograph is lower in mandibular bicuspid region, not constant even over the same image and also the shape of the jaw for each indiviual is different so the 1.3 magnification ratio informed by the manufacturer is not reliable for these measurements.[32-35] We contended to minimize distortion problem by positioning the head of each patient accurately during taking panoramic radiograph and making all the measurements according to the tangetinal line intersecting with the most inferior points at the mandibular angle and the lower border of the mandibular body due to oblique projection angle of x-rays.[12,15,35] We also tried to eliminate non-uniformed magnification problem in both planes by multiplying radiographic measurement by the ratio of the real crown height to the radiographic crown height of bicuspid close to mental foramen. Wilding et al who compared dry mandible measurements with panoramic radiographs stated that the accuracy of measurements is limited by easily recognized mental foramen and inferior alveolar nerve in panora-

mic radiograph.[32] They stated that panoramic radiograph is reliable to evaluate the mandibular alveolar bone resorption, obtaining similar results in mandibular direct measurements. Further studies are needed to determine the relation between the size of mental foramen and age, dental status, gender and race.

In conclusion, mental foramen is commonly located between and below the line passes from the apices of bicuspids, situated more posteriorly and inferiorly, decreased in size and closer to alveolar crest and lower cortex of mandible with advancing age in panoramic radiograph. Mental foramen showed continuity with mandibular canal at most of the panoramic images and significantly higher rate of unidentified foramen was observed in younger subjects possibly because of undefined cortical borders with lower bone density when compared with older subjects.

The results of this study can help to understand the changing morphometric changes and radiographic appearance properties related to age in interforaminal region, guiding clinicians during pre-surgical dental implant planning and quantitative radiomorphometric measuring on most routinely used radiodiagnostic image. According to findings of this study, longer MF-S (Distance between contralateral mental foramens), smaller size of mental foramen and more prevalent continous radiographic appearance of mental foramen and inferior alveolar nerve, can give advantage to safely placement of more wider, longer and number of dental implants but these affirmative changes can negatively be affected by the prominence decrease of MF-AC (Distance between superior border of the mental foramina and the most superior border of alveolar crest) and MF-LC (Distance between the most apical border of the mental foramen to the outer lower cortex of the mandible) in older patients. To minimize the risk of mental foramen injury during implantation and for choosing the ideal implant number and size, these radiomorphometric measurements and appearance properties must be considered toroughly in panoramic radiograph of every dental implant patient.

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