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Assessment of Mental Foramen Related Morphologic Anatomy for Accurate Surgical Treatment Options

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Abstract
Introduction: *Pantomography is the most suitable method for radiographic images indicated in dental evaluation. The word panoramic denotes to an unlimited vision of a site in all important available direction. The detection of the anatomical and structural relationships of mandible and its structure related to it as mandibular canal, mental nerve, incisive canal, and mental foramen and determination of the mental foramen site can assess to gain sufficient dose of local anesthetic solution and to reduce the accidental deterioration during surgical treatments.*
Aim of the Work: *Assessment of mental foramen related morphologic anatomy for accurate surgical treatment options. All the measurements of the anatomical structural related to mandibular canal were done in millimeter using a new computerized method (Image J program) by using panoramic x-ray which was not used in the previous studies for prober assessment of bone height measurements.*
Material and Methods: *Forty cases which were taken from the panoramic radiographic machine in the Department of Prosthodontics, Faculty of Dentistry at Alexandria University, Alexandria, Egypt. Fabrication of upper and lower metallic casted partial denture and lower bilateral distal extension Kennedy class I. Possessing of prosthesis, finishing. At the follow up periods starting (at first month with delivery of the finished denture, at six and twelve months).*
Results: *Anatomical structures in the mandible (mandibular canal, mandibular foramen, mental foramen, and incisive canal) were detected on the panoramic radiographic films. The statistical difference were evaluated with a $P < 0.05$ through t-test which detected between different anatomical structure related to the mandibular canal and its appearance comparing between males and females in P values were evaluated and recorded.*
Conclusions: *The advantages of panoramic radiograph were low cost, easily used and requiring a limited time to obtain a radiograph. So, the best surgical treatment depends on the panoramic radiography used for diagnosing, imaging, and deciding the best surgical treatment options.*
Key Word: *Mental foramen, Panoramic x-ray, Anatomical landmark*

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I. Introduction

Pantomography is the most suitable method for radiographic images indicated in dental evaluation. The word panoramic denotes to an unlimited vision of a site in all important available direction. The detection of the anatomical and structural relationships of mandible and its structure related to it as mandibular canal, mental nerve, incisive canal, and mental foramen and determination of the mental foramen site can assess to gain sufficient dose of local anesthetic solution and to reduce the accidental deterioration during surgical treatments. So, the detection of mental foramen can help the surgeon to use sufficient dose of local anesthetic solution and to decrease the accidental failure during surgical treatments.

The presence of variation of morphology and anatomy related to mandibular canal and other related important structures are very critical in surgical prosthetic placement because the inferior nerve bundle take many locations and variations which depends on several factors like individual, gender, race, age, the technique used and the percentage of alveolar ridge resorption that affects greatly in the measurements. So, these big differences in the interforaminal region of the mandible is important to provide the mandibular canal and other related anatomical structures which help the patient who lost part or complete of their teeth to get the successful treatment.

So, the stable anatomical landmarks are important to help the surgeon to detect the foramen position. There are limited studies, mostly on skulls, which have evaluated the distance of mental foramen to the related anatomical landmarks. The horizontal and vertical sites of mental foramen were detected through the study of the mandibular inferior border and skeletal midline landmarks[1-3].

Some studies use other factors as the adjacent premolars and molars on the mandible, conventional radiographs, and CBCT to detect the vertical and horizontal sites of mental foramen[4-11].

The diagnosis of pathology in the mandible needs certain information for anatomical landmarks by using radiograph such as the morphologic differences related to the mandible which is important for prosthetic surgery as a result of the various locations that causes changes of the inferior alveolar nerve bag which affects by the factors like age, sex, x-ray machine used and alveolar ridge height[12,13].

So, some surgeons consider the anterior area of the mandible (intermental area) as a safe area for implant positioning, orthognathic surgery, and screw fixation. But the incisive canal is providing a problem in the region and this occurs during the placement of implant in the anterior region. The inferior alveolar nerve and the related blood vessels present in the mandibular canals and also the mental foramen present in front of the inferior alveolar nerve may provide an intraosseous anterior loop that must be taken into consideration during surgical treatment.

For diagnosis and treatment planning before any surgical treatment, the radiographic method is considered a non-invasive method which were performed for of the mandible. In some cases, the radiologically show the incisive branches that may be detected[14]. The technique of panoramic x-ray is a curved plane tomographic in which the two outer radiopaque lines limiting a radiolucent line which is the mandibular canal.

The advantages of panoramic radiograph are the magnification of the anatomical structure. Low cost factor safe time. So, the panoramic radiography was used generally for effective diagnosis, perfect imaging, and gave excellent surgical treatment options[15,16].

Some limitations for the use of panoramic radiograph to detect MF were the presence of inaccurate information and site of MF as a result of the present magnification and geometrical inaccuracies[17].

To evaluate the mandibular anatomical related structures to mental foramen on the panoramic x-ray and it's relation to the gender groups and the clarity of this structure at different sites by using a new computerized method image J program.

II. Material and Methods

Forty patients ranged from 45-60 year old (20 males and 20 female) came to the department of prosthodontics, Alexandria University with past medical history. They had no medical problems. Past dental history: they extracted many teeth, all because of dental caries. Extractions were simple without problems. The patient complains from pain in some teeth inability to masticate and chew her food and unsatisfactory esthetic, so they need to have prosthesis to eat on. No clicking or pain during opening and closing her mouth. Intra-oral examination: Clinical examination: normal appearance in mucosa. There are multiple missing teeth, the upper jaw is class III Kennedy classification with modification 2, the lower jaw is class I Kennedy classification without modification.

From radiographs and clinical examinations, there are multiple teeth needing restorations.

- Phase 1: Diagnostic phase:

Taking alginate primary impressions, surveying the upper and lower study casts, occlusal analysis and diagnostic wax up.

- Phase II: Prosthetic and restorative phase:

1. Endodontic treatments and other simple fillings of carious teeth. Drawing the designee for the metalic bases.
2. Preparations of bilateral L/r 4 and 5 to have crowns.
3. Upper and lower final impressions poring the master cast jaw relation record and face bow transfer.
4. Try-in of L/Lt crowns on prepared teeth.
5. Fabrication of upper acrylic and lower attachments with metallic frameworks to connect the casted metal crowns and attachments.

The diagnostic wax-up was completed and the RPD was designed.

- A putty matrix impression material was made.
- Maxillary teeth were prepared and full contour wax-up made.
- The crowns were fabricated and veneered.
- A pick-up impression of fixed components was made and poured to obtain the cast.
- The partial denture wax-up was done conventionally. Caution was taken when the patrix was covered with the wax.

Phase III: Definitive treatment, Try-in in patient's mouth. Insertion of the attachments and crowns. Try in, metalic base metal insertion then occlusal adjustment.

- After the patient's approval of the waxed-up RPD, they were acrylized and inserted.

Phase IV: Maintenance phase, Post insertion care, Oral hygiene, Periodic recall. Continual periodic follow- up to monitor the function and maintenance of the partial denture was done.

The patient was instructed about correct insertion and removal of the finished dentures and preservation of good oral hygiene. Periodic follow-up was carried out.

This study consisted of 40 cases which were retained in the panoramic radiographic machine in the Department of Prosthodontics, Faculty of Dentistry at Alexandria University, Alexandria, Egypt. The radiographs were selected based on the following criteria.

Inclusion criteria

All images were evaluated in standard faint condition. Both right and left mental foramina were observed separately and recorded. Descriptive statistics analysis of various positions was used (mean and t-test).

Measurement procedure

The location of MF was detecting as being below or between the apices of mandibular teeth from 1st molar to 1st premolar. The relation of the MF and AMF to the mandibular bone was evaluated by the distances extended from the alveolar bone crest to the MF and AMF superior borders (MF-MSB, AMF-MSB), and from the MF and AMF inferior borders to the lower border of the mandible (MF-MIB, AMF-MIB).

All the cases were selected have as partially dentate patients with the lower jaw is class I Kennedy classification without modification. At the follow up period the evaluation of alveolar mandibular bone height were registered at baseline (after delivery of the denture at 1 month), after 6 and 12 months by using of a new computerized method (Image J Program) for prober assessment of bone condition[18].

The results were presented according to the different detected sites and gender. The SPSS (version 21) was used for analysis.

Assessment is done by using a new computerized method image J program which not used in other previous studies and comparing between all values of all measurements. The differences between the two sides of the two groups (male and female) as regards to gender using t-test and differences between genders were considered significant at $P < 0.05$. (Figure 1-3)

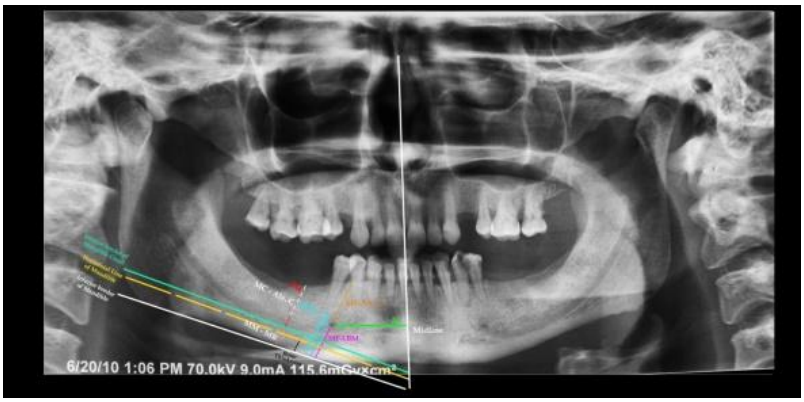

Figure (1): Measurements on the panoramic radiograph. Mandibular bone measurements were made as follow; **Horizontal line of mandible,** Line parallel to long axis of mandible and tangential to inferior border of mandible was drawn. **UMBV-LBM**, Line perpendicular to this tangent intersecting inferior border of mental foramen was constructed, along which the following measurements were made: **MC-Alv. C**, Lower border to top of alveolar crest: total height of the mandible; **MF-LBM**, distance from lower border to inferior edge of mental foramen: basal height; **bone thickness** of mandibular cortex (So, in our study we measured the (**bone thickness**) of the mandibular cortex). These measurements were made on both sides of the mandible.

Figure (2): Cast with metal framework for lower metallic removable partial denture.

Figure (3): Fabrication of metal crowns with ball type attachment for the lower metallic removable partial denture.

Patients' satisfaction about the prosthesis in relation to function and prosthetic were recorded. (Table 1)

Table (1): Patients' satisfaction about the prosthesis in relation to function and prosthetic were recorded.

	Function		Esthetic	
	Yes	No	Yes	No
At 1st month				
Male	6	34	32	8
Female	4	36	35	5
At 6th months				
Male	35	5	35	5
Female	34	6	36	4
At 12th months				
Male	40	0	40	0
Female	40	0	40	0

III. Results

Anatomical structures in the mandible (mandibular canal, mandibular foramen, mental foramen, and incisive canal) were detected and measurements in millimeter were recorded by using panoramic radiographic images and the measurements were compared at baseline (after delivery of the denture at 1 month), after 6 months and after 12 months which measured at MC - Alv. C: (Mandibular Canal Alv. Crest), MM – MB: (Mandibular Canal Border), IC: (Incisive Canal Medline), MF-LBM: (Lower Border of Mandible), MF-Alv. C: (Mental foramen - Alv. Crest), UBMC – FM: (Upper border mandibular Canal - First Molar), UBMC- LBM: (Upper border mandibular Canal - Lower border of mandible), UBM-LBM: (Upper border of mandibular canal - lower border of mandible).

The evaluation of measurements of normal mandibles using panoramic radiograph as regard to the present anatomical landmark, it was found there were increase in percentage of films which gave information about the lower edge of the MF were lies very close to a line separating the mandible bone height into thirds and through the using of relative ratio of 3: 1 of the original height of the mandible alveolar bone can be measured from the height of the lower edge of the MF which found superior to the inferior border of the mandible bone and the decrease in its height of the bone can be also measured. And so the amount of bone resorption can be easily measured in case of presence of any related abnormalities detected that may affect the classification or the collecting patients.

All evaluated measurements were recorded in millimeters with computerized Image J system which is not used in the previous study. (Table 2)

Table (2): Comparison between males and females according to mental foramen X-ray in each period

	Mental foramen X-ray	At baseline			After six months			After 12 months		
		Male (n = 20)	Female (n = 20)	p	Male (n = 20)	Female (n = 20)	p	Male (n = 20)	Female (n = 20)	p
MC - Alv. C	Right	9.5 ± 2.4	9.6 ± 2.2	0.902	9.2 ± 2.5	9.4 ± 2.2	0.783	8.9 ± 2.5	9.1 ± 2.2	0.731
	Left	9.8 ± 2.6	9.6 ± 2.3	0.727	9.4 ± 2.7	9.1 ± 2	0.739	9 ± 2.7	8.8 ± 1.9	0.756
	p_0	0.318	0.977		0.572	0.519		0.663	0.409	
MM - MB	Right	5.4 ± 0.8	4.9 ± 0.9	0.067	5.1 ± 0.9	4.8 ± 0.9	0.300	4.7 ± 0.7	4.6 ± 0.9	0.654
	Left	4.8 ± 1.2	4.1 ± 1.2	0.102	4.6 ± 1.1	4 ± 1.1	0.088	4.5 ± 1.6	3.9 ± 1.7	0.305
	p_0	0.001*	0.002*		0.006*	<0.001*		0.450	0.071	
IC	Right	17 ± 1.5	16.8 ± 2.4	0.773	16.7 ± 1.5	16.8 ± 1.8	0.807	16 ± 2	16.6 ± 1.8	0.337
	Left	16.8 ±1.5	17.1 ± 1.9	0.652	17.9 ± 5.9	16.7 ± 1.8	0.423	16.1 ± 1.6	16.4 ± 1.8	0.568
	p_0	0.632	0.384		0.393	0.508		0.769	0.476	
MF-LBM	Right	7.6 ± 1.1	7 ± 0.9	0.058	7.3 ± 1.1	6.8 ± 1	0.148	7.1 ± 1.1	6.6 ± 0.9	0.152

	Left	7.2 ± 0.8	7.1 ± 0.8	0.727	7.1 ± 0.9	7 ± 0.9	0.753	7 ± 0.9	6.7 ± 0.8	0.376
	p_0	0.100	0.594		0.541	0.370		0.729	0.644	
MF-Alv. C	Right	10.2 ± 1.3	10.6 ± 1.1	0.358	9.8 ± 1.4	10.2 ± 1.2	0.388	9.5 ± 1.4	9.9 ± 1.2	0.233
	Left	9.7 ± 2.3	10.2 ± 2.5	0.497	9.4 ± 2.3	9.6 ± 2	0.778	9.1 ± 2.3	9.3 ± 1.9	0.750
	p_0	0.236	0.491		0.361	0.159		0.400	0.112	
UBMC - FM	Right	9 ± 2.1	8.9 ± 2.8	0.890	8.9 ± 2	8.7 ± 2.9	0.819	8.5 ± 1.9	8.3 ± 2.7	0.776
	Left	9.7 ± 1.8	9.2 ± 2.7	0.460	9.6 ± 1.7	8.9 ± 2.6	0.291	9.2 ± 1.8	8.6 ± 2.5	0.391
	p_0	0.004*	0.201		0.001*	0.410		0.015*	0.303	
UBMC- LBM	Right	9.6 ± 0.7	9.5 ± 0.9	0.640	9.3 ± 0.8	9.1 ± 0.9	0.521	8.9 ± 0.8	8.8 ± 0.9	0.778
	Left	9 ± 0.8	9 ± 1	0.877	8.5 ± 1.7	8.7 ± 1	0.686	7.9 ± 2.2	8.4 ± 0.9	0.418
	p_0	0.004*	0.042*		0.066	0.045*		0.074	0.045*	
Mad line	Right	19.9 ± 1.9	18.9 ± 2.2	0.132	19.4 ± 2.2	17.7 ± 2.9	0.047*	19.2 ± 1.9	17 ± 3.2	0.011*
	Left	19.6 ± 2.2	19.2 ± 2.5	0.599	19.2 ± 3.5	18.9 ± 2.4	0.756	19 ± 1.9	18.6 ± 2.3	0.489
	p_0	0.267	0.117		0.727	0.117		0.083	0.081	
Bone thickness	Right	2.6 ± 0.3	2.7 ± 0.6	0.264	2.3 ± 0.3	2.6 ± 0.4	0.024*	2.1 ± 0.3	2.4 ± 0.4	0.010*
	Left	2.4 ± 0.4	2.5 ± 0.4	0.773	2.1 ± 0.3	2.2 ± 0.3	0.390	1.8 ± 0.3	2 ± 0.3	0.139
	p_0	0.079	0.060		0.060	0.001*		0.021*	<0.001*	
Opening of mandibular height	Right	1.9 ± 0.8	1.7 ± 0.6	0.344	1.8 ± 0.9	1.5 ± 0.6	0.308	1.6 ± 0.8	1.4 ± 0.6	0.364
	Left	1.5 ± 0.5	1.5 ± 0.5	0.855	1.3 ± 0.5	1.3 ± 0.4	0.986	1.2 ± 0.4	1.1 ± 0.4	0.685
	p_0	0.008*	0.205		0.005*	0.199		0.012*	0.112	
UBM-LBM	Right	6.6 ± 1.1	5.9 ± 0.9	0.049*	6 ± 0.9	5.7 ± 1	0.411	5.8 ± 1	5.6 ± 1	0.580
	Left	5.5 ± 0.5	5.6 ± 0.9	0.808	5.3 ± 0.5	5.3 ± 0.7	0.805	4.9 ± 0.6	5 ± 0.8	0.575
	p_0	0.002*	0.105		0.006*	0.025*		0.001*	0.002*	

Data was expressed by **Mean ± SD.** **t: Student t-test**
p: p value for comparing between **males** and **females** in each period
p_0: p value for **Paired t-test** for comparing between **Right** and **Left**
*: Statistically significant at $p \leq 0.05$

MC - Alv. C: (Mandibular Canal Alv. Crest) **MM – MB**: (Mandibular Canal Border)
IC: (Incisive Canal Medline) **MF-LBM**: (Lower Border of Mandible)
MF-Alv. C: (Mental formen - Alv. Crest) **UBMC – FM**: (Upper border mandibular Canal - First Molar)
UBMC- LBM: (Upper border mandibular Canal - Lower border of mandible)
UBM-LBM: (Upper border of manibular canal - lower border of manible)

There was no statistically significance difference between right and left sides except at the following sites mad line (p=0.011), bone thickness (p=0.010) at 12 months and at six months (p= 0.047) and (p= 0.024) in the right side.

IV. Discussion

The mandibular canal is one of the most major anatomical landmarks in the mandible. Due to the existence of inferior alveolar nerve, artery and vein passing in it. This structure is very critical during surgical prosthetic treatment[19].

Injury to nerve or vascular content may occur leading to more serious problems during prosthetic surgical insertion.

The mandibular canal course starts in the mandibular foramen and end at the mental foramen[20].

So, the evaluation of the correct site of the mandibular canal and the related anatomical information in this region is considered as important prosthetic site in the mandible to achieve its oestointegration[16].

The perfect anatomical information and proper detection of bone quality and quantity of this region is considered an important factor of success or failure for surgical and prosthetic treatment[20].

Computed tomography (CT) is considered one of the important imaging factors for surgical treatment it helps the acquisition of quickly, representation and definitive images[21-25]. Previous studies have explaining the possibility of single-slice CT for dental treatment studying in the mandible and maxilla jaw bones[26,27]. More recently evaluations accurately by the utilization of multislice CT have also been reported[28,29].

In dentistry, the most important mandibular anatomical landmarks are mental foramen because it is important for the surgical treatment of the patient when receiving local anesthesia and surgical treatment. It contribute both the mental nerves and blood vessels that give branches to the buccal mucosa of incisors, canines, premolars, chin, lower lip, and oral mucosa limited xerostomia may result from surgical trauma[14,30].

In the dental field, the use of both intraoral and rotational panoramic radiograph (PAN) images not frequently provide the accurate anatomical differences in the mental foramen area, which is provided by using Two-dimensional radiographs that are the most famous detecting imaging technique used[31]. In a study using by PAN, Al-Khateeb et al.[32] identified a presence of AMF; however, Toh et al.[33] evaluated that AMF information is problems with intraoral and PAN radiographic images which detect that they are decreased than 1.0 mm in size. In contrast, evaluation by using computed tomography (CT) before surgery more diagnostic effective technique for the detection of AMF. Assessment of osseous landmarks in the jaws and presurgical location of AMF were perfectly evaluated by cone beam computed tomography (CBCT) due to its effective resolution[18,34,35].

Mistry et al.[36], comparing diabetic and non-diabetic patients the bone loss was similar statistically while bone resorption was increase in low glycemic controlled patients.

Yoon et al.,[37] in case of the existence of lingual concavity should be evaluated and carefully determined in case of prosthetic treatment and placement is indicated in the posterior first molar area region of the mandible.

V. Conclusions

Mental foramen is a principle anatomical structure present buccaly on the mandible and superior to the mandibular canal and the inaccurate site of mental canal lead to injury to the mental nerve and numbness in the lower lip of the patient that may result from the incorrect detection of the mental foramen before surgical operation. The location of the vertical site of mental foramen is usually inferior to the apices of the mandibular second premolars. At equidistant between the crest of the alveolar ridge and the inferior border of the mandible. The situation of mental foramen is usually detected by panoramic x-ray in most previous studies. Some limitation for panoramic radiography that the probable magnification and geometrical deformation causes in perfect recognization and discovering of mental foramen.

Panoramic radiography has some advantages, such as being cost effective and easily accessible and requiring a minimum amount of time to obtain a radiograph. Therefore, panoramic radiography is widely used for diagnosing, imaging, and deciding the best surgical treatment options.

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