



A CBCT aided assessment for the location of mental foramen and the emergence pattern of mental nerve in different dentition status of the Saudi Arabian population

Avaliação auxiliada por CBCT para a localização do forame mental e o padrão de emergência do nervo mental em diferentes estados de dentição da população da Arábia Saudita

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ABSTRACT

Objective: The anatomy of mental foramen (MF) is a noteworthy landmark during any surgical procedures in the inter-foraminal region. Thus, the study aims at evaluating the location of MF and the emergence pattern of MN in three status of dentition in Saudi Arabian population. **Material and Methods:** In a prospective study, we have analyzed 240 cone beam computed tomography (CBCT) for the location of MF and the emergence pattern of MN. The study comprising three groups, namely dentulous, partially edentulous and edentulous, each having eighty CBCT scans. We presented the data in percentages. The chi-square and McNemar's test were used for testing association and pair-wise analysis, respectively. **Results:** The most common location of MF was below the apex of the second premolar irrespective of dentition status, with 54.2% in right and 60% in the left side of the jaw. Among the dentition status, left side of the mandible has shown significant variation for the location of MF, whereas gender and age showed variation in the right side. Anterior loop (AL) (Type-III) the emergence pattern of MN was the highest in all dentition status, with 51.7% in right and 53.8% on the left side. The variation in the emergence pattern of MN in terms of gender and side of the jaw was statistically significant. **Conclusion:** In the Saudi Arabian population, the apex of second premolar and type III/AL was the most prevalent location of MF and the emergence pattern of MN, respectively.

KEYWORDS

Anterior loop; Cone beam CT; Mandible; Mental foramen; Mental nerve.

RESUMO

Introdução: A Anatomia do forame mental (FM) é de grande importância durante qualquer procedimento cirúrgico na região inter-foraminal. Por tanto, como objetivo o estudo visa avaliar a localização do FM e o padrão de emergência do NM em três estados de dentição na população da Arábia Saudita. **Material e Métodos:** Em um estudo prospectivo, analisamos 240 tomografias computadorizadas de feixe cônico (TCFC) para a localização do FM e o padrão de emergência de NM. O estudo compreendeu três grupos, a saber, dentados, parcialmente edêntulos e edêntulos, cada um com oitenta imagens de TCFC. Apresentamos os dados em porcentagens. O teste do Qui-quadrado e o teste de McNemar foram usados para testar associação e análise de pares, respectivamente. **Resultados:** A localização mais comum do FM foi abaixo do ápice do segundo pré-molar independente do estado da dentição, com 54,2% no lado direito e 60% no lado esquerdo da mandíbula. Dentre as condições da dentição, o lado esquerdo da mandíbula apresentou variação significativa para a localização dos FM, enquanto o sexo e a idade mostraram variação no lado direito. O padrão de emergência (Tipo III) da alça anterior (AL) do NM foi o mais alto em todos os estados de dentição, com 51,7% no lado direito e 53,8% no lado esquerdo. A variação no padrão de emergência de NM em termos de gênero e lado da mandíbula foi estatisticamente significativa. **Conclusão:** Na população da Arábia Saudita, o ápice do segundo pré-molar e tipo III / AL foi a localização mais prevalente de FM e o padrão de emergência de NM, respectivamente.

PALAVRAS-CHAVE

Alça anterior; Forame mental. Mandíbula. Nervo mandibular. Tomografia computadorizada. Tomografia computadorizada de feixe cônico.

INTRODUCTION

The mental foramen (MF) is an essential anatomical landmark in the mandible through which the terminal branch of the inferior alveolar nerve (IAN), known as mental nerve (MN) and vessels take an exit. Having knowledge about MF's position and the emergence pattern of MN is of paramount importance in various surgical procedures. The risk of damaging the MN during various oral surgical procedures, including genioplasty, orthognathic surgery, removal of cyst and tumors and placement of dental implants (DI) are relatively high [1,2]. One of the complication of MN injury can be a paraesthesia because of overfilling of local anesthesia in the close vicinity of MF [3].

The mandible is a constantly growing structure, and they reported that the MF changes its location with age [3]. In elderly individuals because of the atrophic mandible the MF shifts superiorly whereas in children, its position is relatively inferior to the elder age group, towards the lower border of mandible [4]. MF has shown variation in size, location, shape, gender and number [5-15]. Its difference concerning ethnic race is a significant factor and should consider it during the pre-surgical planning phase, and during clinical procedures [12-16].

An essential aspect of MF is how the MN is taking an exit from it. During its exit, it can show a loop formation known as an anterior loop (AL) of the MN. According to solar et al. [17], they have categorized the AL into three types, i.e. type I, type II and type III.

With the limitation of overlapping structures in two-dimensional (2D) radiographic techniques such as intraoral periapical radiograph (IOPA) or orthopantomography (OPG), it cannot identify the exit pattern of MN accurately. Radiographic technique using three-dimensional (3D) technology is beneficial over 2D radiographic modalities [18-20]. The cone beam computed tomography (CBCT) is a 3D radiographic technique commonly used in various dental surgical procedures to assess normal anatomical landmarks and to identify any pathology.

We should consider an analysis of the factors which can influence the MF via pre-surgical planning on CBCT. Apart from the factors mentioned in the literature, the dentition status can affect the location of MF. Thus, this study aimed at evaluating the position of MF and the exit pattern of MN in three dentition status in Saudi Arabian population.

MATERIAL AND METHODS

Description of the Study

The study followed a prospective, cross-sectional study design during December 2018 to November 2019 at the college of dentistry, the Kingdom of Saudi Arabia (KSA). The study has got the ethical clearance from institutional ethical board (08-09/41). Patients willing to take part in the study had signed the informed consent.

Description of the sample

We took good quality scans with complete coverage of dental arches for Saudi patients referred for CBCT examination for diagnosis and various treatment needs. The study excluded the patient with attributes such as age below 18 years, coexisting chronic systemic conditions like diabetes mellitus, chronic renal failure, osteoporosis, long-term medication which affects bone metabolism. Additional exclusion criteria includes patient bearing any local or systemic bone pathology, mandibular skeletal deformity, or any local pathologic lesion obscuring the mandibular premolar-molar region. Along with the above criteria, we executed additional exclusion criteria pertaining to the dentition status corresponding to three study groups. Dentulous patients with or without the third molar, included in the first (I) study group. The study adopted the criteria of Kalender et al. [15] for group II partially edentulous patients. In case of missing mandibular premolar or molar, we ensured that the same tooth was present in the opposing arch. The edentulous area in group II and III (edentulous) was no older than 2 years. We calculated the sample size with software—G Power 3.1.9.2 (Heinrich-Heine-Universität Düsseldorf, Germany). Chi square tested at the confidence interval of (α).05 with effect size (w) 0.3 in three study groups. A total sample size of 240 achieved with a statistical power of 0.99.

Specification of CBCT machine and Image analysis:

In the current study, we have used SCANORA® 3Dx CBCT machine (Nahkelantie 160, Tuusula, Finland) for generating scans of the mandibular region of patients. We adopted the specifications of the machine, exposure settings, image acquisition protocol and display software from Sghaireen et al. [21].

We identified the position of MF and the emergence pattern of MN through the MF by using Tebo and Telford classification [22] and solar et al. [17] respectively. In Solar et al. [17] classification, in type-I, AL was not noticeable, and it forms a "Y" shape with no loop. In type-II, AL was absent, and it formed "T" shaped anatomy, whereas the type-III pattern AL was noticeable (Figure 1 A–D).

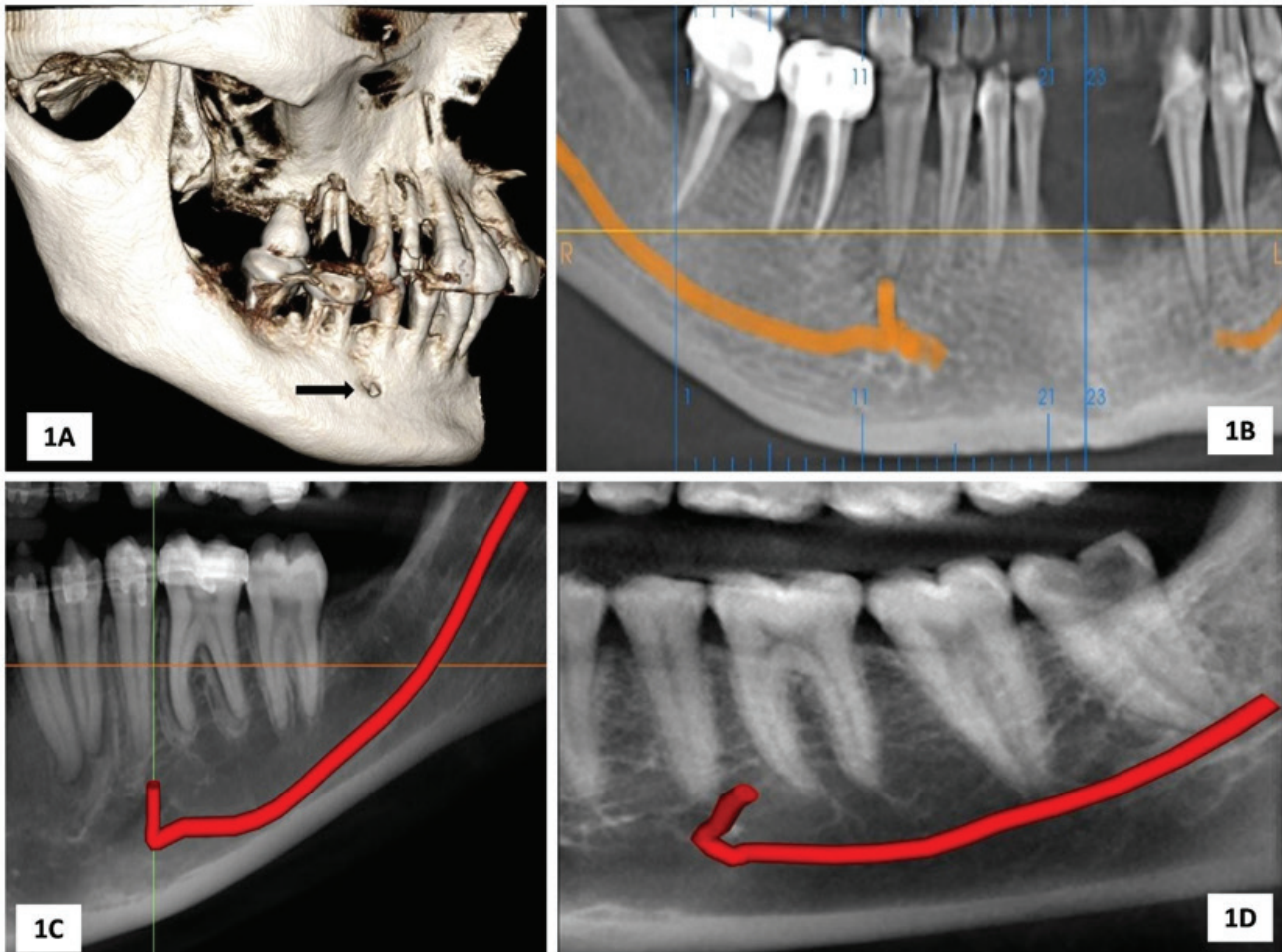


Figure 1 - This is a figure depicting the CBCT scan images showing the various aspects of mental nerve (MN) and its related anatomical structures investigated in the study: (A) Volume rendering image of CBCT is shown with a arrow (black) pointing towards the most common location of the mental foramen (MF) – apex of the 2nd premolar; (B) panoramic reformatted image of CBCT showing the emergence pattern of MN while taking exit from MF – Type I (C) Type II (D) the most common pattern seen in the study – Type III (anterior loop).

We carried all CBCT Image Analysis out by two independent investigators who were professionally certified oral radiologists with over ten years of experience. At the beginning of study, the two examiners underwent a training schedule to standardize the criteria for evaluation. Later, we assessed the inter- and intra-examiner reliability and found to be 0.93 and 0.94 respectively, thus showing high agreement.

Statistical analysis

We entered all the data into the MS excel sheet. According to the data, we presented it either in number/percentages or mean with

standard deviation. Chi-square tested the association and McNemar analyzed the pair-wise comparison. We performed the data analysis with the Statistical package for social sciences (SPSS) version 21 with $p < .05$ considered as statistically significant.

RESULTS

Descriptive statistical analysis

We analyzed 240 CBCT scans for the current study. Based on the patient's dentition status, we categorized the total scans into three study groups with 80 patients in each group. The dentulous group had a majority (43.8%) of

subjects in 18-25 years' age group. The group composed of 44 male (55%) and 36 female (45%), with a mean age of 38.83 ± 14.389 (Standard deviation; Range: 18-60 years). The second group has a male predominance (Male - n = 43; 53.8%; Female - n = 37; 46.3%) with a mean age of 41.54 ± 12.702 (Range: 19-60). The edentulous group has all subjects ≥ 54 Years of age (mean age - 58.41 ± 2.928 ; Range: 54-66) with an equal representation of both gender groups (Table I).

Table I - Descriptive analysis of Sample characteristics

Variable	Response	Study Groups			Total
		Study Group I – Dentulous (n=80)	Study Group II – Partially Edentulous (n=80)	Study Group III – Edentulous (n=80)	
Age	Mean \pm SD	38.83 ± 14.389	41.54 ± 12.702	58.41 ± 2.928	-
	18 – 35 Yrs.	35 (43.8)	28 (35)	-	63 (26.25)
	36 – 53 Yrs.	24 (30)	28 (35)	-	52 (21.66)
Age	≥ 54 Yrs.	21 (26.3)	24 (30)	80 (100)	125 (52.08)
	Male	44 (55)	43 (53.8)	40 (50)	127 (52.91)
Gender	Female	36 (45)	37 (46.3)	40 (50)	113 (47.08)

Results are expressed as number (%); SD- Standard Deviation.

Inferential statistical analysis regarding the location of mental foramen

Determination of the location of MF was the primary aim in the current study. We found the apex of 2nd premolar to be the most prevalent location of MF (Right -54.2%; Left -60%), whereas the least reported was at apex of 1st premolar (Right -18.3%; Left- 9.6%) (Figure 2). We found this variation significant on the right side of the jaw in relation to gender ($p = .034$) and age ($p = .034$). However, on the left side, we observed a significant variation with dentition status ($p = .006$). While observing the sides within individual dentition status, a significant variation existed in dentulous ($p = .005$) and an edentulous group ($p = .007$). Apex of 1st premolar showed the maximum variation in side-wise comparison, whereas the apex of 2nd premolar showed the highest rate of similarity. Significant ($p = .004$) variation existed between

the right and left sides irrespective of dentition status (Table II and III).

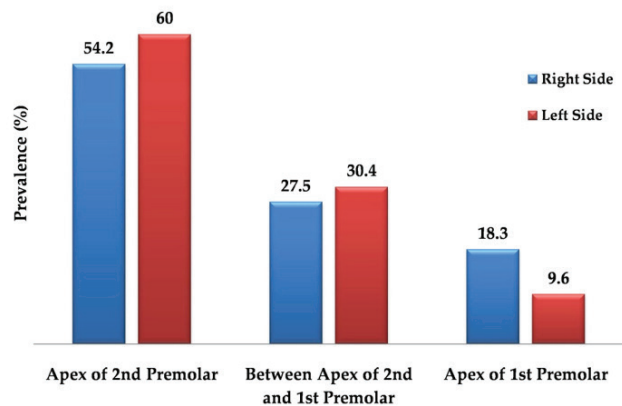


Figure 2 - Locations of mental foramen observed in the current study, with apex of 2nd premolar as the most common irrespective of side of the jaw.

Table II - Comparative analysis of parameters influencing the location of mental foramen

Parameter	Side of the Mandible	Dentition Status	Types of location of Mental Foramen			P Value
			Apex of 2 nd Premolar	Between Apex of 2 nd and 1 st Premolar	Apex of 1 st Premolar	
Dentition	Right	Dentulous	47 (58.8)	18 (22.5)	15 (18.8)	.121
		Partially Edentulous	49 (61.3)	19 (23.8)	12 (15)	
		Edentulous	34 (42.5)	29 (36.3)	17 (21.3)	
	Left	Dentulous	59 (73.8)	18 (22.5)	3 (3.8)	
		Edentulous	46 (57.5)	22 (27.5)	12 (15)	
		Edentulous	39 (48.8)	33 (41.3)	8 (10.0)	
Gender	Right	Male	71 (55.9)	30 (23.6)	26 (20.5)	.034*
		Female	59 (52.2)	36 (31.9)	18 (15.9)	
	Left	Male	80 (63)	36 (28.3)	11 (8.7)	
		Female	46 (56.6)	22 (32.7)	12 (10.6)	
Age	Right	18-35	38 (60.3)	10 (15.9)	15 (23.8)	.034*
		36-53	32 (61.5)	11 (21.2)	9 (17.3)	
		≥ 54	60 (48)	45 (36)	20 (16)	
	Left	18-35	38 (60.3)	18 (28.6)	7 (11.1)	
		36-53	38 (73.1)	9 (17.3)	5 (9.6)	
		≥ 54	68 (54.4)	46 (36.8)	11 (8.8)	

Results are expressed as number (%), Chi-square test was applied at 95% confidence interval. Significant difference at * $P < .05$, ** $P \text{ value} < .01$.

Table III - Comparative Analysis of inter-arch pattern of Mental Foramen location

Study Group	Right side of mandible	Left side of mandible			Inter-arch comparison	
		Apex of 2 nd Premolar	Between Apex of 2 nd and 1 st Premolar	Apex of 1 st Premolar	Patient-wise	Overall
Dentulous	Apex of 2 nd Premolar	44 (93.6)	3 (6.4)	0	.005**	.004**
	Between Apex of 2 nd and 1 st Premolar	6 (33.3)	12 (66.7)	0		
	Apex of 1 st Premolar	9 (60)	3 (20)	3 (20)		
Partially Edentulous	Apex of 2 nd Premolar	36 (73.5)	8 (16.3)	5 (10.2)	.875	
	Between Apex of 2 nd and 1 st Premolar	5 (26.3)	12 (63.2)	2 (10.5)		
	Apex of 1 st Premolar	5 (41.7)	2 (16.7)	5 (41.7)		
Edentulous	Apex of 2 nd Premolar	24 (70.6)	10 (29.4)	0	.007**	
	Between Apex of 2 nd and 1 st Premolar	6 (20.7)	23 (79.3)	0		
	Apex of 1 st Premolar	9 (52.9)	0	8 (47.1)		

Results are expressed as number (%); McNemar’s test was applied at 95% confidence interval. Significant difference at **P value<.01.

Inferential statistical analysis regarding the emergence pattern of mental nerve

Evaluation of the emergence pattern of MN was the second objective of the study. We observed that AL (Type III) was the most frequent (Right - 51.7%; Left -53.8%) and Type I (Y type) was the least reported (Right-20.8%; Left-17.5%) the emergence pattern of MN (Figure 3).

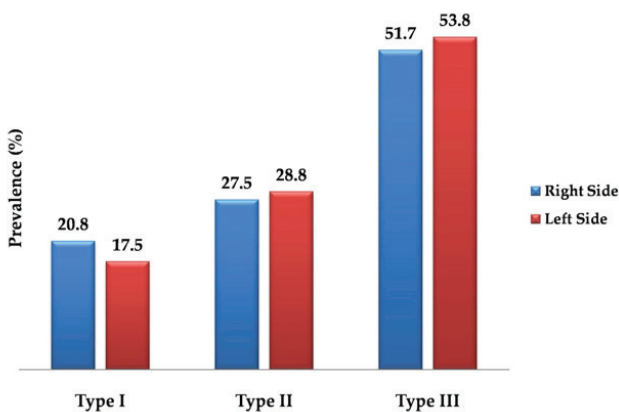


Figure 3 - Emergence pattern of mental nerve observed in the current study, with Type III pattern as the most common irrespective of side of the jaw.

On the right side, the dentition (P =.966), gender (p =.066) and age groups (P =.829) showed a non-significant variation regarding emergence pattern. Conversely, the left side showed a significant variation among gender (p =.004). We observed significant results for the study group I (p =. 012) and II (p =.030) in comparing their emergence pattern within the dentition groups. The type I pattern reported the highest variation between the sides and type III, the least. A significant variation (p =.025) existed between the emergence pattern on the right and left sides irrespective of the dentition status (Table IV and V).

Table IV - Comparative analysis of parameters influencing the emergence pattern of mental nerve

Parameter	Side of the Mandible	Left side of mandible	Emergence pattern of the mental nerve			P Value	
			Type I- Y type	Type II – T type	Type III - Loop		
Dentition	Right	Dentulous	15 (18.8)	24 (30)	41 (51.3)	.966	
		Partially Edentulous	18 (22.5)	21 (26.3)	41 (51.3)		
		Edentulous	17 (21.3)	21 (26.3)	42 (52.5)		
	Left	Dentulous	17 (21.3)	24 (30.0)	39 (48.8)		.717
		Edentulous	11 (13.8)	24 (30)	45 (56.3)		
		Edentulous	14 (17.5)	21 (26.3)	45 (56.3)		
Gender	Right	Male	30 (23.6)	27 (21.3)	70 (55.1)	.066	
		Female	20 (17.7)	39 (34.5)	54 (47.8)		
	Left	Male	30 (23.6)	27 (21.3)	70 (55.1)		
		Female	12 (10.6)	42 (37.2)	59 (52.2)		
Age	Right	18-35 Years	12 (19)	18 (28.6)	33 (52.4)	.829	
		36-53 Years	12 (23.1)	11 (21.2)	29 (55.8)		
		≥54 Years	26 (20.8)	37 (29.6)	62 (49.6)		
	Left	18-35 Years	8 (12.7)	21 (33.3)	34 (54)		.396
		36-53 Years	13 (25)	11 (21.2)	28 (53.8)		
		≥54 Years	21 (16.8)	37 (29.6)	67 (53.6)		

Results are expressed as number (%); Chi-square test was applied at 95% confidence interval. Significant difference at *P < .05 , **P value<.01.

Table V - Comparative Analysis of inter-arch pattern of emergence of mental nerve

Study Groups	Right side of mandible	Left side of mandible			Inter-arch comparison	
		Type I- Y type	Type II – T type	Type III - Loop	Patient-wise	Overall
					P value	
Dentulous	Type I- Y type	12 (80)	3 (20)	0	.012*	.025*
	Type II – T type	0	21 (87.5)	3 (12.5)		
	Type III - Loop	5 (12.2)	0	36 (87.8)		
Partially Edentulous	Type I- Y type	11 (61.1)	3 (16.7)	4 (22.2)	.030*	
	Type II – T type	0	21 (100)	0		
	Type III - Loop	0	0	41 (100)		
Edentulous	Type I- Y type	14 (82.4)	0	3 (17.6)	.083	
	Type II – T type	0	21 (100)	0		
	Type III - Loop	0	0	42 (100)		

Results are expressed as number (%); McNemar's test was applied at 95% confidence interval. Significant difference at **P value<.01.

DISCUSSION

Knowledge of MF anatomy in both clinical practice and forensic dentistry is indispensable. The researchers performed studies in the past to locate the MF and the emergence pattern of MN. The technique commonly used to locate was by studying the dissected dry mandible (s) or by

using various radiographic techniques, including OPG, computed tomography (CT) and CBCT. In this study, CBCT has been used to identify MF due to its added advantage over OPG. The CBCT produces less distortion and blurred image compared to 2D radiological techniques [23]. Among 3D visualization, CT scans has 1.5-12.3 times more radiation exposure compared to the

average field of view of a CBCT scan [24]. The study is novel as it gives a complete insight into the location of MF and the emergence pattern of MN in three dentition status among the Saudi Arabian population.

Variation in the position of Mental Foramen

The location of MF was by large reported below the apex of mandibular 2nd premolar. We have reported the similar site in our study, irrespective of dentition status. Comparing the location of MF within the Saudi population, our research is consistent with other studies [14, 25]. Although a study by Shoukry et al. [8] on the Saudi population found the highest prevalence of MF between 1st and 2nd premolar (PM). Ari et al. have reported that the position of the MF is not only dependent on the population but also geographical environment leading to variation within the inhabitant of the same population [26]. The second most common position of MF reported in the present study was between 1st and 2nd mandibular premolar in all the dentition status. Other studies have reported this as a prevalent location in their respective populations [13, 15, 27]. The probable reason for such variation is perhaps because of the ethnicity.

Influence of dentition on location of mental foramen

The left side showed a significant variation among the dentition status for the location of MF. This is not in agreement with the study carried out by Kalender et al. [15] where there was no significant difference reporter regarding the location of MF on either side of the mandible. Additionally, in this study, MF was prevalent between first and second PM.

Influence of gender on location of mental foramen

In the present study, we have reported a gender variation on the right side of the mandible regarding position of MF. This resembles to the observations made in a study by Alam et al. where they found in males it was below the

second premolar and in females, it was between the premolars [14]. In a study by Khojastepour et al. on the Iranian population, they reported a statistically significant difference in the left side in relation to gender [13]. In another study by Voljevica et al. in Bosnian population, the most common position of MF on the right side was at the long axis of 2nd premolar, whereas it was between 1st and 2nd premolar on the left side [28]. Conversely, Zmyslowska-Polakowska E et al. did not report any gender disparity in relation to the side for the position of MF [5].

Influence of side of mandible on location of mental foramen

When we compared the right and left side position of the MF in dentition status; we reported a statistically significant difference in dentate individuals and edentulous patients. However, the partially edentulous group displayed a non-significant difference. Analysis of the symmetrical position of the MF, on the patient-basis, showed a statistically significant difference, which was consistent with Alam et al. [14]. The fact of being ethnic variation, could attribute it. During prenatal growth, there is a lag in the developmental position, and even it can be because of genetic variation [29]. Contrary to this, there are studies in which it reports a symmetrical pattern of location of MF [15,30].

Influence of age on the location of mental foramen

Age has an influence on the position of the MF. This observation was obvious in the present study. The MF position on the right side of the mandible displayed a statistically significant difference in distinct age groups. The most common pattern was below the apex of the second PM in 18-35 years age group and the second most common pattern was between the 1st and 2nd premolar except for the age group 18-35 years, where it was below the first molar. This is contrary to the findings of other researchers [5,15,31].

Prevalence of the emergence pattern of mental nerve

An important anatomical landmark which has clinical relevance in implant dentistry as well in oral surgical procedures, including periapical surgeries, is the emergence pattern of MN. The growth of the mandible is a dynamic process which varies with the eruption of the primary tooth. Authors have reported that the MF gets displaced anteriorly till the eruption of a deciduous molar. Later, it develops posteriorly after the second deciduous molar eruption. This could be a probable reason for the development of the AL of MN while it emerges through MF [18]. Solar et al., [17] Kieser et al., [32] and Demir et al. [33] gave classifications about the emergence pattern of MN.

Influence of dentition on the emergence pattern of mental nerve

Type-III pattern or formation of AL was the most common pattern observed in all the three-dentition status, which was in a range of 48.4% - 56.3%. This is contrary to the other Saudi population study where the type-I linear pattern was more prevalent [19, 34]. Conversely, there are studies done in the varied population where AL pattern (type-III) was more frequent [33, 35, 36]. As per literature, the prevalence of AL of the MN can range from 14.6% -90% [19]. Lorenzo et al. had found variation among the three dentition status wherein they perceived the emergence pattern was in a superior direction in dentate patients and a direct emergence pattern in partially edentulous and edentulous individuals [12].

Influence of side of the mandible on the emergence pattern of mental nerve

In the present study, we reported a statistically significant difference in the right and left side of the mandible concerning emergence pattern in the dentate and the partially edentulous patient. In contrast, the difference was not statistically significant in the edentulous patient. This is contrary to the study done in the Spanish population [12]. In a study by Al-Mahalawy et al., 79.1% of cases the same

pattern observed on the left and right side [34].

Influence of gender on the emergence pattern of mental nerve

Studies have shown that there is gender variation seen in the emergence pattern of MN [37-39]. In the present study, we also have observed the same pattern on the left side of the mandible which was statistically significant. The most common design was type-III in both the male and female group, but type-II was the second most common in female, whereas type-I was in the male. AL was more common in the male compared to female. Contrary to this, Torres MV et al. reported non-significant variation in the emergence pattern of MN among the gender [40].

Influence of age on the emergence pattern of mental nerve

Irrespective of the age group, type-III was more prevalent. This observation contradicted another study by Lorenzo et al. [12] where he found that people with less than 50 years had superior emergence and above 50 years had a direct emergence pattern of MN. In another study by Torrens et al., found that AL pattern was inversely proportional to age [40].

Considering the observation in the present study, a variation in the different dentition status as well asymmetrical pattern, age, gender, it is imperative to evaluate pre-surgically the position and emergence of the MN. Literature too supports that mishap can happen because of the nerve injury leading to paraesthesia of the region [2]. Hence, clinicians should give due consideration to the anatomy of this region while doing any surgery, including DI placement.

Limitations and Future direction of the study

Morphometric analysis with an assessment of accessory mental foramen will provide a holistic picture about the MF anatomy. Multicenter studies will provide a global comparison of the variations existing in MF anatomy.

CONCLUSIONS

The present study concludes that irrespective of the dentition status in the Saudi population, the most favourable location of the MF, was at the apex of the second premolar. Along with this, AL formation of MF was the most frequent pattern among all dentition status with no gender or side variation for the type-III pattern.

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Conflict of interest

The authors have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subject's oversight committee guidelines and policies of: Jouf University, Kingdom of Saudi Arabia. The approval code for this study is: 08-09/41.

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