

Prevalence and Morphometric Analysis of Double Mental Foramen and Double Mandibular Foramen from Digital Panoramic Radiographs

Prevalencia y Análisis Morfométrico de Foramen Mental y Foramen Mandibular Dobles a Través de Radiografías Panorámicas Digitales

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SUMMARY: The morphological variations of the mental foramen (MF) and mandibular foramen (MBF) have been studied for several years, and the prevalence and morphometric characteristics of double and triple foramina have been reported. The objective of this study was to establish the prevalence of variations in the MF and MBF, and to carry out a morphometric analysis of a Chilean population using digital panoramic radiographs. The study included 927 radiographs; the observed prevalence of double MF was 2.58 %, while the prevalence of double MBF was 1.51 %. No cases of triple foramina were found. In men, double MF was found more frequently in the left hemiarch (64.28 % of cases), while in women it was more frequent in the right hemiarch (80 %). Double MBF was found more frequently in the right hemiarch in women (80 % of cases), while the distribution between left and right in men was even. The mean area, width and height of the double MF were 5.46 mm², 2.77 mm and 2.57 mm respectively. The means of the same morphometric measurements in double MBF were 6.37 mm², 2.27 mm and 3.19 mm respectively. In both foramina, statistically significant differences were only found between the height of the foramen and the age of the subjects, with the observation that the greater the subject's age, the smaller the height. Dental surgeons must take these anatomical variants into consideration in clinical and surgical actions; timely diagnosis by radiograph is important to avoid possible complications.

KEY WORDS: Mental foramen; Mandibular foramen; Accessory foramen; Digital panoramic radiograph.

INTRODUCTION

The mental foramen (MF) is located in the anterolateral face of the body of the mandible, close to the inferior margin, generally between the first and second premolars (Olasoji *et al.*, 2004; Al-Khateeb *et al.*, 2007; El-Anwar *et al.*, 2016; Fuentes *et al.*, 2017). The visibility of the MF has been studied in panoramic radiographs in different populations. Ngeow *et al.* (2010) described a frequency of 77.8 % in a Malay population. Chkoura & El Wady (2013) analysed a Moroccan population sample and observed a frequency of 79 %. Fuentes *et al.* (2014) analysed the visibility of the MF in a Chilean population sample in conventional panoramic radiographs and reported a rate of 87.9 %, observing that detection of the MF is less frequent with advancing age and that it is more prevalent in men. The variations in this foramen have been studied in different populations in dry mandibles (Zografos & Mutzuri, 1989; Roopa *et al.*, 2003), radiographic imaging techniques like

CBCT (Naitoh *et al.*, 2009a,b) and panoramic radiographs (Naitoh *et al.*, 2011; Al-Shayyab *et al.*, 2016; Srinivas *et al.*, 2017); the reported prevalence varies between 3 % and 7 %.

The mandibular foramen (MBF) is located in the centre of the mandibular ramus, and is related with the mandibular lingula (Monnazzi *et al.*, 2012). Its position has been studied in dry mandibles, with the conclusion that the MBF is symmetrical on the two sides; however the literature on the anatomical reference points used to locate it is still scarce (Marzola *et al.*, 2005). The MBF may be accompanied by an accessory foramen, which may or may not contain the vasculo-nervous bundle (Narayana & Prashanthi, 2003; Das & Suri, 2004; Manikandhan *et al.*, 2010). The position of this accessory foramen has been studied more frequently in dry mandibles (Thangavelu *et al.*, 2012; Matveeva *et al.*, 2018).

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Digital panoramic radiographs offer good possibilities of detecting accessory foramina, due to the continuity and extent of the image. This examination, used for diagnostic purposes in dental practice, provides an image of sufficiently good quality to allow immediate viewing of the patient's whole maxillofacial area (Fuentes *et al.*, 2014), as well as being quick and safe for users (Pyun *et al.*, 2013). Discovering variations in the shape, size and position of the foramina has become an essential step for dental surgeons prior to any surgery, due to their intimate relation with the inferior alveolar nerve (Balcioglu *et al.*, 2010; Gupta *et al.*, 2015). Correct identification of these morphological variations is useful for avoiding injury during anaesthetic and surgical procedures, such as the placing of implants, periapical surgery, endodontic treatment and orthognathic surgery (Cillo & Stella, 2005; Al-Khateeb *et al.*). The aim of this study was therefore to establish the prevalence of variations in the MF and MBF, and to carry out a morphometric analysis of a Chilean population using digital panoramic radiographs.

MATERIAL AND METHOD

A cross-sectional study was carried out, approved by the Scientific Ethics Committee (CEC) of Universidad de La Frontera (Folio no. 015/2014). The study analysed digital panoramic radiographs (ratio 1:1) taken using the standard technique with a PAX-400C orthopantomograph (VATECH, Korea, 2010), between January 2010 and December 2015, in the Dental Teaching Clinic of the Dental School, Universidad de La Frontera, Temuco, Chile. The measurements were made by two previously calibrated examiners and a third examiner, a dental surgeon specialising in radiology, who was responsible for taking a decision in doubtful cases.

A total of 1400 digital panoramic radiographs were available for analysis. The following exclusion criteria were applied: radiographs with inadequate image quality (distortion or alteration in the contrast), patients with teeth in intraosseous evolution (except third molars), presence of any pathology or development conditions which affected the visibility of the study area (tumours, cysts, fractures or malformations), isolated radio-opacities in edentate areas which may be associated with excessive ossification in a post operative site, and radiographs showing evidence of orthognathic surgery.

Because it is impossible to tell which is the accessory foramen in cases of double or triple MF or MBF, all the foramina present were included in the analysis. To determine the morphometric measurements of double or triple foramina we used the ImageJ software (version 1.45), which allows the user to draw lines and to measure distances, areas

and angles of the various anatomical references observed in the radiograph. In each selected image we determined the area, width (greatest horizontal measurement) and height of the foramen (greatest vertical measurement) as shown in Figure 1. For statistical analysis we used the SigmaPlot 12.0 software, analysing the variables sex and age range (<30 years, >30 years) and relating them with the area, height (supero-inferior) and width (medio-lateral) of each foramen (double MF and double MBF).

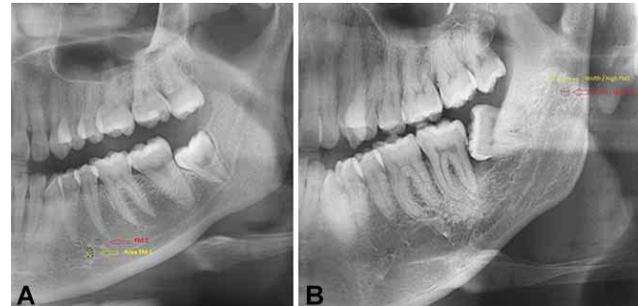


Fig. 1. Digital panoramic radiograph showing the measurements taken in ImageJ software (version 1.45). A) Measurement of the area of a double MBF, B) Measurement of the width (greatest horizontal measurement) (*) and height (greatest vertical measurement) (à) of a double MF.

RESULTS

In total, 927 radiographs were included in the study, after applied selection criteria, of which 327 belonged to men (35.27 %) and 600 to women (64.72 %). The patients' ages ranged between 18 and 86 years (mean age 36 ± 16.23). Only double MF and MBF were observed, no triple foramina were found.

Double mental foramen. We observed 24 cases (2.58 %) of double MF (Fig. 2A) among all the radiographs analysed. 58.33 % of cases (n=14) were men aged between 18 and 53 years, while 41.67 % of cases (n=10) were women aged between 22 and 54 years. The position of the double MF was in the right hemiarch in 54.17 % of cases (n=13) and in the left hemiarch in 45.83 % of cases (n=11). In men there was a preponderance of cases in the left hemiarch, 64.28 % of cases (n=9), while in women the preponderance was in the right hemiarch, 80 % of cases (n=8). The mean area of the double MF identified was $6.25 \pm 3.96 \text{ mm}^2$ ($6.7 \pm 3.66 \text{ mm}^2$ for men and $5.85 \pm 4.48 \text{ mm}^2$ for women). Table I shows the mean area, width and height of the double MF identified, grouped by sex and age range. There were 6 groups, but a statistically significant difference was found only between the height and the patient's age ($p=0.015$), with the observation that the greater the subject's age, the smaller the height. No cases of bilateral double MF were found.

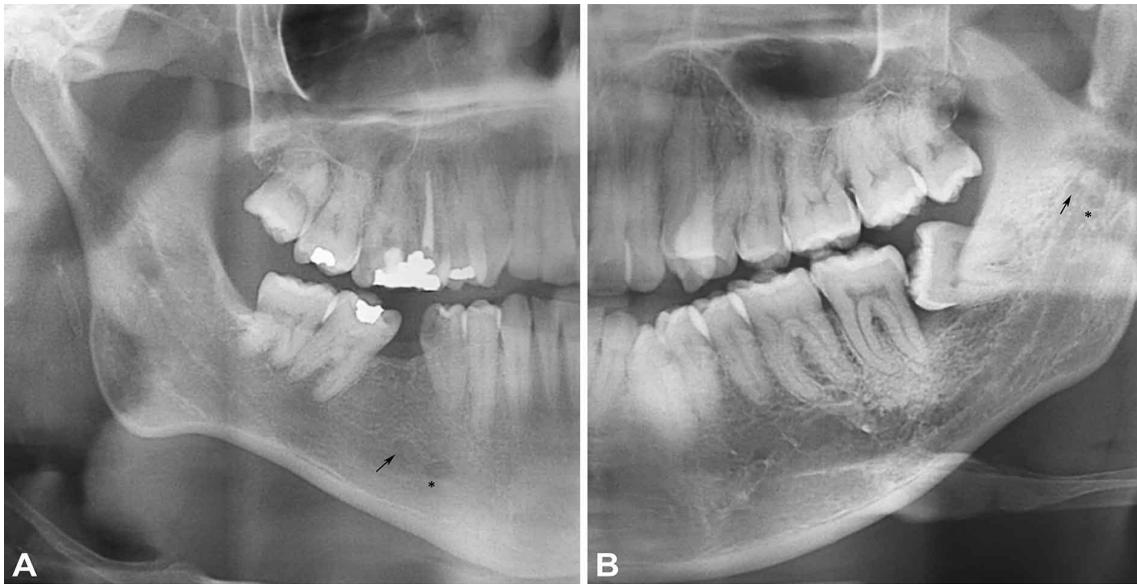


Fig. 2. Digital panoramic radiograph showing A) a double MF (à *), and B) a double MBF (à *).

Table I. Distribution of the data by median, Q1 and Q3, and p value of six groups distributed by the relationship of the area, width and height of the double MF with the patient's sex and age range.

Group	Variable	Median	25 %	75 %	p value
AREA / SEX	Area women	4.139	3.047	7.093	0.124
	Area men	6.259	3.722	9.125	
WIDTH / SEX	Width women	2.284	2.207	3.623	0.058
	Width men	2.703	1.841	2.944	
HEIGHT / SEX	Height women	2.310	1.616	2.863	0.167
	Height men	2.51	1.917	3.238	
AREA/ AGE RANGE	< 30 years	5.651	3.840	6.677	0.264
	> 30 years	3.492	2.738	9.092	
WIDTH/ AGE RANGE	< 30 years	2.628	2.017	3.440	0.464
	> 30 years	2.243	1.916	3.516	
HEIGHT/ AGE RANGE	< 30 years	2.674	2.197	3.364	0.015
	> 30 years	1.820	1.632	2.677	

Table II. Distribution of the data by mean, standard deviation and p value of six groups distributed by the relationship of the area, width and height of the double MBF with the patient's sex and age range.

Group	Variable	Mean	SD	p value
AREA / SEX	Area	6.453	3.124	0.666
	Area men	6.795	2.385	
WIDTH / SEX	Width women	2.193	0.908	0.674
	Width men	2.490	0.631	
HEIGHT / SEX	Height	2.878	1.028	0.674
	Height men	3.325	1.048	
AREA/ AGE RANGE	< 30 years	2.864	0.906	0.077
	> 30 years	2.722	0.642	
WIDTH/ AGE RANGE	< 30 years	2.677	0.874	0.621
	> 30 years	2.056	0.177	
HEIGHT/ AGE RANGE	< 30 years	3.773	0.613	0.019
	> 30 years	2.878	1.028	

Double mandibular foramen. We observed 14 cases (1.51 %) of double MBF (Fig. 2B) among all the radiographs analysed. All cases were unilateral. 71.43 % of cases (n=10) were women aged between 18 and 55 years, while 28.57 % of cases (n=4) were men aged between 26 and 36 years. In women there was a preponderance of cases in the right hemiarch, 80 % of cases (n=8), while in men there was an even split between left and right hemiarch (50/50). The mean area of the double MBF identified was $6.55 \pm 2.89 \text{ mm}^2$ ($6.79 \pm 2.38 \text{ mm}^2$ for men and $5.96 \pm 3.12 \text{ mm}^2$ for women). Table II shows the mean area, width and height of the double MBF identified, grouped by sex and age range into 6 groups. As with the MF, a statistically significant difference was found only between the height and the patient's age ($p=0.019$), with the observation that the greater the subject's age, the smaller the height of the double MBF.

DISCUSSION

Various studies have reported the prevalence and characteristics of double MF and MBF, in different populations and using different instruments (Zografos & Mutzuri; Al-Khateeb *et al.*; Manikandhan *et al.*; Naitoh *et al.*, 2011; Afkhami *et al.*, 2013). The frequency of double MF has been studied in dry mandibles and in CBCT, with reported frequencies of around 7 % in Greek and Indian populations (Zografos & Mutzuri; Roopa *et al.*), and 3 % to 13 % in Asiatic populations (Katakami *et al.*, 2008; Naitoh *et al.*, 2009a,b; Oliveira-Santos *et al.*, 2011; Imada *et al.*, 2014; Srinivas *et al.*). In our study of digital panoramic radiographs in a sample of Chilean patients, we report a prevalence of 2.58 %; this is lower than that described in the literature (around 5 %) (Naitoh *et al.*, 2011; Al-Shayyab *et al.*; Srinivas *et al.*). The percentage difference in the prevalence may be due to the sample size (much larger in our case) and to ethnic origin (most studies of prevalence have been carried out in Asian populations). The predominant hemiarch has been studied in an Indian population, where the left side is described as more frequent. This is the case in Singh & Srivastava (2010), who found a prevalence of 5 % on the right side and 8 % on the left (Kalender *et al.*, 2012). Similarly, Udhaya *et al.* (2013) described a frequency of 2.22 % on the right side and 3.33 % on the left. These data contrast with our results, which show a preponderance in the right hemiarch (1.4 %) over the left (1.18 %). By sex, the preponderance of double MF was in the left hemiarch in men, and the right hemiarch in women; however Al-Shayyab *et al.* found a preponderance on the right side in both men and women. The literature on the size of double MF is scarce. Some studies report the diameter, from which the calculated mean area is 1.34 mm (Katakami *et al.*; Naitoh *et al.*,

2009a,b; Oliveira-Santos *et al.*, 2011; Imada *et al.*; El-Anwar *et al.*); others report the area, for example Naitoh *et al.* (2011) who reported a mean area of 1.5 mm^2 in a study based on 365 panoramic radiographs. In our study the mean value was 5.46 mm^2 for both sexes. Of all the variables analysed, only the relationship between the height of the foramen and the patient's age presented statistically significant results ($p=0.015$), indicating that obliteration of the foramen in its supero-inferior dimension occurs with advancing age.

The MBF has been studied principally in dry mandibles. The reported prevalence of double MBF varies from 0.3 % to 32.36 % (Manikandhan *et al.*; Udhaya *et al.*; Shalini *et al.*, 2016). Choi & Han (2014) analysed 446 CBCT records and described a prevalence of 1.35 %, similar to our results obtained from panoramic radiographs (1.51 %); there are few reports in the literature using this method. In the same study, which analysed three types of accessory mandibular canals, type 3 was a canal originating in another foramen than the MBF; the prevalence of double MBF reported by the authors was 0.06 % (Choi & Han). In our study, the analysis by sex showed that there was a higher prevalence of double MBF in women (71.42 %), and that the predominant location was in the right hemiarch. This agrees with Freire *et al.* (2012) results in a population in Brazil, but contrasts with the results of Naitoh *et al.* (2009a,b) who describe predominance in the left side in an Asian population. As with the double MF, we analysed the height in relation to age and observed that a diminution in the supero-inferior dimension of the foramen occurs in patients aged over 30 years. This agrees with the findings of Al-Khateeb *et al.* who describe that the invisibility of the foramen increases with advancing age and is accentuated in patients aged over 50 years.

Studying the anatomical variables in the foramina is important, because lack of knowledge of these variations could explain failures in nerve block in this zone during surgery and routine dental procedures using conventional anaesthetic techniques.

CONCLUSIONS

Accessory MF and MBF occur infrequently in the Chilean population; in our results only double foramina were found, which were more frequent in the MF. In both foramina the supero-inferior height diminished in patients aged over 30 years. Consideration of these anatomical variants is important for dental surgeons carrying out various clinical and surgical actions, therefore radiograph diagnosis by either conventional or high resolution methods is necessary to avoid possible complications.

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RESUMEN: Las variaciones morfológicas del foramen mental (FM) y mandibular (FMB) han sido estudiadas durante varios años, reportándose su prevalencia y las características morfométricas de forámenes dobles y triples. El objetivo de este estudio fue establecer la prevalencia de variaciones de los FM y FMB y realizar un análisis morfométrico a través de radiografías panorámicas digitales de una muestra de población chilena. En el estudio se incluyeron 927 radiografías y se observó una prevalencia de FM doble de 2,58 %, mientras que la prevalencia de FMB doble fue de 1,51 %. No se encontraron casos de forámenes triples. En hombres, el FM doble se encontró mayoritariamente en la hemiarcada izquierda (64,28 % de los casos), mientras que en mujeres fue en la hemiarcada derecha (80% de los casos). Para el caso de los FMB dobles, en mujeres se presentó mayoritariamente en la hemiarcada derecha (80 % de los casos), mientras que en hombres fue equitativo en ambos lados. El promedio del área, ancho y alto de los FM dobles fue de 5,46 mm², 2,77 mm y 2,57 mm, respectivamente. Asimismo, los promedios de estas medidas morfométricas para el FMB doble fueron 6,37 mm², 2,27 mm y 3,19 mm, respectivamente. Para ambos forámenes sólo se encontraron diferencias estadísticamente significativas entre el alto y la edad de los sujetos, observando que, a mayor edad menor era el alto del foramen. Los cirujanos dentistas deben tener en consideración estas variantes anatómicas para la realización de distintas acciones clínicas y quirúrgicas, su diagnóstico radiográfico oportuno es importante para prevenir posibles complicaciones.

PALABRAS CLAVES: Foramen mental ; Mandibular foramen; Foramen accesorio; Radiografía panorámica digital.

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