RESEARCH ARTICLE

Aydın Dental - Volume 9 Issue 1 - Nisan 2023 (15 - 27)

Aydın Dental Journal

Journal homepage: http://dergipark.ulakbim.gov.tr/adj

Evaluation of Mental Foramen and Accessory Mental Foramen in Retrospective Magnetic Resonance Images

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DOI: 10.17932/IAU.DENTAL.2015.009/dental_v09i1002

Abstract

Objective: This retrospective study aims to assess the morphologic characteristics of mental foramen (MF) and the incidence of accessory mental foramina (AMF) by using magnetic resonance imaging (MRI).

Material and Method: 3.0-Tesla Turbo Spin Echo (3T TSE) MRI sequences of 40 patients were included in the study group. MF was detected in axial sections bilaterally, and the diameter of MF was measured. Also, the presence of AMF was recorded. Data were statistically analyzed ($p<0.05$).

Results: A total of 80 semi-mandibles (40 right, 40 left) were evaluated in the study. The incidence of AMF was found as 6.3%. The mean diameter of MF was statistically nonsignificant regarding age groups, gender, and the side of the mandible ($p>0.05$).

Conclusion: MRI is a promising imaging method for the evaluation of morphological features of MF and its anatomical variations (AMF). MRI should be recommended when CBCT represents an unclear appearance of MF.

Keywords: *Accessory mental foramen, Magnetic resonance imaging, Mental foramen, Neurovascular imaging*

Mental Foramen ve Aksesuar Mental Foramenin Manyetik Rezonans Görüntüleme ile Retrospektif Değerlendirilmesi

Özet

Amaç: Bu çalışmanın amacı, Manyetik Rezonans Görüntüleme (MRG) yöntemi kullanarak mental foramenin (MF) morfolojik özelliklerini ve aksesuar mental foramen (AMF) görülme sıklığını saptamaktır.

Gereç ve Yöntemler: 40 hastaya ait 3.0-Tesla Turbo Spin Eko (3T TSE) MRG görüntüleri çalışmaya dahil edilmiştir. MF bilateral olarak aksiyel kesitlerde tespit edilerek çapı ölçülmüştür. Ayrıca, AMF varlığı kaydedilmiştir. Veriler istatistiksel olarak analiz edilmiştir (p<0.05).

Bulgular: Toplam 80 yarım mandibula (40 sağ, 40 sol) değerlendirilmiştir. AMF sıklığı %6.3 olarak tespit edilmiştir. MF çapı yaş grupları, cinsiyet ve mandibulanın sağ veya sol tarafında olmasına göre değerlendirildiğinde anlamlı bir fark elde edilememiştir (p>0.05).

Sonuç: MRG, MF morfolojisini değerlendirmede ve anatomik varyasyonlarının (AMF) görüntülenmesinde gelecek vaat eden bir yöntemdir. Konik ışınlı bilgisayarlı tomografinin MF görüntülemede yetersiz kaldığı durumlarda MRG önerilebilir.

Anahtar Kelimeler: *Aksesuar mental foramen, Manyetik rezonans görüntüleme, Mental foramen, Nörovasküler görüntüleme*

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Introduction

The mental foramen (MF) is an important anatomical structure for surgical procedures of the mandible and the anterior opening of the mandibular canal.[1] The MF is described as a round or oval foramen located between the apexes of the first and second premolar teeth or in the apex of the second premolar tooth. In some cases, small accessory foramen can be observed in the surrounding area of MF. These variations can be described as accessory mental foramen (AMF).[2] AMFs primarily contain blood vessels and alveolar nerve branches.[3]

Detection of the location, anatomical variations, and morphological features of MF are critical to avoid complications. The inferior alveolar nerve or mental nerve can be damaged during the preparation of an osteotomy or implant surgery. In addition to surgeries, non-surgical operations such as endodontic treatment or periapical lesions breached to MF may lead to complications. Sensory dysfunction or haemorrhage can occur postoperatively.[1,4,5]

The imaging methods for viewing hard tissues are inadequate for the neurovascular tissue. The foramen may not appear on conventional radiographs, and linear measurements must be adjusted for radiographic distortion. Estimating actual anatomical sizes might cause misdiagnose of the location or diameter of MF due to the magnification effect.[6] Cone beam computed tomography (CBCT) is the most common imaging method to assess these structures. Nevertheless, CBCT may not represent the actual appearance of the mental nerve.[7] AMF might not be easily visible due to the higher interaction of the radiation with the cortical bone rather than the trabecular bone. Also, sparse trabeculation of mandibular bone is an inhibitory feature of CBCT image quality.[6,7] Therefore, understanding the branching pattern of the mandibular neurovascular bundle may require further imaging methods, such as magnetic resonance imaging (MRI).

MRI is a soft tissue imaging method that allows the viewing of neurovascular structures of the head and neck region in dentistry. MRI might be an auxiliary imaging method for imaging neurovascular tissues and anatomical variations pre-operatively in cases of sparse trabeculation.[8] Identification of mandibular nerve with MRI has been shown in various studies.[9-17]

Radiomorphologic analysis and classification of the mandibular nerve with MRI Turbo Spin Echo sequences revealed high detectability of soft tissue components of the mandible.[9] A study comparing CT and MRI images of two human cadaver heads found that MRI could accurately determine the location of the mandibular canal.[10] The ability to differentiate soft tissues from bone structures with MRI may be more advantageous and non-invasive than x-ray imaging which is associated with the ability to identify inferior alveolar nerve and anatomical variations of the mandibular canal when it cannot be distinguished by CBCT images.[11-13] It should be noted that MRI imaging enables a high image contrast between the inferior alveolar nerve and the mandible or dental structures.[13]

Due to the fact that the MF and anatomical variations are crucial for dental surgical operations, it is necessary to detect the location and morphology of MF with accurate imaging methods. Therefore, this retrospective magnetic resonance study aims to assess the morphologic characteristics of MF and the incidence of AMF in relation to age, gender, and side of the mandible.

Material and Method

The protocol of this retrospective study was approved by the Non-invasive Clinical Research Ethics Committee, Marmara University, Faculty of Medicine (Project no: 09202272).

This retrospective study was performed by analyzing the MRI archive of the Radiology Department at the Medical Hospital of Marmara University. Exclusion criteria were; the absence of an informed consent form that allows using recorded images for research and scientific reasons, poor quality images (metal artifacts, motion artifacts, artifacts caused by head stabilizer of MRI machine), inadequate region of interest, presence of pathologies (tumors, cysts), presence of post-operative reconstructive or fixative materials, presence of mandibular or bimaxillary orthodontic wire, presence of impacted or partially erupted teeth in the MF area.

Images of patients who underwent MR imaging for various reasons were included in the study. Imaging of the mandible was performed with 3.0-T (MagnetomVerio, Siemens Healthcare, Erlangen, Germany) as standard procedure in all MRI scans with a standard Siemens multi-coil.

Routine MRI protocol of turbo spin echo (TSE) sequences [T1-weighted (T1w), T2-weighted (T2w), Proton density (PD)] were used. The slide thickness was 0.6 mm. Sequence distributions were presented in Tables 1 and 2.

All images were exported into Digital Imaging and Communications in Medicine (DICOM) file format for reconstruction and image analysis. Then, image analysis was performed using INFINITT software (Version 3.0.11.4 BN11, INFINITT Healthcare Co., Ltd, South Korea)."

Table 1. Turbo Spin Echo (TSE) MRI sequence parameters

	T1-w	**T2-w**	**Proton Density**
Matrix size (mm)	295 x 229	240x220	240 x 205
FOV (mm)	178 x 178	150 x 150	150 x 150
FA (Flip angle)	90	90	90
TR (Repetition time)	450	2500	2000
TE (Echo time)	7	80	21

Table 2. Distribution of parameters

		n	**%**
Age (n=40)	<35	17	42.5
	≥35	23	57.5
Gender (n=40)	Female	27	67.5
	Male	13	32.5
Right / Left	Right	40	50
	Left	40	50
AMF	No	75	93.8
	Yes	5	6.3
Sequence	T1w	42	52.5
	T2w	13	16.3
	T3w	25	31.3

During the evaluation of MR images, MF diameter was measured linearly in multiplanar MR images. The TSE sequence of the 3.0T MR image was also recorded as T1w, T2w, and PD. Slice thickness was considered to assess the optimal plane, including the MF area bilaterally. MF was determined by means of multiplanar reformation (MPR) using the INFINITT software. MF was detected in axial sections. The specific region was viewed in sagittal sections. The horizontal length was measured to evaluate the diameter. AMF was recorded if present (Fig. 1). The same researcher (MO) in the Department of Maxillofacial

During meetings for the pilot study, a specialist (MOB) working in the Department of Oral and Maxillofacial Radiology, Faculty of Dentistry trained the radiology specialist (MO), and an agreement on the objective criteria for the qualitative evaluation of the images was forged. Radiology evaluated the images to ensure efficient evaluation.

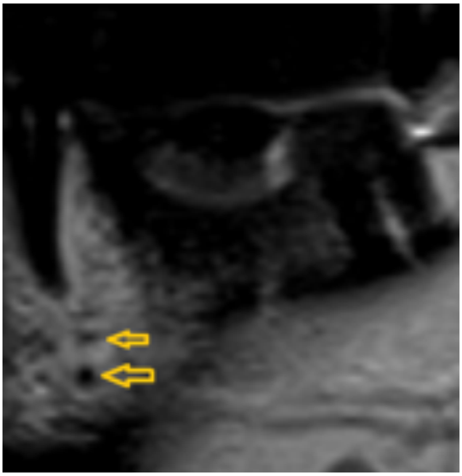

Figure 1. Accessory mental foramen (AMF) (small yellow arrow) at the superior of mental foramen (MF) (large yellow arrow) on the sagittal section of 3T Turbo Spin Echo Proton Density MRI.

Statistical Analysis

IBM SPSS Statistics 22 program was used for statistical analysis. First, the suitability of the parameters to the normal distribution was evaluated with the Kolmogorov-Smirnov test. Descriptive statistical methods (mean, standard deviation, frequency) and Student's t-test were used for the comparison of the parameters between two groups. Paired sample t-test was used for the comparison of the right and left sides. Pearson correlation analysis was used to examine the relationships between parameters. Statistical significance was set at $p<0.05$.

Results

A total of 80 mandibles (40 right, 40 left) of 27 female (67.5%) and 13 male (32.5%) patients aged between 10-75 years (40.60±18.57) were evaluated in the study.

The mean age was 40.60±18.57 years. The patients were classified into two age groups as <35 years (n=17, 42.5%) and ≥35 years (n=23, 57.5%). Four patients were under 18 years of age (Table 2).

Of the MF, 93.8% (n: 75) showed no anatomical variation (Fig. 2). AMF was detected in only 6.3% of them (n:5), (Table 2).

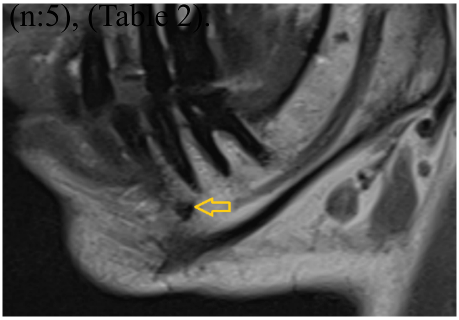

Figure 2. Single mental foramen on the sagittal section of T1-weighted MRI (yellow arrow).

The mean diameter of MF was statistically nonsignificant regarding age groups, gender, and side of the mandible (p>0.05) (Table 3 and 4).

Also, there was no statistically significant correlation between the presence of AMF and the mean diameter of MF (r:0.174; p:0.122; p>0.05), (Table 5)

Table 3. Diameter of mental foramen according to age and gender

		Diameter	
		Mean±SD	**p**
Age	<35	3.38±0.92	0.132
	≥35	3.07±0.90	
Gender	Female	3.29±0.89	0.222
	Male	3.02±0.96	

Student t-test

Table 4. Diameter of mental foramen according to the side of the mandibular canal

		Diameter	
		Mean±SD	**p**
Right / Left	Right	3.28±0.91	0.129
	Left	3.12±0.93	

Paired samples t-test

Table 5. Diameter of main mental foramen according to the presence of AMFs.

		Diameter	**p**
		Mean±SD	
AMF	No	3.38±0.92	0.132
	Yes	3.07±0.90	

Student t-test

Discussion

MRI is a non-invasive soft tissue imaging method that provides high accuracy in the determination of neurovascular structures like the mandibular canal, inferior alveolar nerve, and MF.[9] Additionally, anatomical variations related to these structures can be detected using MRI.[14,15] Evaluation of normal anatomy and anatomical variations is critical to avoid both pre-operative and post-operative complications before surgical procedures or endodontic treatment.[16]

Previous MRI studies used various sequences for imaging of mandibular neurovascular structures. Even though MRI is a new imaging method for dentistry, choosing particular sequences may increase the detectability of specific structures. Burian et al. viewed the mandibular canal with black bone sequences and revealed that STIRR sequence showed the highest apparent signal to noise ratio and best apparent nerve-muscle contrast to noise ratio.[15] Also, Kreutner et al. compared gradient echo and spin echo sequences and found that both sequences can be used to achieve high-resolution images with good contrast and can be used for precise localization of the mandibular canal.[12] As TSE sequences are the most common modalities and present satisfying results, TSE sequences were used in this retrospective study.

Difficulties for the clinician and the patients may be putting distance between this method and radiological dentistry.[13] Although MRI has several advantages, the cost-effectiveness of MRI is skeptical. Additionally, it is hard to reach patients and scanning time is long compared to CBCT.[13] Dental MR imaging is not accessible for all dental clinicians because of these negative aspects. So that, previous MR images were used in this study. The aim is to encourage the dental clinician to examine the previous images of the patient instead of a new scanning.

In MRI, the insufficient spatial resolution of 1.5T MRI cannot display small lesions and small anatomical structures properly. Some researchers have demonstrated the introduction of high-resolution 3-T MRI.[17] The main feature of a 3.0 Tesla magnet is the increase in the signal-to-noise (SNR) ratio, which leads to a gain of the spatial resolution with improving the quality of the image.[18]

MR imaging of mandibular neural

structures is possible with various sequences. T1w sequence provides high contrast between nerve bundles and bone structure. Neural tissues display as a high signal intensity structure, while bone tissue is depicted as a very low signal intensity structure.[18] The signal-to-noise ratio was reported to be relatively low in the T2w sequence, and the mandibular canal and the bone marrow could not be clearly imaged with T2w imaging.[19-21] In this regard, we selected fewer images from the T2W sequence as a result.

Retrospective CBCT studies in the literature examined MF and the incidence of AMF and revealed various findings. Han et al. reported the incidence of AMF as 8.1%, which was statistically higher in male patients than in females.[22] The incidence of AMF ranged from 7.3% to 14.3% in the previous studies [23-25]. Iwagana et al. reported no significant correlation between the presence of AMF and gender, which was in agreement with the results of our study.[24]

In most of the CBCT studies, the mean diameter of the MF was reported to be as approximately 3 mm.[26-28] These results were compatible with our study. Moreover, there were studies indicating that the mean diameter of MF was statistically higher in males than in females.[29,30] Contrary to these studies, no statistically significant difference was found between genders in our study. If there was an AMF ipsilateral to MF, the main foramen's diameter was reported to be smaller.[31-33] Although it was not statistically significant, the mean diameter was found smaller in MFs with AMF than in MFs without AMF in our study. In the literature, there were various results regarding the incidence of AMF. In a retrospective computed tomography study, the incidence of AMF was found to be as 2%, which was relatively low compared to other studies in the literature.[34] These differences may be related to the different imaging techniques used in the studies and the sample size of the studies. The incidence of AMF in our study was also relatively low compared to other studies in the literature. The small number of images in the study group may be the reason for these results; we evaluated only 40 MR images, which was the most important limitation of our study. Future comprehensive MRI studies with the increased number of images should be conducted to investigate the incidence of AMF.

Conclusion

MRI is a promising imaging method for the evaluation of morphological features of MF and its anatomical variations (AMF). Therefore, MRI should be recommended when CBCT represents an unclear appearance of MF. Also, this study may courage clinicians to evaluate the previous MR images of the patients instead of a new MRI.

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