RESEARCH ARTICLE

Determination of the mental foramen position in dental radiographs in 18–30 year olds

Charlotte C Currie, John G Meechan, John M Whitworth, Andrew Carr and Ian P Corbett

Centre for Oral Health Research, School of Dental Sciences, Newcastle University, Newcastle upon Tyne, UK

Objectives: To determine the radiographic position and reliability of assessing mental foramen (MF) position in relation to premolar crowns in an 18- to 30-year-old UK-based population.

Methods: Following ethical approval and a power calculation, the position of the MF was recorded in relation to premolar crowns and apices in 100 dental panoramic tomographs. Positions were assessed by three senior clinicians independently, then by consensus. Data were analysed using descriptive statistics, χ^2 and Fleiss' and Cohen's kappa.

Results: Reliability data showed only fair to moderate agreement on independent scoring. Substantial to almost perfect agreement was achieved by consensus, demonstrating the most common position for the MF to be between the first and second premolar teeth when using both premolar crowns (51%) and apices (76%) as reference points. There was a significant difference in the position of the foramen between the left and right sides ($p < 0.05$), with only 62% of cases showing symmetry.

Conclusions: The most common position for the MF is between the first and second premolar teeth; however, anatomical variation is seen. Use of pre-operative radiographs to relate the position of the MF to premolar crowns may not be reliable.

Dentomaxillofacial Radiology (2016) **45**, 20150195. doi: [10.1259/dmfr.20150195](https://doi.org/10.1259/dmfr.20150195)

Cite this article as: Currie CC, Meechan JG, Whitworth JM, Carr A, Corbett IP. Determination of the mental foramen position in dental radiographs in 18–30 year olds. *Dentomaxillofac Radiol* 2016; **45**: 20150195.

Keywords: dental radiography; reproducibility of results; anatomy

Introduction

The inferior alveolar nerve, a branch of the trigeminal nerve, divides into its terminal mental and incisive branches at the mental foramen (MF) with the incisive nerve continuing an intraosseous course through the anterior mandible. The position of the MF may be an important consideration during the administration of local anaesthetic solution for anaesthesia of the anterior mandibular teeth and associated bone and soft tissues and for surgical procedures in this region. The position of the MF demonstrates anatomical variations, although typically it is reported to be either between the apices of the first and second premolars or below the apex of the second premolar.¹ It can, however, be found

as far anterior as the canine² and as far posterior as the first molar.³

A recent study by Santini and Alayan⁴ investigated the position of the MF in relation to the long axis of mandibular teeth in dry skulls of a mixed European population. They found the most common position to be between the first and second premolar teeth. The authors concluded that the position of the MF was variable between different ethnic groups and that “pre-operative radiographs are mandatory” before commencing surgery.

Studies determining the position of the MF in dental radiographs frequently include measurements of the position of the MF in relation to the mandibular midline and other bony landmarks; however, magnification and incorrect patient positioning frequently make

Correspondence to: Dr Charlotte C Currie. E-mail: charlotte.currie@newcastle.ac.uk

Received 12 June 2015; revised 4 September 2015; accepted 14 September 2015

Table 1 Scoring system used to assess position of mental foramen

<i>Mental foramen position score</i>	
Crown score	
1	Anterior to first premolar cusp tip
2	Directly inferior to first premolar cusp tip
3	Posterior to the first premolar cusp tip and anterior to the second premolar cusp tip
4	Directly inferior to the second premolar cusp tip
5	Posterior to the second premolar cusp tip
Apex score	
1	Mesial to the first premolar apex
2	Directly below the first premolar apex
3	Distal to the first premolar apex, mesial to the second premolar apex
4	Directly below the second premolar apex
5	Distal to the second premolar apex

absolute measurements inaccurate.⁵ As the apices of teeth cannot be readily visualized on clinical examination, the relationship of the MF to the apices of teeth may also be of limited clinical use. It would be useful to relate the position of the foramen to clinically visible structures, such as the crowns of teeth in dentate individuals.

The primary aims of the present study were to determine the position of the MF in relation to the crowns of teeth, as well as to the apices of the premolar teeth to allow comparison with previous studies. The secondary aims were to compare the position of the MF between genders and sides of the mandible and to consider examiner agreement in assessment of MF position in dental radiographs.

Methods and materials

Using data from a previous study,⁶ a power calculation dictated that a sample size of 100 radiographs would provide a 95% chance of finding a significant difference between genders or sides at the 5% level.

Following ethical approval (11/NE/0051), 100 consecutive dental panoramic radiographs were selected from the Newcastle upon Tyne Hospitals' National Health Service Foundation Trust pictures archiving and communications system (INFINITT Healthcare, Seoul, Korea).

The panoramic radiographs were selected according to the following inclusion criteria: age range 18–30 years inclusive, MF visible on both sides of the mandible, all mandibular premolar teeth present, premolar region clearly visible on the panoramic radiographs. The radiographs were selected from the pictures archiving and communications system by a dental and maxillofacial radiology staff member, so that only radiographs of grade one quality⁷ were included. The panoramic radiographs were then randomized and made anonymous, with only the patient age and gender being recorded for each.

Three examiners (JGM, JMW, IPC), all senior clinicians (two consultant oral surgeons and one consultant

endodontist) who were blinded to subject age and gender, scored the position of the MF in relation to the crowns and the apices of the premolar teeth. The member of the research team who selected the radiographs was not involved in the scoring process. The scoring system, as previously described, is shown in Table 1 and Figure 1.^{8–10} A training session was completed by the examiners before commencement of the study. Scoring was initially carried out independently by the examiners and repeated 1 month later. The examiners then scored the radiographs together reaching a consensus score for each side of the mandible on three occasions, 1 month apart, to determine reliability. On one of the scoring sessions, the examiners rescored the radiographs blinded to the fact that the panoramic radiographs had been flipped 180° to exclude a scoring order effect (the right side as presented was always scored first). The radiographs were assessed on the same computer screen, in the same room and under the same viewing conditions at each session. The images were digital and taken on a Proline XC (Planmeca OY, Helsinki, Finland).

Data were analysed using descriptive statistics in Minitab® 16 (Minitab Inc., State College, PA), and intra-examiner variability was assessed using (non-weighted) Fleiss' and Cohen's kappa, using the classification described by Landis and Koch.¹¹ Variations in MF position between sides of the mandible and between genders were analysed using χ^2 in SPSS® v. 17.0 (IBM Corporation, Armonk, NY; formerly SPSS Inc., Chicago, IL).

Figure 1 Scoring system used to assess position of the mental foramen. Score 1, anterior to first premolar cusp tip or apex; Score 2, directly inferior to first premolar cusp tip or apex; Score 3, distal to the first premolar cusp tip or apex, mesial to the second premolar cusp tip or apex; Score 4, directly inferior to the second premolar cusp tip or apex; Score 5, distal to the second premolar cusp tip or apex.

Table 2 Kappa scores for independent scoring

Type of examiner agreement	Right crown	Left crown	Right apex	Left apex
Interexaminer agreement	0.367	0.380	0.586	0.553
	Fair	Fair	Moderate	Moderate
Intraexaminer agreement	0.652	0.502	0.696	0.479
	Substantial	Moderate	Substantial	Moderate

Results

100 consecutive radiographs taken for diagnostic purposes, and meeting the inclusion criteria were obtained from the institution's department of Dental and Maxillo-facial Radiology (Newcastle upon Tyne NHS Foundation Trust), corresponding to 66 males and 34 females, with a mean age 24.0 years (range 18–30 years).

The 3 examiners initially scored the 100 radiographs independently, and interexaminer agreement was analysed using Fleiss' kappa statistics in Minitab 16. Kappa scores indicated fair to moderate agreement between examiners, with scores of 0.367 and 0.380 for right and left crown scores, respectively, and scores of 0.586 and 0.553 for right and left apex scores, respectively. Kappa scores for intraexaminer agreement were 0.652 and 0.502 for right and left crown scores, respectively, and 0.696 and 0.479 for right and left apex scores, respectively, showing substantial to moderate agreement (Table 2).

Reliability for consensus scoring was assessed using Cohen's kappa in SPSS v. 17.0 (Table 3) showing moderate to almost perfect agreement. Comparing the two occasions with the radiograph unchanged, the kappa scores were 0.670 for the right crown, 0.765 for the left crown, 0.894 for the right apex and 0.973 for the left apex. When comparing two occasions between which the radiograph was reversed, the kappa scores were 0.531 for the right crown, 0.701 for the left crown, 0.704 for the right apex and 0.768 for the left apex. All kappa scores had a p -value of <0.01 showing that agreement was not due to chance.

Consensus scoring revealed that the MF was located most frequently between the first and second premolar, with the second most frequent position being below the second premolar for both crown and apex scores (Tables 4 and 5).

The MF position was symmetrical in 62% for crown scores (Table 6) and in 68% for apex scores (Table 7). Differences between sides of the mandible were analysed using a Monte Carlo χ^2 test in SPSS, with a significant difference between sides of the mandible being noted ($p < 0.01$) for crown scores and ($p = 0.024$) for apex scores on the first consensus viewing.

There remained a significant difference between the right and left sides for both crown ($p = 0.002$) and apex scores ($p = 0.004$) after the radiographs were reversed, showing that there was no scoring order effect present.

While comparing genders, the most frequent position was between the first and second premolar teeth for both males and females, and there was no significant difference between genders using a χ^2 test ($p = 0.094$) for crown scores and ($p = 0.449$) for apex scores.

Discussion

The primary aim of this study was to determine the feasibility of relating the position of the MF to a clinically apparent landmark, the premolar crowns, using dental panoramic radiographs. In order to compare the results of this study with existing data, the MF position was also related to the premolar apices.

The results of the present study suggest that the most common position for the MF in a young UK-based population is between the apices of the first and second premolars (76%), followed by lying directly below the second premolar apex (20%). This finding is in agreement with a previous study of Caucasian dried skulls,¹² mean age of 79.1 years, in which the MF was most commonly found between the most apical part of the first and second premolars (58%), closely followed by being immediately below the second premolar tooth (42%). The position of the MF has been found to vary among ethnic origin,¹ with the MF being located directly below the second premolar apex in Chinese, Melanesian, Mongoloid and Negroid skulls.⁹ Data were not available on the pictures archiving and communications system on the ethnicity of the participants in this study, but regional demographics would suggest a predominantly white Caucasian population.

When the position of the MF was related to the premolar crowns, the most common position was also beneath the first and second premolar contact (51%),

Table 3 Kappa scores for consensus viewing

Radiograph orientation	Right crown	Left crown	Right apex	Left apex
Radiographs unchanged	0.670	0.765	0.894	0.973
	Substantial	Substantial	Almost perfect	Almost perfect
Radiographs reversed	0.531	0.701	0.704	0.768
	Moderate	Substantial	Substantial	Substantial

Table 4 Position of the mental foramen in relation to premolar crowns

Position	First viewing		Second viewing		Third viewing	
	Right	Left	Right	Left	Right	Left
Anterior to the first premolar crown (Score 1)	0	0	0	0	0	0
Below the first premolar crown (Score 2)	0	3	2	0	4	2
Between the first and second premolar crowns (Score 3)	44	59 ^a	54 ^a	62 ^a	35	52 ^a
Below the second premolar crown (Score 4)	47 ^a	34	41	34	59 ^a	43
Posterior to the second premolar crown (Score 5)	9	4	3	4	2	3

^aMode score.

closely followed by lying directly below the second premolar crown (43%). Other studies^{2,8,10,13} have related the position of the MF to the long axis of premolar teeth in other ethnic groups. The foramen has been reported to be between the first and second premolars in Jordanian⁸ and Asian Indian populations.¹³ By contrast, the MF was located in line with the second premolar in both Saudi population² and Malay population.¹⁰

The foramen position was found to be symmetrical in 62%, with a statistically significant difference between the right and left sides of the mandible; the foramen was more frequently apical to the second premolar on the left, scored by both crown and apex. There was no significant difference in MF position between genders.

Reliability data showed only fair agreement between examiners when scoring the MF position independently in relation to the premolar crowns, compared with moderate agreement when scoring the position in relation to the premolar apices. There was an improvement in reliability scores when the clinicians rated the radiographs together by consensus, with substantial agreement for crowns and almost perfect agreement for apices on three occasions (one occasion with films flipped 180°), using the same method. Santini and Alayan⁴ suggested that “pre-operative radiographs are mandatory” prior to surgery as a result of variations in foramen position; however,

the results of the present study suggest that these may not always be helpful as three experienced clinicians could not agree on MF position when assessing radiographs independently. Furthermore, the foramen is not visible on all dental radiographs, with the MF being more commonly visible on panoramic dental radiographs than periapical radiographs,¹⁴ and although the MF is reported to be visible in 94% of panoramic radiographs, it is only clearly identifiable in 49%.¹⁵ Given such limitations, the exposure of a patient to irradiation for the sole purpose of identifying the position of the foramen may not be clinically justifiable for many less invasive procedures, such as soft-tissue surgery.

This study does present some limitations, including there being no patient information available to assess participant ethnicity and previous dental treatment, such as if patients included had had orthodontic treatment, which may affect the position of the MF in relation to the landmarks used.

In conclusion, this study suggests that the most common position of the MF is between the first and second premolar teeth in a young UK-based population; however, it may be found directly below the second premolar in a high proportion of cases. A radiograph may aid in locating the foramen in relation to the tooth apices, however, when relating position to the premolar crowns the technique is less reliable.

Table 5 Position of the mental foramen in relation to premolar apices

Position	First viewing		Second viewing		Third viewing	
	Right	Left	Right	Left	Right	Left
Anterior to the first premolar apex (Score 1)	0	0	0	0	0	0
Below the first premolar apex (Score 2)	3	4	3	1	3	1
Between the first and second premolar apices (Score 3)	68 ^a	76 ^a	78 ^a	78 ^a	78 ^a	78 ^a
Below the second premolar apex (Score 4)	27	18	16	20	18	21
Posterior to the second premolar apex (Score 5)	2	2	3	1	1	0

^aMode score.

Table 6 Relationship between the right and left side crown scores

Mental foramen position score		Left score				
		2	3	4	5	Total
Right score	3	3	36	5	0	44
	4	0	21	24	2	47
	5	0	2	5	2	9
	Total	3	59	34	4	100

Table 7 Relationship between the right and left side apex scores

Mental foramen position score		Left score				
		2	3	4	5	Total
Right score	2	1	2	0	0	3
	3	3	58	7	0	68
	4	0	16	9	2	27
	5	0	0	2	0	2
	Total	4	76	18	2	100

References

1. Greenstein G, Tarnow D. The mental foramen and nerve: clinical and anatomical factors related to dental implant placement: a literature review. *J Periodontol* 2006; **77**: 1933–43. doi: [10.1902/jop.2006.060197](https://doi.org/10.1902/jop.2006.060197)
2. al Jasser NM, Nwoku AL. Radiographic study of the mental foramen in a selected Saudi population. *Dentomaxillofac Radiol* 1998; **27**: 341–3. doi: [10.1038/sj/dmfr/4600388](https://doi.org/10.1038/sj/dmfr/4600388)
3. Phillips JL, Weller RN, Kulild JC. The mental foramen: 3. Size and position on panoramic radiographs. *J Endod* 1992; **18**: 383–6. doi: [10.1016/S0099-2399\(06\)81224-0](https://doi.org/10.1016/S0099-2399(06)81224-0)
4. Santini A, Alayan I. A comparative anthropometric study of the position of the mental foramen in three populations. *Br Dent J* 2012; **212**: E7. doi: [10.1038/sj.bdj.2012.143](https://doi.org/10.1038/sj.bdj.2012.143)
5. Laster WS, Ludlow JB, Bailey LJ, Hershey HG. Accuracy of measurements of mandibular anatomy and prediction of asymmetry in panoramic radiographic images. *Dentomaxillofac Radiol* 2005; **34**: 343–9. doi: [10.1259/dmfr/28020783](https://doi.org/10.1259/dmfr/28020783)
6. Afsar A, Haas DA, Rossouw PE, Wood RE. Radiographic localization of mandibular anesthesia landmarks. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998; **86**: 234–41. doi: [10.1016/S1079-2104\(98\)90131-7](https://doi.org/10.1016/S1079-2104(98)90131-7)
7. Royal College of Surgeons of England. *Selection criteria for dental radiography*. London, UK: FGDP(UK); 2013.
8. Al-Khateeb T, Al-Hadi Hamasha A, Ababneh KT. Position of the mental foramen in a northern regional Jordanian population. *Surg Radiol Anat* 2007; **29**: 231–7. doi: [10.1007/s00276-007-0199-z](https://doi.org/10.1007/s00276-007-0199-z)
9. Green RM. The position of the mental foramen: a comparison between the southern (Hong Kong) Chinese and other ethnic and racial groups. *Oral Surg Oral Med Oral Pathol* 1987; **63**: 287–90. doi: [10.1016/0030-4220\(87\)90191-5](https://doi.org/10.1016/0030-4220(87)90191-5)
10. Ngeow WC, Yuzawati Y. The location of the mental foramen in a selected Malay population. *J Oral Sci* 2003; **45**: 171–5. doi: [10.2334/josnusd.45.171](https://doi.org/10.2334/josnusd.45.171)
11. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977; **33**: 159–74. doi: [10.2307/2529310](https://doi.org/10.2307/2529310)
12. Neiva RF, Gapski R, Wang HL. Morphometric analysis of implant-related anatomy in Caucasian skulls. *J Periodontol* 2004; **75**: 1061–7. doi: [10.1902/jop.2004.75.8.1061](https://doi.org/10.1902/jop.2004.75.8.1061)
13. Rupesh S, Winnier JJ, John SA, Joy T, Rao AP, Reddy V. Radiographic study of the location of mental foramen in a randomly selected Asian Indian population on digital panoramic radiographs. *J Med Sci* 2011; **11**: 90–5. doi: [10.3923/jms.2011.90.95](https://doi.org/10.3923/jms.2011.90.95)
14. Yosue T, Brooks SL. The appearance of the mental foramina on panoramic and periapical radiographs. II. Experimental evaluation. *Oral Surg Oral Med Oral Pathol* 1989; **68**: 488–92. doi: [10.1016/0030-4220\(89\)90151-5](https://doi.org/10.1016/0030-4220(89)90151-5)
15. Jacobs R, Mraiwa N, Van Steenberghe D, Sanderink G, Quirynen M. Appearance of the mandibular incisive canal on panoramic radiographs. *Surg Radiol Anat* 2004; **26**: 329–33. doi: [10.1007/s00276-004-0242-2](https://doi.org/10.1007/s00276-004-0242-2)