THE ANTERO-POSTERIOR LOCATION OF THE MENTAL FORAMEN IN SUBJECTS WITH DIFFERENT SKELETAL PATTERN

JULIANA BINTI KHAIRI

FACULTY OF DENTISTRY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2017

THE ANTERO-POSTERIOR LOCATION OF THE MENTAL FORAMEN IN SUBJECTS WITH DIFFERENT SKELETAL PATTERN

JULIANA BINTI KHAIRI

RESEARCH REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF CLINICAL DENTISTRY ORAL AND MAXILLOFACIAL SURGERY

DEPARTMENT OF ORAL AND MAXILLOFACIAL CLINICAL SCIENCES,
FACULTY OF DENTISTRY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2017

UNIVERSITY OF MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: Juliana binti Khairi

Matric No: DGJ140002

Name of Degree: Master of Clinical Dentistry (Oral and Maxillofacial Surgery) Title of Research Report:

The Antero-Posterior Location of the Mental Foramen in Subjects with Different Skeletal Pattern

Field of Study: Oral and Maxillofacial Surgery

I do solemnly and sincerely declare that:

(1) I am the sole author/writer of this Work;
(2) This Work is original;
(3) Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
(4) I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
(5) I hereby assign all and every rights in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
(6) I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature Date:

Subscribed and solemnly declared before,

Witness's Signature Date:

Name:

Designation:

ABSTRACT

Background: The mental foramen is an important landmark. Previous studies in Malays and Chinese indicated that its most common location is in line with the longitudinal axis of the second premolar. However, these studies did not differentiate between gender and the effect of different (prognathic, retrognathic, or normal) skeletal pattern.

Patients and Methods: In this study, the antero-posterior locations of the mental foramina in relation to the dentition of 64 patients with different skeletal patterns were determined. These subjects must have a dentopantomograph with the mental foramina clearly seen on both sides of the mandible, and a lateral cephalic radiograph that enables the determination of their skeletal pattern.

Results: Radiographs of 27 Malay and 37 Chinese patients were reviewed. More than seventy percent (70.3%) of subjects were female, with the remaining being male. More than half of them have a Class I skeletal pattern (51.6%), followed by Class III (28.1%) and Class II (20.3%). The mental foramen can be found anywhere from anterior to the first premolar to being in line with the first molar. The most common antero-posterior location of mental foramen was in line with the longitudinal axis of the second premolar. This finding remains constant irrespective of the gender, site and skeletal pattern of the patients. The second most common location for the mental foramen was between the first and second premolars.

Conclusion: The gender, site and skeletal pattern of patients did not influence the antero-posterior location of the mental foramen in relation to the dentition.

Keywords: dental panoramic tomograph, mental foramen, location, skeletal pattern.

ABSTRAK

Latar Belakang Penyelidikan: Foramen mentum merupakan mercu tanda yang penting. Hasil penyelidikan terdahulu pada bangsa Melayu dan Cina mendapati bahawa kedudukan paling kerap foramen mentum adalah segaris dengan paksi longitudinal gigi pramolar kedua. Tetapi kajian tersebut tidak membuat perbandingan di antara jantina dan kesan perbezaan bentuk rangka muka (prognatik, retrognatik, atau normal).

Pesakit dan Kaedah Penyelidikan: Dalam penyelidikan ini, hubungan kedudukan anterior-posterior foramen mentum kepada kegigian 64 orang pesakit telah ditentukan. Semua subjek mesti mempunyai pantomograf pergigian dengan foramen mentum jelas di kedua-dua bahagian mandibel dan radiograf *lateral cephalic* untuk penentuan bentuk rangka muka.

Keputusan: Radiograf 27 orang Melayu dan 27 orang Cina telah dianalisa. Lebih daripada tujuh puluh peratus adalah perempuan (70.3%) manakala selebihnya adalah lelaki. Bentuk skeletal kelas I melebihi separuh (51.6%), diikuti kelas III (28.1%) dan kelas II (20.3%). Foramen mentum boleh dijumpai dari anterior kepada pramolar pertama sehingga segaris dengan paksi longitudinal molar pertama. Kedudukan anterior-posterior foramen mentum yang paling kerap adalah segaris dengan paksi longitudinal pramolar kedua. Keputusan ini sama walaupun terdapat perbezaan jantina, tempat, dan bentuk rangka muka pesakit. Ini diikuti dengan kedudukan foramen mentum antara pramolar pertama dan kedua.

Kesimpulan: Jantina, tempat dan bentuk rangka muka pesakit tidak mempengaruhi kedudukan anterior-posterior foramen mental apabila merujuk kepada kegigian.

Kata kunci: Tomograf panoramik pergigian, foramen mentum, tempat, bentuk rangka muka.

ACKNOWLEDGEMENTS

I would like to thank Allah the Almighty - the most powerful and most merciful for granting me strength and tremendous opportunities to finish this research project.

I would like to express my deepest gratitude to my patient and passionate supervisor, Professor Dr. Ngeow Wei Cheong who never fail to give guidance and path from the impossible to possible to complete this study. Along the journey to complete this research, there were many times I felt lost and he always bring me back to my feet. Also, my deepest thank you note to my co-supervisor, Dr Zakiah Mat Ripen for the guidance to complete this study.

My special thanks to Dr Wey Mang Cheek from Department of Peadiatric Dentistry and Orthodontic Department, Dr Lee Chiong Weng and Dr Lew Chee Kong for their advice and support. The completion of this study would not be possible without the support and encouragement from my colleagues especially Dr Tan Chuey Chuan, Dr Syahir Hassan, Dr Nor 'Izzati Mohtar, Dr Sabrina Peter, and Dr Noor Azwani Mat Nawi.

I would also like to take this opportunity to express my gratitude to all lecturers and staff of the Department of Oral Maxillofacial Clinical Sciences, and the Department of Orthodontics and Paediatric Dentistry of the University of Malaya for their continuous support that enabled me to complete this study. Lastly I would like to thank my family especially my parents who always believe in me in whatever direction I choose and decision made. This thesis is dedicated to all of them.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

AMF	:	Accessory Mental Foramen
CBCT	:	Cone Beam Computerized Tomography
DPT	:	Dental Panoramic Tomogram
LC	:	Lateral Cephalogram
MF	:	Mental Foramen

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

1.1 Backgrounds

The mental foramen is an important anatomical landmark at the mandible parasymphysis area that need to be avoided when performing any surgical or dental procedure at this region (W. C. Ngeow, 2010). It is the anatomical structure where the terminal end of the mandibular canal allows the inferior alveolar nerve to exit the mandible to become the mental nerve (Gershenson, Nathan, & Luchansky, 1986).). Three mental nerve branches exit from this foramen. They innervate the skin of the mental area and lower lip, mucous membranes, and the gingival. The mental nerve also innervates adjacent structures on the ipsilateral side, namely the gingiva of the incisor teeth, all the way to the mesiobuccal root of the mandibular first molar (W. C. Ngeow, 2010). Hence, injury of the nerve can lead to nerve function disturbance at lower lip and chin region. It is important landmark for many dental procedures such as mental nerve block, dental implant placement, orthognathic surgery and endodontic microsurgery (Fishel, Buchner, Hershkowith, & Kaffe, 1976). One case report noted patient developed neuropathy following dental extraction at that region (Elahi, Manolitsis, Ranganath, & Reddy, 2014).

The mental foramen is normally located halfway between the alveolar crest and the lower border of the mandible in a vertical line with the supraorbital notch (Gershenson et al., 1986). There is usually one mental foramen on each side of the mandible. The mental foramen can be found in various antero-posterior locations, ranging from being apical to the canine to apical of the first molar. Most often, it is usually located anywhere between the apices of two mandibular premolars. The most common (modal) location is apical the second premolar, but variations have been reported (Green, 1987). Three decades ago, Green reported that the modal location of the mental foramen in Caucasians and middle eastern was between the first and second premolars, but was more distally placed in the

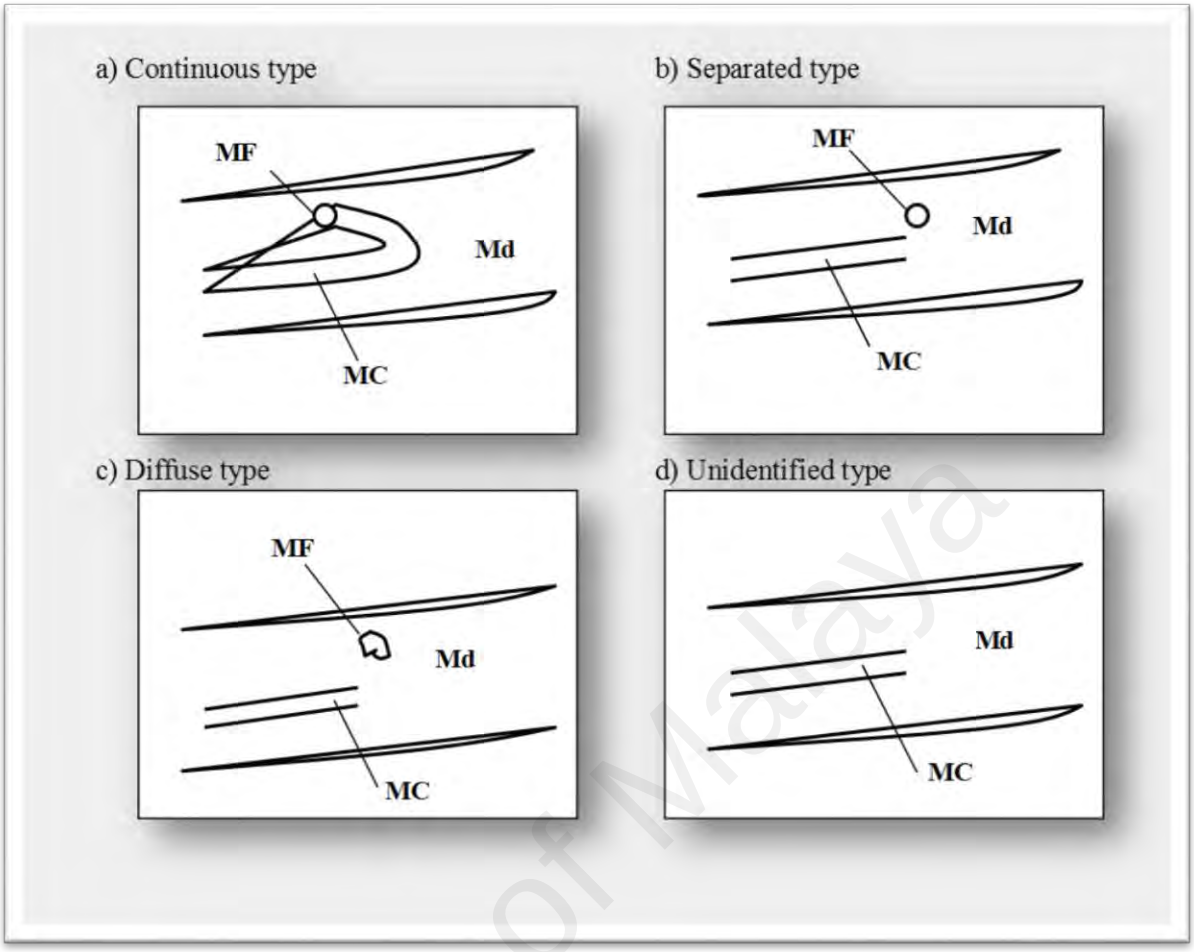
Mongoloids, Melanesian and Negroids (Green, 1987). Similarly, a recent study from South Africa found that in Asians and Blacks, the most frequent position of the mental foramen was in line with the long axis of the second premolar and in Caucasians the most common position was between the first and second premolars (Laher, Motara, & Moolla, 2016). Such findings suggested that these variations may be ethnic related. The locations of the mental foramen in different ethnics are summarized in Table 2.1, based on the comprehensive reviews published by Green et al. (1987) and Laher et al. (2016) with a combination of several other literature.

The existence of multiple mental foramina has been described since 1903 (Le Double, 1906). It has been suggested that separation of the mental nerve into several fasciculi earlier than the formation of the mental foramen until the twelfth gestational week could be a reason for this phenomenon (M. Naitoh, Hiraiwa, Aimiya, Gotoh, & Ariji, 2009). In modern literature, it is often termed as accessory mental foramen (AMF) but Serman considered them as a possible mental-incisive foramen complex (Serman, 1987) Concepcion and Rankow (2000) claimed to be the first to observe a 'real' accessory foramen that was discovered during endodontic surgery. AMF can be mistaken a tumour if observed using conventional panoramic radiography (Gamoh et al., 2014). A review of clinical cases showed that paraesthesia can happen if large AMF was subjected to injury (Iwanaga et al., 2015). The prevalence of accessory foramina varies between ethnic groups, with a higher prevalence reported among the non-Caucasians (Sawyer, Kiely, & Pyle, 1998). On rare occasions, the mental foramen may be absent (da Silva Ramos Fernandes, Capelozza, & Rubira-Bullen, 2011; de Freitas, Madeira, Toledo Filho, & Chagas, 1979; Lauhr, Coutant, Normand, Laurenjoye, & Ella, 2015; Matsumoto, Araki, & Honda, 2013; C. Oliveira-Santos et al., 2011). Oliveira-Santos reported a prevalence of 0.7% for unilateral missing mental foramen (C. Oliveira-Santos et al., 2011). In a study

that reviewed 169 DPTs of Malays, Ngeow and Yuzawati reportedly found 8 dental panoramic tomographs with a missing mental foramen on one side of the mandible, giving rise to a prevalence of 2.4% for this anomaly (Wei Cheong Ngeow & Yuzawati, 2003). However, no cases show bilaterally missing mental foramen. Another study from Malaysia reported that missing mental foramen made up almost ten-fold (22.2%) of mental foramen, and attributed this non-visibility to aging (W. C. Ngeow, Dionysius, Ishak, & Nambiar, 2010).

The mental foramen can be vaguely palpated clinically but can be confirmed by using dental radiographs. However, routine periapical radiograph may not show the presence of this foramen if it is below the margin of the film (Philips, Weller, & Kulild, 1992). On dental radiographs, the mental foramen usually appears as a round or an oval radiolucent structure. According to Yosue and Brook, the radiographic appearance of the mental foramen can be classified into 4 types (Figure 1.1), namely (Yosue & Brooks, 1989) :-

1. Continuous type: the mental canal is continuous with the mandibular canal.
2. Separated type: the foramen is distinctly separated from the mandibular canal.
3. Diffuse type: the foramen is diffuse but with a distinct border of the foramen.
4. Unidentified type.



* **MF:** Mental Foramen, **MC:** Mandibular Canal, **Md:** Mandibular bone

Figure 1.1: Radiographic appearance of mental foramen (Yosue & Brooks, 1989)

Recently, Laher et al. reported the use of ultrasonography to detect the position of the mental foramen with great accuracy (Laher, Motara, & Moolla, 2016).

Knowledge of the expected location of the mental foramen is of more than anthropological interest, being directly important in dentistry for the effectiveness of mandibular local anaesthesia (mental) block of the anterior segment, for radiographic and forensic diagnoses, as well as for treatment planning of surgical procedures to ensure avoidance of causing iatrogenic injury (W. C. Ngeow, 2010). Neurosensory disturbance has been reported to result from inadvertent orthodontic (Baxmann, 2006), endodontic

(Knowles, Jergenson, & Howard, 2003; Pogrel, 2007; Poveda, Bagán, Fernández, & Sanchis, 2006; Scarano, Di Carlo, Quaranta, & Piattelli, 2007). The etiology of altered sensation in the inferior alveolar, lingual, and mental nerves as a result of dental treatment (Morse, 1997a; Orstavik, Brodin, & Aas, 1983) in the mandibular premolars region. Other practical implications are for prevention of neuralgia caused by pressure on the mental nerve from denture fitting. This is because, with loss of teeth and bone resorption, the mental foramen is located relatively more upward, closer to the alveolar crest (Gershenson et al., 1986). Lastly, several cases of accidental compression of the mental nerve have been reported in patients subjected to general anaesthesia (Azar & Lear, 1986; Bhuiyan & Chapman, 2006; Gimmon, 1988; Lorentz, Podstawski, & Osswald, 1988).

The aim of this study was confirmed previous findings that the second premolar is the most common location to find the mental foramen in two ethnic groups, the Malays and Chinese. More importantly, this study tried to determine if any correlation exists between location of the mental foramen (relative to the mandibular dentition) and the skeletal pattern of patients.

1.2 Objectives

1.2.1 General objective

To determine if a relationship exists between position of the mental foramen (in relation to teeth) and skeletal base/pattern.

Null hypothesis: There is no correlation between the radiographic position of mental foramen and the skeletal base of the patients.

1.2.2 Specific objectives

i. To determine location of mental nerve in a selected group of Mongoloid patient using dental panoramic tomogram, and

ii. To determine relationship of the location of the mental foramen with the skeletal pattern, if present.

CHAPTER 2: LITERATURE REVIEW

2.1 Anatomy and developmental of mental foramen

The mental foramen is an important anatomical landmark at the lateral body of mandible and carries neurovascular branches of the inferior alveolar nerve. It is the anatomical structure where the terminal end of the mandibular canal allows the inferior alveolar nerve to exit the mandible to become the mental nerve (Shankland, 1994). Three mental nerve branches exit from this foramen. They innervate the skin of the mental area and lower lip, mucous membranes, and the gingival. The mental nerve also innervates adjacent structures on the ipsilateral side, namely the gingiva of the incisor teeth, all the way to the mesiobuccal root of the mandibular first molar (W. C. Ngeow, 2010).

In 2007 Hu KS did an anatomical study and showed that mental nerve can branched into four when exit from mental foramen (a) angular branch which innervates the area around the angle of the mouth, (b) medial and (c) lateral inferior labial branches which innervate the skin of the lower lip, oral mucosa, and gingiva as far posterior as the first molar teeth and (d) mental branch which innervates the skin of the mental region branches according to the distribution area (Hu et al., 2007).

Mental foramen can be oval or rounded in shape. Mental foramen have average horizontal dimension 4.6 mm with a range from 2.4 to 7.3 mm. The average vertical dimension was 3.4 mm with a range of 2.1 to 5.8 mm. (Phillips, Weller, & Kulild, 1990). Classically in the textbook, mental foramen open between apex of premolars (Janfaza, 2011; Sinnatamby, 2011). But studies showed that the position of mental foramen may vary across the population. It may occur between the apices of the lower premolars, below the apex of the first premolar or below the apex of the lower second premolar (Aminoshariae, Su, & Kulild, 2014; Green, 1987; Laher et al., 2016; Shankland, 1994). Mental foramen position changes dynamically during developmental of mandible. During

prenatal, mental foramen located between developing primary canine and primary first molar. As mandible growth, mental foramen positioned more distally. This change may due to osseous growth and mesial drift of the dentition (Balcioglu, Kilic, Akyol, & Ulusoy, 2011; Kjaer, 1989).The mental foramen migrate posteriorly under due to developmental anterior root of developing premolar and remain at birth and maintain during eruption of primary dentition (Williams & Krovitz, 2004). During eruption of the second primary molar, the mental foramen generally migrates to a position inferior to the second premolar (Williams & Krovitz, 2004).

2.2 Clinical significance of mental foramen

Mental foramen is an important vital structure of mandible. It plays a great role during dental procedures and any surgery involving mandible. It is important to determine position of mental foramen to avoid injury to mental nerve.

2.2.1 Endodontic treatment.

The accurate identification of the mental foramen is important for both diagnostic and clinical procedures for endodontic cases. Periapical radiography is a prerequisite for all endodontic procedures (Moiseiwitsch, 1995). However, the radiographic appearance of the mental foramen may result in a misdiagnosis of a radiolucent lesion in apical area of mandibular premolar teeth. The clinician need to interpret the radiograph appearance with caution and relate to patient sign and symptoms.

The proximity of mental foramen to adjacent apical of tooth also can cause the pulpal infection travel to mental nerve and via mental foramen. Morse (1997) reported two cases where patient developed paraesthesia of mental nerve after pulpal infection from the premolar. Post endodontic treatment, symptoms were resolved. Infection from pulpal origin can travel and causes infection and inflammation of mental nerve which subsequently results in paraesthesia (Morse, 1997b).

2.2.2 Flap design and periapical surgery

Many dentists avoid periapical surgery involving the lower premolar region for fear of paraesthesia after the procedure. Thus, proper preoperative diagnosis, correct flap design, and atraumatic flap retraction can significantly lower the incidence of this postsurgical complication (Concepcion & Rankow, 2000)

For flap reflection for any surgery around the region of the periapical of the premolar, a full trapezoidal or mini trapezoidal flap with wide relieving incision away from the estimated location of mental foramen is flap of choice. With this approach, when carrying out apical surgery on a tooth posterior to the mental foramen, the mental nerve will be stretched within the bed of the flap to achieve sufficient access for the surgical procedure (Moiseiwitsch, 1995).

If a triangular flap is plan, Moiseiwitsch (1995) has recommended that for each reflection, the releasing incision is placed mesial to the surgical site, at the mesial line angle of the canine (Figure 2.1).

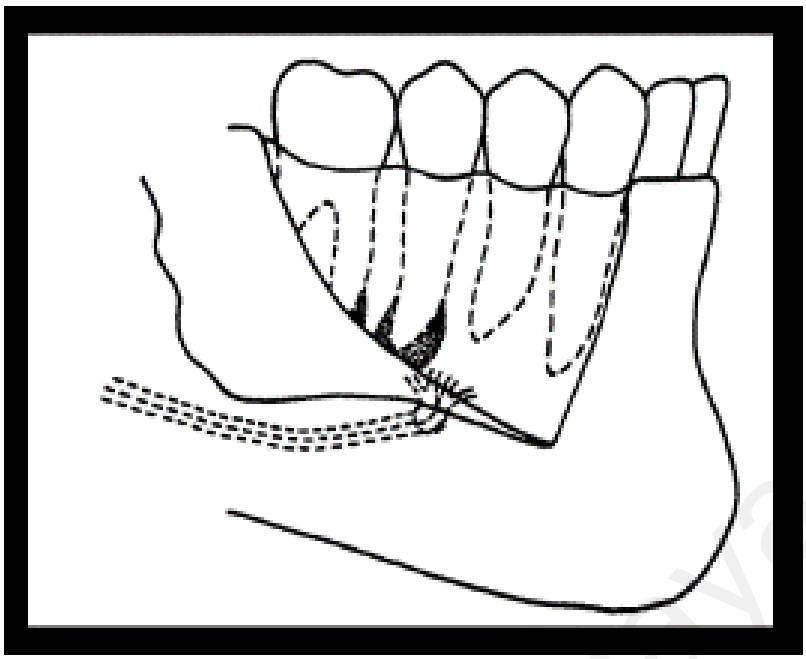


Figure 2.1: Mesial incision for triangular flap (Moiseiwitsch, 1995)

Besides that, periapical surgery or dental extraction of the poor prognosis tooth that have close relationship with the mental foramen can lead to neuropathy disturbance to the lips and chin region. This will cause discomfort to the patient. Elahi et al. (2014) reported two cases where patient developed mental nerve neuropathy after dental extraction. Patient had to undergo radiofrequency nerve ablation to relief the pain (Elahi et al., 2014).

Prior to dentoalveolar surgery to mandible, injection of inferior alveolar nerve sometimes failed to create anaesthesia to the mental nerve distribution. This may due to present of accessory mental foramen that carried additional neurosensory fiber. Several authors have studied this problem and found that branches of the facial nerve and the mylohyoid nerve in some cases provide additional sensory fibres to the mandible. A knowledge of accessory foramina is therefore of clinical importance (Sutton, 1974).

2.2.3 Placement of dental implants and dental prosthesis

Many patients prefer fully supported implant prosthesis because it eliminates pressure on the tissues in the region of the posterior mandible and is usually not removable. This also yields increased chewing efficiency and improved speech and may result in more self-confidence and self-esteem. Bavitz et al. (1993) mentioned that is common to place five to six implants between the mental foramina of the edentulous for fabrication of dental prosthesis. The most distal implant usually was placed a closed to mental nerve region to maximize the distance or spread between anterior implant to counteract forces generated on the distal cantilevers of the prosthesis. (Bavitz, Harn, Hansen, & Lang, 1993).

In edentulous patient, some the mental foramen was recorded as a semi-ovoid form and is located at the top of the residual ridge (Xie, Wolf, Soikkonen, & Ainamo, 1996). Sensory disturbance may be caused by pressure on the mental foramen or the mental nerve or in the case of severe mandibular-bone loss of the alveolar ridges, by pressure of a (complete) denture on the alveolar nerve itself (Wismeijer, van Waas, Vermeeren, & Kalk, 1997). About 25% of patients report sensory disturbance of the lower lip while wearing dentures. This may be explained by the pressure of the bearing area in the region of the mental foramen, which irritates the mandibular nerve (Wismeijer et al., 1997).

The prosthodontist can release the pressure at this foramina area with one layer of aluminium foil. It is, therefore, important to be able to locate the mental foramen correctly (Bavitz et al., 1993). The other treatment option that available was to do transposition of the mental nerve as preprosthetic procedure by using conventional burs or piezograph (Sakkas, Otten, Gutwald, & Schmelzeisen, 2008) . It was effective for patients with hyperaesthesia caused by the effect of a dental prosthesis on the alveolar ridge (Sakkas et al., 2008; Shibahara et al., 1996).

2.2.4 Orthognathic surgery

Injury to mental nerve is one of the complications during orthognathic surgery that maxillofacial and plastic surgeon try to avoid. It can happen due to direct or indirect injury to the nerve during mandibular osteotomy cut. Presurgically, determination of mental foramen positon help surgeons plan mandibular osteotomy cut. This is important in orthognathic surgery procedure example in subapical mandibular osteotomy, genioplasty and mandibular chin-body osteotomy for correction of broad chin. It helps to reduce the risk of direct injury to the mental nerve intraoperatively.

Stretching of mental nerve during retraction of soft tissue flap around premolars region sometimes lead to unintentional neurosensory injury. This happen in patient with limited space between mental foramen and soft tissue after flap was raised. Westermark (1998) reported paresthesia of the mental nerve in 3.4% and 12% following genioplasty procedure (Westermark, Bystedt, & von Konow, 1998). In 2015, Wang et al did a rectangular corticotomy around mental foramen during narrowing genioplasty procedure to allow free movement of mental nerve and to avoid nerve stretching (Figure 2.2) (C. Wang, Gui, & Liu, 2015)

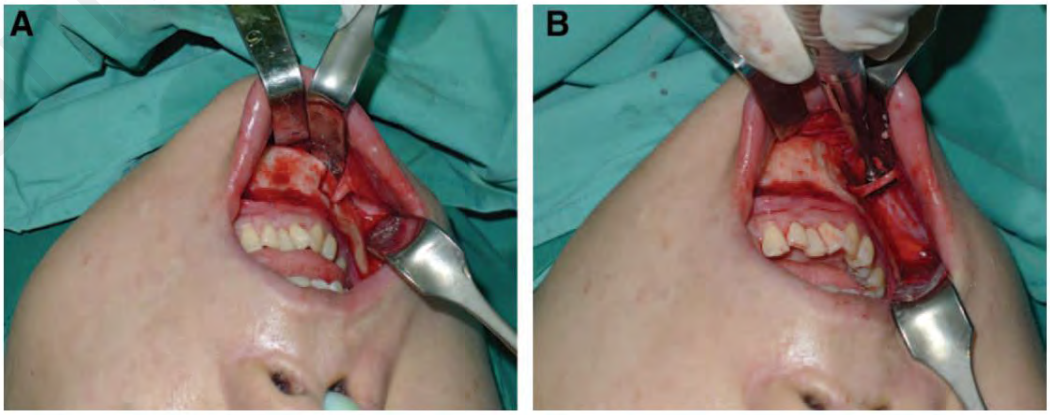


Figure 2.2: Before (A) and after(B) corticotomy procedure around mental foramen (C. Wang et al., 2015)

2.2.5 Anthropology and forensic odontology study.

In the anthropology and forensic science study, many researchers try to find the correlation of mental foramen with age and gender. Study by Chrcanovic, Abreu et al (2011) noted there were significant changes of mental foramen position in dentate and edentulous patient. When the tooth was lost, the alveolar bone will undergo resorption. Mental foramen position appeared closer to occlusal surface compared to dentate patient. (Chrcanovic, Abreu, & Custodio, 2011). The distance between crest of alveolar ridge to superior margin of mental foramen decreases significantly with age in edentulous patient (Ajmal, 2014).

Cutright et al. (2003) did an anthropology study and found there is small but significant differences in facial foramen location between white and black males and females (Cutright, Quillopa, & Schubert, 2003). However Angel et al. in 2011 did not find any significant correlation between mental foramen position with age and gender.

The position of mental foramen remains constant regardless age and sex (Angel, Mincer, Chaudhry, & Scarbecz, 2011). This findings also support finding by Bhardawaj et al. in 2014 where there is no statistically significant of mental foramen with age and gender (Bhardwaj, Kumar, & Mohan, 2014)

2.2.6 Glycerol injection for treatment of trigeminal neuralgia

Glycerol injections have been found to be effective alone in the management of idiopathic trigeminal neuralgia without significant complication in most patients when compared with carbamazepine. It is claimed that glycerol injected at the foramina, where the peripheral branches of trigeminal nerve leave the skull, can be effective in the treatment of trigeminal neuralgia (Tarek L. Al-Khateeb, 1998). Injection into the mental foramina is done to control peripheral trigeminal neuralgia of the mental nerve.

2.3 Variation of mental foramen among population

Traditionally in text book reported the most common site for mental foramen positon located between lower premolars (Janfaza, 2011; Sinnatamby, 2011). However a lot of studies noted variation in premolar location across the population (Table 2.1).

Most mental foramen in caucasoid origin located more anteriorly compare to mongoloid. Caucasoid mental foramen usually located between premolars whereas mongoloid origin located in line second premolars. This finding also was mentioned by Green (1987) in his study. The most common position of the mental foramen in Caucasian and Middle Eastern populations is between the 1st and 2nd premolars. While in negroid and mongoloid the mental foramen located more posteriorly (Green, 1987). The size of the dentition and skeletal pattern may contribute this factor. So far there is no study that try to relate the mental foramen position with different skeletal pattern. Our study try to find whether there is relation of the different skeletal pattern in relation to mental foramen.

Table 2.1: Variation of mental foramen among population – modified from (Green, 1987)

Modal location	Ethnics	Population	References
Apical to first premolar	Caucasoid	French	Oliver E 1928, (Green, 1987)
Between first and second premolar	Caucasoid	American*	(Moiseiwitsch, 1998)
		German*	Moral H 1931, Merkel F 1885-1890, Hubner O 1904 (Green, 1987)
		British	(Santini & Land, 1990) Kay 1974 (Green, 1987)
		Saudi Arabian*(male)	(T. L. al-Khateeb, Odukoya, & el-Hadidy, 1994)
		Turkish*	(Aktekin, Celik, Celik, Aldur, & Aksit, 2003)
		Yugoslavian	(Stosic, Bogdanovic, Mrvaljevic, & Mijac, 1978)
		European	(Santini & Alayan, 2012)
	Unknown	Kosovarian	(Kqiku et al., 2013)
		Austria	(Kqiku, Sivic, Weiglein, & Stadtler, 2011)
	Negroid	Northern Nigerian	(Olasoji, Tahir, Ekanem, & Abubakar, 2004)
Apical to second premolar	Australoid	Australian aborigines	Murphy 1957 (Green, 1987)
	Caucasoid	American*	(Moiseiwitsch, 1998)
		British	Kay 1974 (Green, 1987)
		Central European	Ashley-Montagu 1954 (Green, 1987)
		Italian	Toni and Favero 1955 (Green, 1987)
		Russian	Gruber 1872 (Green, 1987)
		Saudi Arabian*	(T. L. al-Khateeb et al., 1994; al Jasser & Nwoku, 1998)
		Turkish*	(K. Gungor, Ozturk, Semiz, & Brooks, 2006; Yesilyurt et al., 2008)
		Morroccan	(Chkoura & El Wady, 2013)
		Nepalese	(Kadel, Sedhain, & Dangol, 2016)

Table 2.1 (continued) : Variation of mental foramen among population – modified from (Green, 1987)

Modal location	Ethnics	Population	References
Apical to second premolar (cont.)	Mongoloid	Brazilian	(Chrcanovic et al., 2011; Chu et al., 2014)
		Chinese	(Green, 1987; Santini & Alayan, 2012; Santini & Land, 1990)
		Indian	(Shankland, 1994)
		Japanese	(Fujita & Suzuki, 2014)
		Kentucky Indian	Simonton RV 1923 (Green, 1987)
		Korean	(Kim, Kim, Kim, & Kim, 2006)
		Malays	(Neo, 1989; W. C. Ngeow et al., 2010; Wei Cheong Ngeow & Yuzawati, 2003)
		Melanesian**	Esposito 1968 (Green, 1987)
		Mexican (Ketchipauan)	Kay LW 1974 (Green, 1987)
		Mixed Amerindian	Simonton 1923 (Green, 1987)
		Thai	(Apinhasmit, Methathrathip, Chompoopong, & Sangvichien, 2006)
	Negroid	Malawian (Bantu)	Schultz 1970 (Green, 1987)
		Malawian	(Igbigbi & Lebona, 2005)
		South Eastern Nigerian	(Ukoha et al., 2013)
		African (Teita)	Kay LW1974 (Green, 1987)

*Some studies reported a modal location between the apices of the premolars, while others reported it to be apical to the second premolar.
**Evenly distributed between 2 locations i.e. apex to the second premolar and between the second premolar and first molar.
¤Observed in children.

Mental foramen usually present one for each side of mandible. However it can sometimes absent from mandible whether involved one site or bilaterally. Lauhr reported one case of bilateral absence mental foramen from cone beam computerized tomography (CBCT) without any neusosensory disturbance (Lauhr et al., 2015).

Mental foramen can have multiple foramina or also known as accesory mental foramen in 1%–10% of patients (Aminoshariae et al., 2014; M. Naitoh et al., 2009). The contents of the AMF exit commonly in an anteroinferior location (Kalender, Orhan, & Aksoy, 2012). The AMF tends to exist in the apical area of the first molar and posterior or inferior area of the mental foramen (Aminoshariae et al., 2014; K. Katakami et al., 2008). Mental nerve can also classified based on the shape of the anterior loop into loop, straight, and vertical patterns, which constituted 61.5%, 23.1%, and 15.4%, respectively (Aminoshariae et al., 2014).

2.4 Determination of mental foramen by dental panoramic tomogram (DPT)

DPT is the common radiographic examination done by dentist. Its allow the clinician to visualize maxilla and mandible for diagnostic purposes. DPT able to detected most of mental foramen as high as 99% (Jalili, Esmaeelinejad, Bayat, & Aghdasi, 2012; Serman, 1987; Yosue & Brooks, 1989). But the mental foramen shape in DPT may be different shape compare to the real mental foramen due to image distortion. In patient with high density of bone mental foramen visualization will be more difficult (Yosue & Brooks, 1989).

DPT subject to a lot of possible error that made difficult to assess mental foramen. The position of the head, the shape of the dental arch, the tooth location, the use and location of a bite block, and the type of panoramic equipment could be some factors

causing image distortion di DPT (Yim, Ryu, Lee, & Kwon, 2011; Yosue & Brooks, 1989). Example in patient positioning, backward positioning of the skull leads to distal angulation on the horizontal plane at the area of the mental foramen whereas forward positioning shows mesial angulation on the horizontal plane. Chin-up and chin-down positioning show slight distal and mesial angulation, respectively (Yosue & Brooks, 1989).

In this study we used DPT for assessment for mental foramen position as is readily available in our faculty for retrospective cohort study.

CHAPTER 3: MATERIAL AND METHOD

3.1 Study Design

This retrospective cohort study aimed to review the radiographs of 150 Malay or Chinese patients that fulfilled the inclusion criteria listed below. This study conducted between April 2016 and April 2017.

In essence, all radiographs of patients attending to the Faculty of Dentistry from 2010 -2016 were reviewed. Only Malay and Chinese ethnics were included because of their similar anthropological (Mongoloid) origin. Because of the need to determine the skeletal pattern of the patients, only orthodontic patients or patients planned for orthognathic surgery were recruited. All of them must have an initial pre-treatment dental panoramic tomograph (DPT) and a lateral cephalogram (LC). The panoramic radiographs were taken using Sirona Orthophos® and Planmeca® x-ray machine. The magnification factors reported by the manufacturers were 1.2 and 1.25, respectively.

3.1.1 Sample size

Three group with 50 set of x-ray in each group (Class I, Class II and Class III skeletal pattern) using convenient sampling.

3.2 Study population and setting

3.2.1 Inclusion and exclusion criteria

3.2.1.1 Inclusion criteria

a) This study will be limited to Malay and Chinese subjects only. This is because Malays and Chinese are of similar anthropological (Mongoloid) ancestry (Wei Cheong Ngeow & Yuzawati, 2003)

b) All subjects must have an initial pre-treatment dental panoramic tomogram (DPT) and lateral cephalogram (LC)

c) Age: 20-40 years old,

d) The inclusion and exclusion criteria for the DPT were as follows:

   i. High quality with respect to angulation and contrast.

   ii. All mandibular permanent teeth must be present from the right first molar to the left first molar with good alignment within the dental arch.

   iii. Images must be free from any radiolucent or radiopaque lesion(s) in the mandible and showed no radiographic over exposure or processing artefacts.

   iv. Radiographs where any lower anterior teeth were missing were excluded because of possible mesial drift of the posterior teeth.

   v. Panoramic radiographs where the mental foramen could not be identified were excluded. These were considered to be cases classified as 'unidentified type' mental foramen according to the classification described by Yosue and Brooks (Yosue & Brooks, 1989)

   vi. Radiographs in which the lower teeth (between 36 and 46) were missing, had deep caries, root canal treatment or various restorations were excluded because of possible associated periapical radiolucency

e) The inclusion and exclusion criteria for the lateral cephalogram were as follows:

   i. High quality with respect to angulation and contrast.

   ii. Subject should be biting in intercuspal position (ICP).

   iii. Only normal non-cleft, non-syndromic patients will be included.

   iv. Subjects should have both upper and lower central incisors present.

3.2.1.2 Exclusion criteria

The exclusion criteria for this study as listed below:

a) Mixed dentition or any missing mandibular teeth from 36-46

b) Present of radiographic artefact

c) Any bony pathology or surgical procedure involving craniofacial and mandible area

d) Non visible mental foramen

3.3 Data collection

All data were collected with using data collection form (Appendix B). The patient register from 2010-2016 were assessed for the following criteria: -

a) The inclusion criteria were used to obtain suitable subjects.

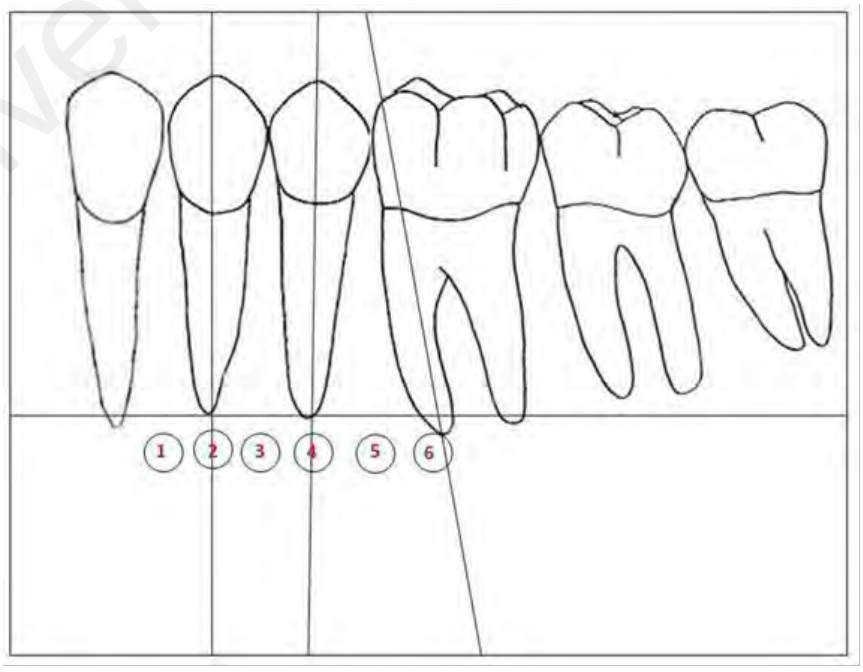
b) One examine was performed data collection.

c) Patient demographic data – age, gender and site of mental foramen (right or left) was recorded

d) Determination of mental foramen using the dental panoramic tomogram (DPT) view

The locations of the mental foramen were assessed from the DPTs. The location of the mental foramen was recorded according to the description used by Al Jasser & Nwoku (1998) and Ngeow & Yuzawati (2003). They were shown and described in Figure 3.1.The position of the mental foramen was recorded in line with the longitudinal axis of a tooth with a metal ruler. The ruler edge was followed the angulation of the teeth.

The position of the image of the mental foramen was recorded as Figure 3.1 below:



Legend:
Position 1: Situated anterior to the first premolar.
Position 2: In line with the first premolar.
Position 3: Between the first and second premolar.
Position 4: In line with second premolar.
Position 5: Between second premolar and first molar.
Position 6: In line with first molar.

Figure 3.1: Schematic diagram shows possible location of the mental foramen (Yosue & Brooks, 1989).

A metal ruler was used to relate the mental foramen to the long axis of teeth or the inter-radicular area. The edge of the ruler followed the angulation of the teeth. If the mental foramen was too large or was located exactly in between two teeth, the position of the foramen was indicated by drawing an imaginary line parallel to the long axis of the teeth. In addition, the mental foramen also was determined by accessing the site with the most obvious radiolucency. The side that showed more radiolucency was designated the location of the mental foramen to be used analysis. Using a modification of Yosue and Brooks (1989) when there appeared to be multiple foramina, the true radiographic mental foramen was considered to be the largest, uppermost one and nearest the mandibular canal (Yosue & Brooks, 1989). Nevertheless, the presence of accessory mental foramen (AMF) was recorded and its spatial relationship to the main mental foramen (MF) was determined. The position of the AMF was recorded as posterosuperior, posterior, posteroinferior, superior, inferior, anterosuperior, anterior, or anteroinferior to the MF.

e) <u>The skeletal pattern was assessed from the lateral cephalogram (LC) tracing</u>

The skeletal patterns were determined from the LC. Angular measurements of ANB (Mills, 1987) were used to determine the skeletal pattern and classified according to the followings:

Class I: ANB 1-5 degrees

Class II: ANB of >5 degrees

Class III: ANB of <1 degree

To do so, a piece of translucent tracing paper was secured over the LC. LC tracing done using pencil of four point below as describe by Mills JRE 1987:

a) A point (A): The point of the deepest concavity anteriorly on the maxillary alveolus
b) B point (B): The point of the deepest concavity anteriorly on the mandibular symphysis
c) Sella (S): The midpoint of the sella turcica (pituitary fossa)
d) Nasion (N): The most anterior point on the fronto-nasal suture,

The relevant points were connected to make up the SNA and SNB lines. The SNA and SNB angle values were determined using a protractor, to the nearest 0.5º. The ANB angle was be calculated as the difference between the SNA and SNB angles.

In order to ensure the validity of the study and reliability of the examiner, 10% of the DPTs and LCs were reassessed, at least two weeks following the first exercise.

3.3.1 Data Analysis

Data were entered and analysed using IBM SPSS Statistic software version 22 and Microsoft Excel 2013. Descriptive and appropriate analytical statistics was performed. Chi-square test was employed to compare the findings, with the significant value set at $P<0.05$. Pearson's correlation test was performed to detect possible relationship between the location of the mental foramen and the type of skeletal pattern.

3.3.2 Ethical approval and funding

This research had received ethical approval from the Medical Ethic Committee of Faculty of Dentistry, University of Malaya [Reference number: DF OS1620/0060(P)]. (Appendix A). This research was self-funded.

CHAPTER 4: RESULTS

4.1 Demographic profile

From 385 panoramic radiographs that were analysed, only 64 radiographs met the inclusion criteria, whereby the mental foramen can be seen on both sides of the mandible. The other 311 radiographs were excluded due to the following reasons:

a) The loss of the first premolars as a result of orthodontic treatment prescribed elsewhere.

b) Unidentified mental foramen on either side of the jaw. This is due to low film quality or perhaps the anatomy of the mental foramen position.

c) Pathological lesions around the mental area such as existing radiopacity or radiolucency at the area of study.

d) Low film quality that also affects the process of analysing the radiographs. These radiographs were either overexposed or underexposed.

4.1.1 Race of the study

In this study, we had 27 Malays (42%) and 37 Chinese (58%) patient's radiograph respectively (Figure 4.1).

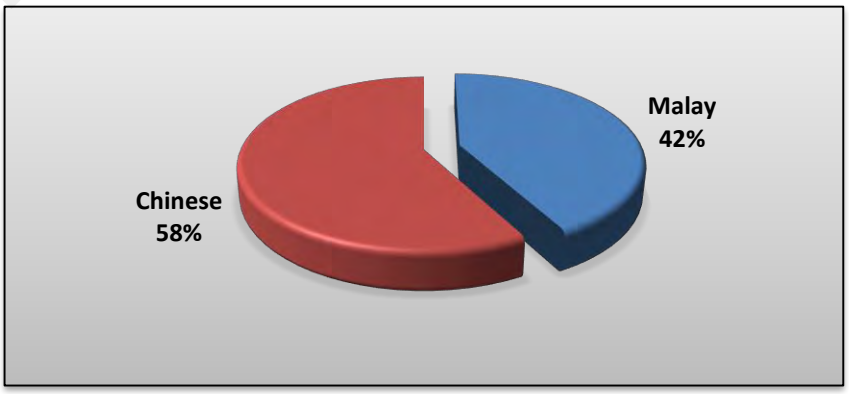


Figure 4.1: Patient's ethnicity

4.1.2 Gender of patient

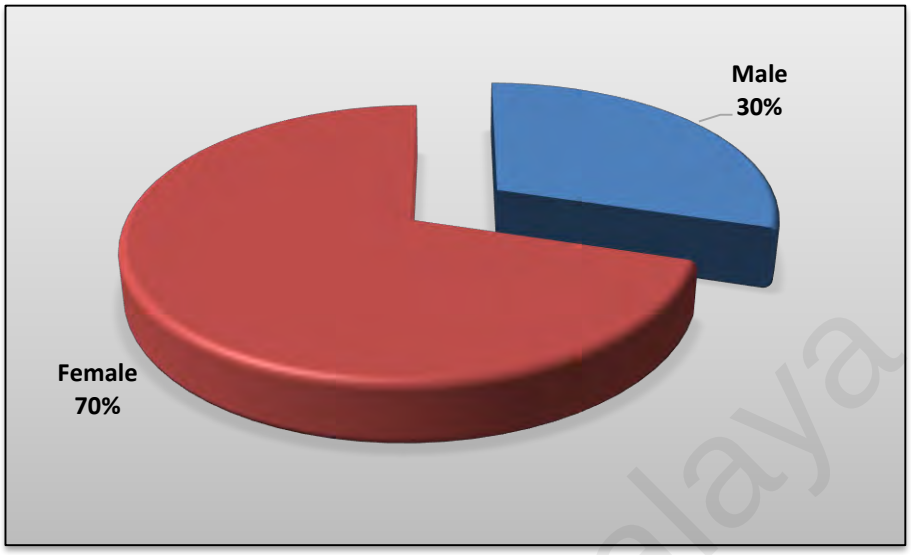


Figure 4.2: Gender of patient

More than seventy percent (70.3%) of subjects were female, with the remaining being male (Figure 4.2). The mean age of the patients was 25.0 (SD 3.9) years.

4.2 Statistical analysis

4.2.1 Relationship of Skeletal Pattern with Race

Table 4.1: Relationship of Skeletal Pattern with Race

Skeletal Pattern Classification	Race n (%)		Total
	Malay	Chinese	
I	14 (51.9%)	19 (51.4%)	33 (51.6%)
II	6 (22.2%)	7 (18.9%)	13 (20.3%)
III	7 (25.9%)	11 (29.7%)	18 (28.1%)
Total	27 (100%)	37(100%)	64 (100%)

More than half of patient had Class I skeletal pattern (n=33; 51.6%), followed by Class III (n=18; 28.1%) and Class II (n=13; 20.3%). This same distribution was seen in both ethnic groups (Table 4.1). Pearson Chi-Square test done was run with P value = 0.921. There is no relationship between skeletal patterns with race (P value > 0.05).

4.2.2 Mental foramen position

All mental foramen observed in this study was of the continuous type. The majority of the patients (n=59; 92.2%) had only one mental foramen on each side of the jaws. There were 4 subjects who had more than 1 mental foramen on one side of the mandible. Three of them have 2 mental foramina present while another person had 3 mental foramina on the right side of mandible. Three of them had Class III skeletal pattern. In details, they were:

a) One Chinese female with Class III; the site with 2 foramina had a main mental foramen located in line with the second premolar (Position 4)
b) One Malay female with Class III; the site with 2 foramina had a main mental foramen located between the first and second premolars (Position 3)
c) One Chinese male with Class III; the site with 3 foramina had a main mental foramen located anterior to the first premolar (Position 1)
d) One Chinese female with Class I; the site with 2 foramina has a main mental foramen located between the second premolar and the first molar (position 5)

Only one subject had 2 mental foramina present on each side of the mandible. He was a Chinese male with Class I skeletal pattern. One of his main mental foramen was located anterior to the first premolar (Position 1), while on the opposite site, the main mental foramen was located in line with the first premolar (Position 2). In summary, it can be noted that patients with multiple mental foramina did not present in any pattern of distribution for the location of the main mental foramen.

The mental foramen can be found anywhere from anterior to the first premolar to being in line with the first molar, i.e. all locations described in this study (Table 4.2). However, when analysed according to ethnic, the mental foramen were located between positions 2 & 6

among the Malays, but between positions 1 & 5 among the Chinese. However, due to the small number of patients recruited, this ethnic-influenced difference was not statistically significant.

Table 4.2: The location of mental foramen in Malay and Chinese patients

Position	Number (%)		
	Malay	**Chinese**	**Overall**
Position 1	-	3 (4.1%)	3 (2.3%)
Position 2	2 (3.7%)	6 (8.1%)	8 (6.3%)
Position 3	23 (42.6%)	21 (28.4%)	44 (34.4%)
Position 4	20 (37.0/%)	36 (48.6%)	56 (43.8%)
Position 5	6 (11.1%)	8 (10.8%)	14 (10.9%)
Position 6	3 (5.6%)	-	3 (2.3%)
Total	54 (100%)	74 (100%)	128 (100%)

The most common antero-posterior location of mental foramen was in line with the longitudinal axis of the second premolar (n=56; 43.8%). This finding remains constant irrespective of the gender, and skeletal pattern of the subjects (Table 4.2). The second most common location for the mental foramen is between the first and second premolars (n=44; 34.4%) (Table 2). However, ethnic-wise, the mental foramen was more often found at between the first and second premolars (Position 3) among the Malays as compared to the Chinese. This tendency appears to be contributed mainly by the female Malay patients, which outnumber male patients 2:1. Among the Chinese, the most common location was in line with the second premolar (Position 4) (Table 4.3).

Half of the patients reviewed have symmetrically located mental foramen on both side of the jaws, with a configuration of Positions 4-4 (n=17; 53.1%) being the most common, followed by the Positions 3-3 configuration (n=13; 40.6%). One patient each had the Positions 5-5 configuration and the Positions 6-6 configuration.

The remaining half of the patients presented with various asymmetry configurations for the location of mental foramina on both side of the jaws, as shown in Figure 3. In general, it can be noted that the most common configurations were those where one side of the jaw had the mental foramen located in line with second premolar. The affected 68.8% of the subjects, involving the 3-4 configuration (n=11; most common), 4-5 configuration (n=7) and 2-4 configuration (n=4). This gives an impression that the most common location to find the mental foramen revolves around the second premolar region.

In summary, the analysis showed that the most common location to find the mental foramen revolves around the second premolar region, irrespective of the fact that the mental foramen were symmetrically and not symmetrically located.

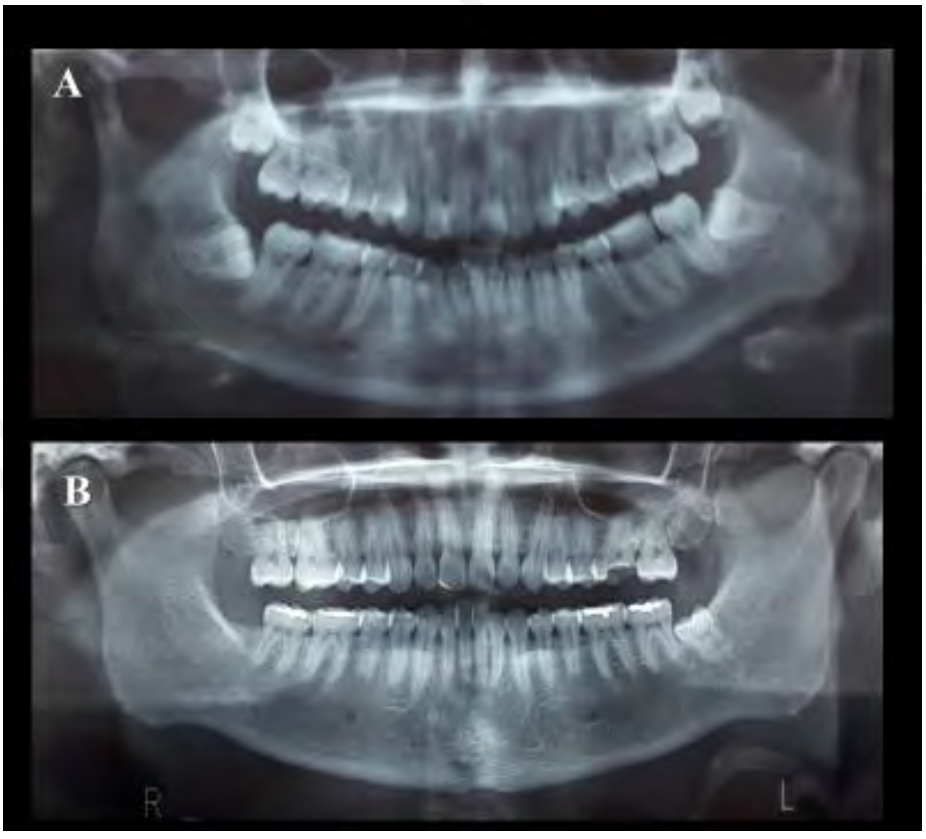


Figure 4.3: Symmetrical mental foramen position. A. MF at position 3; B. MF at position 4

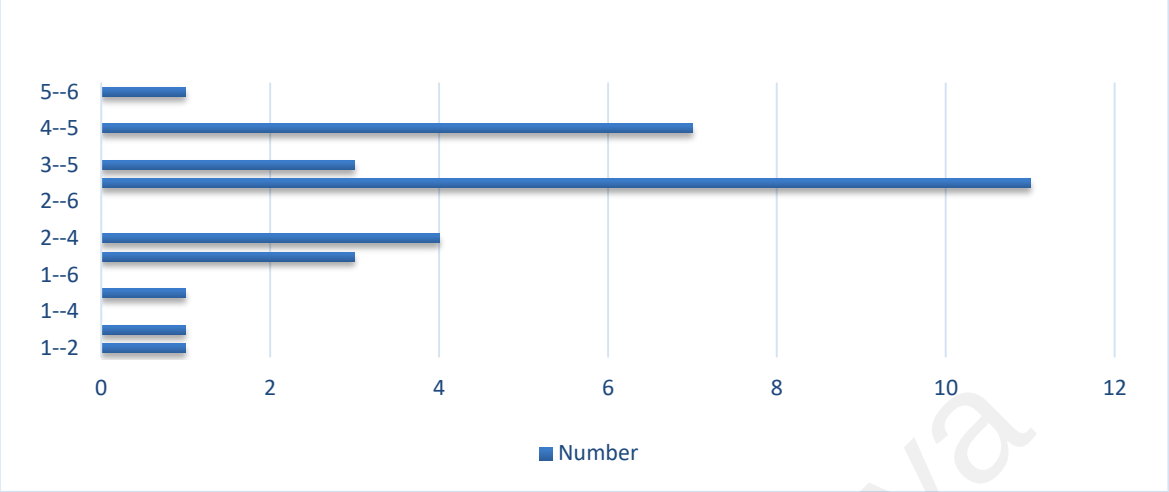


Figure 4.4: The distribution for various combination configurations of mental foramen in cases with asymmetry locations.

Table 4.3: Comparison of the locations of mental foramina between Malays and Chinese with different skeletal patterns and gender

	Number (%)			
	Malay		Chinese	
	Male (n=18)	Female (n=36)	Male (n=20)	Female (n=54)
Class I				
Position 1	-	-	2 (20.0%)	-
Position 2	-	1 (5.6%)	1 (10.0%)	2 (7.1%)
Position 3	-	7 (38.9%)	3 (30.0%)	8 (28.6%)
Position 4	5 (50%)	9 (50.0%)	4 (40.0%)	15 (53.6%)
Position 5	3 (30%)	1 (5.6%)	-	3 (10.7%)
Position 6	2 (20%)	-	-	-
Class II				
Position 1	-	-	-	-
Position 2	-	-	-	-
Position 3	-	5 (41.7%)	2 (25.0%)	1 (16.7%)
Position 4	-	3 (50.0%)	4 (50.0%)	3 (50.0%)
Position 5	-	3 (50.0%)	2 (25.0%)	2 (33.3%)
Position 6	-	1 (8.3%)	-	-
Class III				
Position 1	-	-	1 (50%)	-
Position 2	1 (12.5%)	-	-	3 (15%)
Position 3	3 (37.5%)	3 (50.0%)	-	7 (35%)
Position 4	2 (25.0%)	3 (50.0%)	-	10 (50%)
Position 5	2 (25.0%)	-	1 (50%)	-
Position 6	-	-	-	-

CHAPTER 5: DISCUSSION

The mental foramen is the opening of the short mental canal, located at the buccal cortex of the mandible. It allows a terminal branch of the inferior alveolar nerve to exit the mandible to provide innervation to the lower lip, labial mucosa, the premolars and its surrounding gingiva. It is an important landmark to locate when administering local anaesthetic agent for anaesthetizing the mandibular premolars and its surrounding structures. However, it is also the landmark to avoid during endodontic, orthodontic and surgical treatments and during the placement of both conventional and orthodontic (mini-screw) implants as iatrogenic injury resulting in neurosensory disturbance to the area of innervation has been reported (W. C. Ngeow, 2010).

Although on most panoramic radiographs, the radiographic landmarks of the mental foramen can be observed, the appearance of these landmarks varies without any change of radiographic conditions. This may be related to difference in bony density and the age of patients (W. C. Ngeow et al., 2010). For the purpose of this study, only DPTs with mental foramina present on both sides of the jaws were included. The reason for doing so was to allow determination of a possible relationship between the location of the mental foramen and the type of skeletal pattern, which is the main objective of this study.

Consistent with the finding of other studies, the majority of the patients (n=59; 92.2%) had only one mental foramen on each side of the jaws. This prevalence is similar to that reported by Shukla on North Indian population (Shukla, Gupta, Hussein, Hussain, & Singh, 2015). Based on the number of DPTs analysed, a prevalence of 7.8% of multiple foramina can be deduced. Cases of multiple foramina made up of those with one main mental foramen and 1 or more accessory mental foramen in close proximity with the former.

5.1 Accessory mental foramen

Accessory mental foramen is defined as any foramen in addition to the mental foramen on the lateral body of mandible (Figure 5.1) (Cagirankaya & Kansu, 2008; V. Gupta, Pitti, & Sholapurkar, 2015; Jha & Kumar, 2012; Mraiwa, Jacobs, van Steenberghe, & Quirynen, 2003; Paraskevas, Mavrodi, & Natsis, 2015; Prabodha & Nanayakkara, 2006b; R. Singh & Srivastav, 2011) (Ahmed, Jasani, Ali, & Avery, 2015; Kalender et al., 2012; M. Naitoh et al., 2009; Thakur, Thomas, Thayil, & Nair, 2011).

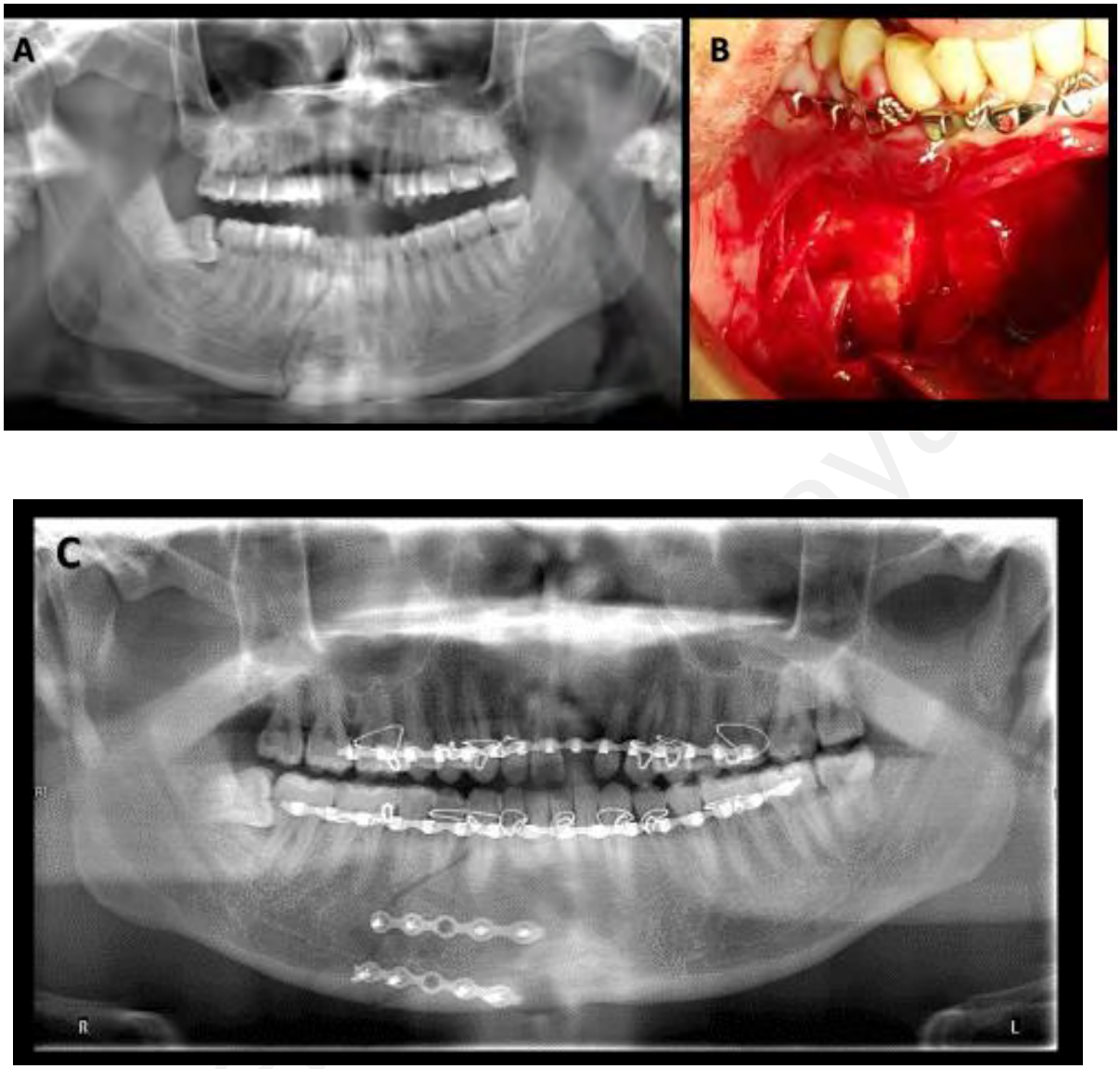


Figure 5.1: Accessory Mental foramen during open reduction of mandible (Image courtesy W.C Ngeow) - (A) Notice accessory mental foramen at superior to mental foramen position in DPT (B) Accessory mental foramen at right side of mandible following open reduction of right parasymphysis fracture . (C) DPT post-operative post-surgery

It was previously defined as a small foramen in the area surrounding the mental foramen (Riesenfeld, 1956; Sutton, 1974), however, with the advent of cone-beam computed tomography (CBCT) some researchers prefer to describe it as a foramen which is continuous with the mandibular canal, smaller than the mental foramen on each side in images (M.

Naitoh et al., 2009; M. Naitoh, Yoshida, Nakahara, Gotoh, & Ariji, 2011; Y Sisman et al., 2014; Y. Sisman et al., 2012). Other terms used to describe them are double mental foramina (Arx, Lozanoff, & Bosshardt, 2014; Igarashi, Kobayashi, Yamamoto, Morita, & Tanaka, 2004; Lopes, Pereira, & Santos, 2010), additional mental foramina (C. Oliveira-Santos et al., 2011; Santos Junior, Pinheiro, Umetsubo, Sales, & Cavalcanti, 2013), multiple mental foramina (Ilayperuma, Nanayakkara, & Palahepitiya, 2009; Munetaka Naitoh et al., 2009) or accessory buccal foramen (Y. Sisman et al., 2012).

The prevalence of accessory mental foramen has been reported to range from 0%-13.97% (Table 5.1) when studied using different methods of observation (Iwanaga et al., 2015; Moogala et al., 2014; Rai, Shrestha, & Jha, 2014; Rehman). One previous discrete cranial traits study of major human populations suggested that the prevalence of accessory mental foramen was higher among Central Asians and sub-Saharan Africans (over 20%) (Hanihara & Ishida, 2001).

However, more recent studies suggested a wider range of variations, with differences that cannot be based solely on the ethnic of the population studied. The Japanese, for example have been reported to show 5 different prevalence that ranged from 6.7% to 12.5% (Akabori, 1933; Hanihara & Ishida, 2001; K. Katakami et al., 2008; M. Naitoh et al., 2009; M. Naitoh et al., 2011), based on 3 different methods of study. Similarly, 14 studies from Indian provided a wide range from 0% to 13.97%, with only 2 studies showing prevalence that was identical (Bala, Shahdad, & Bashir, 2017; Chandramohan, Ramanathan, Rethinasamy, & Muthulingam, 2016; S. Gupta & Soni, 2012; Jaju, Jaju, & Garcha, 2013; Moogala et al., 2014; Pokhrel & Bhatnagar, 2013; Rai et al., 2014; R. Roopa, Manjunath, & Balasubramanum, 2003; Sankar, Bhanu, & Susan, 2011; Sawyer et al., 1998; Shankland, 1994; Shukla et al., 2015; R. Singh & Srivastav, 2010b; R. Singh & Srivastav, 2011; S. Singh,

Gopinathan, Bhall, & Chhabra, 1992; Udhaya, Saraladevi, & Sridhar, 2013). Do note that all these studies did not even employed panoramic imaging which has been confirmed to yield a lower detection rate of AMF (M. Naitoh et al., 2011; Neves, Torres, Oliveira, Campos, & Crusoe-Rebello, 2010).

Only one research group tried to determine the prevalence of AMF using DPT which they found to be <1% (Kqiku et al., 2013). Previous study undertaken at the University of Malaya did not reported any finding of AMF as the researchers followed the strict criteria set by Al Jasser and Nwoku (al Jasser & Nwoku, 1998), where AMF was excluded. The finding of 7.8% of AMF in this current study conforms to the range reported in the literatures, and is close to the prevalence reported for the Japanese by Naitoh et al.(M. Naitoh et al., 2011). Surprisingly, this figure was derived by studying dental panoramic radiographs. Perhaps the strict inclusion criteria enable better detection of the mental foramen and its accessory foramen.

Table 5.1: The prevalence of Accessory Mental Foramen determined using different observation methods.

Authors	Ethnic / sample	Method of assessment	Prevalence (%)	Reference
Akabori (1934)	Japanese	Dry mandible	6.7%	(Akabori, 1933)
Gerhenson et al. (1986)	Israelites (n=575)	Cadever & dry mandible	5.3	(Gershenson et al., 1986)
Serman et al. (1989)	African (n=508) American Caucasian	Dry mandible	0.88%	(Serman, 1987)
Zografos & Mutzuri (1989)	Greek (n=464)	Dry mandible	6.68%	(Zografos & Kolokoudias, 1988)
Mwaniki et al. (1992)	Kenyan (n=79)	Dry mandibles	4.5%	(Mwaniki & Hassanali, 1992)
Singh et al. (1992)	North Indians. (n=96)	Dry mandible	11.45%	(S. Singh et al., 1992)
Shankland (1994)	Indians (n=68)	Dry mandible	6.62%	(Shankland, 1994)
Mbajiorgu et al. (1998)	Zimbabweans (n=32)	Dry Mandible	9.4%	(Mbajiorgu, Mawera, Asala, & Zivanovic, 1998)
Sawyer et al. (1998)	American White (n=255) Asian Indian (n=234) African American (n=166) Nazca Indian (n=50)	Dry mandible	1.4% 1.5% 5.7% 9.0%	(Sawyer et al., 1998)
Hanihara & Ishida (2001)	Japanese	Skull & mandible	12.5%	(Hanihara & Ishida, 2001)
R Roopa, Manjunath, and Balasubramanum (2002)	South Indian (n=142)	Dry mandible	7.74%	(R Roopa et al., 2002)
Kokten et al. (2004)	Turkish (n=159)	Dry mandible (n=45) DPT (n=114)	2.2%	(Kokten, Buyukanten, & Balcioglu, 2004)
Agthong et al. (2005)	Thai (n=110)	Dry mandible	1.8%	(Agthong, Huanmanop, & Chentanez, 2005)
Igbigbi & Lebona (2005)	Malawian (n=70)	Dry mandible	4.3%	(Igbigbi & Lebona, 2005)
Prabodha and Nanayakkara (2006a)	Sri Lankan (n=24 hemimandibles)	Dry mandible	8.33%	(Prabodha & Nanayakkara, 2006a)
Taiseer Al-Khateeb, Hamasha, and Ababneh (2007)	Jordan (n=860)	Panoramic radiograph	10.0%	(T. Al-Khateeb, Al-Hadi Hamasha, & Ababneh, 2007)

Table 5.1 (continued): The prevalence of Accessory Mental Foramen determined using different observation methods

Authors	Ethnic / sample	Method of assessment	Prevalence (%)	Reference
Kaori Katakami et al. (2008)	Japanese (n=150)	CBCT	10.7%	(K. Katakami et al., 2008)
Ilayperuma et al. (2009)	Sri Lankan (n=51)	Dry mandible	3.92%	(Ilayperuma et al., 2009)
Naitoh et al. (2009)	Japanese (n=157)	CBCT	7%	(M. Naitoh et al., 2009)
Haktanır, Ilgaz, and Turhan-Haktanır (2010)	Turkish (n=100)	MDCT	4%	(Haktanir, Ilgaz, & Turhan-Haktanir, 2010)
Lopes et al. (2010)	Southern Brazilian (n=80)	Dry mandible	11.3%	(Lopes et al., 2010)
Naitoh et al. (2010)	Japanese (n=28)	CBCT	7.0%	(Munetaka Naitoh et al., 2010)
*R. Singh and Srivastav (2010a)	Indian (n=100)	Dry mandible	13.0%	(R. Singh & Srivastav, 2010b)
Naitoh et al. (2011)	Japanese (n=365)	CBCT & Panoramic radiograph	7.7%	(M. Naitoh et al., 2011)
Christiano Oliveira-Santos et al. (2011)	Brazilian Caucasian (n=285)	CBCT	9.4%	(C. Oliveira-Santos et al., 2011)
Sankar et al. (2011)	Indian (n=90)	Dry mandible	8.9%	(Sankar et al., 2011)
*Singh & Srivastav (2011)	Indian (n=100)	Dry mandible	13.0%	(R. Singh & Srivastav, 2011)
Gupta & Soni (2012)	Indian (n=200)	Dry mandible	6.7%	(S. Gupta & Soni, 2012)
Kalender et al. (2012)	Turkish (n=193)	CBCT	6.5%	(Kalender et al., 2012)
Sisman et al. (2012)	Turkish (n=504)	CT	2.0%	(Y. Sisman et al., 2012)
Göregen et al. (2013)	Turkish (n=315)	CBCT	6.3%	(Göregen, Miloğlu, Ersoy, Bayrakdar, & Akgül, 2013)
Jaju et al. (2013)	Indian (n=100)	CBCT	8.4%	(Jaju et al., 2013)
Kqiku et al. (2013)	Kosovarian (n=500)	DPT	<1%	(Kqiku et al., 2013)
Orhan et al. (2013)	Turkish (n=63 children)	CBCT	6.34%	(Orhan et al., 2013)
Pokhrel et al. (2013)	Indian (n=83)	Dry mandible	7.22%	(Pokhrel & Bhatnagar, 2013)
Udhaya et al. (2013)	Indian (n=90)	Dry mandible	5.55%	(Udhaya et al., 2013)
Arquez (2014)	Colombian (n=13)	Cadaver	7.7%	(Arquez)
Cantekin & Sekerci (2014)	Turkish children (n=275)	CBCT	6.5%	(Cantekin & Sekerci, 2014)
Hoque et al. (2014)	Bangladeshi (n=185)	Dry mandible	2.18%	(Hoque, Ara, Begum, Kamal, & Momen, 2014)
Imada et al. (2014)	Brazil (n=100)	CBCT	3.0%	(Imada et al., 2014)

Table 5.1: (continued): The prevalence of Accessory Mental Foramen determined using different observation methods

Authors	Ethnic / sample	Method of assessment	Prevalence (%)	Reference
Moogala et al. (2014)	Indian (n=219)	Dentate dry mandible (n=127) Edentulous dry mandible (n=92)	13.97% 2.76%	(Moogala et al., 2014)
Neves et al. (2014)	Brazilian (n=127)	CBCT & Panoramic radiograph	7.4%	(Neves et al., 2010)
Rai et al. (2014)	Indian (n=40)	Dry mandible	0%	(Rai et al., 2014)
Zarie et al. (2014)	Iranian (n=50)	Dry mandible	11.%	(Zarei, Ebrahimi, Dashti, Pourentezari, & Karizbodagh, 2013)
Ebrahimi et al. (2015)	Thai (n=107)	CBCT	6.6%	(Ebrahimi, Pripatnanont, Omami, & Tharanon, 2015)
Khojastepour et al. (2015)	Iranian (n=156)	CBCT	5.1%	(Khojastepour, Mirbeigi, Mirhadi, & Safaee, 2015)
Paraskevas et al. (2015)	Greek (n=96)	Dry mandible	4.17%	(Paraskevas et al., 2015)
Shukla et al. (2015)	Indian (n=70)	Dry mandible	7.2%	(Shukla et al., 2015)
Ur Rehman et al. (2015)	Pakistani (n=50)	Dry mandible	0%	(Re Rehman, Muhammad Habib Ur Bashir, Aruna Gulnaz, & Humarahman, 2015)
Zhang et al. (2015)	Chinese (n=172)	CBCT	5.81%	(Lan, Qinghua, Xuedong, Yin, & Dingming, 2015)
Chandramohan et al. (2016)	Indian (n=300)	Dry mandible	3.33%	(Chandramohan et al., 2016)
Kadel et al. (2016)	Nepalese (n=100)	Dry mandible	6.0%	(Kadel et al., 2016)
Zeng et al. (2016)	Han Chinese (n=287)	CBCT	4.88%	(Zeng, Gao, Gao, Yu, & Wu, 2016)
Bala et al. (2017)	Indian (n=41)	Dry mandible	4.87%	(Bala et al., 2017)
Zmysłowska-Polakowska et al. (2017)	Polish (n=200)	CBCT	7.0%	(Zmyslowska-Polakowska et al., 2017)

*Duplicate study

A number of studies reported that unilateral AMF was more common than bilateral ones and our finding agrees to these reports (S. Gupta & Soni, 2012; Haktanir et al., 2010; Imada et al., 2014; Jaju et al., 2013; Kalender et al., 2012; K. Katakami et al., 2008; M. Naitoh et al., 2009; C. Oliveira-Santos et al., 2011; Prabodha & Nanayakkara, 2006b; Y. Sisman et al., 2012). Bilateral accessory mental foramina are considered rare and were found in only 6–8% of accessory mental foramen cases, corresponding to approximately 0.53% of the total population ((Kalender et al., 2012; C. Oliveira-Santos et al., 2011; Y. Sisman et al., 2012). We found one such case of bilateral AMF, and in addition, this study even found one case with two accessory foramina located on a unilateral side of a subject, similar to the findings by Haktanir et al. (2010) (Haktanir et al., 2010), Katakami et al. (2008), Oliveira-Santos et al. (2011) and Naitoh et al. (2009).

Accessory mental foramen (AMF) are usually unequal in size, usually having a single large foramen with smaller satellite foramina (Kadanoff, Mutafov, & Jordanov, 1970). Our finding in one subject confirms this observation. In cases with a single AMF, its location has been reported to be variable, and can be located at any of these 8 positions: posterior, posterior-inferior, posterior-superior, anterior, anterior-superior, anterior inferior, inferior or superior to their respective mental foramen (Göregen et al., 2013; Jaju et al., 2013; Kalender et al., 2012; K. Katakami et al., 2008; M. Naitoh et al., 2009; Neves et al., 2010; C. Oliveira-Santos et al., 2011; Orhan et al., 2013; Y. Sisman et al., 2012). Studies differed as to whether accessory mental foramen is located posteroinferior, posterior or anteroinferior to the mental foramen. The findings are summarized in the Table 5.2 below.

Table 5.2: Location of the mental foramen and accessory mental foramina

Study	N	ANTERIOR			POSTERIOR			SUPERIOR	INFERIOR
		Anterosuperior	Anterior	Anteroinferior	Posterosuperior	Posterior	Posteroinferior		
Naitoh et al. (2009)	15	20%	-	-	20.%	-	60%	-	-
Katakami et al. (2008)	17	-	-	5.8%	5.8%	41.2%	11.8%	5.8%	29.4%
Kalender et al. (2012)	27	-	3.7%	37%	11.1%	-	22.2%	-	11.1
Sisman et al. (2012)	14	7.1%	7.1%	28.6%	21.4%	-	18.8%	-	-
Oliveira-Santor et al. (2011)	32	18.8%	6.3%	3.1%	15.6%	21.9%	18.8%	12.5%	3.1%
Orhan et al. (2013)	4	-	-	-	25.%	25%	60%	-	
Neves et al. (2014)	19	5.3%	-	-	10.5%	10.5%	42.1%	10.5%	21.1%
Göregen et al. (2013)	22	-	45%	-	-	-	54.6%	-	-
Jaju et al. (2013)	9	-	-	22.2%	11.1%	-	66.7%	-	-
Current Study	11	-	27.3%	9.1%	-	18.2%	18.2%	18.2%	9.1%

In our study, we found that the majority AMF were located anterior to mental foramen (27.3%, n =3). Figure 5.2 showed the AMF located anterior to right mental foramen at position 3. Otherwise AMF were equally distributed (Table 5.2). However due to limited sample size, this number was not significant.

Figure 5.2: AMF at the right mandible at the anterior position

5.2 Comparison with previous studies

5.2.1 Location

Studies involving comparison of human mandibles from different chronological periods have shown a tendency of anterior migration of mental foramen in modern humans (Liang, Jacobs, Corpas, Semal, & Lambrichts, 2009; Williams & Krovitz, 2004). Ngeow and co-workers reported on two occasions that the most common location to find a mental foramen in Malays was Position 4, with no observation at Position 1 (W. C. Ngeow et al., 2010; Wei Cheong Ngeow & Yuzawati, 2003). Their findings supported an earlier report from Singapore on the Malay population there (Neo, 1989). The finding of this current study however, does not agree with previous findings for the Malays. Firstly, the mental foramina were observed in Position 1. Secondly, the most common location for the mental foramen in the Malays appeared to be at between the first and second premolars (Position 3) followed by being in line with the second premolar (Position 4). This change of location appeared to be contributed mainly by the female Malay patients, who outnumbered male patients 2:1, instead of anterior migration as suggested by some researchers. E. Gungor, Aglarci, Unal, Dogan, & Guven, (2017) recently reported that location of the mental foramen differed significantly according to gender with that in female typically located in Position 3 when compared to male. The other explanation for this observation is local differences, which had been reported to occur in different populations (Yesilyurt et al., 2008). The finding of an ethnic or race showing two different modal positions seems to happen more commonly in the Caucasoid race (Table 1), but a similar occurrence appear to happen with the Malay subjects of this study.

The mental foramen has been reported to lie either mesial to the first premolar or lateral to the first molar in only 1–2 % of cases (Shah, Vaze, & Kinhal, 2010). Various studies conducted on different human races have shown the rarity of mental foramen being positioned in line with mandibular first molar. For example, studies done in Africa, and the middle east (K. Gungor et al., 2006; Haghanifar & Rokouei, 2009) were not able to substantiate the presence of the mental foramen in line with the mandibular first molar, while studies in Chinese found a prevalence of <1% (Santini & Land, 1990) and Wang et al. (T. M. Wang, Shih, Liu, & Kuo, 1986). An evaluation of 161 panoramic radiographs in Malaysian population (Wei Cheong Ngeow & Yuzawati, 2003) pointed out that the incidence of this uncommon position was 0.93%, which is extremely rare. The current study however found a higher prevalence of 5.6% of Position 6 in Malays but none in Chinese. This finding needs further verification as the source of interpretation is dental panoramic radiograph, which is subjected to distortion.

Studies on Chinese consistently reported that the most common position for mental foramen is Position 4 (Green, 1987; Guo et al., 2009; Lan et al., 2015; Santini & Alayan, 2012; T. M. Wang et al., 1986; Zeng et al., 2016) and the finding of this current study agreed with them. The only difference was that Santini & Land (1990) reported finding mental foramen at Position 6, which this study did not.

Lastly, except two studies (T. L. al-Khateeb et al., 1994, Gungor et al., 2017), there was generally no gender difference in the distribution of the mental foramen, which this current study agreed with.

5.2.2 Symmetry

Several authors have reported that the mental foramen was not always symmetrical in the same patient. (Bharathi, Rani, Basappa, Kanwar, & Khanum, 2016; Mohammad H. Al-Shayyab, 2015; W. C. Ngeow et al., 2010). This current study found that this was true in half of the radiographs reviewed. In comparison, previous study at this centre reported the mental foramen was symmetrically placed in 67.7% of radiographs (T. Al-Khateeb et al., 2007; Wei Cheong Ngeow & Yuzawati, 2003), while other studies elsewhere reported between 63% and 86.8% of symmetrically located mental foramina (T. Al-Khateeb et al., 2007; Parnami et al., 2015). The Zimbabwean shows difference in modal position between the sides of the mandible. The modal position on the right side was below the lower second premolar but on the left side, it was posterior to it (Mbajiorgu et al., 1998). The current finding shows no such tendency with the most modal mental foramen being Position 4.

5.2.3 Effect of skeletal growth and pattern on the mental foramen

Yamaguchi (1959) reported that the mental foramen was not completely formed until the twelfth gestational week. By this time, the mental nerve would have separated into several fasciculi at this site (Yamaguchi, 1959). This early separation of soft tissue and later formation of hard tissue may explain for the occurrence of a sensory mental foramen described above (Toh, Kodama, Yanagisako, & Ohmori, 1992). However, this embryological finding does not explain why the mental foramen was more commonly located at the apical region of the second premolar irrespective of the size of the mandible. At twelfth gestational week, the dental buds of primary teeth have not even formed, so they cannot act as a centre to influence the branching of the inferior alveolar nerve into the mental and incisive nerves.

Previous study from this centre found that the mental foramen was located between the first and second premolars in children, but 'drifted' distally as the age of children increases (Lim, Lim, Rajan, Nambiar, & Ngeow, 2015). Similar observation has been reported with the increase of age in several other populations, where there was an increase in the frequency of more posterior locations of the mental foramen (T. Al-Khateeb et al., 2007; Santini & Land, 1990; Soheilifar et al., 2016). This supports the suggestion that variations in facial characteristics of patients associated with growth and development can lead to mesial or distal angulation of the mental foramen. Thus, local studies in adults of different age groups found that the location of the mental foramen remains constant with changes in age (W. C. Ngeow et al., 2010). Based on currently available knowledge, it can only be summarised that the location of mental foramen changes when the jaw grow, but it is not influenced by the skeletal pattern of subjects. Somehow, for unknown reason, there is a tendency for the mental foramen to be related closely with the second premolars in Malays and Chinese.

CHAPTER 6: CONCLUSION

6.1 Conclusion

This study was designed to compare the antero-posterior location of mental foramina in two major racial ethnics in Malaysia, namely the Malays and Chinese, and to determine if their skeletal pattern influenced its location. The mental foramen when viewed on the panoramic radiographs was most commonly found in the long axis of the second premolar. Only half of these mental foramina appeared to be symmetrical in the same antero-posterior position, with the majority (53.1%) located at Position 4, followed by Position 3. The gender, site and skeletal pattern of patients did not influence the antero-posterior location of the mental foramen in relation to the dentition. The result of this study is comparable to other findings in the Orientals/Mongoloid population.

6.2 Limitation of the study

This study using DPT to evaluate the position of the mental foramen. However usage of the DPT have a lot of external factor that influence the outcome of the study such as patient positioning, type of panoramic machine, exposure and superimposition of the image with surrounding soft tissue may distort the image.

Beside that have the sample size that fulfil the criteria of study is small. Most patient have skeletal pattern class I with less patient seen with class II and class III.

6.3 Recommendation

For the future study we would recommend larger sample size. To eliminate the distortion of image in DPT we would recommend the CBCT to evaluate the mental foramen.

REFERENCES

Agthong, S., Huanmanop, T., & Chentanez, V. (2005). Anatomical variations of the supraorbital, infraorbital, and mental foramina related to gender and side. *J Oral Maxillofac Surg, 63*(6), 800-804.

Ahmed, S., Jasani, V., Ali, A., & Avery, C. (2015). Double accessory mental foramina: report of an anatomical variant. *Oral Surgery, 8*(1), 51-53.

Ajmal, M. (2014). Evaluation of mental foramen position from panoramic dental radiographs. *J Contemp Dent Pract, 15*(4), 399-402.

Akabori, E. (1933). Crania Nipponica Recentia. I. Analytical inquiries into the non-metric variations in the Japanese skull according to age and sex. *Japanese Journal of Medical Science, Section 1, Anatomy, 4*, 61-315.

Aktekin, M., Celik, H. M., Celik, H. H., Aldur, M. M., & Aksit, M. D. (2003). Studies on the location of the mental foramen in Turkish mandibles. *Morphologie, 87*(277), 17-19.

Al-Khateeb, T., Al-Hadi Hamasha, A., & Ababneh, K. T. (2007). Position of the mental foramen in a northern regional Jordanian population. *Surg Radiol Anat, 29*(3), 231-237.

Al-Khateeb, T., Hamasha, A. A.-H., & Ababneh, K. T. (2007). Position of the mental foramen in a northern regional Jordanian population. *Surgical and Radiologic Anatomy, 29*(3), 231-237.

Al-Khateeb, T. L. (1998). Morphologic effects of glycerol on the mental nerve. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 85*(3), 248-251.

al-Khateeb, T. L., Odukoya, O., & el-Hadidy, M. A. (1994). Panoramic radiographic study of mental foramen locations in Saudi Arabians. *Afr Dent J, 8*, 16-19.

al Jasser, N. M., & Nwoku, A. L. (1998). Radiographic study of the mental foramen in a selected Saudi population. *Dentomaxillofac Radiol, 27*(6), 341-343.

Aminoshariae, A., Su, A., & Kulild, J. C. (2014). Determination of the location of the mental foramen: a critical review. *J Endod, 40*(4), 471-475.

Angel, J. S., Mincer, H. H., Chaudhry, J., & Scarbecz, M. (2011). Cone-beam computed tomography for analyzing variations in inferior alveolar canal location in adults in relation to age and sex. *J Forensic Sci, 56*(1), 216-219.

Apinhasmit, W., Methathrathip, D., Chompoopong, S., & Sangvichien, S. (2006). Mental foramen in Thais: an anatomical variation related to gender and side. *Surg Radiol Anat, 28*(5), 529-533.

Arquez, H. F. (2014). Accessory Nerve and Mental Foramen. *International Journal of Pharma and Bio Sciences, 5(4)*, 739 - 744.

Arx, T., Lozanoff, S., & Bosshardt, D. (2014). Accessory mental foramina: anatomy and histology of neurovascularisation in four cases with apical surgery. *Oral Surgery, 7*(4), 216-227.

Azar, M. D. I., & Lear, M. D. E. (1986). Lower Lip Numbness Following General Anesthesia. *Anesthesiology, 65*(4), 450-450.

Bala, S. S., Shahdad, S., & Bashir, S. (2017). Morphology and morphometry of mental foramen in dry human mandibles. *International Journal of Research in Medical Sciences, 5*(4), 1461-1463.

Balcioglu, H. A., Kilic, C., Akyol, M., & Ulusoy, A. T. (2011). Horizontal migration of pre- and postnatal mental foramen: an anatomic study. *Int J Pediatr Otorhinolaryngol, 75*(11), 1436-1441.

Bavitz, J. B., Harn, S. D., Hansen, C. A., & Lang, M. (1993). An anatomical study of mental neurovascular bundle-implant relationships. *International Journal of Oral & Maxillofacial Implants, 8*(5).

Baxmann, M. (2006). Mental paresthesia and orthodontic treatment. *Angle Orthod, 76*(3), 533-537.

Bharathi, U., Rani, R. P., Basappa, S., Kanwar, S., & Khanum, N. (2016). Position of the mental foramen in Indian and Iranian subjects: a radiographic study. *Journal of International Oral Health, 8*(1), 41.

Bhardwaj, D., Kumar, J. S., & Mohan, V. (2014). Radiographic evaluation of mandible to predict the gender and age. *J Clin Diagn Res, 8*(10), ZC66-69.

Bhuiyan, M. S., & Chapman, M. (2006). Mental nerve injury following facemask anaesthesia. *Anaesthesia, 61*(5), 516-517; author reply 517.

Cagirankaya, L. B., & Kansu, H. (2008). An accessory mental foramen: a case report. *J Contemp Dent Pract, 9*(1), 98-104.

Cantekin, K., & Sekerci, A. (2014). Evaluation of the accessory mental foramen in a pediatric population using cone-beam computed tomography. *J Clin Pediatr Dent, 39*(1), 85-89.

Chandramohan, R. V., Ramanathan, S., Rethinasamy, M., & Muthulingam, V. (2016). A Comparative Study of Morphological and Morphometric Analysis of Mental Foramen and Its Clinical Importance on Human Dry Mandibles of South Indian Population. *Journal of Evolution of Medical and Dental Sciences, 5*(74), 5439-5444.

Chkoura, A., & El Wady, W. (2013). Position of the mental foramen in a Moroccan population: A radiographic study. *Imaging Sci Dent, 43*(2), 71-75.

Chrcanovic, B. R., Abreu, M. H., & Custodio, A. L. (2011). Morphological variation in dentate and edentulous human mandibles. *Surg Radiol Anat, 33*(3), 203-213.

Chu, R. A., Nahas, F. X., Di Martino, M., Soares, F. A., Novo, N. F., Smith, R. L., & Ferreira, L. M. (2014). The enigma of the mental foramen as it relates to plastic surgery. *J Craniofac Surg, 25*(1), 238-242.

Concepcion, M., & Rankow, H. J. (2000). Accessory branch of the mental nerve. *J Endod, 26*(10), 619-620.

Cutright, B., Quillopa, N., & Schubert, W. (2003). An anthropometric analysis of the key foramina for maxillofacial surgery. *J Oral Maxillofac Surg, 61*(3), 354-357.

da Silva Ramos Fernandes, L. M., Capelozza, A. L., & Rubira-Bullen, I. R. (2011). Absence and hypoplasia of the mental foramen detected in CBCT images: a case report. *Surg Radiol Anat, 33*(8), 731-734.

de Freitas, V., Madeira, M. C., Toledo Filho, J. L., & Chagas, C. F. (1979). Absence of the mental foramen in dry human mandibles. *Acta Anat (Basel), 104*(3), 353-355.

Ebrahimi, M., Pripatnanont, P., Omami, G., & Tharanon, W. (2015). Cone-Beam Computed Tomography analysis of mental and genial spinal foramina in a Thai population. *International Journal of Dentistry and Oral Science*.

Elahi, F., Manolitsis, N., Ranganath, Y. S., & Reddy, C. (2014). Mental nerve neuropathy following dental extraction. *Pain Physician, 17*(3), E375-380.

Fishel, D., Buchner, A., Hershkowith, A., & Kaffe, I. (1976). Roentgenologic study of the mental foramen. *Oral Surg Oral Med Oral Pathol, 41*(5), 682-686.

Fujita, A., & Suzuki, T. (2014). Computed tomographic analysis of the mental foramen and nerve in Japanese patients. *Implant Dent, 23*(4), 471-476.

Gamoh, S., Mori, Y., Nakatsuka, M., Akiyama, H., Ogawa, Y., Iwai, Y., Shimizutani, K. (2014). Accessory mental foramen misdiagnosed as radiolucent tumour by conventional dental radiography. *Open Journal of Radiology, 2014*.

Gershenson, A., Nathan, H., & Luchansky, E. (1986). Mental foramen and mental nerve: changes with age. *Acta Anat (Basel), 126*(1), 21-28.

Gimmon, Z. (1988). Neuropraxia of the mental nerve. *Anaesthesia, 43*(7), 613.

Göregen, M., Miloğlu, Ö., Ersoy, İ., Bayrakdar, İ. Ş., & Akgül, H. M. (2013). The assessment of accessory mental foramina using cone-beam computed tomography. *Turkish Journal of Medical Sciences, 43*(3), 479-483.

Green, R. M. (1987). 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, 63*(3), 287-290.

Gungor, E., Aglarci, O. S., Unal, M., Dogan, M. S., & Guven, S. (2017). Evaluation of mental foramen location in the 10-70 years age range using cone-beam computed tomography. *Niger J Clin Pract, 20*(1), 88-92.

Gungor, K., Ozturk, M., Semiz, M., & Brooks, S. L. (2006). A radiographic study of location of mental foramen in a selected Turkish population on panoramic radiograph. *Coll Antropol, 30*(4), 801-805.

Guo, J. L., Su, L., Zhao, J. L., Yang, L., Lv, D. L., Li, Y. Q., & Cheng, F. B. (2009). Location of mental foramen based on soft- and hard-tissue landmarks in a chinese population. *J Craniofac Surg, 20*(6), 2235-2237.

Gupta, S., & Soni, J. S. (2012). Study of anatomical variations and incidence of mental foramen and accessory mental foramen in dry human mandibles. *Natl J Med Res, 2*(1), 28-30.

Gupta, V., Pitti, P., & Sholapurkar, A. (2015). Panoramic radiographic study of mental foramen in selected dravidians of south Indian population: A hospital based study. *J Clin Exp Dent, 7*(4), e451-456.

Haghanifar, S., & Rokouei, M. (2009). Radiographic evaluation of the mental foramen in a selected Iranian population. *Indian J Dent Res, 20*(2), 150-152.

Haktanir, A., Ilgaz, K., & Turhan-Haktanir, N. (2010). Evaluation of mental foramina in adult living crania with MDCT. *Surg Radiol Anat, 32*(4), 351-356.

Haktanır, A., Ilgaz, K., & Turhan-Haktanır, N. (2010). Evaluation of mental foramina in adult living crania with MDCT. *Surgical and Radiologic Anatomy, 32*(4), 351-356.

Hanihara, T., & Ishida, H. (2001). Frequency variations of discrete cranial traits in major human populations. IV. Vessel and nerve related variations. *J Anat, 199*(3), 273-287.

Hoque, M. M., Ara, S., Begum, S., Kamal, A. M., & Momen, M. A. (2014). Study of number, shape, size and position of mental foramen in bangladeshi dry adult human mandible. *Bangladesh Journal of Anatomy, 11*(1), 7-10.

Hu, K.-S., Yun, H.-S., Hur, M.-S., Kwon, H.-J., Abe, S., & Kim, H.-J. (2007). Branching Patterns and Intraosseous Course of the Mental Nerve. *Journal of Oral and Maxillofacial Surgery, 65*(11), 2288-2294.

Igarashi, C., Kobayashi, K., Yamamoto, A., Morita, Y., & Tanaka, M. (2004). Double mental foramina of the mandible on computed tomography images: a case report. *Oral Radiology, 20*(2), 68-71.

Igbigbi, P. S., & Lebona, S. (2005). The position and dimensions of the mental foramen in adult Malawian mandibles. *West African Journal of Medicine, 24*(3).

Ilayperuma, I., Nanayakkara, G., & Palahepitiya, N. (2009). Morphometric Analysis of the Mental Foramen in Adult Sri Lankan Mandibles. *International Journal Of Morphology, 27*(4).

Imada, T. S. N., Fernandes, L. M. P. d. S. R., Centurion, B. S., de Oliveira-Santos, C., Honório, H. M., & Rubira-Bullen, I. R. F. (2014). Accessory mental foramina: prevalence, position and diameter assessed by cone-beam computed tomography and digital panoramic radiographs. *Clinical Oral Implants Research, 25*(2), e94-e99.

Iwanaga, J., Saga, T., Tabira, Y., Nakamura, M., Kitashima, S., Watanabe, K., Yamaki, K. (2015). The clinical anatomy of accessory mental nerves and foramina. *Clin Anat, 28*(7), 848-856.

Jaju, P. P., Jaju, S. P., & Garcha, V. (2013). Accessory mental foramina detection by cone beam CT in Indian population. *Sdj, 8*, 32-36.

Jalili, M. R., Esmaeelinejad, M., Bayat, M., & Aghdasi, M. M. (2012). Appearance of anatomical structures of mandible on panoramic radiographs in Iranian population. *Acta Odontol Scand, 70*(5), 384-389.

Janfaza, P. (2011). *Surgical anatomy of the head and neck*: Harvard University Press.

Jha, A. K., & Kumar, N. G. (2012). Accessory mental nerve: case report, review and its role in trigeminal neuralgia. *Surgical and Radiologic Anatomy, 34*(5), 469-473.

Kadanoff, D., Mutafov, S., & Jordanov, J. (1970). [The principle openings and incisures of the facial bones (incisura frontalis seu foramen frontale, foramen supraoriitale seu incisura supraorbitalis, foramen infraorbitale, foramen mentale)]. *Gegenbaurs Morphol Jahrb, 115*(1), 102-118.

Kadel, M., Sedhain, B. P., & Dangol, P. M. (2016). *Morphometric analysis of mental foramen in human dry mandibles of nepalese population* (Vol. 7).

Kalender, A., Orhan, K., & Aksoy, U. (2012). Evaluation of the mental foramen and accessory mental foramen in Turkish patients using cone-beam computed tomography images reconstructed from a volumetric rendering program. *Clin Anat, 25*(5), 584-592.

Katakami, K., Mishima, A., Shiozaki, K., Shimoda, S., Hamada, Y., & Kobayashi, K. (2008). Characteristics of accessory mental foramina observed on limited cone-beam computed tomography images. *J Endod, 34*(12), 1441-1445.

Katakami, K., Mishima, A., Shiozaki, K., Shimoda, S., Hamada, Y., & Kobayashi, K. (2008). Characteristics of accessory mental foramina observed on limited cone-beam computed tomography images. *Journal of Endodontics, 34*(12), 1441-1445.

Khojastepour, L., Mirbeigi, S., Mirhadi, S., & Safaee, A. (2015). Location of Mental Foramen in a Selected Iranian Population: A CBCT Assessment. *Iran Endod J, 10*(2), 117-121.

Kim, I. S., Kim, S. G., Kim, Y. K., & Kim, J. D. (2006). Position of the mental foramen in a Korean population: a clinical and radiographic study. *Implant Dent, 15*(4), 404-411.

Kjaer, I. (1989). Formation and early prenatal location of the human mental foramen. *Scand J Dent Res, 97*(1), 1-7.

Knowles, K. I., Jergenson, M. A., & Howard, J. H. (2003). Paresthesia Associated with Endodontic Treatment of Mandibular Premolars. *J Endod, 29*(11), 768-770. doi:

Kokten, G., Buyukanten, M., & Balcioglu, H. (2004). Foramen mentalenin cap ve lokalizasyonunun kuru kemik ve panoramik radyografilerde. *Istanbul Univ Dishekim Fak Derg, 38*, 65-71.

Kqiku, L., Sivic, E., Weiglein, A., & Stadtler, P. (2011). Position of the mental foramen: an anatomical study. *Wien Med Wochenschr, 161*(9-10), 272-273.

Kqiku, L., Weiglein, A., Kamberi, B., Hoxha, V., Meqa, K., & Stadtler, P. (2013). Position of the mental foramen in Kosovarian population. *Coll Antropol, 37*(2), 545-549.

Laher, A. E., Motara, F., & Moolla, M. (2016). The Ultrasonographic Determination of the Position of the Mental Foramen and its Relation to the Mandibular Premolar Teeth. *J Clin Diagn Res, 10*(6), OC23-27.

Laher, A. E., Wells, M., Motara, F., Kramer, E., Moolla, M., & Mahomed, Z. (2016). Finding the mental foramen. *Surg Radiol Anat, 38*(4), 469-476.

Lan, Z., Qinghua, Z., Xuedong, Z., Yin, L., & Dingming, H. (2015). Anatomic relationship between mental foramen and peripheral structures observed by cone-beam computed tomography. *Anatomy and Physiology, 5*(4), - -.

Lauhr, G., Coutant, J. C., Normand, E., Laurenjoye, M., & Ella, B. (2015). Bilateral absence of mental foramen in a living human subject. *Surg Radiol Anat, 37*(4), 403-405.

Le Double, A.-F. (1906). *Traité des variations des os de la face de l'homme: et de leur signification au point de vue de l'anthropologie zoologique*: Vigot frères.

Liang, X., Jacobs, R., Corpas, L. S., Semal, P., & Lambrichts, I. (2009). Chronologic and geographic variability of neurovascular structures in the human mandible. *Forensic Sci Int, 190*(1-3), 24-32.

Lim, M. Y., Lim, W. W., Rajan, S., Nambiar, P., & Ngeow, W. C. (2015). Age-related changes in the location of the mandibular and mental foramen in children with Mongoloid skeletal pattern. *Eur Arch Paediatr Dent, 16*(5), 397-407.

Lopes, P., Pereira, G., & Santos, A. (2010). Location of the mental foramen in dry mandibles of adult individuals in Southern Brazil. *J Morphol Sci, 27*(1), 23-25.

Lorentz, A., Podstawski, H., & Osswald, P. M. (1988). [Numbness of the lower lip following general anesthesia]. *Anaesthesist, 37*(6), 381-383.

Matsumoto, K., Araki, M., & Honda, K. (2013). Bilateral absence of the mental foramen detected by cone-beam computed tomography. *Oral Radiology, 29*(2), 198-201.

Mbajiorgu, E. F., Mawera, G., Asala, S. A., & Zivanovic, S. (1998). Position of the mental foramen in adult black Zimbabwean mandibles: a clinical anatomical study. *Cent Afr J Med, 44*(2), 24-30.

Mills, J. R. E. (1987). *Principles and practice of orthodontics*: Churchill Livingstone.

Mohammad H. Al-Shayyab, F. A., Najla S. Dar-Odeh, Soukaina Ryalat & Zaid H. Baqain. (2015). The mental foramen I: radiographic study of the anterior-posterior position and shape in Iraqi population. *International Journal Of Morphology, 33*(1), 149-157.

Moiseiwitsch, J. R. (1995). Avoiding the mental foramen during periapical surgery. *J Endod, 21*(6), 340-342.

Moiseiwitsch, J. R. (1998). Position of the mental foramen in a North American, white population. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 85*(4), 457-460.

Moogala, S., Sanivarapu, S., Boyapati, R., Devulapalli, N. S., Chakrapani, S., & Kolaparthy, L. (2014). Anthropometrics of mental foramen in dry dentate and edentulous mandibles in Coastal Andhra population of Andhra Pradesh State. *J Indian Soc Periodontol, 18*(4), 497-502.

Morse, D. R. (1997a). Endodontic-related inferior alveolar nerve and mental foramen paresthesia. *Compend Contin Educ Dent, 18*(10), 963-968, 970-963, 976-968 passim; quiz 998.

Morse, D. R. (1997b). Infection-related mental and inferior alveolar nerve paresthesia: literature review and presentation of two cases. *J Endod, 23*(7), 457-460.

Mraiwa, N., Jacobs, R., van Steenberghe, D., & Quirynen, M. (2003). Clinical assessment and surgical implications of anatomic challenges in the anterior mandible. *Clin Implant Dent Relat Res, 5*(4), 219-225.

Mwaniki, D., & Hassanali, J. (1992). The position of mandibular and mental foramina in Kenyan African mandibles. *East African medical journal, 69*(4), 210-213.

Naitoh, M., Hiraiwa, Y., Aimiya, H., Gotoh, K., & Ariji, E. (2009). Accessory mental foramen assessment using cone-beam computed tomography. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 107*(2), 289-294.

Naitoh, M., Nakahara, K., Hiraiwa, Y., Aimiya, H., GOTOH, K., & ARIJI, E. (2009). Observation of buccal foramen in mandibular body using cone-beam computed tomography. *Okajimas Folia Anat Jpn, 86*(1), 25-29.

Naitoh, M., Nakahara, K., Suenaga, Y., Gotoh, K., Kondo, S., & Ariji, E. (2010). Comparison between cone-beam and multislice computed tomography depicting mandibular neurovascular canal structures. *Oral Surgery, Oral Medicine, Oral*

Naitoh, M., Yoshida, K., Nakahara, K., Gotoh, K., & Ariji, E. (2011). Demonstration of the accessory mental foramen using rotational panoramic radiography compared with cone-beam computed tomography. *Clin Oral Implants Res, 22*(12), 1415-1419.

Neo, J. (1989). Position of the mental foramen in Singaporean Malays and Indians. *Anesth Prog, 36*(6), 276-278.

Neves, F. S., Torres, M. G., Oliveira, C., Campos, P. S., & Crusoe-Rebello, I. (2010). Lingual accessory mental foramen: a report of an extremely rare anatomical variation. *J Oral Sci, 52*(3), 501-503.

Ngeow, W. C. (2010). Is there a "safety zone" in the mandibular premolar region where damage to the mental nerve can be avoided if periapical extrusion occurs? *J Can Dent Assoc, 76*, a61.

Ngeow, W. C., Dionysius, D. D., Ishak, H., & Nambiar, P. (2010). Effect of ageing towards location and visibility of mental foramen on panoramic radiographs. *Singapore Dent J, 31*(1), 15-19.

Ngeow, W. C., & Yuzawati, Y. (2003). The location of the mental foramen in a selected Malay population. *Journal of Oral Science, 45*(3), 171-175.

Olasoji, H. O., Tahir, A., Ekanem, A. U., & Abubakar, A. A. (2004). Radiographic and anatomic locations of mental foramen in northern Nigerian adults. *Niger Postgrad Med J, 11*(3), 230-233.

Oliveira-Santos, C., Souza, P. H., De Azambuja Berti-Couto, S., Stinkens, L., Moyaert, K., Van Assche, N., & Jacobs, R. (2011). Characterisation of additional mental foramina through cone beam computed tomography. *J Oral Rehabil, 38*(8), 595-600.

Oliveira-Santos, C., Souza, P. H. C., De AZAMBUJA BERTI-COUTO, S., Stinkens, L., Moyaert, K., Van Assche, N., & Jacobs, R. (2011). Characterisation of additional mental foramina through cone beam computed tomography. *Journal of oral rehabilitation, 38*(8), 595-600.

Orhan, A. I., Orhan, K., Aksoy, S., Ozgul, O., Horasan, S., Arslan, A., & Kocyigit, D. (2013). Evaluation of perimandibular neurovascularization with accessory mental foramina using cone-beam computed tomography in children. *J Craniofac Surg, 24*(4), e365-369.

Orstavik, D., Brodin, P., & Aas, E. (1983). Paraesthesia following endodontic treatment: survey of the literature and report of a case. *Int Endod J, 16*(4), 167-172.

Paraskevas, G., Mavrodi, A., & Natsis, K. (2015). Accessory mental foramen: an anatomical study on dry mandibles and review of the literature. *Oral Maxillofac Surg, 19*(2), 177-181.

Parnami, P., Gupta, D., Arora, V., Bhalla, S., Kumar, A., & Malik, R. (2015). Assessment of the Horizontal and Vertical Position of Mental Foramen in Indian Population in Terms of Age and Sex in Dentate Subjects by Pano-ramic Radiographs: A Retrospective Study with Review of Literature. *Open Dent J, 9*, 297-302.

Philips, J. L., Weller, R. N., & Kulild, J. C. (1992). The mental foramen: Part II. Radiographic position in relation to the mandibular second premolar. *J Endod, 18*(6), 271-274.

Phillips, J. L., Weller, R. N., & Kulild, J. C. (1990). The mental forman: Part I. Size, orientation, and positional relationship to the mandibular second premolar. *J Endod, 16*(5), 221-223.

Pogrel, M. A. (2007). Damage to the inferior alveolar nerve as the result of root canal therapy. *J Am Dent Assoc, 138*(1), 65-69.

Pokhrel, R., & Bhatnagar, R. (2013). Position and number of mental foramen in dry human mandibles: Comparison with respect to sides and sexes. *Open Access Anatomy, 1*(4), 31.

Poveda, R., Bagán, J. V., Fernández, J. M. D., & Sanchis, J. M. (2006). Mental nerve paresthesia associated with endodontic paste within the mandibular canal: report of a case. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 102*(5), e46-e49. doi:

Prabodha, L., & Nanayakkara, B. (2006a). The position, dimensions and morphological variations of mental foamen in mandibles. *Galle Medical Journal, 11*(1).

Rai, R., Shrestha, S., & Jha, S. (2014). Mental foramen: A morphological and morphometrical study. *Int J Health Biomed Res, 2*, 144-150.

Rehman, M. H. U. B., Aruna Gulnaz, Humara. (2015). A morphological study of Mental Foramen in adult human mandibles of unknown age and sex in Pakistani population. *Pakistan Journal of Medicaal & Health Sciences, 9*(2), 614-616.

Riesenfeld, A. (1956). Multiple infraobaital, ethmoidal, and mental foramina in the races of man. *Am J Phys Anthropol, 14*(1), 85-100.

Roopa, R., Manjunath, K., & Balasubramanum, V. (2002). The direction and location of mental foramen and incidence of accessory mental foramen in south Indian mandibles. *Indian journal of dental research: official publication of Indian Society for Dental Research, 14*(1), 57-58.

Sakkas, N., Otten, J.-E., Gutwald, R., & Schmelzeisen, R. (2008). Transposition of the mental nerve by piezosurgery followed by postoperative neurosensory control: A case report. *British Journal of Oral and Maxillofacial Surgery, 46*(4), 270-271.

Sankar, D. K., Bhanu, S. P., & Susan, P. J. (2011). Morphometrical and morphological study of mental foramen in dry dentulous mandibles of South Andhra population of India. *Indian J Dent Res, 22*(4), 542-546.

Santini, A., & Alayan, I. (2012). A comparative anthropometric study of the position of the mental foramen in three populations. *Br Dent J, 212*(4), E7. doi: 10.1038/sj.bdj.2012.143

Santini, A., & Land, M. (1990). A comparison of the position of the mental foramen in Chinese and British mandibles. *Acta Anat (Basel), 137*(3), 208-212.

Santos Junior, O., Pinheiro, L. R., Umetsubo, O. S., Sales, M. A. O., & Cavalcanti, M. G. P. (2013). Assessment of open source software for CBCT in detecting additional mental foramina. *Brazilian oral research, 27*(2), 128-135.

Sawyer, D. R., Kiely, M. L., & Pyle, M. A. (1998). The frequency of accessory mental foramina in four ethnic groups. *Archives of Oral Biology, 43*(5), 417-420.

Scarano, A., Di Carlo, F., Quaranta, A., & Piattelli, A. (2007). Injury of the inferior alveolar nerve after overfilling of the root canal with endodontic cement: a case report. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod, 104*(1), e56-59. doi: 10.1016/j.tripleo.2007.01.036

Serman, N. J. (1987). Differentiation of double mental foramina from extra bony coursing of the incisive branch of the mandibular nerve--an anatomic study. *Refuat Hashinayim, 5*(3), 20-22.

Shah, S., Vaze, S., & Kinhal, K. (2010). A variation in the position of the mental foramen: a case report. *J Maxillofac Oral Surg, 9*(3), 307-309.

Shankland, W. E., 2nd. (1994). The position of the mental foramen in Asian Indians. *J Oral Implantol, 20*(2), 118-123.

Shibahara, T., Noma, H., Yamane, G., Katakura, A., Takasaki, Y., & Tamada, Y. (1996). Transposition of the mental nerve and inferior alveolar nerve trunk. *Bull Tokyo Dent Coll, 37*(2), 103-107.

Shukla, R. K., Gupta, P., Hussein, M., Hussain, F., & Singh, A. B. (2015). Morphometric Measurement of Mental Foramen in Dry Human Mandible in North Indian Population.

Singh, R., & Srivastav, A. (2010a). Study of position, shape, size and incidence of mental foramen and accessory mental foramen in Indian adult human skulls. *Int J Morphol, 28*(4), 1141-1146.

Singh, R., & Srivastav, A. K. (2011). Evaluation of position, shape, size and incidence of mental foramen and accessory mental foramen in Indian adult human skulls. *Int J Exp Clin Anat, 5*, 23-29.

Singh, S., Gopinathan, K., Bhall, U., & Chhabra, S. (1992). Variations in the position and number of mental foramen in mandibles of North Indian population. *J Anat Soc India, 41*(1), 47-51.

Sinnatamby, C. S. (2011). *Last's anatomy: regional and applied* (12th ed.): Elsevier Health Sciences.

Sisman, Y., Sahman, H., Sekerci, A., Tokmak, T., Aksu, Y., & Mavili, E. (2014). Detection and characterization of the mandibular accessory buccal foramen using CT. *Dentomaxillofacial Radiology*.

Sisman, Y., Sahman, H., Sekerci, A. E., Tokmak, T. T., Aksu, Y., & Mavili, E. (2012). Detection and characterization of the mandibular accessory buccal foramen using CT. *Dentomaxillofacial Radiology, 41*(7), 558-563.

Soheilifar, S., Bidgoli, M., Shokri, A., Faradmal, J., Kafilzadeh, S., Eyvazi, P., & Nikkhah, M. (2016). Panoramic radiographic study of mandibular canal and

mental foramen in a selected Iranian population. *SRM Journal of Research in Dental Sciences, 7*(4), 209.

Stosic, T., Bogdanovic, D., Mrvaljevic, D., & Mijac, M. (1978). [Mental foramen variations]. *Stomatol Glas Srb, 25*(3), 203-208.

Sutton, R. (1974). The practical significance of mandibular accessory foramina. *Australian dental journal, 19*(3), 167-173.

Thakur, G., Thomas, S., Thayil, S. C., & Nair, P. P. (2011). Accessory mental foramen: a rare anatomical finding. *BMJ Case Rep, 2011*. doi: 10.1136/bcr.09.2010.3326

Toh, H., Kodama, J., Yanagisako, M., & Ohmori, T. (1992). Anatomical study of the accessory mental foramen and the distribution of its nerve. *Okajimas Folia Anat Jpn, 69*(2-3), 85-88.

Udhaya, K., Saraladevi, K. V., & Sridhar, J. (2013). The morphometric analysis of the mental foramen in adult dry human mandibles: a study on the South Indian population. *J Clin Diagn Res, 7*(8), 1547-1551. d

Ukoha, U. U., Umeasalugo, K. E., Ofoego, U. C., Ejimofor, O. C., Nzeako, H. C., & Edokwe, C. G. (2013). Position, shape and direction of the mental foramen in mandibles in South-Eastern Nigeria. *International journal of biomedical research, 4*(9), 499-503.

Wang, C., Gui, L., & Liu, J. (2015). A Practical Surgical Technique to Expose the Mental Nerve in Narrowing Genioplasty. *Plastic and Reconstructive Surgery Global Open, 3*(11), e554.

Wang, T. M., Shih, C., Liu, J. C., & Kuo, K. J. (1986). A clinical and anatomical study of the location of the mental foramen in adult Chinese mandibles. *Acta Anat (Basel), 126*(1), 29-33.

Westermark, A., Bystedt, H., & von Konow, L. (1998). Inferior alveolar nerve function after mandibular osteotomies. *Br J Oral Maxillofac Surg, 36*(6), 425-428.

Williams, F. L., & Krovitz, G. E. (2004). Ontogenetic migration of the mental foramen in Neandertals and modern humans. *J Hum Evol, 47*(4), 199-219. d

Wismeijer, D., van Waas, M. A. J., Vermeeren, J. I. J. F., & Kalk, W. (1997). Patients' perception of sensory disturbances of the mental nerve before and after implant surgery: a prospective study of 110 patients. *British Journal of Oral and Maxillofacial Surgery, 35*(4), 254-259.

Xie, Q., Wolf, J., Soikkonen, K., & Ainamo, A. (1996). Height of mandibular basal bone in dentate and edentulous subjects. *Acta Odontol Scand, 54*(6), 379-383.

Yamaguchi, K. (1959). Development of the mental and its adjacent area and their histological studies – Report 2. The mid embryological stage and the latter embryological *ShikwaIgaku, 2*, 296-312.

Yesilyurt, H., Aydinlioglu, A., Kavakli, A., Ekinci, N., Eroglu, C., Hacialiogullari, M., & Diyarbakirli, S. (2008). Local differences in the position of the mental foramen. *Folia Morphol (Warsz), 67*(1), 32-35.

Yosue, T., & Brooks, S. L. (1989). The appearance of mental foramina on panoramic and periapical radiographs. II. Experimental evaluation. *Oral Surg Oral Med Oral Pathol, 68*(4), 488-492.

Zarei, R., Ebrahimi, R. S., Dashti, G., Pourentezari, M., & Karizbodagh, M. P. (2013). Anatomical variations of mental foramen and accessory mental foramen. *Global Journal of Medicine Researches and Studies, 1*(1), 17-19.

Zeng, T., Gao, Q., Gao, X., Yu, H., & Wu, Y. (2016). Interforaminal regions of 287 Han adults evaluated by cone-beam computed tomography. *Shanghai kou qiang yi xue= Shanghai journal of stomatology, 25*(6), 715.

Zmyslowska-Polakowska, E., Radwanski, M., Leski, M., Ledzion, S., Lukomska-Szymanska, M., & Polguj, M. (2017). The assessment of accessory mental foramen in a selected polish population: a CBCT study. *BMC Med Imaging, 17*(1), 17.

Zografos, J. S., & Kolokoudias, M. A. (1988). [The horizontal localization of the mental foramen to a sample of Greek population]. *Stomatologia (Athenai), 45*(3), 189-192.

LIST OF PUBLICATIONS AND PAPERS PRESENTED

No publications

APPENDIX A: ETHICAL APPROVAL

UNIVERSITY OF MALAYA
The Leader in Research & Innovation

MEDICAL ETHICS COMMITTEE
FACULTY OF DENTISTRY
ADDRESS: 50603, KUALA LUMPUR, MALAYSIA
TELEPHONE: 03-79676461 FAXIMILE: 03-79676456

NAME OF ETHICS COMMITTEE/IRB: Medical Ethics Committee, Faculty of Dentistry **ADDRESS:** Faculty of Dentistry, University of Malaya, 50603, Kuala Lumpur	**ETHICS COMMITTEE/IRB REFERENCE NUMBER:**
PROTOCOL NO: **TITLE:** Radiographic Location of Mental Foramen in Subjects with Different Skeletal Pattern Based on ANB Angle	**DF OS1620/0060(P)**
PRINCIPAL INVESTIGATOR: Prof Ngeow Wei Cheong / Dr Juliana Binti Khairi **TELEPHONE:** 013-3932228	

The following item [√] have been received and reviewed in connection with the above study to be conducted by the above investigator.

[√] Investigator's Checklist — Ver date: 30 May 2016
[√] Application Form — Ver date:
[√] Approval Form for Presentation at Department
[√] Brief CV of Main Investigator
Patient Information Sheet (PIS):
[ ] BM version
[ ] English version
[ ] Others: _____
Consent Form:
[ ] BM version
[ ] English version
[ ] Others: _____
[ ] Questionnaire

and have been

[√] Approved
[ ] Conditionally approved (identify item and specify modification below or in accompanying letter)
[ ] Rejected (identify item and specify reasons below or in accompanying letter)

Investigator are required to:
1) follow instructions, guidelines and requirements of the Medical Ethics Committee.
2) report any protocol deviations/violations to Medical Ethics Committee.
3) comply with International Conference on Harmonization – Guidelines for Good Clinical Practice (ICH-GCP) and Declaration of Helsinki
4) note that Medical Ethics Committee may audit the approved study.
5) Please update your project status (on-going/ completed) by submitting study report/ study closure report form (UM-DMEC-SR01).

Approval period: 30 May 2016 – 28 February 2017

c.c Dean
Faculty of Dentistry

Head
Department of Oral and Maxillofacial Clinical Sciences

Secretary
Medical Ethics Committee
Faculty of Dentistry

PROF. DR. NOOR HAYATY ABU KASIM
Chairperson
Medical Ethics Committee

APPENDIX B: DATA COLLECTION FORM

Bil	DRN	Age	Sex	Race	Site of Mental foramen (R/L)	Number of mental foramen	Position of Mental Foramen	ANB