

Review

Mental foramen location and its implication in dental treatment plan

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The aim of the study is to evaluate the location of the mental foramen between races and its effect on the clinical treatment plan decision. In human the mental foramen is normally present as a single opening on each side of the mandible. Previous studies found the size, shape, number, location, and the direction of the opening of the mental foramen have many variations and these variations are influenced by race and sometimes gender. Mental foramen may not be detected in panoramic radiographs and usually bifurcates at inferior superior or medial lateral plane. After this literature review, we can conclude that the location of the mental foramen is variable between races, in vertical and horizontal direction. 3D imaging is needed if difficulty finds to locate the foramen with 2D radiograph to avoid nerve damaging or impairment during surgical procedures.

Key words: Mental foramen, Dental implant, Races, Nerve injury, Anatomical variation.

INTRODUCTION

Mental foramen (MF) is the front opening of the mandibular canal on the body of mandible alongside and above the tubercle of chin. Normally, MF is located below the interval between the two premolars (Rajani and Srivastav, 2010; Ngeow and YusofYuzawati, 2003). But, studies have shown that there are variations in the position of MF in different populations. It may lie between the apices of premolars, below the apex of second premolars (Rajani and Srivastav, 2010). The aim of the study is to evaluate the location of the mental foramen between races and its implication on the clinical treatment plan decision, when implant placed or any surgical procedures is going to be conducted on the mental area.

Any foramina in addition to the MF found in body of mandible are known as accessory MF. It may not present in some of the populations but both MF and accessory MF are important landmarks in surgical procedures (Rajani and Srivastav, 2010).

Mental nerve, a branch of inferior alveolar nerve passes through MF and supplies the chin, lower lip, buccal mucosa of incisors, canines and premolars (Frederico et al., 2010). Preoperative study of MF is important to prevent damage to the mental nerve which will cause paresthesia, patient may complaint that there is transient or permanent loss of sensation of the lip, chin, oral mucosa that is often associated with a limited xerostomia (Gary and Dennis, 2006).

Therefore, preoperative radiographs are recommended before the surgical procedures done (Figure 1). Dental panoramic radiograph, also known as orthopantomograph (OPG) is a 2-dimensional radiograph

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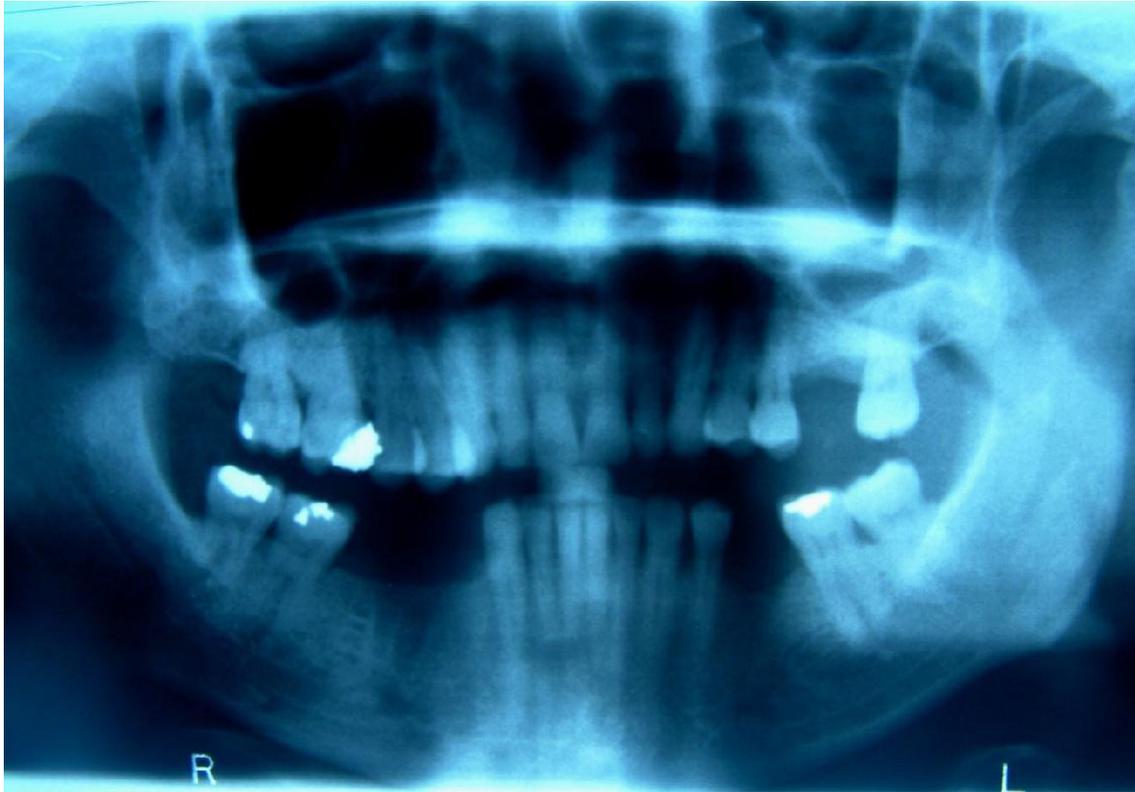


Figure 1. Preoperative OPG for implant placement in lower premolar region, mental foramen should be located and evaluated.

that shows the facial structures including both maxilla and mandible with their supporting structures (Gary and Dennis, 2006).

The MF may not be appearing on conventional radiographs, and linear measurements need to be adjusted to account for radiographic distortion. Computerized tomography (CT) scans are more accurate in detecting the MF than the conventional radiographs (Gary and Dennis, 2006).

Different anatomy and radiology text books give contradicting statements regarding the morphometric characteristics of the MF; thereby, depicting variable racial trends (Santini and Land, 1990).

Among Africans, the MF was observed to exhibit dimorphism; it was 14.89 mm above the lower border of the mandible in males and 14.21 mm in females. Besides, it was 16.16 mm below the alveolar ridge in males and 15.66 mm in females. The average size of the long and the short axis of the foramen were 5.66 and 3.97 mm respectively in the male and 4.99 and 3.87 mm respectively in the female mandibles (Hasan, 2010)

Among Tanzanians, the MF was frequently located below the apex of the second premolar and between the 2nd premolar and 1st molar. A significantly less common location was between 1st and 2nd premolars and below 1st molar. The MF was a-symmetrically located between the

right and left sides and predominantly oval. The direction of opening was mostly superior and postero-superior and rarely labial, mesial or posterior (Hasan, 2010).

Among Mongoloids, the MF was located in line with longitudinal axis of lower second premolar. Among Caucasoid, it is medially located between first and second premolars. It was found to be placed more posterior in blacks than in whites; between the second premolar and first molar (Hasan, 2010).

The most common position of MF was between the first and second premolars on the right side, whereas on the left side it was in line with the lower second premolar in Byzantium population (Hasan, 2010).

Among Japanese, the MF was observed to lie at an average height of 12.96 mm from the inferior edge of mandible. The largest horizontal diameter ranged between 3.25 to 3.32 mm whereas the vertical diameter ranged from 2.38 to 2.39 mm between the right and left sides. The MF was located in similar statistic proportions between the 1st and 2nd premolars and below the 2nd premolar on the right side. On the left side, it was mostly between the 1st and 2nd premolars. The MF was predominantly single and oval with larger horizontal diameter (Hasan, 2010).

The most common MF position was in line with the longitudinal axis of the lower second premolar followed

by a position between first and second premolar.

The mean transverse and vertical diameters of the foramen were 3.31 and 2.5 mm, respectively. The mental foramen was located 24.87 mm (right side) and 24.77 mm (left side) lateral to the symphysis menti. In a majority of cases, the MF was oval in shape and its usual direction of opening was postero-superior. The incidence of multiple MF was 3.92% in Sri Lanka's population (Hasan, 2010).

Among Turkish, the distance of the mental foramen from the lower border of the mandible was noted to be 14.6 and 14.29 mm on the right and the left sides, respectively (Shankland, 1994). The distance from the upper border was 13.6 and 14.62 mm on the right and left sides. The horizontal diameter of the mental foramen was 2.93 mm on the right side and 3.14 mm on the left side. The vertical diameter was 2.38 and 2.64 mm on the right and left sides respectively. The mental foramen was found under the root of the second premolar in most mandibles (Hasan, 2010).

MENTAL FORAMEN ANATOMY

Mandibular nerve is a division of trigeminal nerve (V_3). Inferior alveolar nerve is one of the branches of posterior division of mandibular nerve (Chummy, 2006; Bernard, 2001; Norton, 2007; Gosling et al., 1985). It enters the mandible through the mandibular foramen which is located at the medial surface of the ramus (Ikeda et al., 1996; Wadu et al., 1997). Inferior alveolar nerve runs in mandibular canal which is normally surrounded by cortical bone, it transverses the mandible from lingual to buccal side as it proceeds anteriorly (Wadu et al., 1997) often by the 1st molar (Miller et al., 1990). A research reported that the mandibular canal is 3.4 mm in diameter and the thickness of inferior alveolar nerve is 2.2 mm (Ikeda et al., 1996). The mandibular canal consists of inferior alveolar nerve, inferior alveolar artery, inferior alveolar vein and lymphatic vessel which make up the neurovascular bundles. The artery runs parallel to the nerve as it transverses anteriorly, but being more superiorly to the nerve within the mandibular canal (Ikeda et al., 1996). Inferior alveolar nerve then further divides into mental nerve and incisive nerve at the molar region (Wadu et al., 1997). Mental nerve exits through mental foramen in conjunction with blood vessels. There are 3 nerve branches exit the mental foramen, approximately 1 mm thickness each (Mraiwa et al., 2003). They supply the skin of the mental foramina area, skin of lower lip, chin, mucous membrane, gingiva as far as the 2nd premolar (Bernard, 2001). Occasionally, it innervates incisor teeth (Mraiwa et al., 2003). Yosue and Brooks (1989) classified mental foramen from panoramic radiographs as continuous (21%), separated (43%), diffuse (24%) and unidentified (12%) on 297 patients (Pogrel et al., 1997).

Anterior loop is an extension of the inferior alveolar nerve, anterior to the mental foramen, prior to exiting the canal (Yosue and Brooks, 1989). Bavitz et al. (1993); Jalbout and Tabourian (2004) and Misch et al. (1999) define anterior loop as mental neurovascular bundle crosses inferior and anterior to the mental foramen then doubles or loops back to exit the mental foramen. Identification of anterior loop is significant for placement of dental implants (Misch, 1999; Gary and Dennis, 2006).

Some studies have proven the existence of true incisive canal. It is the continuation of mandibular canal (Mraiwa et al., 2003; Gintaras et al., 2010). Incisive canal may be ill defined and neurovascular bundles run through a labyrinth of intertrabecular spaces (De Andrade et al., 2001).

Ossification of the mandible unites the 2 halves of the mandible at the symphysis menti in 1st year of life. Mental foramen lies near the lower border. After eruption of permanent dentition, the mental foramen lies higher, halfway between upper and lower border. In edentulous jaw, mental foramen is nearer to the upper border of the mandible due to bone resorption (Rajani and Srivastav, 2010). Kjaer found that the mental foramen lies in between primary canine and 1st molar in early life (Pollard et al., 2001).

LOCATION OF MENTAL FORAMEN

Location of mental foramen varies among individuals (Kjaer, 1989; Shankland, 1994) and may be related to races, for example in Chinese people located apical to the premolar (Sawyer et al., 1998; Fishel et al., 1976; Wang et al., 1986) (Figure 2). Some research showed that the location of mental foramen is not gender dependant (Al-Jasser and Nwoku, 1998; Rupesh et al., 2011). Other studies used other anatomical landmarks to measure the location of the mental foramen. Agthong et al. (2005) reported that mental foramen is 28 mm from the midline of mandible and 14-15 mm from inferior border of mandible. Neiva et al. (2004) indicated that 27.6 mm (range: 22-31 mm) from the midline and 12 mm (range: 9-15 mm) from the most apical portion of the lower cortex of the mandible. Apinhasmit et al. (2006) found that the mental foramen has the mean of 28.52 ± 2.15 mm lateral to midline of the mandible. The average distance between the cusp tip and the superior border of mental foramen by direct measurement and panoramic assessment is 23.43 and 25.69 mm respectively. The mean distance between superior border of mental foramen and bottom of mandible by direct measurement and panoramic assessment is 14.33 and 16.52 mm respectively (Apinhasmit et al., 2006), more reports that study the location of the mental foramen in different races can be found in (Table 1). While Fishel et al. (1976) and Gintaras et al. (2010) reported the location of the mental foramen in vertical plane, high percentage of



Figure 2. In Asian people the location of the mental foramen more posterior (within the long axis of the second premolar).

Table 1. Showed different location of mental foramen in horizontal planes.

Study	Population	N	Horizontal plane		
			Apical to 2 nd premolar (%)	Between apices of premolars (%)	Others (%)
Fishel et al. ²⁷ (1976)	Caucasian	1000	18.9	70.4	Apex 1 st premolar: 3.3 Mesial to 1 st premolar: 1.5 By the molar: 1
Wang et al. ²⁸ (1986)	Chinese	100	59	21	Between premolar and 1 st molar: 19 By the molar: 1
Kekere-Ekun ³⁴ (1989)	Nigerian	604	55.63	26.99	Mesial to 1 st premolar: 0.17 Apex 1 st premolar: 1.66 Between premolar and 1 st molar: 12.3 By the molar: 3.3
Shankland ²⁵ (1994)	Asian Indians	138	75.4	5.8	Between premolar and 1 st molar: 14.5 By the molar: 4.3
Al Jasser and Nwoku (1998) ²⁹	Saudi	414	45.3	42.7	Not measured
Ngeow and Yuzuwati ^c (2003)	Malay	169	69.2	19.6	Apex 1 st premolar: 3.4 Between premolar and 1 st molar: 6.6 By the molar: 1

Table 1 Contd.

Neiva et al. ³³ (2004)	Caucasian	22	42	58	Not measured
Apinhasmit et al. ³³ (2006)	Thai	106	56.9	28.7	Between premolar and 1 st molar: 10.2 Apex 1 st premolar: 3 By the molar: 1.2
Kim et al. ³⁵ (2006)	Korean	72	64.3	26.8	Apex 1 st premolar: 8.9
Fabian ³⁶ (2007)	Tanzanian	100	45	12	Between premolar and 1 st molar: 35 By the molar: 8
Yesilyurt et al. ³⁷ (2008)	Turkish	70	Right:55.7 Left: 61.4	Right: 34.3 Left: 25.7	Apex of 1 st premolar: right: 5.7 Left: 7.1 Between premolar and 1 st molar: Right: 4.3 Left: 5.7
Haghanifar and Rokouei ³⁸ (2009)	Iranian	400	46	47.2	Between premolar and 1 st molar: 5.3 By the molar: 1.5
Suneel and Habib et al. ³⁹ (2010)	Pakistani	1000	47.2	40.4	Apex 1 st premolar: 4.5 Between premolar and 1 st molar: 7.1 By the molar: 0.8
Singh and Srivastav. ⁴⁰ (2010)	Indian	100	68.8	17.8	Between premolar and 1 st molar: 11.5 Apex 1 st premolar: 2.1
Rupesh et al. ³⁰ (2011)	Asian Indian	500	33.5	47.6	Between premolar and 1 st molar: 11.4 Mesial to 1 st premolar: 3 Apex of 1 st premolar: 1
Sumit and Jagdish (2012)	Indian	120	75.8	12.2	Apex of 1 st premolar: 8.3 By the molar: 3.33

Table 2. Location of the mental foramen in vertical plane is reported by Fishel et al.²¹ (N=936).

	Coronal to the apex (%)	At the apex (%)	Apical to the apex (%)
1 st premolar	38.6	15.4	46
2 nd premolar	24.5	13.9	61.6

the foramen located apical to the apex of the first and second premolar (Table 2).

SIZE OF MENTAL FORAMEN

Neiva et al. (2004) revealed the mean height and the

mean width of the mental foramen is 3.4 ± 0.71 and 3.59 ± 0.8 mm respectively in Caucasian skulls (N=22). Gershenson et al. (1986) reported that 34.48% of the mental foramen is round with the average diameter of 1.68 mm and 65.52% is oval in shape with average diameter of 2.37 mm (N=575). Other researchers found that the mean diameter of mental foramen was 3.5, 5, 2.8

Table 3. Shape of the mental foramen.

Study	Population	N	Shape of mental foramen (%)
Gershenson et al. (1986) ⁴³	Unknown	575	65.5% oval 34.5% round
Mbajjorgu et al. (1998) ⁴⁴	Zimbabwean	32	56.3% oval 43.8% round
Igbigbi et al. (2005) ⁴⁵	Malawian	70	Majority oval
Fabian et al.(2007) ³⁶	Tanzanian	100	54% oval 46% round
Al-Khateeb et al. (2007) ⁴⁶	Jordanian	860	Majority round
Singh and Srivastav et al. (2010) ^{4u}	Indian	100	Majority round
Sumit and Jagdish (2012) ⁴¹	Indian	120	Majority round

and 2.62 mm wide (Yosue and Brooks, 1989; Solar et al., 1994; Apinhasmit et al., 2006; Sumit and Jagdish, 2012).

Shape of mental foramen

Knowing the shape of the MF is crucial in its detection of its location, essentially in low quality. Many authors reported 2 types of MF shape, from oval – rounded, with different percentage between different races (Table 3)

Numbers of mental foramen

Mandibular canal bifurcate in 1% of the population and it determines the number of mental foramen. It may not be detected in panoramic radiographs (Dario, 2002) and usually bifurcates at inferior superior or medial lateral plane (Dario, 2002; Driscoll, 1990).

Some researchers claimed that the presence of accessory mental foramen varies among populations. Sawyer et al. (1998) found out that the frequency of accessory mental foramen as followed: American Whites (1.4%), Asian Indians (1.5%), African Americans (5.7%) and pre-Columbian Nazca Indian (9.0%). 6.62% (N=138) of the mandibles present with accessory mental foramen in Asian Indians (Shankland, 1994). 10% (N=860) of panoramic radiographs present with accessory mental foramen in Jordanian population⁴⁶. Seventeen accessory mental foramina were diagnosed in 16 patients using limited CBCT in 150 patients. Katakami et al. (2008) claimed that the foramina appear in the apical area of 1st molar and posterior or inferior area of the mental foramen (Katakami et al., 2008). 7% (N=157) of CBCT images was present with accessory mental foramen. The distance between mental foramen and accessory mental

foramen was 6.3 mm (SD 1.5 mm) (Naitoh et al., 2009). 1.8% (N=110) of Asian's skull were discovered with 2 mental foramina (Agthong et al., 2005). Mraiwa et al. (2003) diagnosed 10% (N=50) cadavers present with accessory mental foramen. Sumit and Jagdish (2012) reported 6.6% (N=120) of Indian population present with accessory foramen and was unilateral in position (Sumit and Jagdish, 2012). However, DeFreitas reported that there is no mental foramen found in 2 (N=1439) dry human mandibles. The foramen was absent twice on the right (0.06%) and once on the left (0.03%) (DeFreitas et al., 1979).

Direction of emergence of neurovascular bundles through mental foramen

According to Kieser et al. (2002) cadaveric studies on various populations: Negro skulls (N=117; 53 males), Caucasoid skulls (N=114; 62 males), pre-contact Maori's skulls (N=100; 70 males). He found out that most common type of emergence in Caucasoid and Maori was in posterior direction (86.7% of Caucasoid male, 90.2% of Caucasoid female; 85.5% in Maori male, 93.1% in Maori female). In contrast, most common type of emergence in the blacks was right-angle (45.8% male, 45% female). Kieser et al. (2002) also concluded that the most common emergence pattern of the mental foramen was directed posteriorly in his findings (N= 341; 80.7% males, 86.6% female) supported by other researchers and text (Oguz and Bozkir, 2002; BBerkovitz et al., 2009). Mbajjorgu et al. (1998) found out that most of the black Zimbabwean has right-angled pattern of emergence (N=32; 45.8% male, 45.0% female).

Igbigbi and Lebona (2005) and Apinhasmit et al. (2006) concluded that Malawian (N=70) and Thai

(N=106) populations mostly having emergence of neurovascular bundles in poster superior direction respectively. Fabian (2007) concluded that the pattern of emergence in Tanzanian (N=100) populations present superiorly (44%), postero-superiorly (40%), labially (10%), mesially (anteriorly) (3%) and posteriorly (3%).

At birth, neurovascular bundles emerge in forward direction and alter to upwards and backwards as the mandible develop (Chummy, 2006; BBerkovitz et al., 2009).

CONCLUSION

From above literature, we can conclude that the location of the mental foramen is variable between races, in vertical and horizontal direction. When the implant placed in lower premolar area, special concern should be directed to locate the mental foramen in 2D imaging if possible. Otherwise 3D imaging is needed if difficulty finds to locate the foramen with 2D radiograph to avoid nerve damaging or impairment.

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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.*, 63:800-804.
- Al-Jasser and AL Nwoku (1998). Radiographic study of the mental foramen in a selected Saudi population. *Dentomaxillofac. Radiol.*, 27(6):341-3.
- Al-Khateeb T, Al-HadiHamasha A, Ababneh KT (2007). Position of the mental foramen in a northern regional Jordanian population. *Surg. Radiol. Anat.*, 29(3):231-7. Epub 2007 Mar 21.
- Apinhasmit W, Chompoopong S, Methathrathip D, Sansuk R, Phetphunphiphat W (2006). Supraorbital Notch/Foramen, Infraorbital Foramen and Mental Foramen in Thais: anthropometric measurements and surgical relevance. *J Med Assoc Thai.* 89 (5):675-82.
- Bavitz JB, Harn SD, Hansen CA, Lang M (1993). An anatomical study of mental neurovascular bundle-implant relationships. *Int. J. Oral Maxillofac. Implants.*;8(5):563-7
- BBerkovitz BK, Holland GR, Moaxham BJ (2009). *Oral Anatomy, Histology, and Embryology.* 4th ed, pp 293-294.
- Bernard Liebgott (2001). The anatomical basis of

- dentistry. 2nd ed. Elsevier Mosby, pp. 311-313
- Chummy S. Sinnaṭamby (2006). *Last's Anatomy: regional and applied.* 11th ed. Churchill Livingstone, 35, 366
- Dario LJ (2002). Implant placement above the bifurcated mandibular canal: A case report. *Implant Dent.*, 11:258-452
- De Andrade E, Otomo-Corgel J, Pucher J, Ranganath KA, St George N J r (2001). The intraosseous course of the mandibular incisive nerve in the mandibular symphysis. *Int. J. Periodontics Restorative Dent.*, 21:591-597
- deFreitas V, Madeira MC, Toledo Filho JL, Chagas CF (1979). Absence of the mental foramen in dry human mandibles. *Acta Anat (Basel).* 104(3):353-5.
- Fabian FM (2007). Position, shape and direction of opening of the mental foramen in dry mandibles of Tanzanian adult black males. *Italy J. Anat. Embryol.*, 112(3):169-77
- Fishel D, Buchner A, Hershkowitz A, Kaffe I (1976). Roentgenologic study of the mental foramen. *Oral Surg. Oral Med. Oral Pathol.*, 41:682-686.
- Frederico S Neves, Marianna GG, Torres (2010). Lingual accessory mental foramen: a report of an extremely rare anatomical variation. *J. Oral Sci.*, 52:501-503,
- Gary Greenstein, Dennis Tarnow (2006). The mental foramen and nerve: clinical and anatomical factors related to dental implant placement: A literature review. *J. Periodontol.*, 77:1933-1943.
- Gary Greenstein, Dennis Tarnow (2006). The mental foramen and nerve: Clinical and Anatomical factors related to dental implant placement: A literature review. *J. Periodontol.*, 77:1933-43
- Gershenson A, Nathan H, Luchansky E. Mental foramen and mental nerve: changes with age. *ActaAnat (Basel).* 1986;126(1):21-8.
- Gintaras Juodzbalys, Hom Lay Wang, Gintautas Sabalys (2010). Anatomical and mandibular vital structure. Part 2: mandibular incisive canal, mental foramen and associated neurovascular bundles in relation with dental implantology. *J. Oral maxillofac. Res.* 1:No 1:e3.
- Gosling JA, Harris PF, Humpherson JR, Whitmore I Willan PLT (1985). Head and neck. In: *Atlas of human anatomy with integrated text.* Edinburgh-London-New York: Churchill Livingstone; pp. 250-290.
- HaghanifaS, Rokouei M (2009). Radiographic evaluation of the mental foramen in a selected Iranian population. *Indian J. Dent. Res.*, 20:150-152
- Hasan T.: Characteristics of The Mental Foramen In Different Populations. The Internet
- Igbigbi PS, Lebona S (2005). The position and dimensions of the mental foramen in adult Malawian mandibles. *West Afr. J. Med.*, 24(3):184-9.
- Ikeda K, Ho KC, Nowicki BH, Haughton VM (1996). Multiplanar MR and anatomic study of the mandibular canal. *AJNR Am. J. Neuroradiol.*, 17:579-584.
- Jalbout Z, Tabourian G (2004). *Glossary of Implant Dentistry.* Upper Montclair, NJ: International Congress

of Oral Implantol., 16.

- Katakami K, Mishima A, Shiozaki K. Characteristics of accessory mental foramina observed on limited cone-beam computed tomography images. *J Endod.* 2008 34(12):1441-5. Epub 2008 Oct 11.
- Kekere-Ekun TA (1989). Antero-posterior location of the mental foramen in Nigerians. *Afr. Dent. J.* 3:2-8.
- Kieser J, Kuzmanovic D, Payne A, Dennison J, Herbison P (2002). Patterns of emergence of the human mental nerve. *Arch Oral Biol.*, 47(10):743-7.
- Kim IS, Kim SG, Kim YK, Kim JD (2006). Position of the mental foramen in a Korean population: a clinical and radiographic study. *Implant Dent.*, 15(4):404-11.
- Kjaer I (1989). Formation and early prenatal location of human mental foramen. *Scand J. Dent. Res.*, 97: 1-7.
- Mbajjorgu EF, Mawera G, Asala SA, Zivanovic S (1998). Position of the mental foramen in adult black Zimbabwean mandibles: A clinical anatomical study. *Cent Afr. Med.*, 44:24-30.
- Miller CS, Nummikoski PV, Barnett DA, Langlais RP (1990). Cross-sectional tomography. A diagnostic technique for determining the buccolingual relationship of impacted mandibular third molars and the inferior alveolar neurovascular bundle. *Oral. Surg. Oral Med. Oral Pathol.*, 70:791-797.
- Misch CE (1999). Root form surgery in the edentulous mandible: Stage I implant insertion. In: Misch CE, editors. *Implant Dentistry*, 2nd ed. St. Louis: The CV Mosby Company; pp. 347-370.
- Mraiwa N, Jacobs R, Moerman P (2003). Presence and course of the incisive canal in the human mandibular interforamina region: Two-dimensional imaging versus anatomical observations. *Surg. Radiol. Anat.*, 25:416-423.
- 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.*, 5:219-225.
- Naitoh M, Hiraiwa Y, Aimiya H, Gotoh K, Arijii E (2009). Accessory mental foramen assessment using cone-beam computed tomography. *Oral Surg Oral Med Oral Pathol. Oral Radiol. Endod.* 107(2):289-94. Epub 2008 Dec 13.
- Neiva RF, Gapski R, Wang HL (2004). Morphometric analysis of implant-related anatomy in Caucasian skulls. *J. Periodontol.*, 75:1061-1067.
- Ngeow WC, Yusof Yuzawati (2013). The location of the mental foramen in a selected Malay
- Norton NS (2007). *Netter's Head and Neck Anatomy for Dentistry*. Philadelphia: Saunders, pp. 86-96.
- Oguz O, Bozkir MG (2002). Evaluation of location of mandibular and mental foramina in dry, young, adult human male, dentulous mandibles. *West Indian Med. J.*, 51:14-16.
- Pogrel MA, Smith R, Ahani R (1997). Innervation of the mandibular incisors by the mental nerve. *J. Oral Maxillofac Surg.*, 55:961-963.
- Polland KE, Munro S, Reford G (2001). The mandibular canal of the edentulous jaw. *Clin. Anat.*, 14:445-452.
- Rajani Singh Srivastav AK (2010). Study of position, shape, size and incidence of mental foramen and accessory mental foramen in Indian adult skulls. *Int. J. Morphol.*, 28:1141-1146
- Rupesh S, Jasmin J, Sherin Anna John, Tatu Joy, Arun Prasad Rao, Venugopal Reddy (2011). Radiographic study of the location of mental foramen in a randomly selected Asian Indian population on Digital Panoramic Radiographs. *J. Med Sci.*, 2: 90-95
- Santini A, Land MA (1990). Comparison of the position of the mental foramen in Chinese and British mandibles. *Acta. Anat.*, 137:208-212.
- Sawyer DR, Kiely ML, Pyle MA (1998). The frequency of accessory mental foramina in four ethnic groups. *Arch Oral Biol.*, 43:417-420.
- Shankland WE (1994). The position of the mental foramen in Asian Indians. *J. Oral Implantol.*, 20(2):118-123.
- Singh R, Srivastav AK (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.*, p.1-7
- Solar P, Ulm C, Frey G, Matejka M (1994). A classification of the intraosseous paths of the mental nerve. *Int. J. Oral Maxillofac. Implants*, 9:339-344.
- Sumit Gupta, Jagdish S Soni (2012). Study of anatomical variations and incidence of mental foramen and accessory mental foramen in dry human mandibles. *Nat. J. Health Res.*, 2:28-30.
- Suneel Kumar Punjabi, Habibur Rehman, Shaheen Ahmed, Mehmood Haider (2010). Radiographic position of mental foramen in selected Pakistani population. *J. Pakistan Dental Assoc.*, 19:105-109
- Wadu SG, Penhall B, Townsend GC (1997). Morphological variability of the human inferior alveolar nerve. *Clin. Anat.*, 10(2):82-7.
- Wang TM, Shih C, Liu JC, Kuo KJ (1986). A clinical and anatomical study of the location of the mental foramen in adult Chinese mandibles. *Acta Anat (Basel)* 126:29-33.
- Yesilyurt H, Aydinlioglu A, Kavakli A (2008). Local differences in the position of the mental foramen. *Folia Morphol (Warsz)* 67:32-5.
- Yosue T, Brooks SL (1989). The appearance of mental foramina on panoramic and periapical radiographs. II. Experimental evaluation. *Oral Surg. Oral Med. Oral Pathol.*, 68:488-492.