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Topographic anatomy of mandibular foramen in different age groups using panoramic radiographs

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SUMMARY

The purpose of this investigation was to document the most common position of the mandibular foramen and to compare its position in three different age groups, gender and sides on panoramic radiographs. The knowledge regarding the location of mandibular foramen is essential for administering the inferior alveolar nerve block, peripheral neurectomy and for performing osteotomy cuts with low inferior alveolar nerve morbidity. Two hundred mandibular foramina were studied on panoramic radiographs of one hundred patients (51 female and 49 male) with a mean age of 20.15±10.7 years. The patients were grouped into three age groups (≤13, 14-25, >25 years). Various measurements for the position of mandibular foramen were performed in horizontal and vertical dimensions using different landmarks and reference points. The ratios of horizontal and vertical dimensions were compared within three different age groups, gender and side.

The majority of mandibular foramina were in the ratio range of 0.31-0.40 in all the three age groups horizontally and vertically with a significant difference in patients within the age group of ≤ 13 years from the other two age groups. The study showed that the mandibular foramen was located in the middle third of the ramus and the location of the mandibular foramen maintained bilateral symmetry in all the cases. The study indicated that the location of the mandibular foramen is variable. However, the superior and posterior fifths are found to be the safer zones. So, the positional changes of mandibular foramen with age are imperative, as in children they may be occasionally found in inferior third and therefore preoperative knowledge of the exact position of the mandibular foramen may guide the surgeon to develop a safe and accurate surgical technique avoiding any violation of the neurovascular bundle.

Key words: Horizontal ratio – Mandibular foramen – Panoramic radiographs – Vertical ratio

INTRODUCTION

The mandibular foramen is located on the medial aspect of the mandibular ramus through which the inferior alveolar nerve and vessels pass. Inferior alveolar nerve block anaesthesia, also known as Halsted approach, is the most commonly used nerve block technique in dentistry (Malamed, 1981). The success of this technique depends on placing the needle tip in close proximity to the mandibular foramen. The variability in the location of the mandibular foramen may lead to the failure of anaesthesia. Thus, the intricate knowledge of position the of the mandibular foramen enables a more effective anaesthesia, for peripheral neurectomy and is also significant in planning of orthognathic surgery, especially the bilateral sagittal split osteotomy, vertical ramus osteotomy and mandibular resection.

As the mandibular foramen is an internal structure which cannot be palpated clinically, the best two means of estimating the mandibular foramen

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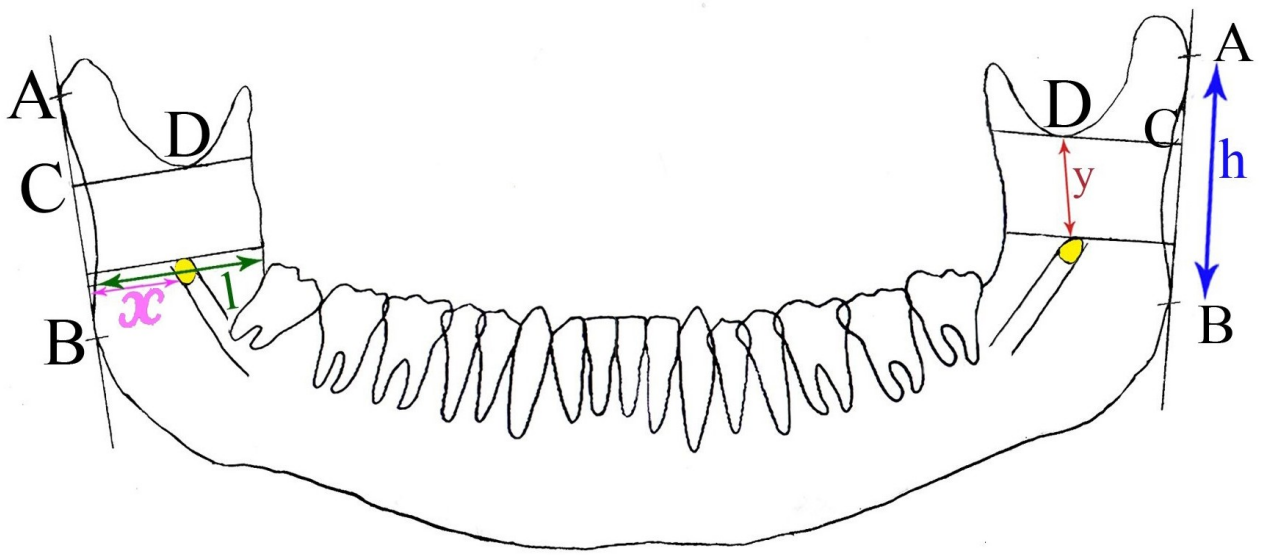

Fig 1. Schematic presentation of position of mandibular foramen. AB: The vertical axis tangential to the posterior border of mandibular head and mandibular angle. CD: The horizontal axis perpendicular to AB and tangential to mandibular incisure.

'h' The distance between points A and B.

'y' The shortest distance between superior border of mandibular foramen and CD.

'l' The width of the ramus at the horizontal level of the centre of mandibular foramen.

'x' The distance between posterior border of mandibular foramen and AB.

position are either to relate its location with the anatomical structures visualized intra-operatively (coronoid notch, mandibular inferior border and mandibular posterior border) or to identify it on the preoperative panoramic radiograph (Da Fontoura et al., 2002).

Radiography is the only available non-invasive method for diagnosis and treatment planning of major oral surgical procedures of the mandible. Panoramic radiography (OPG) is a curved plane tomographic radiographic technique in which the mandibular canal appears as a radiolucent line delimited by two outer radiopaque lines which begin at mandibular foramen and extends up to the mental foramen. Although the panoramic radiograph is often magnified with loss of definition and there is anatomical structure superimposition, but it has the advantage of being simple to acquire, requires minimum amount of time for its execution and is cost effective. So, a panoramic radiograph is commonly used for screening, diagnosis and for selecting the best possible surgical approach. In the present study, the position of the mandibular foramen was evaluated bilaterally on 100 panoramic radiographs in three different age groups.

MATERIALS AND METHODS

The study comprised of 100 subjects (51 female and 49 male; mean age 20.15±10.7 years (3.5-56 years) who reported to the Department of Oral and Maxillofacial Surgery at Sri Guru Ram Das Institute of Dental Sciences and Research, Amritsar from 2011 to 2013. The study was approved by institute's ethics committee. Informed consents were taken from the patients before the study was conducted. The subjects with age ≤13 years (n=30; male-17, female-13), between 14-25 years (n=50; male-22, female-28) and more than 25 years (n=20; male-10, female-10) were labelled as Group I, II and III respectively.

The position of the mandibular foramen was determined using panoramic radiographs. These radiographs were taken using Kodak 8000C Digital Panoramic System (tube potential: 60-90 KV, tube current: 2-15 mA, total filtration: 2.5 mm Al, focal spot: 0.5 mm, magnification factor: 1.27) and had high quality processing. Only the patients with normal facial morphology and with all the posterior teeth present in the oral cavity were included and the patients with mandibular ramus abnormalities such as pathologies and fracture were excluded from study.

Each panoramic radiograph was carefully outlined on cellophane paper using 0.5 mm pencil. The drawing was based on the limit of the most external radiopaque portion of the mandibular canal and the mandibular foramen. The posterior border of the ramus, mandibular notch and anterior border of the ramus were taken as the reference points for determining horizontal and vertical location of the mandibular foramen (Thangavelu et al.,

2012).

Following landmarks were traced (Fig. 1):

The vertical axis AB tangential to the posterior border of mandibular head and mandibular angle.

The horizontal axis CD perpendicular to AB and tangential to mandibular incisure.

Morphometric measurements (Fig. 1):

The distance *h* between points A and B.

The shortest distance *y* between superior border of mandibular foramen and CD.

The width *l* of the ramus at the horizontal level of the centre of mandibular foramen.

The distance *x* between posterior border of mandibular foramen and AB.

x/l (horizontal) and y/h (vertical) ratios were calculated. For horizontal ratios, values ≤ 0.33, between 0.33 and 0.66 and ≥ 0.66 were designated as posterior, middle and anterior thirds of the ramus respectively. Similarly for vertical ratios, values ≤ 0.33, between 0.33 and 0.66 and ≥ 0.66 were labelled for superior, middle and inferior thirds respectively.

The ratios of horizontal and vertical dimensions of the mandible were divided into different categories to evaluate the position of the mandibular foramen. These categories were presented as number and percentages.

Statistical analysis

The data was analysed using MS office 2007 Excel spreadsheet (Microsoft corp., Redmond, WA, USA) and program SPSS 20.0 (SPSS Inc, Chicago, IL USA). Mean, standard deviation (SD) and range were computed. Student t test was applied to compare the mean values pertaining to sex and side. The ratios of horizontal and vertical dimensions were compared in three different age groups by chi-square test. P value < 0.05 was considered significant.

RESULTS

In the present study, the mean horizontal and vertical position of the mandibular foramen was studied on panoramic radiographs (Table 1). A statistically significant difference was found for both horizontal and vertical position of the mandibular foramen in Group I when compared to other two age groups in the ratio range of 0.3-0.4. However, no significant difference was observed between the Group II and Group III (Fig. 2a, 2b). Most of the mandibular foramina were noticed in the ratio range of 0.3-0.4, however in group I, II and III; 3.3%, 2% and 10% had horizontal and 23.3%, 7% and 7.5% had vertical ratio in the range of 0.21-0.30 respectively. In group I, only 1.7% of the mandibular foramina were having vertical ratio in ratio range of 0.61-0.70 (Table 2).The horizontal ratio was ≤ 0.33 in 5%, 7% and 12.5% and between 0.33 and 0.66 in 95%, 93% and 87.5% cases from group I, II and III respectively. This ratio was not ≥ 0.66 in any of the cases. The horizontal ratio was between 0.33 and 0.66 in 95% and 90% on the right and left side respectively. The vertical ratio was ≤ 0.33 in 25%, 21% and 15% and between 0.33 and 0.66 in 73.3%, 79% and 85% cases from group I, II and III respectively. However, in

Fig.2

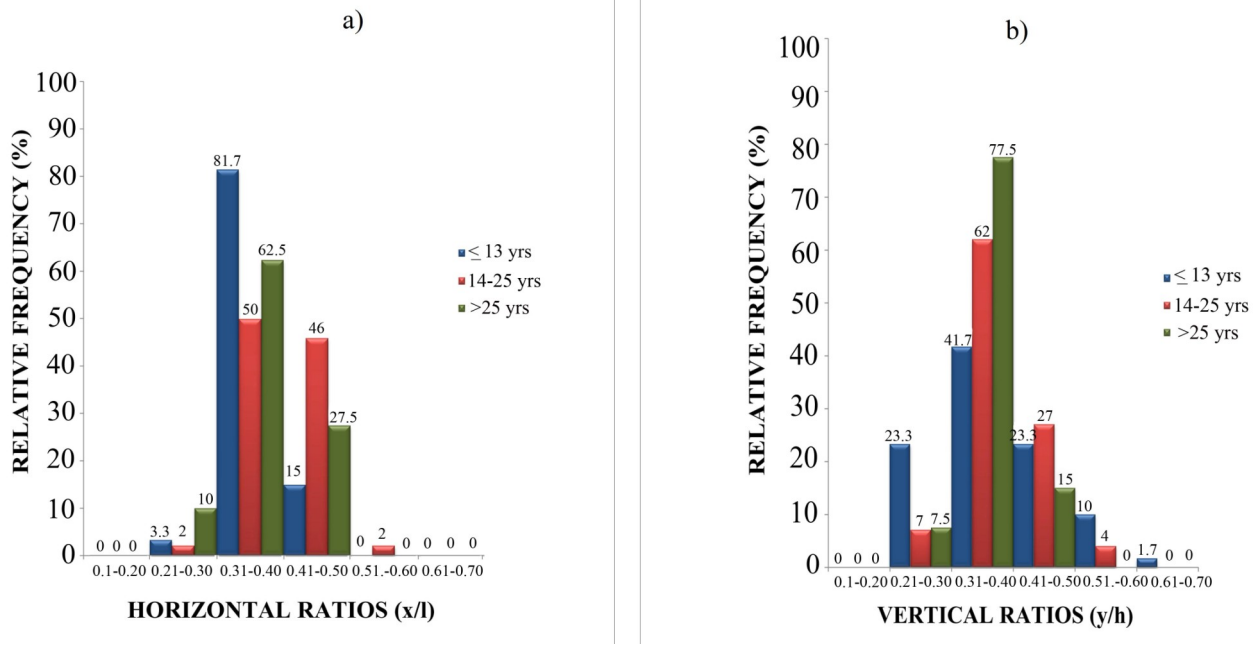

Fig 2. Bar Graph (a,b) shows the group-wise (group I, II, III); (c,d) gender-wise (male, female); (e,f) side-wise (right, left) distribution of horizontal and vertical ratios for position of mandibular foramen respectively.

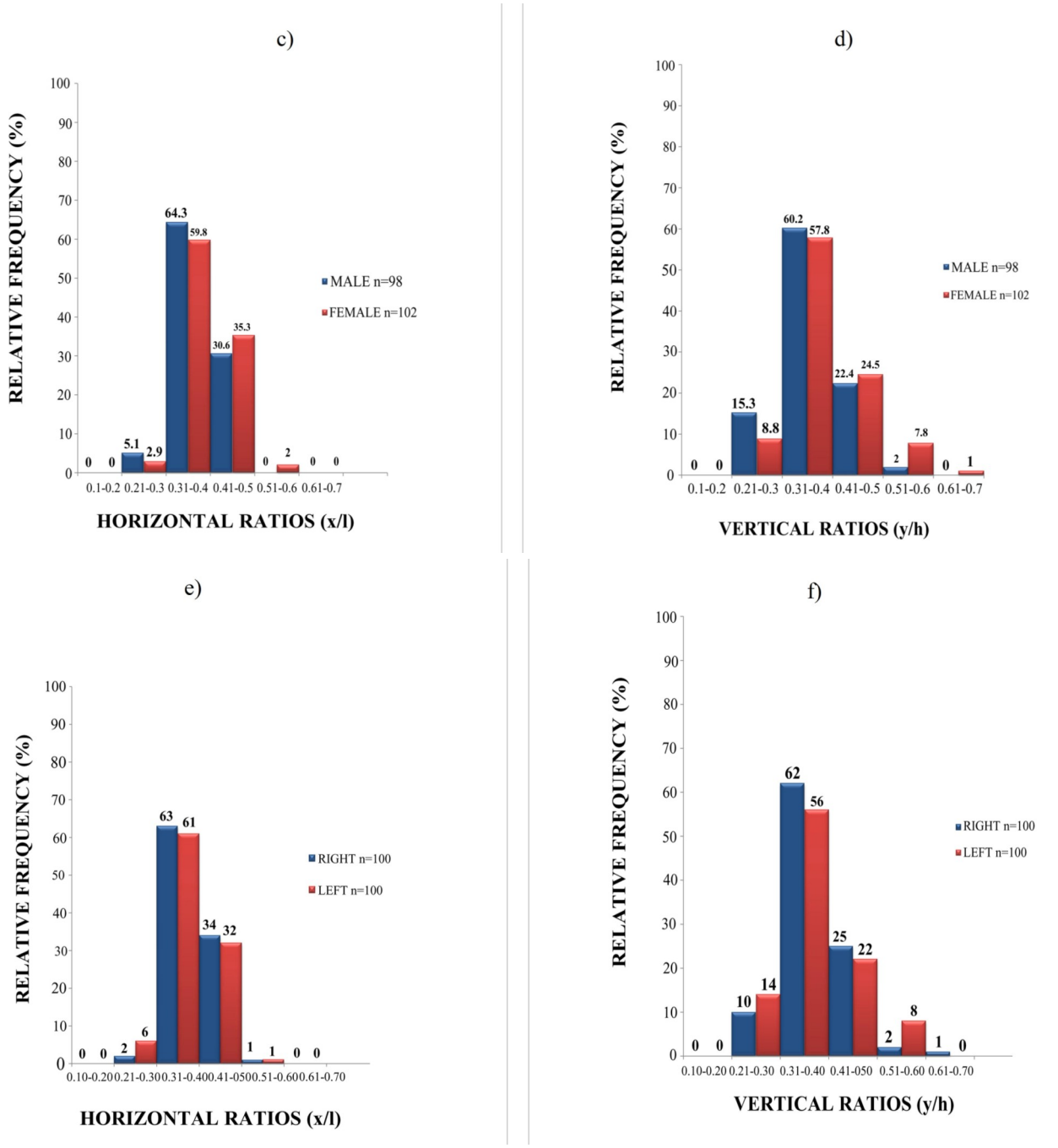

Fig 2. Bar Graph (a,b) shows the group-wise (group I, II, III); (c,d) gender-wise (male, female); (e,f) side-wise (right, left) distribution of horizontal and vertical ratios for position of mandibular foramen respectively.

one case (1.7%) from group I, this ratio was more than 0.66.The vertical ratio was between 0.33 and 0.66 in 81% and 76% cases on the right and left side respectively.

On applying chi square test, besides age no significant difference was observed in ratio range of 0.3-0.4 in relation to gender and side for position of mandibular foramen (Fig.2c, 2d, 2e, 2f). The width *l* of the ramus at the horizontal level of the centre of the mandibular foramen was statistically higher on the left as compared to right side (p= 0.03). The vertical ratio was significantly higher in females (p= 0.03). On comparing the differences between gender in each group, the parameters *x, y, l* and horizontal ratio were significantly higher in females as compared to males of group I; *l* and *h* were significantly higher in males of group II and *x, h* and horizontal ratio were higher in male subjects of group III. However, on comparing the differences between sides in each group, no significant difference was observed. The ratio of mean horizontal and vertical ratios on both right and left sides was found to be near to one.

Table 1. Mean horizontal and vertical dimensions of the position of mandibular foramen.

Mean±SD (cm)	Total n = 200	Male n = 98	Female n= 102	Left n=100	Right n =100	GROUP I n= 60	GROUP II n=100	GROUP III n=40
Age(Years)	20.1 ± 10.65 (3.5-56)	20.48 ± 12.04 (3.5-56)	19.74 ± 9.25 (5.5-52)	20.1 ± 10.65 (3.5-56)	20.1 ± 10.65 (3.5-56)	10.13±2.58 (3.5-13)	19.65±3.65 (14-25)	37.05±10.36 (26-56)
x	1.36 ± 0.23 (0.85-2)	1.35 ± 0.24 (0.9-2)	1.37 ± 0.22 (0.85-1.9)	1.38 ± 0.23 (0.85-1.9)	1.35 ± 0.23 (0.9-2)	1.326 ±0.216 (0.9-1.90)	1.41±0.21 (1-1.86)	1.28±0.24 (0.85-2)
y	1.96 ± 0.39 (1.05-3.6)	1.93 ± 0.38 (1.08-2.8)	1.96 ± 0.40 (1.3-2.8)	1.96 ± 0.4 (1.05-3.03)	1.95 ± 0.38 (1.1-3.6)	1.869±0.463 (1.050-3.6)	2.03±0.36 (1.25-2.80)	1.90±0.27 (1.40-2.6)
l	3.48 ± 0.39 (2.5-4.6)	3.49 ± 0.35 (2.68-4.4)	3.44 ± 0.42 (2.5-4.6)	3.5 ± 0.39 (2.5-4.6)	3.45 ± 0.38 (2.6-4.5)	3.484±0.408 (2.68-4.4)	3.51±0.40 (2.5-4.5)	3.39±0.31 (2.75-4.20)
h	5.1 ± 0.69 (1.6-6.6)	5.15 ± 0.68 (3.6-6.6)	5.03 ± 0.69 (1.6-6.5)	5.06 ± 0.73 (1.6-6.6)	5.14 ± 0.64 (3.65-6.34)	4.723±0.709 (1.60-6.3)	5.27±0.56 (4.12-6.30)	5.23±0.73 (3.65-6.6))
HR	0.39 ± 0.05 (0.28-0.52	0.39 ± 0.05 (0.28-0.51)	0.39 ± 0.05 (0.3-0.52)	0.39 ± 0.05 (0.28-0.52)	0.39 ± 0.05 (0.28-0.52)	0.380±0.037 (0.277-0.475)	0.40±0.65 (0.3-0.52)	0.38±0.05 (0.30-0.49)
VR	0.39 ± 0.08 (0.26-1.0)	0.37 ± 0.06 (0.26-0.54)	0.40 ± 0.09 (0.3-1)	0.39 ± 0.09 (0.29-1)	0.38 ± 0.06 (0.26-0.66)	0.403±0.116 (0.276-1)	0.39±0.06 (0.26-0.55)	0.36±0.03 (0.3-0.44)
Ratio= HR/VR						0.997±0.228 (0.379-1.465)	1.07±0.17 (0.63-1.38)	1.04±0.15 (0.75-1.42)

l- width of the ramus at the horizontal level of the centre of mandibular foramen; *x*- distance between posterior border of mandibular foramen and AB; *h*= distance between points A and B; *y*= distance between superior border of mandibular foramen and CD; *HR* – horizontal ratios and *VR*- vertical ratios.

Table 2. Distribution of horizontal and vertical ratios for position of mandibular foramina in three different age groups.

Range of ratio	Horizontal and vertical ratios within age groups							
	Group I (≤13 yrs) n=60		Group II (14-25yrs) n=100		Group III (>25 yrs) n=40		Total n=200	
	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical	Horizontal	Vertical
0.1-0.2	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
0.21-0.3	**2(3.3%)**	**14(23.3%)**	**2(2%)**	**7(7%)**	**4(10%)**	**3(7.5%)**	**8(4%)**	**24(12%)**
0.31-0.4	**49(81.7%)**	**25(41.7%)**	**50(50%)**	**62(62%)**	**25(62.5%)**	**31(77.5%)**	**124(62%)**	**118(59%)**
0.41-0.5	**9(15%)**	**14(23.3%)**	**46(46%)**	**27(27%)**	**11(27.5%)**	**6(15%)**	**66(33%)**	**47(23.5%)**
0.51-0.6	**0**	**6(10%)**	**2(2%)**	**4(4%)**	**0**	**0**	**2(1%)**	**10(5%)**
0.61-0.7	**0**	**1(1.7%)**	**0**	**0**	**0**	**0**	**0**	**1(.5%)**

n= number of foramina

DISCUSSION

Accurate localization of the mandibular foramen can prevent damage to the inferior alveolar nerve during horizontal, vertical and oblique osteotomies of the ramus, thereby contributing to optimal results and a lower rate of complications (Thangavelu et al., 2012). The image of the mandibular foramen is usually radiolucent and may be identified on panoramic and lateral oblique films preoperatively, in which its outline varies from triangular, oval to funnel shape and it may be faint to prominent (Wood and Goaz, 1997).The impact of the magnification and distortion can be minimised by calculating the horizontal and vertical ratios of the position of mandibular foramen (Kositbowornchai et al., 2007).

The position of the mandibular foramen changes by bone remodelling, as a child matures into adulthood. Therefore, position of the most superoanterior point of the mandibular foramen on the ramus changes horizontally and vertically with age. Hence, for performing various surgical procedures consideration to these changes is imperative (Movahhed et al., 2011). The present authors studied three age groups to observe the positional changes in the mandibular foramen. We considered group I as ≤13 years (Ashkenazi et al., 2011)

of age, as the maximum variation in the position of the mandibular foramen is noticed in this age group (Hwang et al., 1997; Movahhed et al., 2011). As mandibular growth was considered to be definitely achieved at the age of 25 (Mitchell and Littlewood, 2007), so we categorised group II with age 14-25 years and group III as >25 years (Thangavelu et al., 2012).

In the present study, horizontal ratios (x/l) for the position of the mandibular foramen (n=200) were in the range of 0.33-0.66 in 92.5% cases, (95% on right and 90% on left side), which showed that it was located predominantly in the middle third of ramus anteroposteriorly. No mandibular foramen was observed in anterior third, however in 7% cases, it lies in posterior third with ratio range of <0.33. The majority of cases from group I (82%), II (50%) and III (63%) were in between the ratio range of 0.31-0.4. However in 15%, 46% and 28% cases from group I, II and III respectively, the mandibular foramen lied between 0.41-0.5 (Table 2). Our findings indicate that the mandibular foramen is located horizontally around the junction of the anterior two-thirds and the posterior third of the ramus, preferentially in front of this point, as was also reported previously (Table 3) (Hayward et al., 1977; Mwaniki and Hassanali, 1992; Shah et al., 2013; Shenoy et al., 2012; Trost et al., 2010).The location of mandibular foramen has also been reported predominantly just posterior to the middle one third of the mandibular ramus in children or even at the center of mandibular ramus in horizontal plane in the unknown age group (Da Fontoura et al., 2002; Mbajiorgu, 2000; Nicholson, 1985; Viravudth and Plakornkul, 1989).

According to Benham (1976), the average percent depth of the needle used for local anaesthesia ranged from 57.6% in five year old to 60.5% in eleven year old subjects. The author concluded that the depth of penetration of the needle should be slightly over half of the distance from the anterior border to the posterior border of ramus (55 to 60%) signifying that mandibular foramen lied in the middle third of ramus anteroposteriorly.

The mean distance 'x' between the posterior border of the mandibular foramen and line AB which was 1.35 cm on right and 1.38 cm on left side and the mean width 'l' of the ramus at the horizontal level of the centre of mandibular foramen was 3.45 cm on right and 3.50 cm on left side (Table 1). The distance between the posterior border of the ramus and the posterior border of the mandibular foramen and between the anterior and posterior borders of the ramus at the level of the mandibular foramen varied from 0.6-1.6 cm and 2.7-3.6 cm respectively in different anatomical and radiological studies of different origin (Aglarci et al., 2015; Da Fontoura et al., 2002; Ghatak and Yadav, 2012; Gopalakrishna et al., 2016; Hayward et al., 1977; Mwaniki and Hassanali, 1992; Shah et al., 2013; Shenoy et al., 2012; Thangavelu et al., 2012; Viravudth and Plakornkul, 1989).

Ashkenazi et al. (2011) found a significant difference in the anteroposterior dimension of ramus with age. It was also concluded that mandibular foramen moved anteriorly from the posterior border of the ramus with age but appreciably only after adulthood. In the present study, when patients in age group of 13 years or less (group I) were compared to the other two age groups, a statistically significant difference was found in the horizontal position of mandibular foramen in the ratio range of 0.31-0.40 but there was a non-significant difference between the other two age groups (Fig. 2a, 2b) as was also reported previously (Benham, 1976; Kang et al., 2013; Kilarkaje et al., 2005). However, no significant change in the position of mandibular foramen with age in relation to the bony landmarks was reported by Afsar et al. (1998).

The knowledge of vertical location of the mandibular foramen is as important as the horizontal position of mandibular foramina for performing various surgical procedures. According to Enlow's V-principle, the vertical position of the mandibular foramen changes with appositional growth at the

Table 3. Comparison of horizontal and vertical ratios of present study with previous studies for the position of mandibular foramen.

Author's Name	Type of Study	Number of Specimens	Population	Results			
				Horizontal ratios		Vertical ratios	
				Right	Left	Right	Left
Present study	Radiological	100	Indian	0.39	0.39	0.38	0.39
Trost et al. (2010)	Radiological	46	French	0.30-0.35		0.35	
Da Fontoura et al. (2002)	Radiological	280	Brazilian	0.36		–	
	Anatomical			0.32		0.31	
Mbajiorgu (2000)	Anatomical	38	Zimbabwean	0.46	0.47	0.48.	0.48
Mwaniki and Hassanali (1992)	Anatomical	79	Kenyan African	0.35 to 0.44		0.45 to 0.54	

inferior border of the mandible and with the growth of the condylar region (Benham, 1976). In the present study, vertical ratios (y/h) for the position of the mandibular foramen (n=200) were in the range of 0.33-0.66 in 78.5% cases (81% on right and 76% on left side) indicating the approximate position of the foramen in the middle third of the ramus superoinferiorly (Fig. 2a, 2b), as was also reported previously (Table3) (Da Fontoura et al., 2002; Hayward et al., 1977; Mbajiorgu, 2000; Mwaniki and Hassanali, 1992; Shah et al., 2013; Shenoy et al., 2012). In more than half of the cases (59%), this ratio was between 0.31 and 0.4, indicating that the mandibular foramen is placed around the midpoint of the superior one third and the inferior two-thirds of the ramus, preferentially under this point (Trost et al., 2010). In contrast, the position of foramen has also been reported at relatively low position i.e. either midway or in the lower half of ramus vertically in majority of cases (Nicholson, 1985; Viravudth and Plakornkul, 1989). In the present study, in one case (0.5%), the mandibular foramen was in inferior third of the ramus and it belonged to the mandible of less than thirteen years of age (group I) so the positional changes of mandibular foramen must be kept in mind while performing surgical procedures in children.

In the current study, the mean vertical distance from the superior border of the mandibular foramen to the mandibular incisura was 1.95 and 1.96 cm and the distance h between A and B was 5.14 cm and 5.06 cm on right and left side respectively (Table1). Similarly, the mean vertical distance from the superior border of the mandibular foramen to the mandibular incisura and the distance from the sigmoid notch to the inferior border of the mandible varied from 1.5-2.5 cm and 3.6-5.3 cm respectively in previous studies of different study material (anatomical & radiological) of different ethnic origin (Afsar et al., 1998; Aglarci et al., 2013; Da Fontoura et al., 2002; Ghatak and Yadav, 2012; Gopalakrishna et al., 2016; Jalili, 2010; Mbajiorgu, 2000; Mwaniki and Hassanali, 1992; Rashid and Ali, 2011; Shah et al., 2013; Shenoy et al., 2012; Viravudth and Plakornkul, 1989).

In the present study, statistically significant difference was found between group I and other two age groups (groups II and III) for the vertical ratio range of 0.31-0.40, whereas no significant difference was found between groups II and III (Table2) as was also documented previously (Trost et al., 2010). Thus a relative shift was seen from a more inferiorly positioned mandibular foramina (in the ratio range of 0.41-0.50) in patients with age group of less than equal to 13 years to more superiorly positioned mandibular foramina (ratio range 0.31-0.40) in patients with age of 14-25 years and more than 25 years. Some other studies also reported statistically significant differences between children and adults (Benham, 1976; Hwang et al., 1990).

In the present study, the maximum number of mandibular foramina, irrespective of gender had horizontal ratio (64.3% foramina in male subjects and 59.8% foramina in female subjects) and vertical ratio (60.2% foramina in male subjects and 57.8% foramina in female subjects) within range of 0.31-0.40 (Fig. 2c, 2d). A significant difference was found in the vertical ratios of two genders, being higher in the females. On comparing the differences between gender in each group, the parameters *x, y, l* and horizontal ratio were significantly higher in females in group I. Movahhed et al. (2011) conducted a study on panoramic radiographs of 7 to 10 year old children and found significant difference in the distance from the superior and anterior most point of mandibular foramen to occlusal plane and concluded that the mandibular foramen was predominantly located below the occlusal plane in male subjects aged 7 to 10 years and in females aged 7 to 8 years, whereas it is above the occlusal plane in female subjects aged 9 to 10 years. In the current study, *l* and *h* were significantly higher in males in group II and *x, h* and horizontal ratio were significantly higher in male subjects of group III. Earlier studies also found a significant difference between linear measurements and genders for the position of the mandibular foramen (Jalili, 2010; Rashid and Ali, 2011). Jalili (2010) studied position of mandibular foramen in relation to bony landmarks, in patients of above 18 years of age and found significant differences between mandibular foramen and distance from the mylohyoid line, the external oblique line, the angle of mandible, mandibular notch, head of condyle, posterior border of ramus and the occlusal surface in males and females. Similarly, Rashid and Ali (2011) found that the distance from the mandibular foramen to the mandibular incisure and the total length of the mandibular ramus was higher in males as compared to females.

The horizontal (x/l) and vertical (y/h) ratios for the position of mandibular foramen are not influenced by side (Fig. 2e, 2f), as was also reported earlier (Afsar et al., 1998; Hayward et al., 1977; Rashid and Ali, 2011; Shah et al., 2013; Shenoy et al., 2012; Trost et al., 2010).

The mandibular foramen located in the same position on both right and left side are described as symmetrical. In the present study, the location of the mandibular foramen maintained bilateral symmetry both vertically as well as horizontally in all the patients as ratios of both mean horizontal and vertical ratios on both right and left sides was found to be near to 1 (Table1), as was also reported previously in literature (Kilarkaje et al., 2005; Sandhya et al., 2015; Saralaya and Narayana, 2005; Shiliani et al., 2016; Valente et al., 2012).

Conclusions

The present study reveals the valuable insight on

the information concerning the location of the mandibular foramen in Indian population in different age groups. In the present study, statistically significant difference was found between group I and other two age groups (Group II and III) for the vertical and horizontal ratio in range of 0.31-0.40, whereas no significant difference was found between group II and III. It is recommended that superior 1/5th and inferior 2/5th; posterior 1/5th and anterior 2/5th are the safe zones where mandibular foramen is unlikely to be found. The information is important for performing standard, extra oral technique of inferior alveolar nerve block and during the aesthetic and functional reconstructive surgery. Mandibular foramen is located most frequently in middle 2/5th horizontally as well as vertically. However, it is the surgeon's responsibility to gain an understanding of its location with adequate imaging to avoid any violation to the neurovascular bundle.

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