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Age Prediction of Individuals on The Basis of Vertical Positions of Mental Foramen on Panoramic Radiograph–A South Indian Experience

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Abstract

Aim: To predict the age of patients on the basis of vertical position of mental foramen and assess the variations in vertical position and vertical diameter of the mental foramen in dentulous, partially edentulous and edentulous patients on panoramic radiograph. *Material and Method:* The panoramic radiographs of 560 subjects were evaluated. In 60 subjects mental foramina could not be identified on the panoramic radiographs so they were excluded from study. The study population included subjects of all age groups. The maximum subjects were in 20-29 years age group followed by 30-39 years and 40-49 years age groups. The data were analyzed using one way ANOVA (Analysis of variance), Duncan's Multiple Range test, Post-hoc analysis of ANOVA and T-test. *Result:* Mean relative vertical position of mental foramen between each age group showed very high statistical difference (P<0.001). Younger age group has high relative vertical position with maximum in lessthen 20 years age group and older age groups showed low relative vertical position with least in Greater then equal to 80 years age group. The age of any individual can be predicted on the basis of mathematical equations derived from linear regression analysis. Mean relative vertical position in all three status of dentition groups i.e., dentulous, partially edentulous and edentulous subjects showed highly significant (p<0.001) difference. The vertical position was highest in dentulous subjects followed by partially edentulous subjects and least in edentulous subjects. Mean vertical diameter of mental foramen between each age group, gender wise and dentition wise did not show any statistical difference. *Conclusion:* From the mathematical equations derived by linear regression analysis the age of a subject can be predicted with high sensitivity. However due to ethnic, racial, geographical, genetic and environmental factors vertical positions of mental foramen varies from population to population. It was concluded that equations obtained by linear regression analysis may be used as a tool for age estimation in medico-legal cases and clinical dentistry.

Keywords: Mental Foramen; Panoramic Radiograph; Mandible; Premolars; Molars.

Introduction

Mental foramen is an intraosseous foramen which opens on the lateral surface of the body of the mandible on each side below and between the roots of first and second premolars and at times below the second premolars [1] .It may be round, oblong, slit like or very irregular and partially or completely corticated [2,3]. Mental foramen appears as an oval or round radiolucent area[4,5] in the mandibular first molar and premolar region[4,6]. The mental foramen is seen about halfway between the lower border of the mandible and the crest of the alveolar process usually in the region of the apex of the second premolar [2].

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A panoramic radiograph is most often used where broad coverage of the jaws is required. The recognition of normal anatomic structures on panoramic radiographs is frequently challenging because of the complex anatomy of the region and the multiple superimposition of various anatomic structures and the changing projection orientation. Mental foramen is one among the normal anatomic landmarks whose image is quite variable. Thorough review of literature showed no data or study regarding prediction of age on the basis of vertical positions of mental foramen in Indian population till date. So considering the importance of locating mental foramen, the present study was undertaken to study this anatomic entity on panoramic radiographs to be focused on prediction of the age of subjects on the basis of vertical positions and age related changes in vertical diameter.

Materials and Methods

A study of mental foramina on panoramic radiographs over 560 patients was conducted in the Department of Oral Medicine and Radiology, Government dental college, Trivandrum during the period January 2008 to December 2008. The study subjects were selected from the radiology clinic reporting for routine panoramic radiograph. The subjects with developmental malformations of the jaws, systemic conditions affecting the jaw growth or clinical or radiographic evidence of jaw pathologies or fractures were not included in the study. Detailed history and the clinical examination were carried out. The panoramic radiographs were taken and evaluated using standardized technique. Mental foramina could not be identified in 60 panoramic radiographs so they were not included for statistical analysis.

The remaining 500 subjects of total study population were divided into 8 age groups. Interpretation of radiographs was done in a quiet room with subdued lighting. The panoramic film was properly oriented on the flat radiograph viewer box emitting even light and using cardboard sheets extraneous light form the edges of the radiographs was masked out. Tracings of panoramic radiograph was made using tracing paper and measurements for relative vertical position and vertical diameter was done by Yosue and Brooks [6] method using extra-oral radiographic scale (Radiodent Oye, Planmecca PM 2002 cc) calibrated in millimeters and centimeters.

A. Determination of the vertical position of the mental foramen (In superior-inferior plane)

The shortest line connecting the alveolar ridge and the lower border of the mandible passing through the center of the mental foramen was determined. Measurements were made using a divider and extraoral radiographic scale (Radiodent Oye, Planmecca PM 2002 cc) calibrated in millimeters from the alveolar ridge to the upper border of the mental foramen (a) and from the lower border of the mandible to the lower borders of the mental foramen. (c) The relative vertical position of the mental foramen was determined by the ratio a/c. Similar procedure was followed to determine the vertical position of mental foramina on all 500 panoramic radiographs.

B. Determination of the vertical diameter of the mental foramen (In superior-inferior plane)

Shortest line connecting the alveolar ridge and the lower border of the mandible passing through the center of the mental foramen was determined. Using a divider and extra-oral radiographic scale (Radiodent Oye, Planmecca PM 2002 cc) calibrated in millimeters, the vertical diameter of the mental foramen was measured in millimeters from the upper and lower borders of the mental foramen along line passing through the center of the mental foramen. Similar procedure was followed to determine the vertical diameter of mental foramina on all 500 panoramic radiographs. (Fig. A)

The data obtained were tabulated and subjected to statistical analysis. SPSS software was used for the analysis of the data. The analysis for studying the differences in the variables were carried out by One way ANOVA (Analysis of variance), Duncan's Multiple Range test , Posthoc analysis of ANOVA and T-test

Results and Observations

The mean relative vertical position of mental foramen between each age group showed very high statistical difference ($P<0.001$). Younger age group has high relative vertical position with maximum in < 20 years age group and older age groups showed low relative vertical position with least in Greater then equal to 80 years age group (Table 1A & 1B). Thus age plays an important role in vertical position of mental foramen.

The relative vertical position of mental foramen of males and females were compared with student's t

Table 1A: Association between Age groups and side wise relative Vertical Position (mm) of Mental Foramen (One way ANOVA)

Location	Age	Mean(vertical position)	± SD	F value	p value
Right side	< 20	14.765^{e}	3.62	15.715	0.000**
	20 - 29	14.463^{e}	3.59		
	30 - 39	14.119^{de}	3.29		
	40 - 49	13.235^{de}	2.75		
	50 - 59	12.124^{cd}	3.22		
	60 - 69	10.962^{bc}	4.18		
	70 - 79	9.016^{b}	4.34		
	≥ 80	5.350^{a}	1.34		
Left side	< 20	14.488^{e}	3.48	11.394	0.000**
	20 - 29	14.433^{e}	3.01		
	30 - 39	13.995^{de}	3.46		
	40 - 49	12.819^{cde}	2.83		
	50 - 59	12.118^{bcd}	3.35		
	60 - 69	11.402^{bc}	4.62		
	70 - 79	9.942^{b}	5.14		
	≥ 80	6.575^{a}	4.18		

Duncan's Multiple Range Test shows the mean with superscript a, b, c, d, e (** p< 0.001) did not differ from each other

Table 1B: Association between Age groups and overall relative Vertical Position (mm) of Mental Foramen (One way ANOVA)

Location	Gender	Mean	± SD	t value	p value
Right side	Male	13.118	3.726	-1.031	0.303
	Female	13.446	3.827		
Left side	Male	12.976	3.685	-1.721	0.086
	Female	13.555	3.701		
Overall (right and left side together)	Male	13.047	3.200	-1.555	0.120
	Female	13.513	3.419		

Duncan's Multiple Range Test shows the mean with superscript a, b, c, d, e (** p< 0.001) did not differ from each other

test. No significant difference was noted between males and females. However female population showed slightly higher vertical position in right side, left side and in overall (right and left side together) (Table 2)

Regarding sensitivity of prediction of age on basis of vertical position of mental foramen in different age groups it was noted that sensitivity varies between 70.92% and 90.65% in all 8 age groups. The highest sensitivity was in < 20 years of age group

Table 2: Association between Gender and Relative Vertical Position

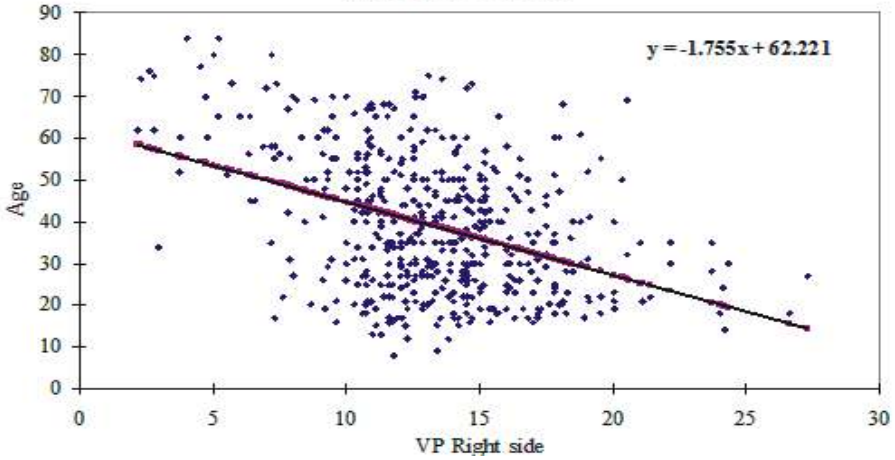
Location	Gender	Mean	± SD	t value	p value
Right side	Male	13.118	3.726	-1.031	0.303
	Female	13.446	3.827		
Left side	Male	12.976	3.685	-1.721	0.086
	Female	13.555	3.701		
Overall (right and left side together)	Male	13.047	3.200	-1.555	0.120
	Female	13.513	3.419		

(90.65%) and lowest was in age group of 50 – 59 years (70.92). To know the significance of age on vertical position of mental foramen in different age groups linear regression analysis of study population considering age versus vertical positions as variables according to side of mandible had been considered.

A. Linear Regression Analysis between Vertical Position for right side of mandible and Age in Panoramic Radiographs (Fig. A)

Right vertical position of mental foramen was found to be negatively correlated with age i.e. as age increases right vertical position of mental foramen was found to be decreasing significantly. Linear regression analysis elucidated a mathematical equation for the relationship between right vertical position and age, $y = - 1.755x + 62.221$, taking y variable as age and x variable as vertical position (mm) of mental foramen. Using this equation age of a subject can be determined if vertical position of mental foramen on right side is known.

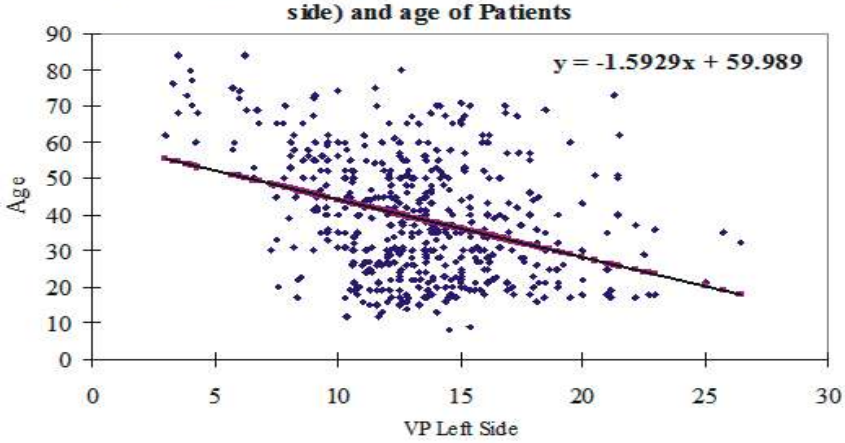
Fig.A Regression analysis between Vertical positions (Right side) and Age of Patients



B. Linear Regression Analysis between Vertical Position for left side of mandible and Age in Panoramic Radiographs (Fig. B)

Left vertical position of mental foramen was found to be negatively correlated with age i.e. as age increases, left vertical position of mental foramen was also found to be decreasing significantly. Linear regression analysis elucidated a mathematical equation for the relationship between left vertical position and age, $y = - 1.5929x + 59.989$, taking y variable as age and x variable as vertical position (mm) of mental foramen. Using this equation age of a subject can be determined if vertical position of mental foramen on left side is known.

Fig B. Regression analysis between Vertical Positions (Left side) and age of Patients

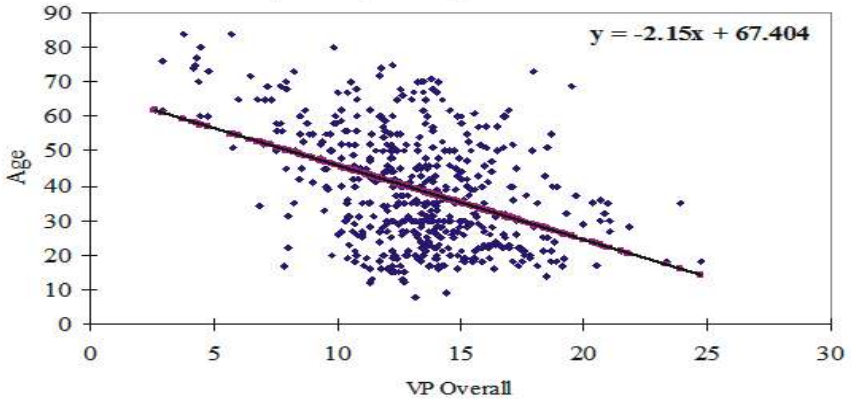


C. Overall (mean of vertical positions of right and left side) vertical position in study Population (Fig. C)

Overall (mean of vertical positions of right and left side) vertical position of mental foramen was found to be negatively correlated with age i.e. as age increasing, overall vertical position mental foramen was found to be decreasing significantly. Linear regression analysis elucidated a mathematical equation for the relationship between overall vertical position and age, $y = - 2.15x + 67.404$, taking y

variable as age and *x* variable as vertical position (mm) of mental foramen. Using this equation age of a subject can be determined if overall (right and left side together) vertical position of mental foramen is known.

Fig C. Regression analysis between Vertical Positions (overall) and Age of Patients



D. Association between Status of Dentition and Relative Vertical Position (mm) of Mental Foramen on Panoramic radiographs (Table 3A & 3B)

Mean relative vertical position in all three status of dentition groups i.e., dentulous, partially edentulous and edentulous subjects showed highly significant ($p<0.001$) difference. The vertical position was highest in dentulous subjects followed by partially edentulous subjects and least in edentulous subjects.

As described above that status of dentition of a subject plays an important role in vertical position of mental foramen. The vertical position was most significant in dentulous subjects followed by partially edentulous subjects and least in edentulous subjects. The sensitivity of prediction of age on basis of vertical position of mental foramen in different status of dentition showed that dentulous subjects had highest sensitivity for age prediction followed by partially edentulous and least in edentulous subjects. To know the significance of age on vertical position of mental foramen in different status of dentition linear regression analysis in dentulous, partially edentulous and edentulous subjects considering age versus overall (right and left side together) vertical positions as variables had been done.

Table 3A: Association between Status of Dentition and sidewise relative Vertical Position (mm) of Mental Foramen on Panoramic radiographs (One way ANOVA)

Location	Status of Dentition	Mean	± SD	F value	p value
Right side	Dentulous	14.205[c]	3.14	68.502	0.000
	Partially edentulous	12.742[b]	3.61		
	Edentulous	7.827[a]	3.84		
Left side	Dentulous	14.080[c]	3.10	55.538	0.000
	Partially edentulous	12.692[b]	3.57		
	Edentulous	8.346[a]	4.31		

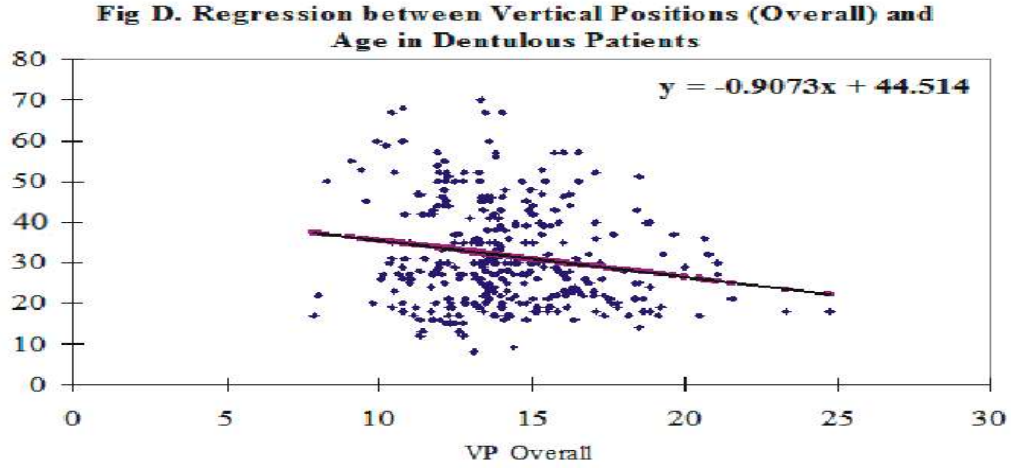
Table 3B: Association between Status of Dentition and overall relative Vertical Position (mm) of Mental Foramen on Panoramic radiographs (One way ANOVA)

Location	Status of Dentition	Mean	± SD	F value	p value
Overall(Right & Left side together)	Dentulous	14.143[c]	2.58	85.316	0.000
	Partially edentulous	12.717[b]	3.09		
	Edentulous	8.087[a]	3.80		

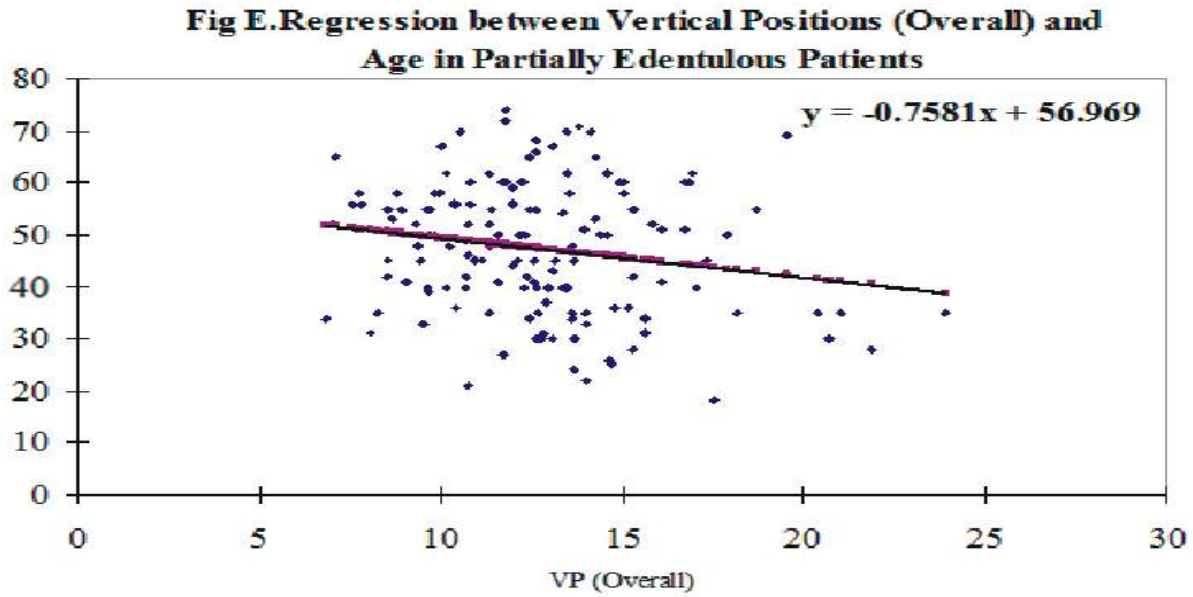
Duncan's Multiple Range Test shows the mean with superscript a, b, c, ($p < 0.001$) did not differ each other.

E. Regression Analysis between Vertical Position and age according to Status of dentition (Fig.D)

For dentulous subjects overall vertical position(mean of vertical positions of right and left side) of mental foramen in dentulous subjects were found to be negatively correlated with age i.e. as age increases, overall vertical position of mental foramen in dentulous subjects were found to be decreasing significantly. Linear regression analysis elucidated a mathematical equation for the relationship between overall vertical position and age, $y = -0.9073\ x + 44.514$, taking y variable as age and x variable as vertical position (mm) of mental foramen. Using this equation age of a dentulous subject can be determined if overall vertical position of mental foramen is known.



For partially edentulous subject (***Fig.E***) overall vertical position(mean of vertical positions of right and left side) of mental foramen in partially edentulous subjects were found to be negatively correlated with age i.e. as age increases, overall vertical position of mental foramen in partially edentulous subjects were found to be decreasing significantly. Linear regression analysis elucidated a mathematical equation for the relationship between overall vertical position and age, $y = -0.7581\ x + 56.969$, taking y variable as age and x variable as vertical position (mm) of mental foramen. Using this equation age of a partially edentulous subject can be determined if overall vertical position of mental foramen is known.



For Edentulous subjects (***Fig.F)***, Overall vertical position (mean of vertical positions of right and left side) of mental foramen in edentulous subjects were found to be negatively correlated with age i.e. as age increases, overall vertical position of mental foramen in edentulous subjects were found to be decreasing significantly. Linear regression analysis elucidated a mathematical equation for the relationship between overall vertical position and age, $y = - 0.6912\ x + 71.102$, taking y variable as age and x variable as vertical position (mm) of mental foramen. Using this equation age of an edentulous subject can be determined if overall vertical position of mental foramen is known.

F. Association of Age, gender and status of dentition with diameter of mental foramen (mm)

Mean diameter of mental foramen between each age group did not show any statistical difference. *(*Table.4A & 4B*)* Mean diameter of mental foramen in dentulous, partially edentulous and edentulous subjects showed no statistical difference (Table 5).Mean diameter of mental foramen of males and females showed no significant difference in right side, left side or in overall. However males showed slightly higher mental foramen diameter in all age group.(Table 6)

Fig F.Regression between Vertical Positions (Overall) and Age in Edentulous Patients

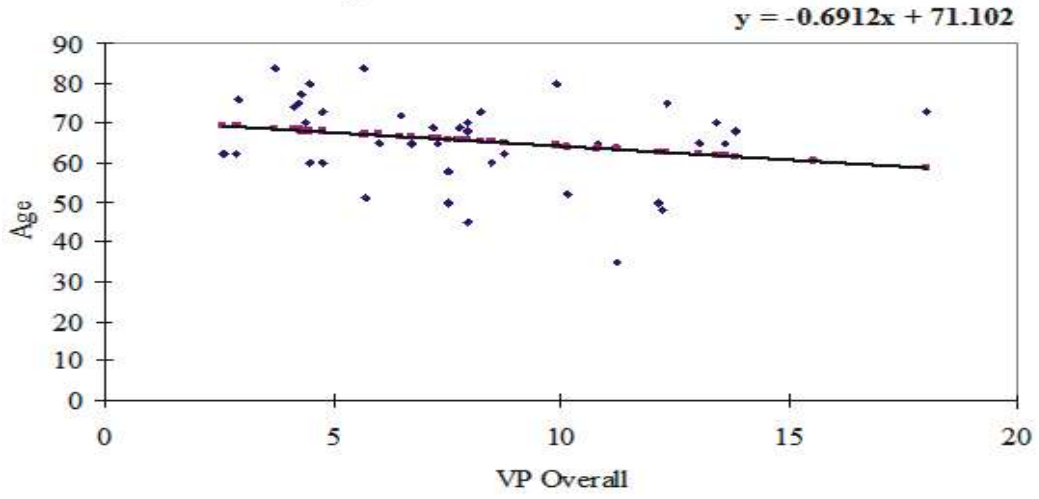


Table.4A: Association between Age groups and Diameter of mental foramen of right and left side (mm) (One way ANOVA)

Location	Age	Mean	± SD	F value	p value
Right side	< 20	0.445[a]	0.11	0.209	0.983
	20 - 29	0.458[a]	0.12		
	30 - 39	0.446[a]	0.11		
	40 - 49	0.450[a]	0.15		
	50 - 59	0.444[a]	0.13		
	60 - 69	0.438[a]	0.15		
	70 - 79	0.455[a]	0.09		
	≥ 80	0.488[a]	0.13		
Left side	< 20	0.453[a]	0.11	1.112	0.354
	20 - 29	0.472[a]	0.12		
	30 - 39	0.443[a]	0.11		
	40 - 49	0.432[a]	0.14		
	50 - 59	0.435[a]	0.13		
	60 - 69	0.464[a]	0.12		
	70 - 79	0.437[a]	0.12		
	≥ 80	0.450[a]	0.15		

Duncan's Multiple Range Test shows the mean (superscript a) did not differ from each other.

Table.4B: Association between Age groups and Overall diameter of mental foramen (mm) (One way ANOVA)

Location	Age	Mean	± SD	F value	p value
Overall (right and left side together)	< 20	0.449[a]	0.08	0.670	0.697
	20 - 29	0.465[a]	0.10		
	30 - 39	0.445[a]	0.09		
	40 - 49	0.441[a]	0.10		
	50 - 59	0.439[a]	0.11		
	60 - 69	0.451[a]	0.10		
	70 - 79	0.446[a]	0.10		
	≥ 80	0.469[a]	0.13		

Duncan's Multiple Range Test shows the mean (superscript a) did not differ from each other.

Table.5: Association between Status of dentition and Diameter of Mental Foramen (mm) (One way ANOVA)

Location	Status of Dentition	Mean	± SD	F value	p value
Right side	Dentulous	0.454[a]	0.13	0.634	0.530
	Partially edentulous	0.442[a]	0.13		
	Edentulous	0.436[a]	0.12		
Left side	Dentulous	0.460[a]	0.12	3.619	0.028
	Partially edentulous	0.427[a]	0.12		
	Edentulous	0.443[a]	0.14		
Overall(right and left side together)	Dentulous	0.457[a]	0.10	2.678	0.070
	Partially edentulous	0.435[a]	0.09		
	Edentulous	0.439[a]	0.11		

Duncan's multiple range test shows the mean (superscript a) did not differ from each other.

Table.6: Association between Gender and Diameter of Mental foramen (Student T-test)

Location	Gender	Mean	± SD	t value	p value
Right side	Male	0.451	0.135	0.418	0.676
	Female	0.446	0.113		
Left side	Male	0.448	0.127	-0.223	0.824
	Female	0.451	0.119		
Overall(right and left side together)	Male	0.449	0.108	0.109	0.914
	Female	0.448	0.086		

Discussion

Mental foramen is an anatomical landmark occurring on the lateral surface of the body of the mandible bilaterally. It is commonly seen on the panoramic radiographs than on the intraoral periapical radiographs. On panoramic radiographs the appearance of mental foramen varies. According to Yosue and Brooks[7] there are four different appearances of mental foramina on panoramic radiographs. Most of studies conducted to determine the types and distribution of mental foramina were retrospective studies. The present study is a prospective type of study and an attempt is made to determine the age of patients on the basis of vertical position of mental foramen on panoramic radiographs.

While analyzing the association between relative vertical positions in all age groups of study population according to side it was found that the mean relative vertical position of mental foramen between each age group showed very high statistical difference ($p<0.001$) .Younger age group has high relative vertical position with maximum in < 20 years age group and older age groups showed low relative vertical position with least in greater then equal to 80 years age group. Regarding gender variation in relative vertical position there was no significant difference between males and females noted. So it

can be concluded age plays an important role in vertical position of mental foramen but gender-wise no significant variation was noted in vertical position of the mental foramen.

The vertical positions of mental foramen on right side and left side of mandible is a subjective feature i.e. the vertical position of mental foramen was found to be different in a individual in right and left side of mandible therefore overall (mean of vertical positions of right and left side of mandible) vertical positions of mental foramen is more reliable for prediction of age of the subject. The linear regression analysis of data in study population for overall (mean of vertical positions of right and left side) vertical positions shows that overall vertical position of mental foramen was found to be negatively correlated with age i.e., as age increases, overall vertical position of mental foramen was found to be decreasing significantly.

Fishel *et al [8]* concluded that the location of the mental foremen was variable in both the horizontal and vertical planes. Ari *et al [9]* concluded that localization of mental foramen may not only differ between populations of different geographic environment but also within the inhabitants of the same geography. Gungor *et al* [10] also discussed the difference of the location of the mental foramen in different ethnics group. Due to ethnic, racial, geographical, genetic and environmental factors, vertical position of mental foramen varies from population to population. Sensitivity of age prediction by equations derived from linear regression analysis can vary from population to population.

While analyzing the association between status of dentition and relative vertical position it was found that Status of dentition of a subject plays an important role in vertical position of mental foramen. The vertical position was most significant in dentulous subjects followed by partially edentulous subjects and least in edentulous subjects. It was also found that for dentulous, partially edentulous and edentulous subjects overall (mean of vertical positions of right and left side) vertical position of mental foramen was found to be negatively correlated with age i.e. as age increases, overall vertical position of mental foramen were found to be decreasing significantly.

The sensitivity of prediction of age on basis of vertical position of mental foramen in different status of dentition was overall very high however highest sensitivity for age prediction was noted in dentulous subjects followed by partially edentulous and least in edentulous subjects.While analyzing the association between vertical diameter of mental foramina of subjects with age, gender and status of dentition, it was found that these parameters had no effect on vertical diameter of mental foramina of subjects.

Conclusion

From the mathematical equations derived by linear regression analysis, the age of a subject can be predicted with high sensitivity. These equations may be used as a tool for age estimation in medico-legal cases and clinical dentistry. However due to ethnic, racial, geographical, genetic and environmental factors vertical positions of mental foramen varies from population to population. So sensitivity of age prediction by these equations can vary from population to population. Hence more study is required on different races and ethnic groups with larger sample size.

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