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Age estimation by determination of the stages of third molar development using Kullman's method

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Abstract--- Determination of dental age in a living person is also equally important to know his /her age where there is no birth record available for legal purposes. The present study involves the radiographic examination of mandibular 3rd molar on digital Panoramic X-Ray. The radiograph of each subject was then interpreted following the guidelines suggested by Kullman et al (1992)

for age estimation based on their developmental stage and root length of mandibular third molar. This study concluded that the developmental stages of root of mandibular third molar gives fairly accurate results and can be considered for the age estimation with the methodology suggested by Kullman et al.

Keywords---age, determination, molar development.

Introduction

As we progress through life, life style also changes. The present century is witnessing tremendous growth in terms of industrialization, economy, research and travel. The rural world is changing into urban with new inventions in every field. Ironically, man is also self-destructive in many ways. His urge to conquer new heights has formed a world full of scientific advancement and technology with skyscrapers, fast cars, high-speed planes one-touch operating systems, cyber technology and nuclear weapons. Incidence of mass disasters like airplane crashes, train accidents & bomb explosion have also increased apart from the natural calamities like earth quake, volcanic eruptions, floods, forest fires and thunderstorms. Loss of life and property is the major issue in these calamities. Practical and legal problems arise after these calamities. Most important is the identification of the bodies of victims in these calamities, as bodies are mutilated beyond recognition. Age estimation helps in identification procedure of whole or fragmented bodies. Identification of victims is very crucial in country like ours as conducting the last rites of a body is of considerable religious importance in India.

Need of age estimation is important in case of human identification in accidents or other natural calamities where legal Issues like evidence of person's death is important to claim the belongings and for the property rights of the family members. Death certificate is a crucial document to claim insurance & also to verify the person has attained the maturity or not. Dental structures are the hardest known structures in human body and in most instances the only identifiable remains in mass disasters and calamities. Forensic expert plays a vital role in these circumstances. Determination of dental age of a mutilated body using stages of tooth mineralization is now old age practice.¹

Determination of dental age in a living person is also equally important to know his /her age where there is no birth record available for legal purposes. Legal consequences can be quite different if a subject of unknown age is judged to be juvenile or an adult. Apart from these, estimation of age also plays an important role in anthropological research and treatment planning of various abnormalities. Age assessment in young children is more precise as multiple teeth are developing and other skeletal maturity factors can be utilized. In case of adolescent and young adults, third molars are the only developing teeth and all other methods of assessing age are of questionable value. Fusion of sutures, fusion of epiphysis of bones and attainment of secondary sex characteristic features takes place by middle of teens and early twenties. Overall there is no biological criterion to estimate chronological age of a person in adolescent and young adults.

Thus, developmental stages of crown & root in third molar make the important method to estimate the age in adolescent and young adults. In the past, several studies have conducted to test the reliability of third molar developmental stages as a marker of age with variable results. Usually the first evidence of calcification of mandibular third molar begins by 8 to 10 years and its eruption in the oral cavity is around 17 to 21 years while its root is completed by 18 to 25 years. It is possible to determine the age assessment by analyzing the length of root & stages of development on radiograph. The present study involves the radiographic examination of mandibular 3rd molar on digital Panoramic X-Ray. The radiograph of each subject was then interpreted following the guidelines suggested by Kullman et al (1992)⁽¹⁾ for age estimation based on their developmental stage and root length of mandibular third molar. With the above background, the present study is designed to judge the reliability in the method in estimation of age in adolescent and young adults visiting the department of Oral Medicine and Radiology, DY Patil University School of Dentistry, Nerul, Navi Mumbai.

Materials and Methods

The aim of this study was to estimate the age of an individual by measuring the length of the root and developmental stage of the mandibular third molar on digital panoramic radiograph by KULLMAN'S METHOD. The study was conducted in the department of Oral Medicine and Radiology, DY PATIL UNIVERSITY SCHOOL DENTISTRY.

Source of data

A retrospective study conducted on 80 digital opg's taken on Kodak Carestream 9000 machine to estimate the age using the root length of mandibular 3rd molars with the help of Diacom software by KULLMAN'S METHOD of age estimation in the Department of Oral Medicine and Radiology, DY PATIL UNIVERSITY SCHOOL DENTISTRY.

Inclusion criteria

Archives of radiographs of patients aged 10 years to 25 years.

Exclusion criteria

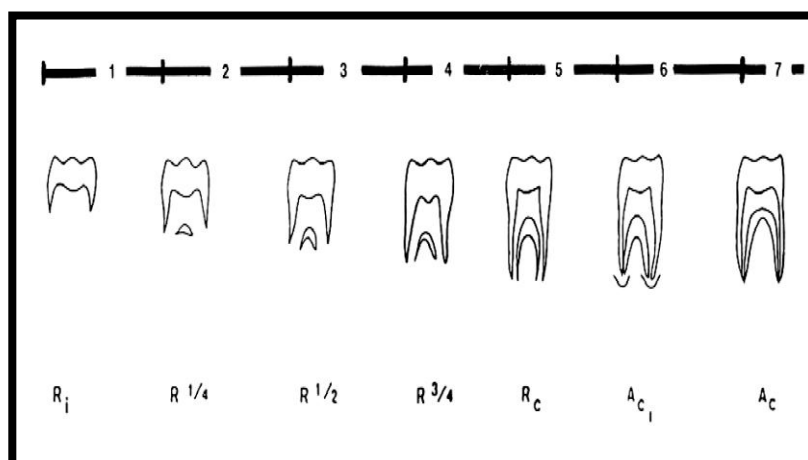
OPG'S SHOWING MISSING 3RD MOLARS

Methodology

Interpretation of the Digital Panoramic Radiograph

The interpretation of digital panoramic radiograph was done and measurement of the mesial root length of mandibular third molar of both sides from the cemento enamel junction upto the point where root has formed. The distances between these two points were considered as root length of the mandibular third molar. The radiograph of each subject was then interpreted following the guidelines

suggested by Kullman et al, (1992) for age estimation using mandibular third molar based on their root length and the developmental stage Fig I



Kullman seven stages based on the root developmental stages of mandibular third molar with their estimated dental age

Stages	Stages Of Root Development	Mean Dental Age	
		Left	Right
Stage 1	R ₁ - R _{1/4} root development initiated but less than 1/4 th of estimated root length	15y5mo	15y5mo
Stage 2	R _{1/4} - R _{1/2} root development >1/4 th But <1/2 of estimated root length	16y5 ^{1/2} mo	16y5mo
Stage 3	R _{1/2} - R _{3/4} root development >1/2 But <3/4 th of estimated root length	16y11 ^{1/2} mo	16y11mo
Stage 4	R _{3/4} -R _c root development >3/4 th But less than full estimated root length	17y2mo	17y
Stage 5	R _c -A _{ci} the full estimated root length is formed but apical closure not initiated	17y7mo	17y7mo
Stage 6	A _{ci} Apical closure started but not closed	18y6 ^{1/2} mo	18y10 ^{1/2} mo
Stage 7	A _c Apex is fully closed and root development completed	>19y	>19 y

Radiographic assessment of mandibular third molar

Evaluation	Left	Right
Root length measurement from CEJ (mm)		
Stage		
Mean dental Age		

Reference For Stages of Root Development

Stages by Kullman et al

- R_1 - $R_{1/4}$ root development initiated but less than $1/4^{\text{th}}$ of estimated root length
- $R_{1/4}$ - $R_{1/2}$ root development $>1/4^{\text{th}}$ But $<1/2$ of estimated root length
- $R_{1/2}$ - $R_{3/4}$ root development $>1/2$ But $<3/4^{\text{th}}$ of estimated root length
- $R_{3/4}$ - R_c root development $>3/4^{\text{th}}$ But less than full estimated root length
- R_c - A_{ci} the full estimated root length is formed but apical closure not initiated
- A_{ci} apical closure started but not closed
- A_c Apex is fully closed and root development completed

Reference table

STAGE	Right mandibular		left mandibular	
	AGE RANGE	Mean age	Age Range	Mean age
1	15y 1mo-15y 10mo	15y- 5mo	15y1mo-15y9mo	15y 5mo
2	16y 1mo-16y 10mo	16y- 5mo	16y 1mo-16y11mo	16y 5 ^{1/2}
3	16y 9mo-17y 1mo	16y-11mo	16y 9mo-17y 2mo	16y 11 ^{1/2}
4	17y - 17y3mo	17y	16y 9mo-17y 7mo	17y 2mo
5	17y mo - 18y1mo	17y-7mo	17y1mo-18y1mo	17y7mo
6	18y 2mo-19y7mo	18y10 ^{1/2}	18y1mo-19y	18y6 ^{1/2} mo
7	19y onwards	>20y	19y	>19y 1mo

The study was carried out to assess the dental age of an individual by radiographic evaluation of the mandibular third molar on digital panoramic and correlate the estimated dental age with the chronological age and also find out whether any significant difference exists between the left and right side of male and female subjects in the developmental stage of the root of the mandibular third molar. A retrospective study was conducted on 80 archived digital opg's to estimate the age using the root length of mandibular 3rd molars by KULLMAN'S METHOD of age estimation.

Results

Root length

Analysis of root length was done by measuring the mesial root length of the mandibular third molar of both sides from the cemento-enamel junction up to the point where the root has formed. The distance between these two points was considered for root length of the mandibular third molar. The root length of each subject was then analyzed following the guidelines suggested by Kullman et al, (1992) for age estimation.

Demographic characteristics of the study participants (N=80)

Variables	Sub-groups	n	%
Gender	Male	35	43.8
	Female	45	56.3
Age (Mean $\pm$ SD)		16.61 $\pm$ 3.902	
Root length (Mean $\pm$ SD)		5.7794 $\pm$ 4.03578	

The study consisted of 80 subjects out of which 35 were males and 45 were females with a mean age of 16.61 $\pm$ 3.902. The mean root length among the 80 subjects was 5.7794 $\pm$ 4.03578.

Comparison of the age in terms of {Mean (SD)} among males and females using unpaired t test

Gender	N	Mean	Std. Deviation	t value	P value
Males	35	16.77	3.835	0.319	0.750
Females	45	16.49	3.992		

The mean age of males was 16.77 whereas the mean age of females was 16.49.

Comparison of root length values in terms of {Mean (SD)} among males and females using unpaired t test

Gender	N	Mean	Std. Deviation	t value	P value
Males	35	5.9100	4.06817	0.254	0.800
Females	45	5.6778	4.05349		

The mean root length was 5.91 in males in comparison to 5.67 in females.

Correlation between root length and age in all the subjects

Age	Root length	
	R (correlation coefficient)	P value
Combined	0.440	<0.001**
Males	0.508	0.002*
Females	0.390	0.008*

The correlation between the root length and age in the overall subjects was highly significant with p value <0.001. The correlation between the root length and age in males was significant with p value 0.002. The correlation between the root length and age in females was significant with p value 0.008

Regression analysis to predict the chronological age using root length of mandibular 3rd molar as predictors

$$(y = a + bx)$$

Variables	Equation	Predicted age
Combined	$Y = 14.151 + 0.426 \times 5.7794$	16.6130
Males	$Y = 13.943 + 0.479 \times 5.9100$	16.7738

Females	$Y = 14.310 + 0.384 \times 5.6778$	16.4902
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The predicted age by using regression formula in the overall 80 subjects was 16.61. The predicted age by using regression formula in males was 16.77. The predicted age by using regression formula in females was 16.49

Discussion

In forensic dentistry, the determination of dental age using stages of tooth development to gauge an individual's degree of maturity is one of a few biological methods for monitoring physiologic development, and the dentition arguably is the only system available from prior birth to early adulthood. Dental development can also be used to estimate dental age during when the death of an unidentified person or the age of a suspect without legal documentation at birth. Younger ages can be assessed with greater accuracy because the intervals between morphological stages are shorter and therefore more precise. Late in adolescence, after the formation of the premolars and canines, only third molars continue to form a reliable source of age estimation. ⁽²⁾

The single compelling reason to rely on third molar formation to estimate chronological age is that there are very few alternative methods during the interval roughly between the mid-teens. All of the other teeth have erupted and completed root formation. With the above background, we carried out the study to assess the age of young adults and adolescents by radiographic evaluation of mandibular third molar on digital panoramic to correlate the age estimation on digital panoramic radiographs with the chronological age based on the developmental stage of the root of the mandibular third molar. In our Study, age groups were selected between 10 to 25 years. The study groups consisted of 35 males and 45 females. An equal distribution of sex among the study sample was done so that the comparison between the male and female could be made easier & accurate when a similar sample has been taken on both sexes. Which is in agreement with Legovic et al (2010).⁽³⁾

Mean Root Length

The normal root length of the mandibular third molar is 11mm(Asher M.M. Wheelers (1993)⁽⁴⁾from the cemento-enamel junction up to the apex of the root. We have measured the mesial root length of the mandibular third molar of both sides from the cemento-enamel junction up to the point where the root has formed on the digital panoramic radiograph. The distance between these two points were considered as root length of the mandibular third molar. The root length of each subject was analyzed following the guidelines suggested by Kullman et al (1992)⁽⁵⁾for age estimation which consisted of seven stages of root development. We determined the root stages and the estimated dental age of the subject. In our study, statistically, no significant difference was found in the mean root length between the left and right sides of the mandibular third molar in each age group. These findings are in agreement with Levesque et al (1991),Daito et al (1992),Messotten et al (2002),Sarnat H et al (2003), Olze et al (2004)· Orhan et al (2007) & Bhat Vrinda et al (2007)⁽⁷⁾. Root Length of any tooth is of equal dimension on either side as stated by Levesque et al (1991)&Asher M (1993)^(22, 4).

Although statistically there was no difference in the mean root length between both sides, the right sides showed more root length because the growth rate of the mandible is slightly higher in the right side as stated by Mota R et al (2010)

Males & Females in the mean root length was assessed and it was found that no difference exists statistically. These findings are in accordance with Levesque et al (1991), Daito et al (1992), Messotten et al (2002), Sarnat H et al (2003), Olze et al (2004), Orhan et al (2007) & Bhat Vrinda et al (2007).⁽⁷⁾ In the development of the tooth, there is no difference in the gender as stated by Levesque et al (1991), Asher M (1993) & Mincer et al (1993).⁽⁸⁾ The mean root length value was slightly more in males as compared to females. These findings are in agreement with the finding of Levesque et al (1991), & Bhat Vrinda et al (2007).⁷ Mean root length is slightly more in males as compared to females this can be an attributed effect of X and Y chromosomes on growth of the root length as suggested by Lahdesmaki R (2006)

Mean Dental Age

Dental age is estimated by comparing the dental development status in a person of unknown age with published developmental survey stated by Gustafson (1966)⁽⁹⁾ In our study we calculated the estimated dental age by measuring the root length of mandibular third molar and using seven stages of root development given by Kullman et al (1992) as a guideline. Estimation of dental age by using mandibular third molar gives a good accuracy with ± 2 years. Demisch A (1956), Garnet al (1962), Moores et al (1963), Miles et al (1963), Demerijin et al (1973), Engstorm et al (1983), Nortje et al (1983), Mincer et al (1993), Uzamis et al (2000), Sarnat et al (2002) & Gunst et al (2003) while Thoreson et al (1991) showed low accuracy in estimating dental age using mandibular molar as a guideline. The Koshy and Tandon (1998) study were based on the Demirjian et al (1973) method of age estimation and they concluded that the accuracy of age estimation was not applicable for south Indian children, probably due to wide ethnic differences.⁽¹⁰⁾

Statistically, no significant difference was found in the mean dental age between the males and females. These observations are in accordance with Engstorm et al (1983), Levesque et al (1991), Prieto et al (2005) & Bhat Vrinda et al (2007). Levesque et al. (1991) reported that besides being ahead of girls in the root development, the course of development was also faster in boys. This finding concurs very much in the present study. This is a surprising fact and is unique for third molar, for the other permanent teeth an advance for girls is usually seen. Correlation Between The Chronological Age & Dental Age. Chronological age - refers to attainment of a certain number of years. It is most obvious and easily determined developmental parameter. Dental age - is estimated by comparing the dental development status in a person of unknown age with published developmental survey stated by Gustafson (1966)⁽⁹⁾

A strong correlation was found between chronologic age and dental development based on third molar root development stages on digital panoramic radiographs. Overall, a strong correlation was observed in the present study between third molar development and the chronological age. This implies that the developmental stages of root of mandibular third molar gives fairly accurate results and can be

considered reliable for the age estimation with the methodology suggested by Kullman et al with an accuracy of ± 2 years for age estimation by third molar. Need of age estimation is important in case of human identification in accidents or other natural calamities and also for other legal Issues. Determination of dental age in a living person is also equally important to know his /her age where there is no birth record available for legal purposes. Legal consequences can be quite different if a subject of unknown age is judged to be a juvenile or an adult.

With the above background, the present study was carried out to assess the dental age of an individual by radiographic evaluation of mandibular third molar on digital panoramic and correlate the estimated dental age with the chronological age and also to find out whether any significant difference exists between left and right side of male and female subjects in the developmental stage of the root of the mandibular third molar. A retrospective study was conducted on 80 archived digital opg's to estimate the age using the root length of mandibular 3rd molars by KULLMAN'S METHOD of age estimation. Root length was measured from the cemento-enamel junction up to the point where the root has formed on a digital panoramic radiograph. The root length of each subject was analyzed following the guidelines suggested by Kullman et al, (1992) for age estimation.

The study consisted of 80 subjects out of which 35 were males and 45 were females with a mean age of 16.61 ± 3.902 . The mean age of males was 16.77 whereas the mean age of females was 16.49. The mean root length among the 80 subjects was 5.7794 ± 4.03 . The mean root length was 5.91 in males in comparison to 5.67 in females. The correlation between the root length and age in the overall subjects was highly significant with p value <0.001 . The correlation between the root length and age in males was significant with p-value 0.002. The correlation between the root length and age in females was significant with p-value 0.008. Regression analysis was used for the age estimation. A strong correlation was found between chronologic age and dental age based on third molar root development stages using digital panoramic radiographs. There was no significant difference found in the mean root length & estimated mean dental age between sex & sides in each age group but males were slightly ahead of females.

Conclusion

Overall, a strong correlation was observed in the present study between third molar development and the chronological age. This implies that the developmental stages of root of mandibular third molar gives fairly accurate results and can be considered for the age estimation with the methodology suggested by Kullman et al. It is recommended further study can be done using different methodology for age estimation and also find out the reliability & accuracy of each method. National data has to be prepared that can be used in forensic studies and also in medico legal purpose to check the individual maturity status.

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