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Morphometric Analysis of Articular Eminence of Temporomandibular Joint in Indian Paediatric Population: A CBCT Study

Akhilanand Chaurasia*, Gaurav Katheriya, Nida Khan*****

*Assistant Professor **Resident, Department of Oral Medicine & Radiology, ***Junior Resident, Faculty of Dental Sciences, King George's Medical Unniversity, Lucknow, Uttar Pradesh 226003, India.

Abstract

Objective: The objective of present study is to assess the age and gender related changes in articular eminence inclination by best fit line method and top roof line method in right and left side of temporomandibular joint. This study is also implemented to predict the age of subjects on the basis of inclination angle by best fit line method and top roof line method. *Material and Methods:* The CBCT scan of 150 children were used in present study. The cone beam images (Scans) were obtained from Carestream 9000cc (USA) CBCT machine at 90 Kvp,4 mA for 6.3 seconds at FOV 17x6 and voxel size of 200.The TMJ was definedon 0.5 mm-thick axial slices. One of the axial views on which the condylar processes were seen with their widest mediolateral extent was used as a reference view for secondary reconstruction. The lateral slices of the TMJ were performed perpendicular to the long axis of the condylar process with 1mm thickness and the coronal slices were performed parallel to the long axis of the condylar process with 1mm thickness on the selected axial image. *Results:* The articular eminence inclination was statistically non significant in males (P value>.05) and females (P value>.05) in both best fit line method and top roof line method. The co-relation between age groups and articular eminence inclination by Best fit line method (right side and left side) and by Top roof line method (right side and left side) was stastically significant (p value<.001). *Conclusion:* Age plays an important role in articular eminence inclination by top roof line method and best fit line method. The age of an individual can be predicted if eminence inclination angle is known.

Keywords*:* Temporomandibular Joint; Best Fit Line Method; Top Roof Line Method; CBCT.

Introduction

The temporomandibular joint (TMJ) is a complex articular system which is located between the mandible and the temporal bone. It achieves the mandibular functions with a dynamic balance mechanism and has the ability to move within the three planes of space. The glenoid fossa creates the superior bone part and the mandibular condylar process creates the inferior bone part of the joint. The articular eminence is a part of the temporal bone on which the condylar process slides during mandibular movements. The inclination of articular eminence varies among people and it dictates the path of condylar movement as well as the degree of rotation of the disc over the condyle [1,2]. Many methods are used to examine the inclination of articular eminence such as measurements on dry skulls [3,4,5] conventional radiography [6] and tomography [1,7], MRI [8,9,10,11] and CT [12,13,14]. However CT machines have limitations in dentistry because of their high cost, large footprint and high radiation exposure. Cone beam CT has recently been developed as an alternative to conventional CT for dental and maxillofacial diagnostic osseous tasks. CBCT which was also used in the present study allows the use of a shorter scanning time while the radiation dose is lower than with conventional CT scans [15]. Radiographs can provide additional details about the health of the temporomandibular joints by revealing information about the morphology of the condyle and the fossa and the relationship between

Corresponding Author: Akhilanand Chaurasia, Assistant Professor, Department of Oral Medicine & Radiology, Faculty of Dental Sciences, King George's Medical Unniversity, Lucknow, Uttar Pradesh 226003, India.
E-mail: chaurasiaakhilanand49@gmail.com

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them. Various radiographic techniques have been used for the evaluation of the temporomandibular joint [16-23]. Because of the superimposition of anatomic structures, accurate and repeatable visualization of temporomandibularjoint disorders was difficult. This problem was solved with tomography. Tomograms are taken with special equipment that is capable of making a radiographic "slice" through an anatomic part at a predetermined level [23-26]. For many years the human temporomandibular joint and its parts have been the subject of extensive investigation and controversy [27].

The articular eminence is that part of the temporal fossa over which the condyle-disk complex slides during the various mandibular movements. It is often confused with the articular tubercle which is an entirely different structure. The articular tubercle [28,29] is the small bony projection at the lateral part of the articular eminence that serves as the origin of the temporomandibular ligament. The articular eminence inclination is defined as the angle formed by the articular eminence and the Frankfort horizontal (FH) plane or any other horizontal plane such as the occlusal or palatal plane. It can be measured by two methods [29,30]. One method is to measure the angle between the bestfit line on the slope of the eminence and the FH plane (Figure 1) hereafter referred as method 1, the other method is to measure the angle between the FH plane and a line connecting the roof of the fossa with the highest point of eminence (Figure 2) hereafter referred as method 2. It must be stressed that although both angles represent the articular eminence inclination, the first angle (best fit line– FH) focuses primarily on the posterior surface of the eminence whereas the other angle (fossa roof–eminence top, FH) focuses on the location of the eminence crest relative to the fossa roof. The normal value of this angle in adults has been reported to be 30^0–60^0 [31].Articular eminences having inclination values smaller than 30^0have been characterized as flat whereas those having values greater than 60^0 have been characterized as steep. However this distinction has not been universally accepted by Ichikawa, Laskin [32] and Granda [33].

Based on subjective criteria Ichikawa, Laskin [32] and Granda [33] divided articular eminence inclinations into flat, moderate and protuberant types. The flatness or steepness of the articular eminences dictates the path of condylar movement as well as the degree of rotation of the disk over the condyle. The steeper the articular eminence, the more the condyle is forced to move inferiorly as it shifts anteriorly. This results in greater vertical movement of the condyle, mandible and mandibular arch upon opening [34].

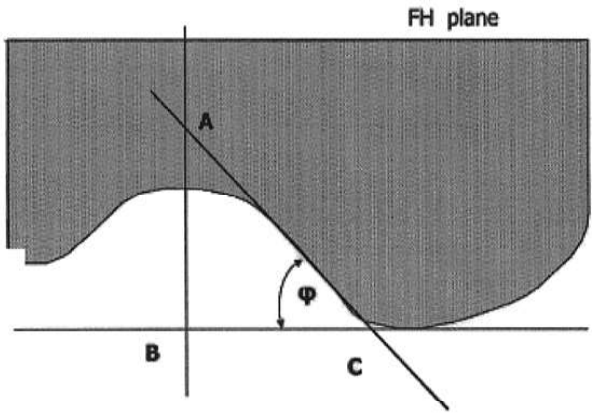

Fig. 1: The articular eminence inclination presented as the best Fit line (Method 1)

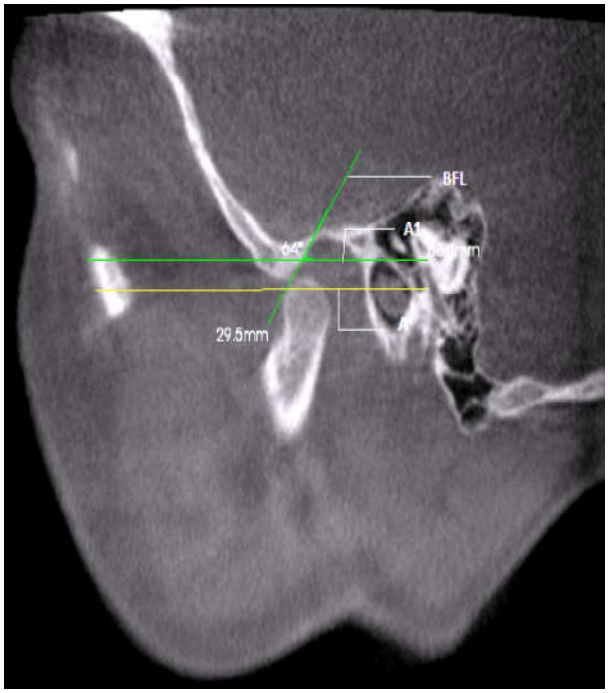

Fig. 2: The articular eminence inclination presented as the roof fossa and eminence-top line (Method 2)

Materials and Methods

Patients

This study was carried out in the Department of Oral medicine and Radiology, King George's Medical University, Lucknow, India. The measurements were performed prospectively on CBCT scan of 150 patients with 300 TMJ Joints. The exclusion criteria includes the congenital/Hereditary craniofacial abnormalities, systemic diseases affecting joint morphology such as rheumatoid arthritis, Hyperparathyroidism etc.

Imaging

The cone beam images were performed using Carestream 9000cc (USA) CBCT machine. The patient was placed in a position so that the Frankfort horizontal plane was perpendicular to the head to obtain a consistent orientation of sagittal images. The CBCT images were obtained at 90 Kvp, 4mA for 6.3 seconds at FOV(17x6) voxel size of 200. After the completion of raw data, the patient left the examination room and the clinician was able to perform the primary reconstruction. The TMJ was defined on 0.5 mm-thick axial slices. One of the axial views on which the condylar processes were seen with their widest mediolateral extent was used as a reference view for secondary reconstruction. The lateral slices of the TMJ were performed perpendicular to the long axis of the condylar process with 1mm thickness and the coronal slices were performed parallel to the long axis of the condylar process with 1mm thickness on the selected axial image.

Measurements

The measurements belonging to the articular eminence were performed on the slices defined above. The Trophy Dicom Ink software program was used for measurements of lines and angles used in the study.Using these planes, the eminence inclination was measured in two ways. The first was the best-fit line method that was the angle between best fit line and Frankfort horizontal plane (Figure 1), the second was the top-roof line method that was the angle between top-roof line and Frankfort horizontal plane (Figure 2).

Statistical Analysis

Categorical variables will be presented in number and percentage (%) and continuous variables will be presented as mean and SD. Quantitative variables will be compared using Unpaired t-test between two groups and ANOVA test between three groups. Pearson correlation coefficients were used to determine the relationship between two scale parameters while correlation was defined as a measure of the strength of a linear relationship between two variables. A p value of <0.05 will be considered statistically significant. The data will be entered in MS EXCEL spreadsheet and analysis will be done using Statistical Package for Social Sciences (SPSS) version 21.0.

Results

The patients were selected randomly.The demographic data shows that the study population consists of 150 study subjects having age range between 6 to 17 years with a mean age of 12.3±3.27years (Table 1). The females (56%) have dominated the study population than Males (44%) (Table 2). The majority of patients belonged to 10-12 years of age (Table 3). The unpaired t-test was performed to evaluate the comparison between articular eminence inclination by best fit line method (right and left side) and top roof line method (right and left side) in both males and females. The articular eminence inclination was statistically non significant in males (P value>.05) and females (P value>.05) in both best fit line method and top roof line method (Table.4).

By using ANOVA test, the articular eminence was compared in study population, age group wise by best fit line methods and top roof line method. By Best fit line method, it was found that highest right articular eminence inclination was 52.33±12.98^0 in age group 15-17 years of age. It was lowest 34.63±9.97^0 in age group 10-12 years of age. However in left side, the highest articular eminence inclination was 48.12±14.08^0 in age group 15-17 years of age. It was lowest 36.38±12.62^0 in 6-7 years of age group. The co-relation between age groups and articular eminence inclination by Best fit line method (right side and left side) was stastically significant (p value<.001). It was concluded that age plays an important role in articular eminence inclination by

Table 1:

	N	Range	Minimum	Maximum	Mean	Std. Deviation
Age	150	11.00	6.00	17.00	12.3133	3.27516
Left BFL	150	67	11	78	42.38	14.661
Left TRL	150	46	10	56	29.45	9.038
Right BFL	150	59	17	76	41.90	14.599
Right TRL	150	39	13	52	28.23	8.744

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Right BFL	150	59	17	76	41.90	14.599
Right TRL	150	39	13	52	28.23	8.744

Table 2:

Gender	Frequency	Percent
Male	66	44.0
Female	84	56.0
Total	150	100.0

Table 3:

Age Intervals	Frequency	Percent
6 to 9 yrs	32	21.3
10 to 12 yrs	43	28.7
13 to 14 yrs	33	22.0
15 to 17 yrs	42	28.0
Total	150	100.0

Table 4:

	Gender	N	Mean	Std. Deviation	P value
Left BFL	Male	66	44.79	14.959	0.074
	Female	84	40.49	14.226	
Left TRL	Male	66	30.21	8.845	0.364
	Female	84	28.86	9.196	
Right BFL	Male	66	42.52	14.354	0.649
	Female	84	41.42	14.857	
Right TRL	Male	66	28.77	9.320	0.500
	Female	84	27.80	8.295	

Applied unpaired t test for significance

Table 5:

		N	Mean	Std. Deviation	P value
Left BFL	6 to 9 yrs	32	36.38	12.623	
	10 to 12 yrs	43	39.58	12.879	
	13 to 14 yrs	33	44.55	16.732	0.002*
	15 to 17 yrs	42	48.12	14.084	
	Total	150	42.38	14.661	
Left TRL	6 to 9 yrs	32	23.47	7.148	
	10 to 12 yrs	43	28.74	7.622	
	13 to 14 yrs	33	32.27	10.072	<0.001*
	15 to 17 yrs	42	32.52	8.660	
	Total	150	29.45	9.038	
Right BFL	6 to 9 yrs	32	35.72	14.907	
	10 to 12 yrs	43	34.63	9.979	
	13 to 14 yrs	33	44.09	13.166	<0.001*
	15 to 17 yrs	42	52.33	12.985	
	Total	150	41.90	14.599	
Right TRL	6 to 9 yrs	32	23.44	7.616	
	10 to 12 yrs	43	24.86	5.846	
	13 to 14 yrs	33	28.21	6.941	<0.001*
	15 to 17 yrs	42	35.33	8.938	
	Total	150	28.23	8.744	

Applied one way ANOVA for significance. *Significant

Table 6:

	Gender	N	Mean	Std. Deviation	P value
Total BFL	Male	66	87.3030	26.50339	0.222
	Female	84	81.9048	26.95852	
Total TRL	Male	66	58.9848	16.32411	0.379
	Female	84	56.6548	15.86957	

Table 7:

		N	Mean	Std. Deviation	P value
Total_BFL	6 to 9 yrs	32	72.0938	24.90156	
	10 to 12 yrs	43	74.2093	19.79365	
	13 to 14 yrs	33	88.6364	27.92492	<0.001*
	15 to 17 yrs	42	1.0045E2	25.03676	
	Total	150	84.2800	26.80482	
Total_TRL	6 to 9 yrs	32	46.9062	13.15996	
	10 to 12 yrs	43	53.6047	11.57612	
	13 to 14 yrs	33	60.4848	15.91603	<0.001*
	15 to 17 yrs	42	67.8571	15.83693	
	Total	150	57.6800	16.05875	

Table 8:

	Pearson correlation coefficients (r)	P value	Mathematical Equations derived from linear regression analysis	
Left BFL	0.259	<0.001	Age =9.858+0.058*(Left BFL)	(Graph.1)
Left TRL	0.329	<0.001	Age=8.798+0.119*(Left TRL)	(Graph.2)
Right BFL	0.410	<0.001	Age=8.457+0.092*(Right BFL)	(Graph.3)
Right TRL	0.469	<0.001	Age=7.352+0.176*(Right TRL)	(Graph.4)
Total_BFL	0.365	<0.001	Age=8.552+0.045*(Total BFL)	(Graph.5)
Total TRL	0.441	<0.001	Age=7.127+0.090*(Total TRL)	(Graph.6)

best fit line method (Table 5).

By Top roof line method, it was found that the articular eminence inclination in left side was highest (32.52 ± 8.66^0) in 15-17 years of age group and lowest (23.47±7.148) in 6-7 years of age however in the right side, the articular eminence inclination was highest (35.33 ± 8.93^0) in 15-17 years of age and lowest in (23.44 ± 7.61^0) in 6-7 years of age.

The relation between age groups and articular eminence inclination by top roof line method was (right side and left side) stastically significant (p value<.001).

It was concluded that age plays an important role in articular eminence inclination by top roof line method (Table 5).

The articular eminence inclination was statistically non significant in males (P value>.05) and females (P value>.05) for both Total(right side + left side) best fit line method and total (right side+left side)top roof line method (Table 6).

By Best fit line method, it was found that highest total (right side + left side) articular eminence inclination was 88.63 ± 27.92^0 in age group 13-14 years of age. It was lowest 72.09 ± 24.90^0 in age group 6-7 years of age. The relation between age groups and articular eminence inclination by total Best fit line method was stastically significant (p value<.001).

By Top roof line method, it was found that total(right side + left side) articular eminence inclination was highest (67.85 ± 15.83^0) in 15-17 years of age group and lowest (46.90±13.15) in 6-7 years of age.

The relation between age groups and articular eminence inclination by total top roof line method was stastically significant (p value<.001) (Table 7).

The pearson corelation corfficient (r) shows that Best fit line method, top roof line method of right and left side temporomandibular joint is directly associated with age and demonstrate a highly significant positive relation (Table 8).

The linear regression analysis have been performed to predict the age of patients on the basis of articular eminence inclination angle. It can be concluded that if articular eminence inclination of any individual is known, the age can be predicted (Table 8) (Graph 1,2,3, 4,5,6).

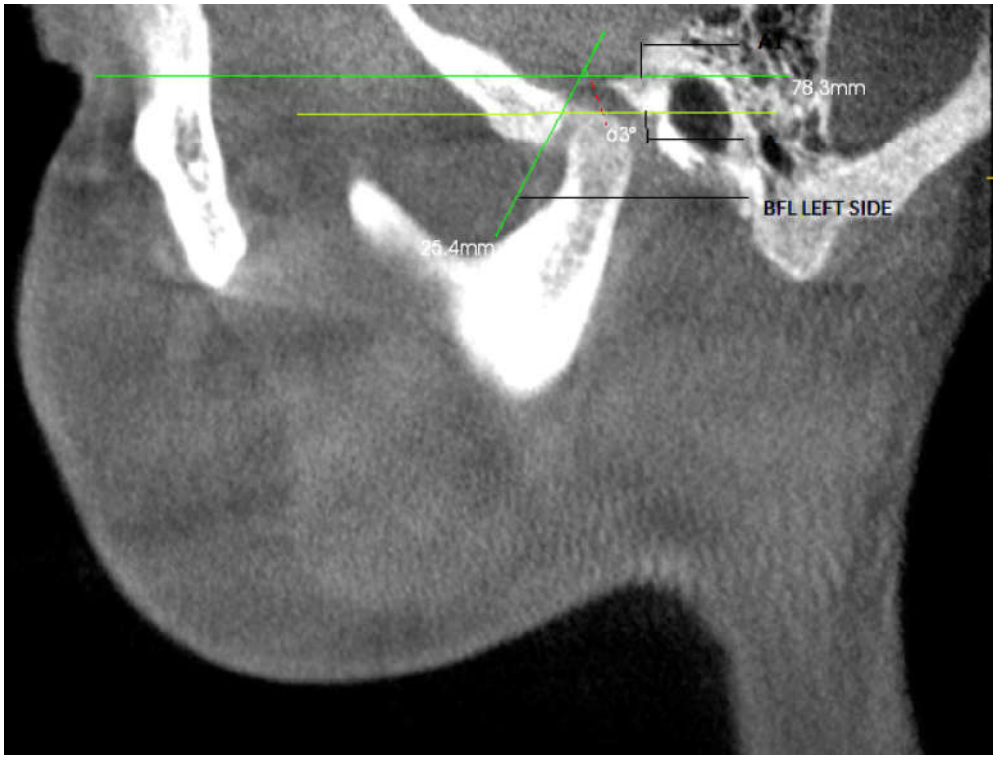


Fig. 1a: The measurement of right articular eminence inclination angle with the best-fit line method (BFL Rt)

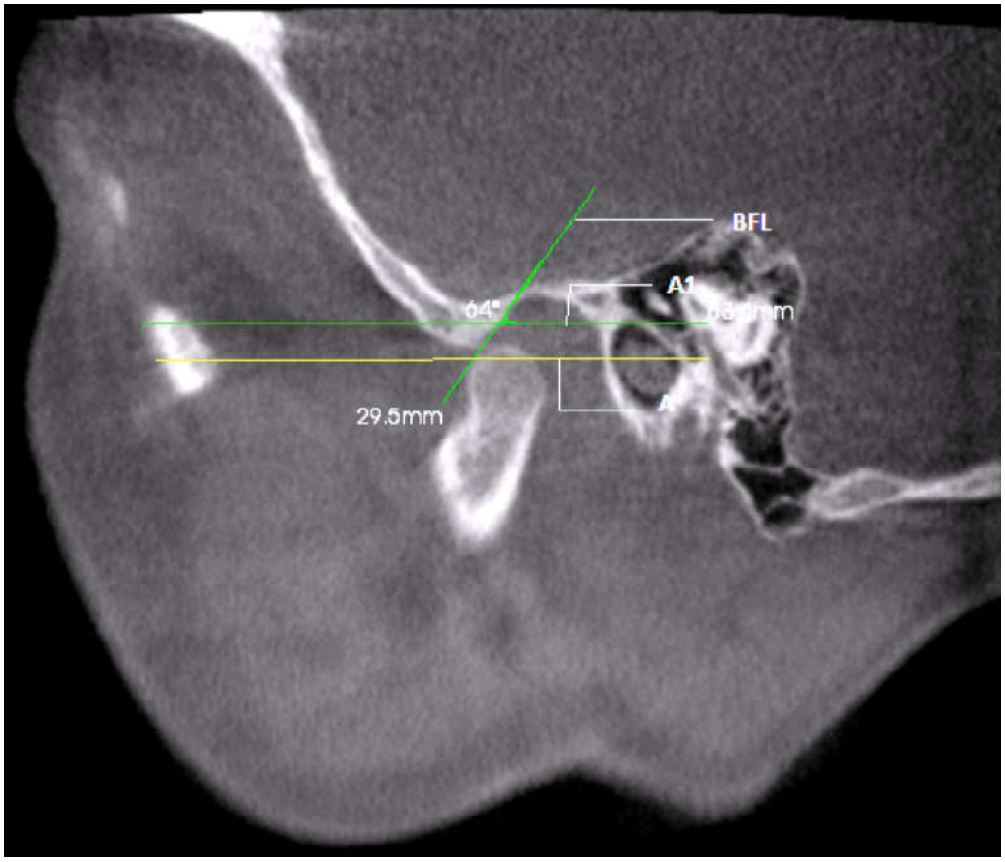


Fig. 1b: The measurement of left articular eminence inclination angle with the best-fit line method (BFL Lt)

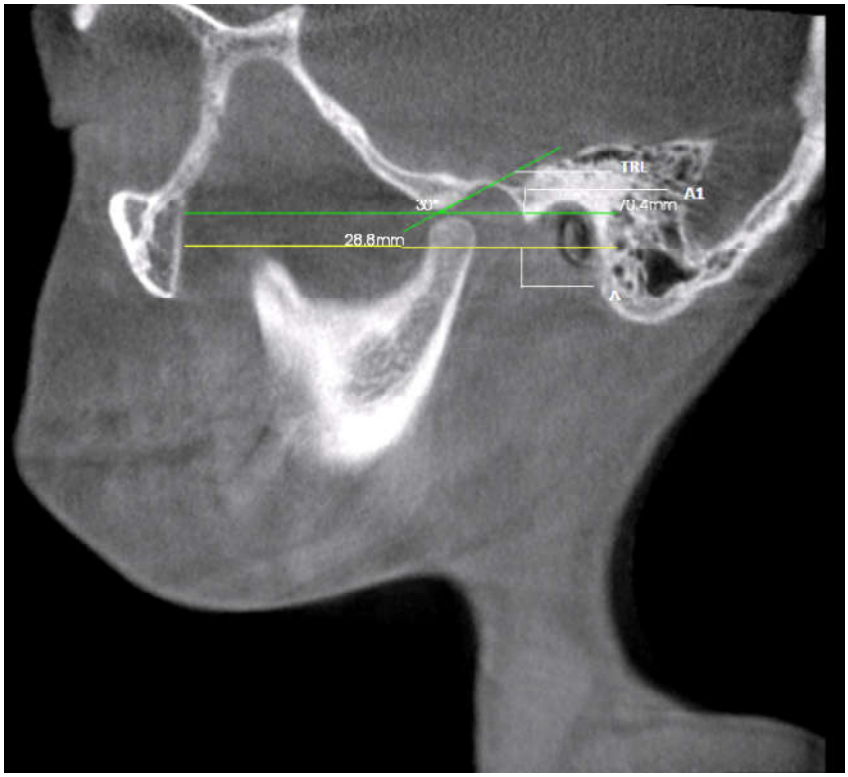


Fig. 2a: The measurement of right articular eminence inclination angle with the top-roof line method(TRL Rt)

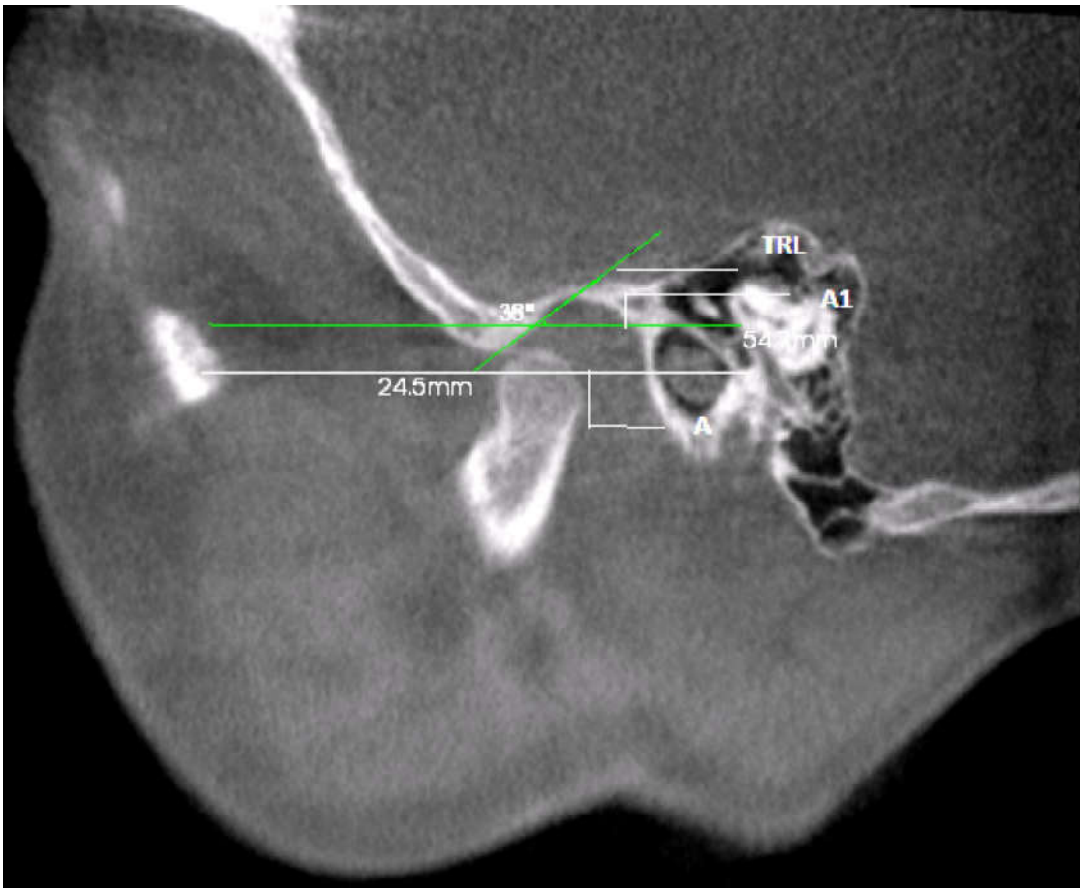
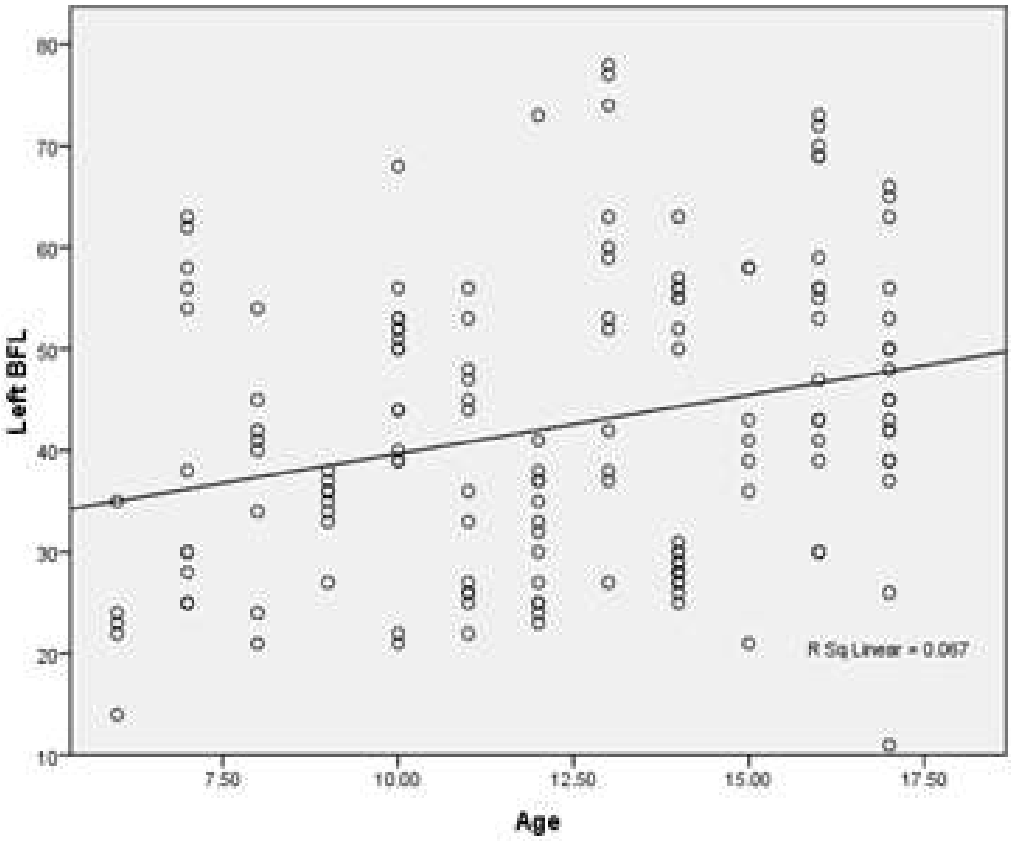
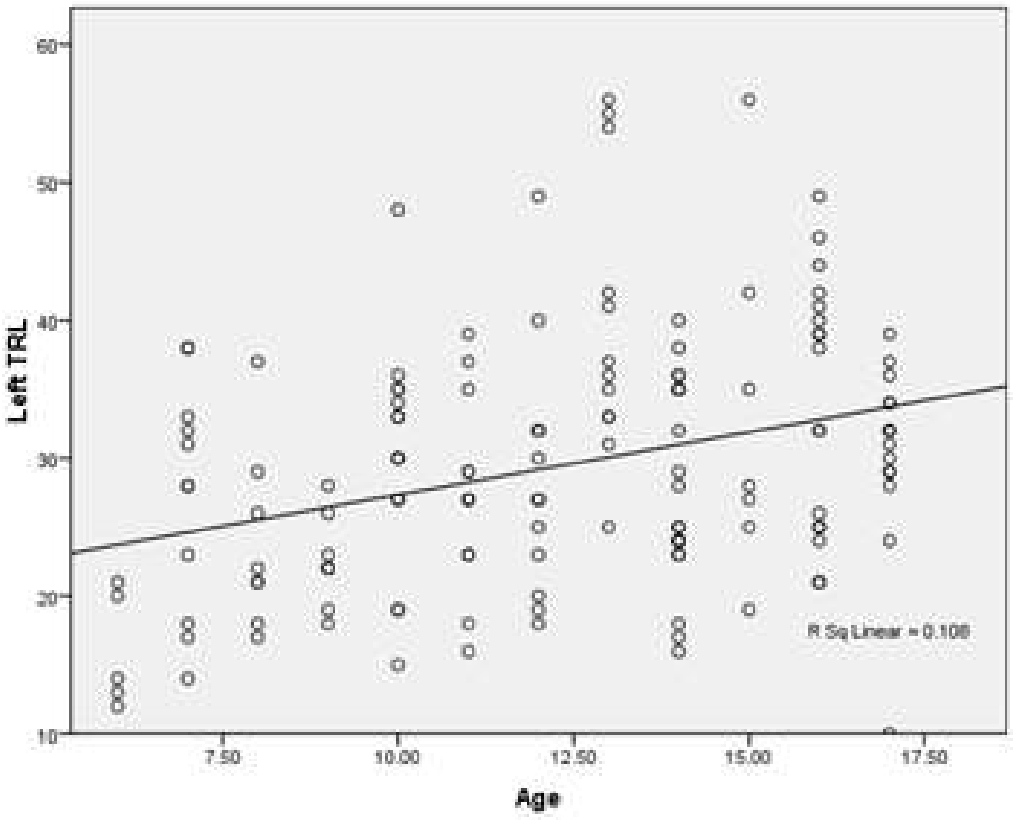


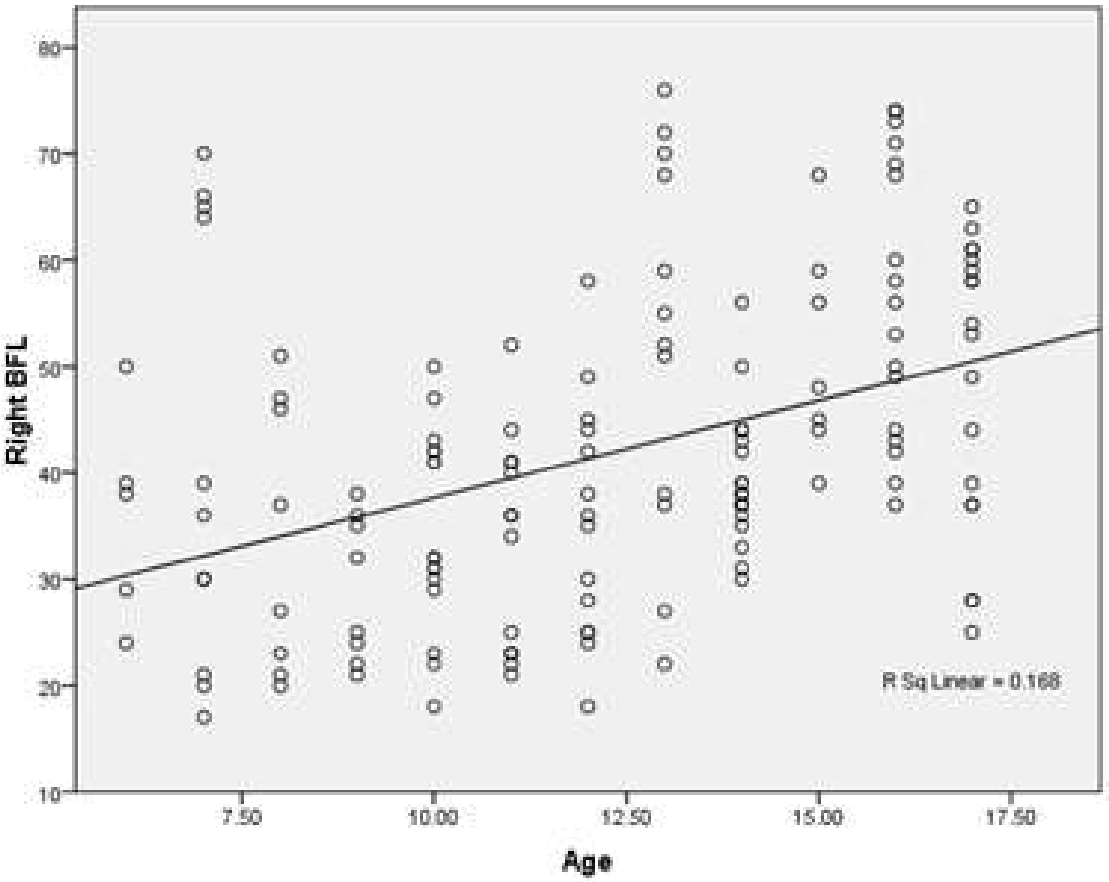
Fig. 2b: The measurement of left articular eminence inclination with the top-roof line method (TRL Lt)

Graph 1:

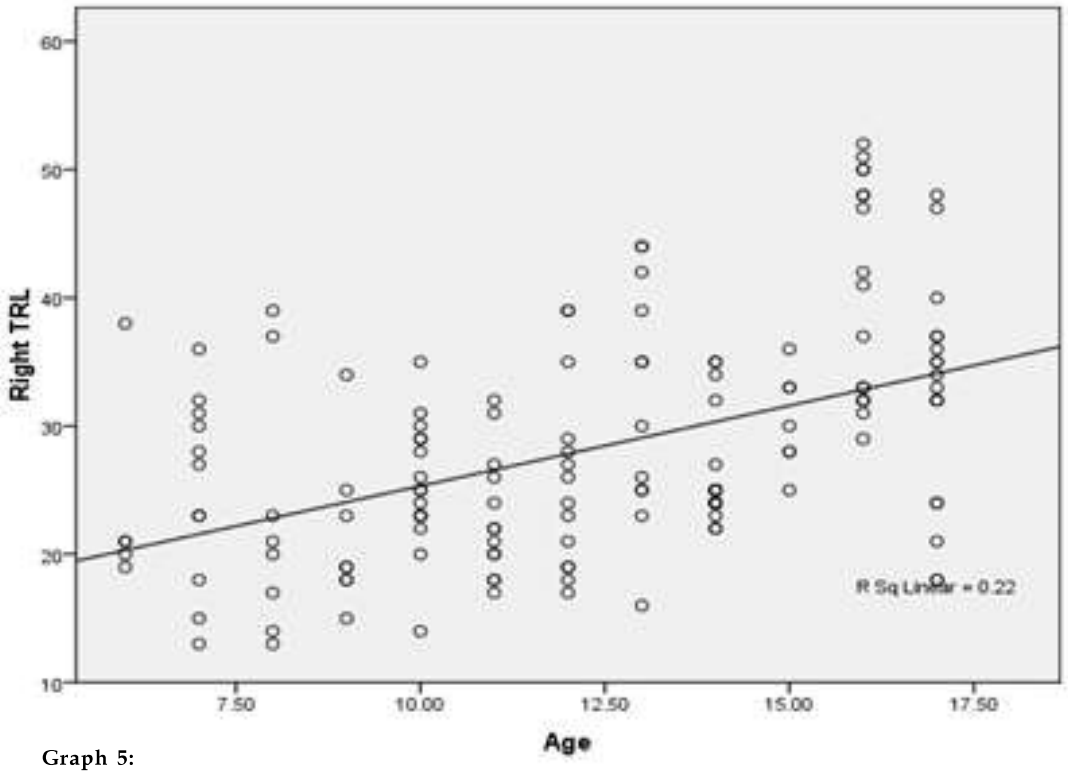


Graph 2:





Graph 3:



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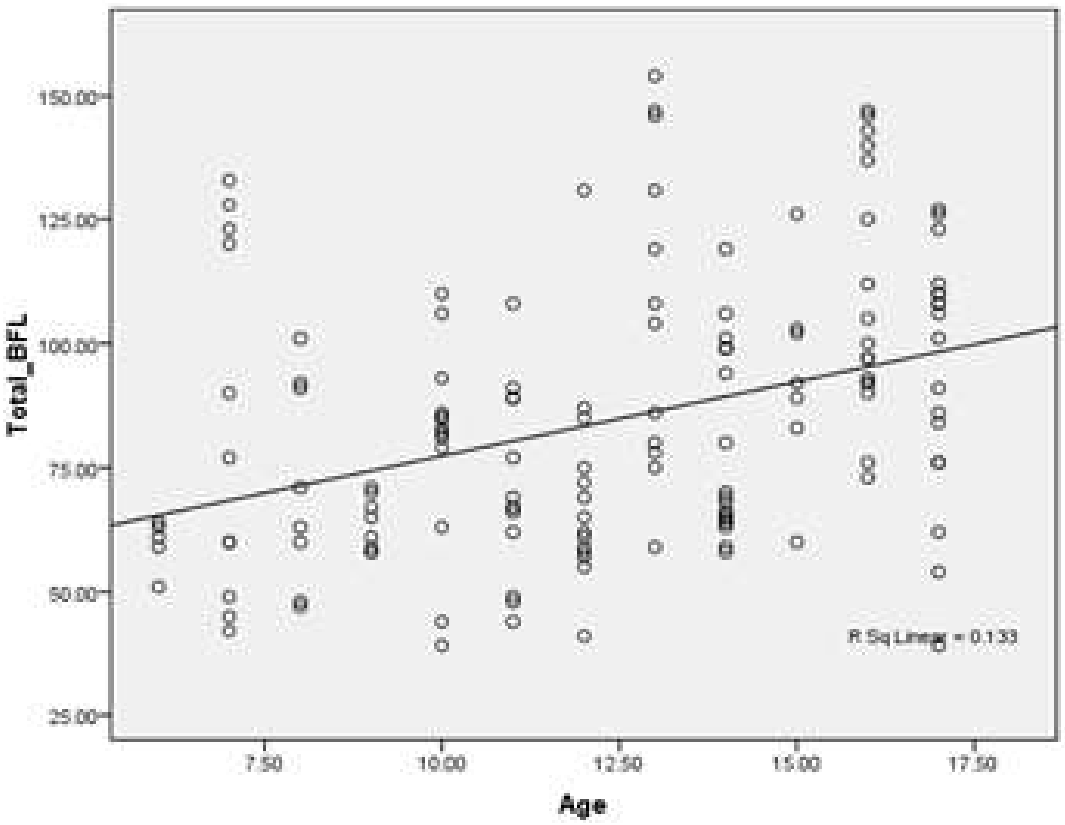

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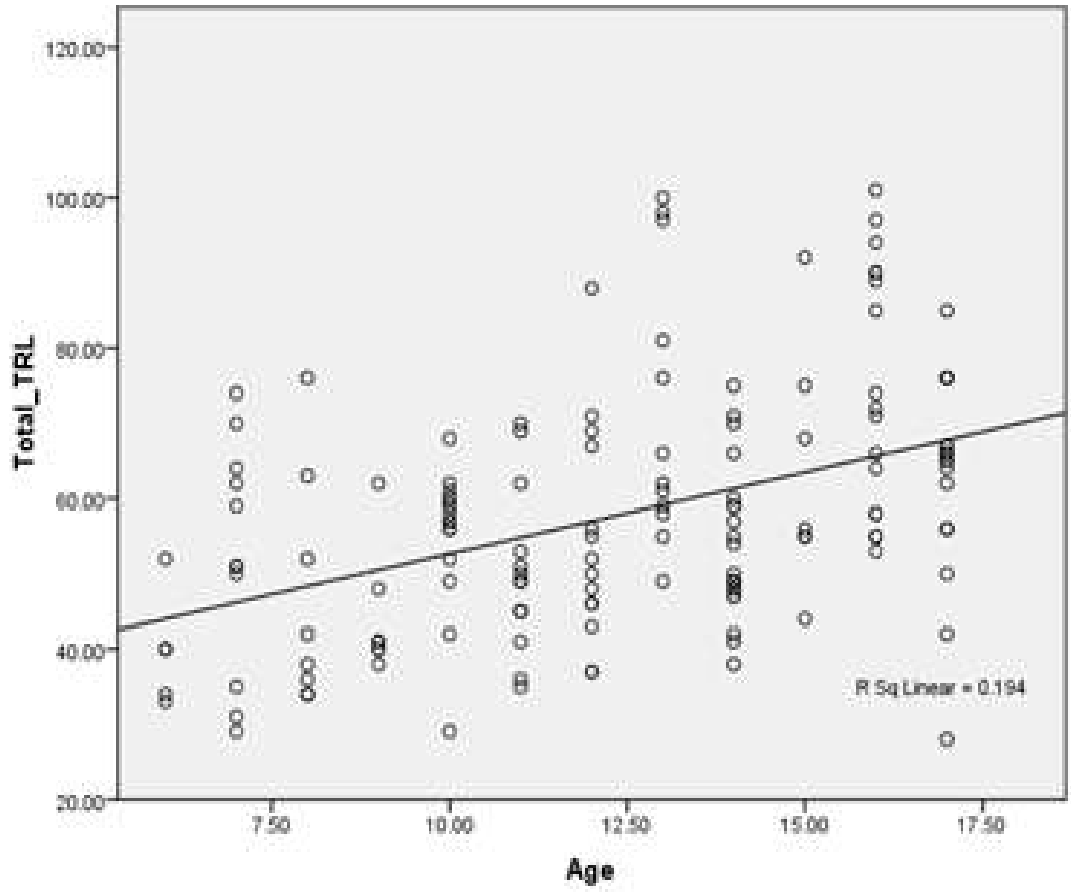

Graph 6:

Discussion

The articular eminence is a small bone part which is situated in front of the glenoid fossa Although it is an anatomical structure belonging to the functional load arising from chewing forces with other structures within the TMJ and these loads influence the morphological shape of it [35].

Various methods have been used in previous studies to measure the inclination of the posterior slope of the articular eminence. It is very important to choose an appropriate method for true measurement of eminence inclination. The direct measurements of eminence inclination on dry skulls or cadaver specimens as well as radiographic examination of tomograms demonstrated differences in inclination of the articular eminence. Consequently it has been noted that studies performed with only a single slice or with transcranial or panoramic radiographic examinations where no slices are made may not depict a true measurement of eminence inclination [36]. The view of the eminence in the central slice is the steepest part of the eminence and it gives the best representation of eminence inclination [37] which is why we chose the central sagittal slice of the condylar process for measurements.

The TMJ is difficult to view with conventional techniques because of superimposition of the adjacent dense temporal bone. In particular panoramic imaging and conventional tomography may yield disappointing results. CT has been used since its development for evaluation of orofacial bone structures. However CT machines have limitations for dentistry as previously mentioned. CBCT addresses these issues and provides many advantages in dentistry. It was mentioned that CBCT offered a dose and cost effective alternative to conventional CT for the diagnostic evaluation of osseous abnormalities of the TMJ [38,39,40].

Sumbullu MA et al [41] stated that mean ± SD of eminence inclination in males by best fit line method is estimated as 58.46±8.13^0 and for females is 56.13 ± 13.95^0 and by top roof line method,Mean ± SD of eminence inclination in males is 38.67±5.12^0 and in females is 37.30 ± 7.71^0. Jasinevicious et al [42] found that there were no differences in eminence inclination by gender. Gilboa et al [43] stated thatthe eminence inclination values usually vary from 21^0 to 64^0. Zoghby et al [44] found a mean value of 47.46^0 using the method of mechanical axiography on participants. Ilguy et al [45] suggested that mean ± SD of eminence inclination in males by best fit line method is estimated as 49.66± 6.88^0 and for females is 47.58±6.75^0. By top roof line method, Mean ± SD of eminence inclination in males is 40.19±6.58^0 and in females is 37.99 ± 6.00^0 which is slightly higher than our results. Paknahad M et al [46] used top roof line method and found that Mean ± SD of eminence inclination in males was 34.56 ± 6.21^0 and for females it was 38.10 ± 7.01^{0}where as in our study mean ± SD of eminence inclination in males by best fit line method was 53.37^{0}and for females 48.8^{0}and by top roof line method,Mean ± SD of eminence inclination in males is 33.77^0 and in females is 30.58^0. Katsavrias and Dibbets [47] et al mentioned that the articular eminence inclination completed approximately 45% of its development with the completion of primary dentition reaching 70–72% of its adult value around the age of 10 years and by the age of 20 years it was 90–94% complete.

Nickel et al [48] reported an adult value of eminence inclination was 45^0. Moffet et al [49] showed that a gradual increase in size of eminence occurs until the age of 40. Sumbullu MA et al [41] stated that the value of eminence inclination was lower in patients aged 16–20 years reached its highest value in patients aged 21–30 years and decreased in patients aged over 30 years in the control group. Whereas in our study by Best fit line method, it was found that highest right articular eminence inclination was 52.33±12.98^0 in age group 15-17 years of age. It was lowest 34.63±9.97^0 in age group 10-12 years of age. However in left side, the highest articular eminence inclination was 48.12±14.08^0 in age group 15-17 years of age. It was lowest 36.38±12.62^0 in 6-7 years of age group.The co-relation between age groups and articular eminence inclination by Best fit line method (right side and left side) was stastically significant (p value<.001). By Top roof line method, it was found that the articular eminence inclination in left side was highest (32.52±8.66^0) in 15-17 years of age group and lowest (23.47±7.148) in 6-7 years of age however in the right side, the articular eminence inclination was highest (35.33±8.93^0) in 15-17 years of age and lowest in (23.44±7.61^0) in 6-7 years of age. The relation between age groups and articular eminence inclination by top roof line method was (right side and left side) stastically significant (p value<.001). Chaurasia et al concluded that in comparison to adult articular eminince inclination, the articular eminence inclination in paediatric population is stastically significant (p value<.001) by both Best fit line method and Top roof line method.

Conclusion

Determination of age by morphological assessment has been one of the oldest approaches in forensic anthropology and medico-legal examinations. Age plays an important role in articular eminence

inclination by top roof line method and best fit line method. The age of an individual can be predicted if articular eminence inclination angle is known.

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