Morphometric analysis of articular eminence of temporomandibular joint in Indian Ethinicity- A cone beam computed tomography study

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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. 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 206 subjects were used in present study. The cone beam images (Scans) were obtained from Care stream 9000cc (USA) CBCT machine at 90 Kvp,4 mA for 6.3 seconds at FOV 17x6 and voxel size of 200.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.

Results: The articular eminence inclination was statistically significant in males and females in both best fit line method and top roof line method. By Best fit line method, it was found that highest articular eminence inclination was 52.31 ± 16.08^0 in age group 31-40 years while it was lowest 49.02 ± 12.49^0 in age group 41-50 years. However by Top roof line method, it was found that the articular eminence inclination was highest 33.16 ± 8.66^0 in age group 21-30 years and lowest 31.50 ± 8.92^0 in 31-40 years.The co-relation between age groups and articular eminence inclination by Best fit line method was stastically significant.

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[8-11] 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 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 temporomandibular joint 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 best fit line on the slope of the eminence and the FH plane (Fig. 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 (Fig. 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 30^0–600.[31] Articular eminences having inclination values smaller than 30^0 have 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]

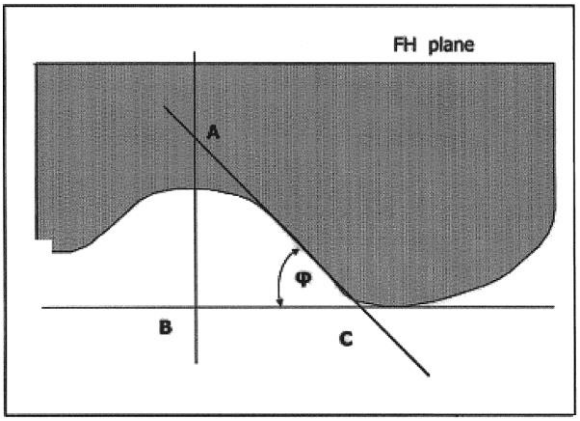


Fig. 1: The articular eminence inclination presented as the best

Fit line (Method 1).

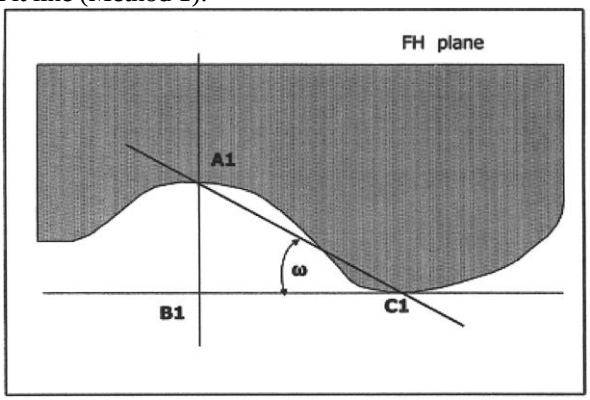


Fig. 2: The articular eminence inclination presented as the roof fossa and eminence-top line (Method 2)

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 206 patients with 412 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 Care stream 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, 4 mA 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 (Fig. 1). Using these planes, the eminence inclination was measured in two ways. The first was the best-fit line method that was the angle between Bfl and Frankfort horizontal plane (Fig. 2), the second was the top-roof line method that was the angle between Trf and Frankfort horizontal plane (Fig. 3).

Statistical analysis: Statistical analysis was conducted with the program SPSS version 16. The one-way analysis of variance (ANOVA) test was used to determine differences in the inclination between age groups. The student's t-test was used to determine the differences in inclination between the patient and control groups and genders. P-value of 0.05 was considered statistically significant. All of the measurements were established by three observers and the mean of the results was used to ensure the reliability of the study.

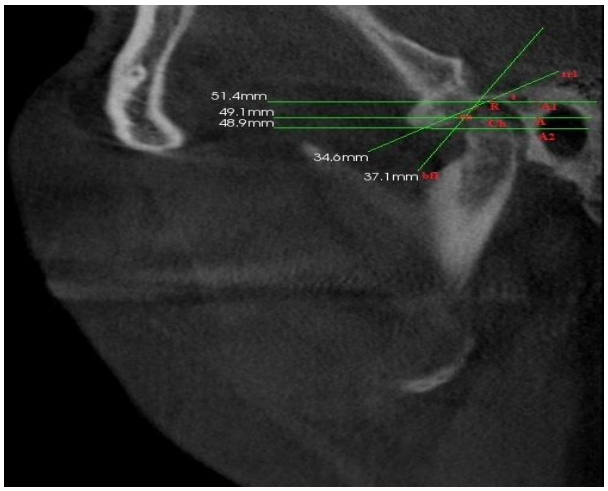


Fig. 1: Lines and angles used in the present study. Bfl, eminence inclination best-fit line; trl, eminence inclination top-roof line

Bfl plane: The best-fit plane of the articular eminence inclination
Trl plane: The plane passing through articular eminence inclination
A: Frankfort horizontal Plane
A1: The parallel line to the F passing through the deepest point of glenoid fossa
A2: The parallel line to the F passing through the highest point on articular eminence
Ch-Highest point on condyle

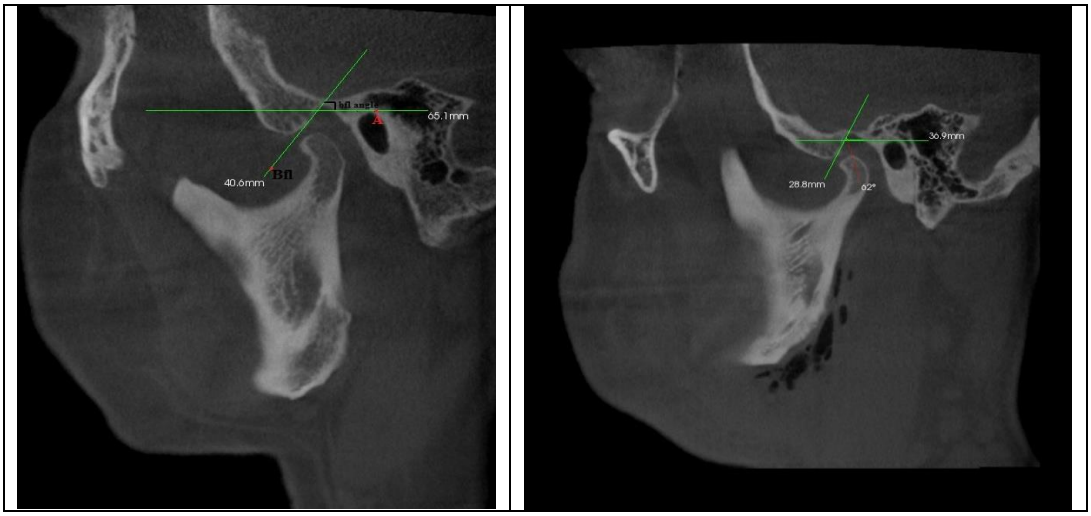


Fig. 2a & 2b: The measurement of eminence inclination with the best-fit line method

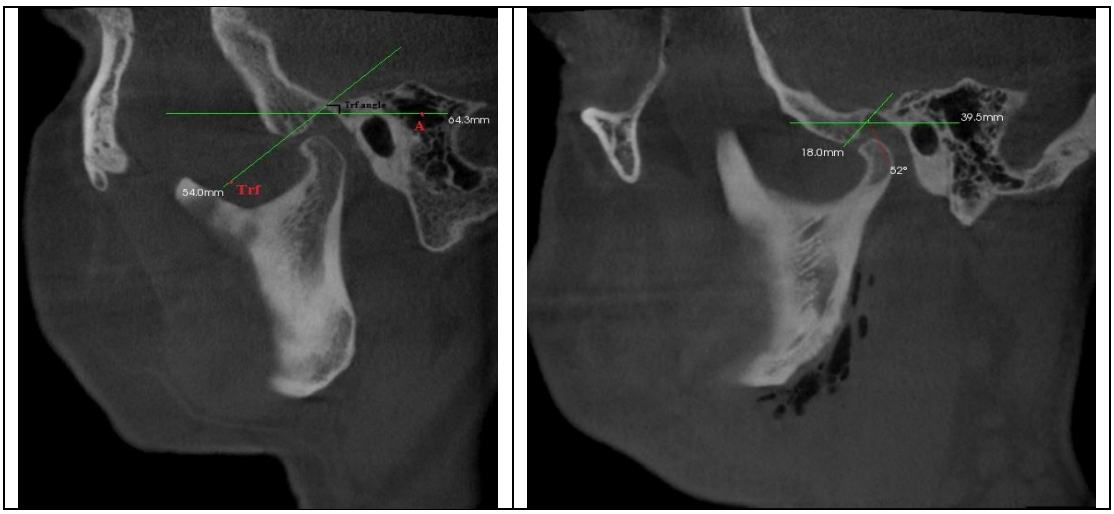


Fig. 3a & 3b: The measurement of eminence inclination with the top-roof line method

Results

The results are presented in mean±SD. The unpaired t-test was used to compare the prediction of eminence inclination Best fit line and eminence inclination Top roof line between male and female. The one way analysis of variance (ANOVA) was used to compare prediction of eminence inclination Best fit line and eminence inclination Top roof line among age groups. The multivariate linear regression analysis was carried out to predict the eminence inclination Best fit line and eminence inclination Top roof line from age and sex. The p-value<0.05 was considered significant. All the analysis was carried out on SPSS 16.0 version (Chicago, Inc., USA).

The patients were selected randomly. The demographic data shows that in study population (n=206), males are mostly in age group of 21-30 years however females were mainly in 41-50 years age group. Overall most patients are in age group of 21-30 years irrespective of gender (Table 1). The unpaired t-test was performed to evaluate the comparison between articular eminence inclination by best fit line method and top roof line method in both males and females. The articular eminence inclination was statistically significant in males(P value=0.02) and females(P value=.008) in both best fit line method(Male 53.37±13.82^0, Female 48.80±14.56^0) and top roof line method(Male 33.77±8.17^0, Female 30.58±8.99^0).(Table 2, Graph 1)

Table 1: Age and sex distribution of patients

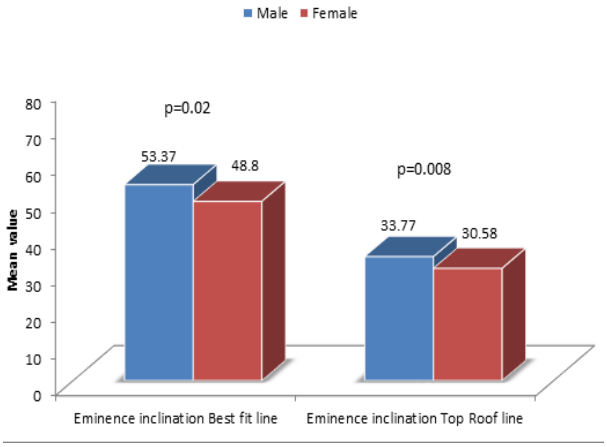
Age in years	Gender				Total	
	Male		Female			
	No.	%	No.	%	No.	%
10-20	22	56.4	17	43.6	39	18.9
21-30	37	66.1	19	33.9	56	27.2
31-40	26	50.0	26	50.0	52	25.2
41-50	13	54.2	11	45.8	24	11.7
>50	19	54.3	16	45.7	35	17.0
Total	117	56.8	89	43.2	206	100.0

Table 2: Comparison of Eminence inclination Best fit line and Eminence inclination Top Roof line between male and female

Gender	Articular eminence inclination Best fit line(In degrees)	Articular eminence inclination Top Roof line(in degrees)
Male	53.37±13.82	33.77±8.17
Female	48.80±14.56	30.58±8.99
p-value[1]	0.02*	0.008*

[1]Unpaired t-test, *Significant

Graph 1: Comparison of Eminence inclination Best fit line and Eminence inclination Top Roof line between male and female



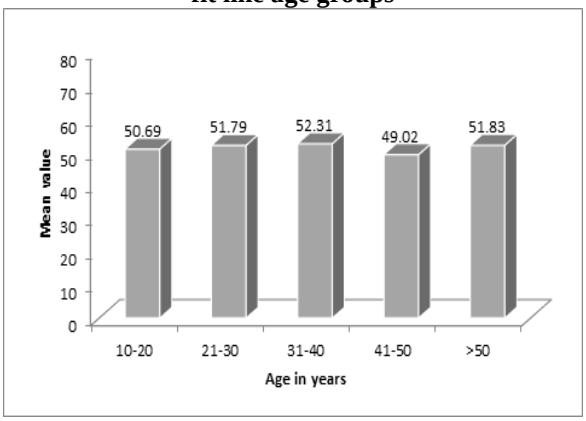
By using ANOVA test, the articular eminence was compared in study population age group wise by best fit line methods and top roof line method. By Best fit line method, it was found that highest articular eminence inclination was 52.31±16.08^0 in age group 31-40 years of age. It was lowest 49.02±12.49^0 in age group 41-50 years of age. The co-relation between age groups and articular eminence inclination by Best fit line method was stastically significant (p value-.90). It was concluded that age plays an important role in articular eminence inclination by best fit line method.(Table 3). By Top roof line method, it was found that the articular eminence inclination was highest 33.16±8.66^0 in age group 21-30 years and lowest 31.50±8.92^0 in 31-40 years. The relation between age groups and articular eminence inclination by top roof line method was stastically significant (p value-.85). It was concluded that age plays an important role in articular eminence inclination by top roof line method.(Table 3, Graph 2, Graph 3). The linear regression analysis have been performed to predict the age of patients on the basis of articular eminence inclination angle.

Table 3: Comparison of Eminence inclination Best fit line and Eminence inclination Top Roof line age groups

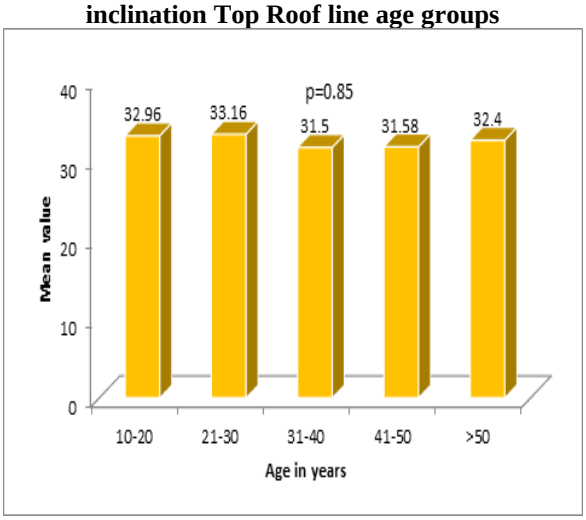
Gender	Eminence inclination Best fit line	Eminence inclination Top Roof line
10-20	50.69±13.75	32.96±9.06
21-30	51.79±13.87	33.16±8.66
31-40	52.31±16.08	31.50±8.92
41-50	49.02±12.49	31.58±8.05
>50	51.83±14.47	32.40±8.53
p-value[1]	0.90	0.85

[1]ANOVA test, *Significant

Graph 2: Comparison of Eminence inclination Best fit line age groups



Graph 3: Comparison of Articular eminence inclination Top Roof line age groups



The regression analysis equation by best fit line method for age prediction of an individual is-

Age=48.79+0.01 X articular eminence inclination angle(Best fit line method)+4.57

The regression analysis equation by top roof line method for age prediction of an individual is

Age=31.40-0.02 X articular eminence inclination angle(Top roof line method) +3.16

It can be concluded that if articular eminence inclination of any individual is known, the age can be predicted.(Table 4).

Table 4: Regression equation for the prediction of articular eminence inclination Best fit line and Eminence inclination Top Roof line by age & sex

Dependent variable	Regression equation
Age determination by Articular eminence inclination Best fit line	48.79+0.01 X Age+4.57 sex (Male=1, Female=0)
Articular eminence inclination Top Roof line	31.40-0.02 X Age+3.16 sex (Male=1, Female=0)

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 that the 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 it is found that mean value of eminence inclination in best fit line method is 50.69^0 in 10-20 years which gradually increases to 52.31^0 in 31-40 years and it is lower into 41-50 years aged persons and its mean value is 49.02^0. In top roof line method mean value of eminence inclination is 32.96^0 in 10-20 years aged persons which increases up to 33.16^0 in 21-30 years and it is lower in 41-50 years of life and mean value is 31.58^0.

Conclusion

Determination of age by morphological assessment has been one of the oldest approaches in forensic anthropology and medico-legal examinations. The method may vary and depend upon the available bones and their conditions, radiographic records, dental records etc. The determination of age is of significance in cases of mass fatality incidents where bodies are damaged beyond recognition. 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.

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