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Assessment Of Changes In Articular Eminence Inclination In Different Skeletal Malocclusions With Various Growth Pattern Using Orthopantomograms

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ABSTRACT

Introduction- The temporomandibular joint (TMJ) is a crucial component of the locomotor system, morphologically and functionally complex, facilitating a wide range of mandibular movements. A distinctive feature of TMJ is the articular eminence, a vital component influencing condylar movement , force transmission during masticatory loading.This study explores the changes in articular eminence inclination across different growth patterns and skeletal malocclusions using orthopantomograms.

Objective- This study explores the changes in articular eminence inclination across different growth patterns and skeletal malocclusions using orthopantomograms.

Methodology- This study was carried out in the Department of Orthodontics and Dentofacial Orthopaedics, Saraswati Dental College and Hospital in digitally acquired images from routinely taken Orthopantomograms which satisfied the inclusion criteria. The radiograph with lead acetate tracing sheet attached was viewed in a radiographic illuminator for marking the following landmarks using 3H pencil .The Angles α, β & γ were measured manually using protractors. The values of the following angles were categorized according to the different skeletal malocclusions and various growth patterns in the data sheet in Microsoft excel.

Result- Three angles (alpha, beta, and gamma) representing different aspects of articular eminence inclination were measured and compared between classes. Significant differences were observed in horizontal growth patterns, indicating variations in mean angles among skeletal classes. However, in vertical and average growth patterns, differences were statistically insignificant.

Conclusion-This study provides valuable insights into the association between articular eminence inclination, skeletal classes, and growth patterns. The horizontal growth pattern demonstrates significant variations, emphasizing the importance of considering these factors in understanding TMJ morphology..

Keywords: Articular eminence inclination; Skeletal malocclusion; Growth patterns; Orthopantomogram; Craniofacial growth

1. INTRODUCTION

The temporomandibular joint is located below the posterior end of the zygomatic arch, right in front of the external auditory meatus[1].TMJ a part of the locomotor system consist of interdependent connective tissues. It is a complex joint both morphologically and functionally. This joint not only serves as an integral element of mastication but also plays a crucial role as an integral part of the basicranium. The TMJ efficiently transfers loads and stresses onto the base of the skull while enabling a broad variety of mandibular motions. The range of mobility of mandible is mostly influenced by two bony components of the TMJ: the mandibular fossa and the AE of the temporal bone.Every element influencing the TMJ also has an impact on the AE and inclination. Mandibular movement is influenced by AE characteristics, such as form, and is further conditioned by skeletal malocclusion, age, sex, masticatory loads, and the lack of teeth[2].Studies have been conducted on the articular eminence inclination in connection to its height, TMJ derangement, tooth inclination, posterior tooth loss, and craniofacial development. However, studies on AEI in relation to growth patterns and different skeletal malocclusions are scant.Thus, the goal of the current study is to use orthopantomograms to ascertain changes in AEI in different skeletal malocclusions and growth patterns..

2. MATERIALS AND METHODOLOGY

The aim is to observe the changes in the slopes of the articular eminence using Orthopantomogrms. The objectives are to assess the changes in slopes of the articular eminence in different skeletal malocclusions using orthopantomogrms and to assess the changes in slopes of the articular eminence in various growth pattern using orthopantomogrms.

The study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics at Saraswati Dental College and Hospital, Lucknow, to evaluate changes in the slope of articular eminence inclination (AEI) across different skeletal malocclusions and growth patterns. Sample Size and Grouping: A total of 270 samples were included, divided into 9 groups of 30 samples each. The OPGs were categorized according to skeletal class (I, II, III) and growth pattern (vertical, horizontal, average):

Skeletal Class I:- Group Ia: Average growth – 30 samples,Group , Ib: Horizontal growth – 30 samples, Group Ic: Vertical growth – 30 samples

Skeletal Class II:- Group IIa: Average growth – 30 samples,Group IIb: Horizontal growth – 30 samples,Group IIc: Vertical growth – 30 samples

Skeletal Class III:- Group IIIa: Average growth – 30 samples,Group IIIb: Horizontal growth –30 samples,Group IIIc: Vertical growth – 30 samples

Radiographic Acquisition: Digital orthopantomograms were used, acquired using a Digital Orthopantomograph machine. The stationary bite block ensured standardized positioning. Kodak X-ray films (8'' × 10'') were exposed at 80 kVp, 10 mA for 0.8 seconds. A lead acetate tracing sheet was attached to the radiographs and viewed on a radiographic illuminator for landmark identification using a 3H pencil.

Reference Plane and Landmarks: The Frankfort Horizontal (FH) plane, passing through the inferiormost point of the left infraorbital margin and both Porion points, served as the reference. The outlines of the articular eminence and mandibular fossa were traced. The lowest point of the AE was designated as "B," and the highest point of the fossa as "A." Line AB connected these points, and line BC was drawn parallel to the FH plane through point B. Angular Measurements:

Alpha (α) angle: Formed between line AB and line BC. Beta (β) angle: Formed between line BC and the best-fit line along the posterior slope of the AE. Gamma (γ) angle: Formed between line BC and the best-fit line along the anterior slope of the AE. All angles were measured manually using protractors. Values were recorded in Microsoft Excel and categorized by skeletal class and growth pattern.

Ethical approval for the study obtained from the institutional review board the portfolio number of which is #FM30R15062025R ,and written informed consent was secured from all the participants.

Statistical Analysis: Means and standard deviations of the angles were calculated. Independent t-tests were applied to compare groups, and statistical significance was set at $p < 0.05$. This methodology ensured a standardized, reproducible, and accurate assessment of AEI across different skeletal malocclusions and growth patterns, while minimizing measurement bias and maintaining patient safety.

3. RESULT :

Comparison of Alpha (α) angle in different groups:

In terms of vertical growth, the mean Alpha (α) angle for Class I is 28.7 ± 3.46, which is slightly smaller than that for Class II (31.0 ± 6.04) and Class III (30.6 ± 4.72). However, the mean differences between the groups are not statistically significant, as evidenced by the p-values of 0.568, 0.637, and 0.921, respectively. Regarding horizontal growth, the mean Alpha (α) angle for Class I (49.0 ± 8.97) is higher than that for Class II (40.8 ± 8.23), with a mean difference of 8.2. This difference is statistically significant (p-value of 0.047*). Similarly, the mean difference between Class I and Class III (18.0) and Class II and Class III (9.8) are also significant, with p-values of <0.001* and 0.019*, respectively.

	Alpha(α) angle	**Mean ± SD**	**Mean ± SD**	**Mean difference**	**P-Value**
Vertical growth	**Class l, Class ll**	28.7 ± 3.46	31.0 ± 6.04	2.3	0.568
	Class l, Class lll	28.7 ± 3.46	30.6 ± 4.72	1.9	0.637
	Class ll, Class lll	31.0 ± 6.04	30.6 ± 4.72	0.4	0.921
Horizontal growth	**Class l, Class ll**	49.0 ± 8.97	40.8 ± 8.23	8.2	0.047*

	Class l, Class lll	49.0 ± 8.97	31.0 ± 3.76	18.0	<0.001*
	Class ll, Class lll	40.8 ± 8.23	31.0 ± 3.76	9.8	0.019*
Average growth	**Class l, Class ll**	34.8 ± 7.82	42.8 ± 4.87	8.0	0.053
	Class l, Class lll	34.8 ± 7.82	37.0 ± 6.36	2.2	0.585
	Class ll, Class lll	42.8 ± 4.87	37.0 ± 6.36	5.8	0.155

*Statistically significant

Table1: Mean difference of Alpha (α) angle between skeletal malocclusions in various Growth patterns.

Finally, for average growth, the mean Alpha (α) angle for Class I (34.8 ± 7.82) is lower than that for Class II (42.8 ± 4.87), with a mean difference of 8.0. However, this difference is not statistically significant (p-value of 0.053). The mean difference between Class I and Class III (2.2) and Class II and Class III (5.8) are also not significant, with p-values of 0.585 and 0.155, respectively.

2.Comparison of Beta (β) angle between different skeletal malocclusions in Various growth Pattern:

In terms of vertical growth, the mean Beta (β) angle measurements for Class I, II, and III are 43.6 ± 3.58, 46.1 ± 6.75, and 47.5 ± 12.1, respectively. The mean differences in the β angle between Class I and II, Class I and III, and Class II and III are 2.5, 3.9, and 1.4, respectively. None of these differences are statistically significant ($p > 0.05$).In terms of horizontal growth, the mean Beta (β) angle measurements for Class I, II, and III are 70.2 ± 12.09, 55.5 ± 15.53, and 49.1 ± 6.63, respectively. The mean differences in the β angle between Class I and II, Class I and III, and Class II and III are 14.7, 21.1, and 6.4, respectively. The differences between Class I and II and Class I and III are statistically significant ($p < 0.05$).In terms of average growth, the mean Beta (β) angle measurements for Class I, II, and III are 44.4 ± 10.09, 56.0 ± 12.37, and 51.2 ± 13.66, respectively.

	Beta(β) angle	**Mean ± SD**	**Mean ± SD**	**Mean difference**	**P-Value**
Vertical growth	**Class l, Class ll**	43.6 ± 3.58	46.1 ± 6.75	2.5	0.720
	Class l, Class lll	43.6 ± 3.58	47.5 ± 12.1	3.9	0.577
	Class ll, Class lll	46.1 ± 6.75	47.5 ± 12.1	1.4	0.841
Horizontal growth	**Class l, Class ll**	70.2 ± 12.09	55.5± 15.53	14.7	0.041*
	Class l, Class lll	70.2 ± 12.09	49.1 ± 6.63	21.1	0.004*
	Class ll, Class lll	55.5 ± 15.53	49.1 ± 6.63	6.4	
Average growth	**Class l, Class ll**	44.4 ± 10.09	56.0 ± 12.37	11.6	0.012
	Class l, Class lll	44.4 ± 10.09	51.2 ± 13.66	6.8	0.332
	Class ll, Class lll	56 ± 12.37	51.2 ± 13.66	4.8	0.492

*Statistically significant

Table 2: Mean difference of Beta (β) angle between different skeletal malocclusions in various growth patterns.

The mean differences in the β angle between Class I and II, Class I and III, and Class II and III are 11.6, 6.8, and 4.8,respectively. None of these differences are statistically significant ($p > 0.05$).Overall, this chart suggests that the Beta (β) angle may differ between different skeletal malocclusion and growth patterns, particularly in terms of horizontal growth. However, the differences in the mean β angle for vertical and average growth patterns are not statistically significant.

3.Comparison of Gama (γ) angle between different skeletal malocclusions in various growth pattern:

In terms of vertical growth, the mean Gama (γ) angle for Class I (22.4 ± 6.35) is significantly smaller than that for Class II (38.7 ± 5.07), with a mean difference of 16.3 and a p-value of 0.028*. However, the mean difference between Class I and Class III (11.5) and Class II and Class III (4.8) are not significant, with p-values of 0.115 and 0.505, respectively. For horizontal growth, the mean Gama (γ) angle for Class I (52.0 ± 12.79) is significantly larger than that for Class II (30.9 ± 2.66), with a mean difference of 21.1 and a p-value of 0.005*. Similarly, the mean difference between Class I and Class III

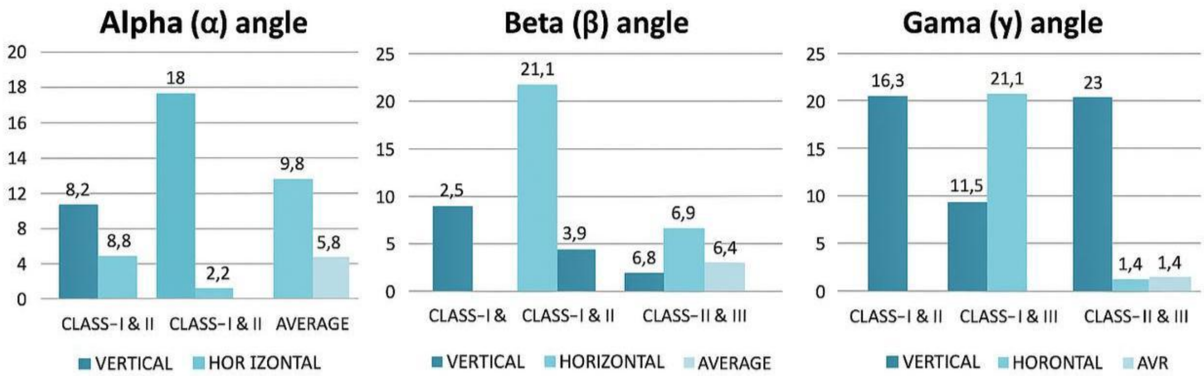
(23.0) is also significant, with a p-value of 0.003*. However, the mean difference between Class II and Class III (1.9) is not significant, with a p-value of 0.791.Regarding average growth, there are no significant differences in the mean γ angle between different skeletal malocclusion and growth patterns.

	Gama (γ) angle	Mean ± SD	Mean ± SD	Mean difference	P-Value
Vertical growth	**Class l, Class ll**	22.4 ± 6.35	38.7 ± 5.07	16.3	0.028
	Class l, Class lll	22.4 ± 6.35	33.9 ± 10.5	11.5	0.115
	Class ll, Class lll	38.7 ± 5.07	33.9 ± 10.5	4.8	0.505
Horizontal growth	**Class l, Class ll**	52.0 ± 12.79	30.9 ± 2.66	21.1	0.005*
	Class l, Class lll	52.0 ± 12.79	29.0 ± 7.31	23.0	0.003*
	Class ll, Class lll	30.9 ± 2.66	29.0 ± 7.31	1.9	0.791
Average growth	**Class l, Class ll**	44.2 ± 16.44	41.4 ± 12.25	2.8	0.697
	Class l, Class lll	44.2 ± 16.44	42.8 ± 17.92	1.4	0.845
	Class ll, Class lll	41.4 ± 12.25	42.8 ± 17.92	1.4	0.845

*Statistically significant

Table 3: Mean difference of Gama (γ) angle between different skeletal malocclusions in various growth patterns.

The mean differences between Class I and Class II, Class I and Class III, and Class II and Class III are 2.8, 1.4, and 1.4, respectively, with p-values of 0.697, 0.845, and 0.845, respectively. Overall, this chart suggests that the Gama (γ) angle may differ between different skeletal malocclusion and growth patterns, particularly in terms of vertical and horizontal growth. However, the differences in the mean γ angle for average growth patterns are not statistically significant.



Graph 1: Mean difference of Alpha, Beta, Gama angles between different skeletal malocclusions in various growth patterns.

4. DISCUSSION

The morphology of the articular eminence (AE) has been studied in relation to various skeletal malocclusions and growth patterns; however, literature on this subject remains limited. The slope of the AE is influenced by masticatory loads and mechanical conditions resulting from different skeletal malocclusions and growth patterns, leading to remodeling and alteration of the osseous structure. Other influencing factors include functional variations due to temporalis muscle attachments and hereditary traits. The present study utilized orthopantomograms (OPGs) to evaluate the inclination of the articular eminence (AEI) across different developmental patterns and skeletal malocclusions. Radiographic techniques were preferred for their standardization, reproducibility, and ability to provide consistent reference points. Despite the potential hazards associated with X-ray exposure, OPGs were chosen because the Frankfort horizontal (FH) plane is clearly visible, providing a reliable reference for measurement. More advanced imaging techniques, such as CT and CBCT, though precise, were not considered due to their higher cost, longer exposure time, and greater radiation dose. Digital panoramic imaging offers several advantages, including wider coverage, reduced exposure, rapid image acquisition, and improved contrast, all of which aid in accurate angular measurements. Since panoramic magnification affects length but not angular measurements, the method is reliable for assessing AE inclination. The study analyzed 270 panoramic images of individuals aged 18 years and above, divided into nine groups of 30 each. The minimum age limit ensured completion of craniofacial growth. The inclination of the AE was determined by measuring three angular parameters: Alpha (α), Beta (β), and Gamma (γ). Alpha (α) was defined as the angle between the line connecting the lowest point of the eminence and the deepest point of the fossa and a line parallel to the FH plane. Beta (β) represented the angle between the FH plane and the posterior slope of the eminence, while Gamma (γ) measured the anterior slope inclination relative to the FH plane. The results of this study partially align with previous research. Studies by Christiansen et al. (1987)[9], Pandis et al.[10], Katsavrias et al.[14], and Ozkan et al.[11] reported AE inclination patterns that differ from the present findings. Ikai et al. (1997)[12] found no significant correlation between AE prominence and ANB angle using dry skull measurements. Similarly, Akahane et al. (2001)[13] and Katsavrias et al. (2005)[14]observed reduced AE-to-horizontal plane angles in Class III subjects. Singh et al. (2017)[15], using both radiographic and clinical approaches, found the Class III group to have smaller AE angles than Class I and II groups, consistent with some but not all aspects of the present findings. Variations may be due to differences in measurement methods, sample characteristics, and the exclusion of growth pattern considerations in previous studies.

In the present investigation, significant differences in Beta (β) and Gamma (γ) angles were observed among skeletal classes within the horizontal growth pattern. Class I demonstrated the highest mean angles, followed by Class II and Class III. However, comparisons within vertical and average growth patterns yielded statistically insignificant results. Lobo et al. (2019)[16]found no significant differences between Class I and II subjects, possibly due to their exclusion of growth pattern variations, which may explain the differing outcomes. For the Alpha (α) angle, results were consistent with those of Ilgüy (2014)[17], Saione Cruz et al. (2017), and Arieta-Miranda (2014), showing no significant relationship among skeletal classes. Beta (β) angles showed significant differences only in the horizontal growth group, while Gamma (γ) angles exhibited significance when comparing Class I with both Class II and III, again only within the horizontal pattern. These findings suggest that growth pattern is a determining factor in AE inclination differences across skeletal classes. Krisjane et al. (2009)[19], using 3D CT analysis, found no significant differences in AEI between sagittal skeletal patterns, which supports the present findings for vertical and average growth patterns. Overall, the current study indicates that while AEI may not differ markedly across skeletal classes in general, it exhibits significant variation within the horizontal growth pattern. Further studies with larger sample sizes and advanced imaging modalities are required to validate and expand upon these findings.

5. CONCLUSION

After statistical examination of the data, the study concluded that:

Articular eminence inclination appears to be associated with different skeletal classes, but this relationship is only evident in the horizontal growth pattern. The horizontal growth pattern demonstrates variations in the mean Alpha (α) angle among the skeletal classes. Specifically, Class-I shows the highest mean α angle, followed by Class-II, and the lowest in Class-III. These differences between the classes are statistically significant. In the horizontal growth pattern, the mean Beta (β) angle is highest in Class-I, followed by Class-II and Class-III. The mean differences between these classes demonstrate statistically significant results. In the horizontal growth pattern, the mean Gama (γ) angle reaches its highest value in Class-I, followed by Class-II and lowest in Class-III. The mean differences between these classes yield statistically significant results. In average growth pattern, the mean Alpha (α) angle reaches its peak in Class-II, followed by Class-III, and it is lowest in Class-I. Nonetheless, the mean differences between these groups lack statistical significance. Within the average growth pattern, the mean Beta (β) angle exhibits its peak value in Class-II, followed by Class-III, and Class-I. Nevertheless, the mean differences between these groups are statistical insignificant. Within the average growth pattern, the mean Gama (γ) angle is highest in Class-I, followed by Class-III and Class-II. However, the mean differences between these groups showed statistical insignificant results.

6. FUTURISTIC CONSIDERATIONS:

We feel that, in the future, it would be interesting to examine if potential correlations exist between AEI and various skeleton classes and all three development patterns, considering the absence of significance in the observed variations between AEI and skeletal classes and growth patterns.

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