CORRELATION OF ANTEGONIAL NOTCH DEPTH WITH CRANIOFACIAL MORPHOLOGY – A CEPHALOMETRIC AND ELECTROMYOGRAPHIC STUDY

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Treatment planning in orthodontics other than the biomechanical considerations requires a thorough understanding of the craniofacial musculature and its association with the growth and development of the dentofacial complex. There is still much controversy regarding the influence of the mandibular muscles on normal growth and development, and on orthodontic treatment and stability. The purpose of this study was to investigate the relationship between antegonial notch depth, masseter muscle activity and the vertical craniofacial morphology. 90 adult individuals (52 females and 38 males) with normal occlusion, no history of - orthodontic treatment, craniomandibular disorder, trauma to face or jaws and muscular disorder, no facial asymmetry, pain or tenderness in TMJ or muscles of mastication, no missing teeth except 3rd molars. A lateral cephalogram was taken of each subject with teeth in occlusion, and the subjects were divided according to the depth of antegonial notch into 3 groups – shallow (<1mm), moderate (1-2.5 mm) and deep (2.5 mm). Cephalometric readings studied for each individual comprised of 8 angular and 8 linear measurements. Masseter muscle activity at rest and at maximum clenching volume was also recorded for each individual. The results suggest that there is an increased masseter muscle activity in subjects with deep antegonial notch thus indicating a positive correlation between masseter muscle activity and the depth of the antegonial notch. No statistically significant correlation was seen between the vertical craniofacial morphology and the depth of the antegonial notch.

Facial morphology is generally thought to be determined by genetic and local environmental factors thus in clinical orthodontics, it is important to identify factors that can influence craniofacial morphology, and affect the stability of the treatment. One such factor is the stomatognathic system, the functioning of which is reported to greatly influence the craniofacial morphology. Moss and Rankow[1] reported that the function of the mandibular muscles affects the growing craniofacial complex and plays a role in its morphogenesis.

Many attempts have been made to investigate the complex relationship between the activity of the mandibular muscles and the facial morphology.[2-9] The mandibular muscle activity is shown to be correlated with the vertical craniofacial morphology indicating an increased masticatory muscle activity in individuals having hypodivergent face when compared to hyperdivergent individuals.

It is documented in literature that: "When the growth of the mandibular condyle fails to contribute to the lowering of the mandible, the masseter and medial pterygoid, by their continued growth, cause the bone in the region of the angle to grow downward, producing antegonial notching." That is in other words, resorption that normally occurs below the gonial angle does not occur, rather a relative tension is generated between the angle and the muscle sling in which it is suspended such that bone deposition occurs in the area under the angle posterior to the notch[10] (Fig. 1). The present study intended to find out whether, the notching was present because of the restricted growth at the mandibular condyle and subsequent pulling by the masseter muscle or it could also be because of an increase in the activity of masseter muslce itself.

Various cephalometric studies have been carried out to correlate the depth of the antegonial notch

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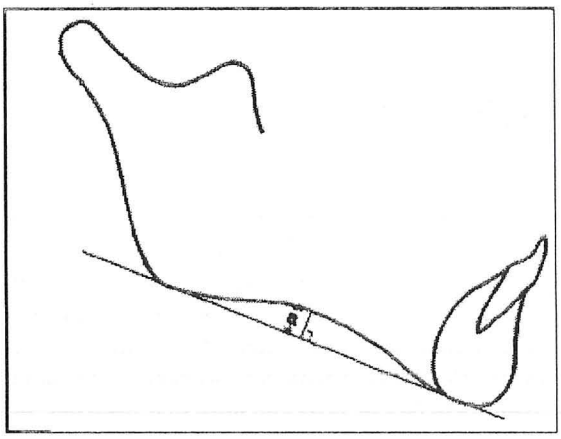


Fig. 1 Antegonial Notch

with the craniofacial variables. Studies correlating the influence of masticatory muscles to the morphological features and growth pattern of face are also documented in the literature. The present study has been undertaken to confirm the hypothesis that mandibular muscles do contribute to the formation of the face.

The aims and objectives of the study are -

- The correlation between antegonial notch depth and craniofacial morphology.
- The correlation between antegonial notch depth and Electromyographic activity of masseter muscle.

Material and Methods

Subjects

90 individuals (30 in each group) with age group of 17-25 years (in order to minimize the effect of growth on the data obtained) were selected from the undergraduate and postgraduate student (with their full consent) volunteers of our institution (Modern Dental College and Research centre, Indore, M.P). The selection criteria were as follows: (1) Normal occlusion with minimal dental discrepancy i.e. minimal crowding, spacing etc, (2) No history of orthodontic treatment, (3) No asymmetry of face on clinical examination, (4) No history of craniomandibular disorder, pain or tenderness in TMJ or muscles of mastication, (5) No missing teeth in incisor region and not more than one missing tooth in molar region, except 3rd molars, (6) Permanent dentition irrespective of 3rd molars, (7) No history of trauma to face or jaws in particular, (8) No history of muscular disorder.

Lateral cephalograms were taken of each subject at the intercuspal position. The samples were then divided into three groups based on the depth of the Antegonial notch visible on the lateral cephalogram. Each group comprised of 30 subjects.

Group I: Shallow Notch (<1mm) 22 Female, 8 Male

Group II: Moderate Notch (1-2.5mm) 20 Female, 10 Male

Group III: Deep Notch (>2.5mm) 10 Female, 20 Male

Cephalometric Readings:

The depth of the notch was measured from the deepest point on the mandibular body and tangent to the lower border of the mandible (Fig. 1). The angular and linear measurements (Fig. 2) recorded for each individual were –

Angular measurements:

Angle SNA, Angle SNA, Angle ANB, Angle SNGoGn (Mandibular Plane Angle), Angle FMA, Angle NSAr, Angle SArGo, Angle ArGoMe (Gonial Angle).

Linear measurements:

1. **Antegonial Notch Depth:** The distance between the deepest point on the mandibular body and tangent to the lower border of the mandible.
2. **Wits Appraisal:** The distance between the perpendiculars dropped from Point A and B onto the occlusal plane
3. **CoGn (Mandibular ramus Length):** The linear distance from gonion to gnathion.
4. **CoGo (Ramus height):** Linear distance between superior condylar point and gonion, measured perpendicular to the SN plane.
5. **CoGn (Total mandibular length):** Linear distance between superior condylar point and gnathion.

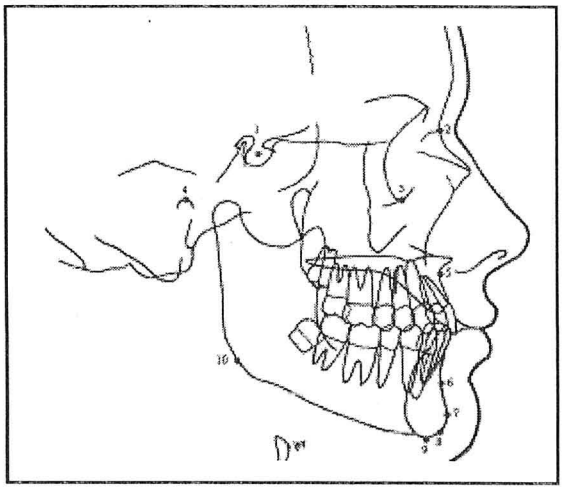


Fig. 2 Cephalometric Points and Landmarks

6. **NMe (Total face height):** Linear distance between nasion and menton.
7. **ANS Me (Lower face height):** Linear distance between the point obtained by projecting ANS along a perpendicular to the nasion-menton line and menton.
8. **S-Go (Posterior Facial Height):** Linear distance from the sella-nasion plane to gonion, measured perpendicular to the SN plane.[11]

Cephalometric Recording

Prior to cephalometric recording, subjects were made to wear lead apron to protect them from radiation exposure. Lateral cephalogram was recorded with the patient standing upright, looking at a distant object and with his/her head so positioned that the FH plane was parallel to the floor. Cephalograms in each group were then traced by locating the following different points[11].

EMG Recording

All the subjects were subjected to electromyographic study of masseter muscle. Electromyographic unit (Nicolet Viasys Viking Quest EMG Unit Fig. 3) including both hardware and software was employed to record the muscle activity.

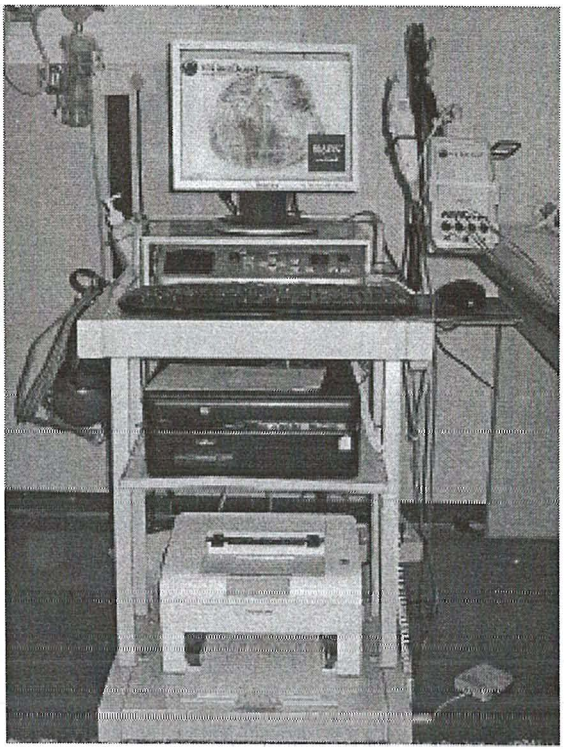


Fig. 3 Nicolet Viasys Viking Quest EMG

Electromyographs were recorded with patients sitting upright and also there was no movement of electrode during recording. Using electrode paste, a set of two surface electrodes fixed to the skin with collodion adhesive were used to record the activity of masseter muscle. Surface electrodes for recording EMG were oriented approximately corresponding to the most thick and superficial portion of masseter muscle at about 2 cm above and parallel to the inferior border of the mandible. Site of measurement was in thickest part of masseter, close to the level of occlusal plane (Fig. 4). The activity of masseter was first recorded in relaxed state and then in maximum voluntary clenching state, by asking the patient to clench (Fig. 5). Three readings of maximal voluntary clenching were recorded for each patient at an interval of 15 seconds. The mean value of these three readings was taken as the maximal voluntary clenching of the muscle.

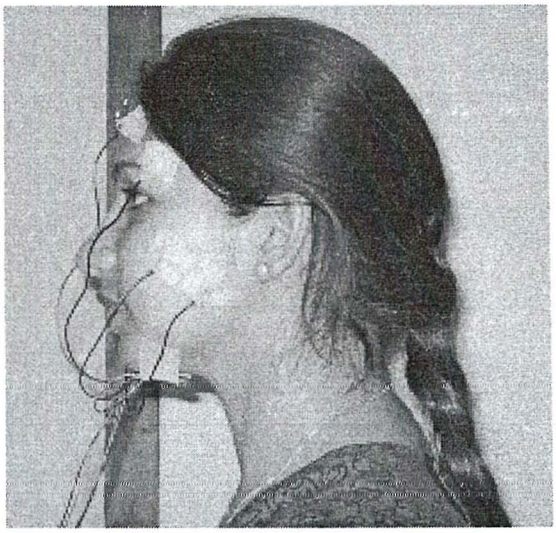


Fig. 4 EMG Recording

EMG form

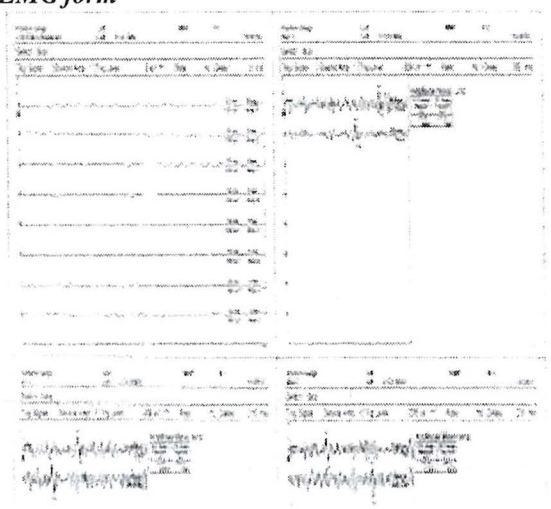


Fig. 5 EMG Reading of Masseter Muscle Activity

Statistical Analysis

T test and analysis of variance test was used to examine the difference between the mean values of the variables under observation in the 3 different groups. To examine the correlation between the depth of the antegonial notch, masseter muscle activity and the vertical craniofacial morphology, coefficient correlation test was employed.

Results

Table I shows the mean, range and standard deviation of the cephalometric variables and masseter muscle activity studied for each group. Significant differences between the groups in the means of Y axis and masseter muscle activity are evident (Table I). The average of Masseter Muscle Activity of Group I (shallow notch depth) is 1791 with a range of 836 to 3513. The mean of Masseter Muscle Activity of Group II (moderate notch depth) group is 1751 with a minimum of 572 and a maximum of 3643. The average of Masseter Muscle Activity of Group III (deep notch depth) group is 2171 with a range of 1175 to 3511. The Standard Deviation for the same is 677, 736 and 668 respectively. The average of Y Axis Angle of Group I (shallow notch depth) is 57.3° with a range of 52° to 64°. The mean of Y Axis Angle of Group II (moderate notch depth) group is 59.5° with a minimum of 52° and a maximum of 67°. The average of Y Axis Angle of Group III (deep notch depth) group is 58.3° with a range of 50° to 65°. The Standard Deviation for the same is 2.70, 3.34 and 3.59 respectively.

Analysis of variance test (Table II) shows that there is a significant difference in the means of Y Axis parameter and masseter muscle activity between the groups. On evaluating the Student t-Test (Table II), one can see that significant difference between the means of Y axis is there in group I and II, of ramus height is there in group II and III. Also it is evident that there is significant difference in the means of Masseter muscle activity in group I and III as well as group II and III.

Analysis of variance test (Table II) shows that there is no significant difference between the means of the other cephalometric variables studied among the groups. The Student t-Test (Table II) also shows a non-significant difference between the means of groups regarding the other cephalometric variables studied.

The correlation coefficient analysis (Table III) shows, that in group I the depth is negatively correlated with the total facial height and lower facial

TABLE I

MEAN, STANDARD DEVIATION AND RANGE OF CEPHALOMETRIC VARIABLES AND MASSETER MUSCLE ACTIVITY

S.No.	Variables	Group I (Shallow Notch)			Group II (Moderate Notch)			Group III (Deep Notch)		
		Mean	Range	SD	Mean	Range	SD	Mean	Range	SD
1	SNA Angle	82.1	73-91	4.68	83.1	77-93	4.76	82	77-93	4.76
2	SNB Angle	80.3	74-86	3.65	81.1	75-97	4.71	81.9	69-92	5.35
3	ANB Angle	1.76	-4 – 8	2.77	2.37	-4 – 10	3.06	2.83	-4 – 8	2.57
4	Wits Appraisal	0.20	-7 – 9	3.21	0.70	-9 – 6	3.92	1.18	-10 – 8	3.50
5	SnGoGn Angle	24.4	16-34	4.85	26.9	15-39	5.98	24.9	12-47	8.53
6	FMA Angle	22.7	16-30	4.66	25	11-35	5.98	21.6	10-44	8.26
7.	Y Axis	57.3	52-64	2.70	59.5	52-67	3.34	58.3	50-65	3.59
8.	Saddle Angle	123.8	106-138	6.17	123.1	109-135	5.82	122.7	112-131	5.03
9.	Articular Angle	140.7	123-160	7.30	141.7	124-153	5.93	142.5	129-154	6.43
10.	Gonial Angle	123.9	117-134	7.30	124.8	112-135	5.42	123	113-138	7.33
11.	Mandibular Length	80.8	68-88	4.32	79.8	72-100	6.03	80.6	67-95	6.17
12.	Ramus Height	62.2	55-72	4.84	60.5	50-72	5.18	63.8	43-73	6.97
13.	Total Mandibular Length	120.5	106-132	6.09	119.9	108-147	8.36	121.4	108-140	7.80
14.	Total Facial Height	120.1	106-138	6.81	124.7	108-143	6.50	121.8	110-135	6.68
15.	Lower Facial Height	68.2	58-84	5.50	69.7	56-84	6.05	69.3	58-80	5.44
16.	Masseter Muscle Activity	1791	836-3513	678	1751	572-3643	736	2174	1175-3511	668

TABLE II

ANALYSIS OF VARIANCE AND STUDENT T-TEST

S No.	Variables	Group I and II		Group I and III		Group II and III		"f" Value
		"t" Value	"P" Value	"t" Value	"P" Value	"t" Value	"P" Value	
1.	SNA Angle	1.15	0.252	2.18	0.233	1.24	0.216	0.902
2.	SNB Angle	0.73	0.464	1.35	0.181	0.61	0.541	0.898
3.	ANB Angle	0.79	0.429	1.54	0.128	0.63	0.524	1.087
4.	Wits Appraisal	0.50	0.591	1.13	0.261	0.51	0.609	0.58
5.	SnGoGn Angle	1.77	0.080	0.26	0.795	1.06	0.289	1.204
6.	FMA Angle	1.67	0.099	0.61	0.541	1.81	0.074	2.13
7.	Y Axis	2.88	0.005*	1.29	0.199	1.33	0.185	3.688*
8.	Saddle Angle	0.40	0.684	0.71	0.480	0.28	0.776	0.251
9.	Articular Angle	0.56	0.575	0.99	0.324	0.50	0.618	0.542
10.	Gonial Angle	0.64	0.522	0.59	0.553	1.10	0.275	0.70
11.	Mandibular Length	0.71	0.478	0.09	0.923	0.52	0.598	0.265
12.	Ramus Height	1.35	0.185	1.05	0.296	2.12*	0.038	2.579
13.	Total Mandibular Length	0.32	0.752	0.49	0.633	0.70	0.485	0.291
14.	Total Facial Height	1.16	0.248	0.99	0.324	0.72	0.469	0.95
15.	Lower Facial Height	0.98	0.330	0.73	0.467	0.29	0.771	0.528
16.	Masseter Muscle Activity	0.22	0.824	2.20*	0.031	2.33*	0.023	3.93*

height. In group III, a negative correlation is seen between the depth and mandibular plane angle and gonial angle. It can also be seen that though there exists a correlation between the depth and the cephalometric parameters in different groups, overall the depth of antegonial notch does not show correlation with the cephalometric parameters. There is overall a positive correlation between the activity of the masseter muscle and the depth of the antegonial notch as is shown in Table III.

Discussion

In orthodontics, it is advised to identify the factors that influence craniofacial morphology, predict the morphological changes as subjects grow and retain the goals achieved after a successful orthodontic treatment. The ability to predict the magnitude and direction of a patient's facial growth would not only allow the clinician to identify patients needing interceptive growth modification but also ensure that the appropriate treatment can be rendered to them while growth is possible.

Though it is desirable to predict the growth of the entire face but even the prediction of mandibular growth would be of great benefit. The assessment of mandibular morphology thus plays an important role in treatment planning. Studies in the past have explored the possibility that mandibular antegonial notch morphology might predict mandibular growth. These studies were based on the findings of Bjork[10,12,13] who reported that mandibles with a forward growth tendency exhibit a pattern of surface apposition below the symphysis and surface resorption under the mandibular angle. The opposite pattern is observed in individuals with a backward mandibular growth tendency, leading to concavity

Table III

Correlation table between notch depth and other parameters

Characters	Group I	Group II	Group III	Overall
SNA angle	0.338	-0.145	0.321	0.182
SNB angle	0.177	-0.007	0.227	0.179
ANB angle	0.294	-0.087	0.111	0.166
Wits angle	0.315	-0.120	0.179	0.136
SNGoGn angle	-0.109	-0.014	-0.428*	-0.065
FMA angle	-0.092	-0.059	-0.342	-0.145
Y axis	-0.231	-0.035	-0.234	0.062
SNAr angle	-0.326	-0.093	-0.242	-0.132
SArGo angle	0.325	-0.097	0.061	0.122
ArGoMe angle	-0.293	-0.090	-0.437*	-0.167
GoMe (mm)	-0.216	-0.106	0.158	-0.002
RH (mm)	-0.134	0.130	0.298	0.176
CoMe (mm)	-0.334	-0.026	0.067	0.040
TFH (mm)	-0.450*	-0.087	-0.124	0.007
LFH (mm)	-0.387*	0.032	-0.155	0.029
MMA	-0.051	-0.025	-0.056	0.216*

on the inferior border of the mandible known as the antegonial notch.

Singer et al[14], Lambrechts[15] and Ronald P. Kolodziej[16] attempted to determine if the antegonial notch depth could indicate future mandibular growth direction or potential. The findings of their study indicate that definite mandibular morphological patterns are associated with deep and shallow mandibular antegonial notch, with deep notch subjects having a more retusive mandible with a shorter corpus, less ramus height, greater gonial angle, longer total facial height and lower facial height, smaller saddle angle and a vertical growth pattern than the shallow notch subjects. Although significant differences in mandibular growth were detected between deep-notched and shallow-notched subjects, the results must be interpreted with caution because the sample consisted exclusively of those with extreme morphology and excluded those who would more closely represent patients routinely encountered in an orthodontic practice.

On comparing the correlation between the antegonial notch and craniofacial morphology, it was found that the depth of antegonial notch is not significantly related to the craniofacial morphology (Table III). 15 cepahlometric variables were traced and compared for the three groups. It was found that the individuals with shallow notch showed a negative correlation with the total facial height and lower facial height (Table III). The individuals with deep notch showed a negative correlation with the mandibular plane angle and gonial angle (Table III). These two findings indicate that with increase in the depth the total facial height and lower facial height decreases and a more horizontal pattern is seen. But there is no overall correlation of the notch depth with these parameters as the findings were not the same for all the groups. On comparing the craniofacial morphologic variables of individuals having a shallow notch depth with those of individuals having a moderate notch depth, it was found that the later showed a more vertical growth pattern (based on Y axis) as shown in table (Table III). But the same was not true between the individuals having shallow and deep notch depth (Table III). The Total mandibular length and Total facial height increases from the shallow notch group to deep notch group. Though these readings are statistically insignificant, but clinically they seem to be significant.

Other then growth prediction, it is important for an orthodontist to retain the goals achieved after a successful orthodontic treatment, which requires thorough understanding of the factors affecting the stability of the treatment. One such factor affecting the retention of orthodontic treatment is the stomatognathic system.

The influence of the masticatory muscle function on the craniofacial growth has been investigated through various studies. It has been shown that human subjects with strong bite forces tend to have brachyfacial patterns, in contrast to those with weak bite forces, who tend to have dolichofacial patterns. This difference in bite force has led to much speculation about the etiology of vertical facial patterns. According to Proffit and Fields[17,26], it is possible that the lower bite force in dolichofacial people may result in excess eruption of the posterior teeth than might otherwise occur, and so are directly related to the excessive tooth eruption and backward rotation of the mandible often seen in such subjects. Similarly, Ingervall and Helkimo[18] suggested that the inter-individual form of the face is smaller in persons with strong muscles than in those with weak muscles. This would support the hypothesis that muscles do actually contribute to the final shape of the face.

Two confirm the above hypothesis, that indeed the muscles of mastication influence the craniofacial morphology, the present study was undertaken. The craniofacial variable undertaken in this study is antegonial notch. It is written in literature that subsequent to the restricted growth of the mandibular condyle, the pull of masseter and medial pterygoid muscle result in notching of the mandible. The purpose of this study was to find out if notching could also be because of an increased masseter muscle activity.

The principal finding of the study indicates that the muscle activity influences the craniofacial

morphology. The individuals having a deep notch showed a higher masseter muscle activity than the individuals having either shallow or moderate notch depth (Table I), thus showing that the notching may be a result of a higher muscle activity.

Conclusion

Significant difference in the maximal clenching volume of the masseter muscle was found between individuals having shallow, moderate and deep antegonial notch. Individuals with deep notches showed a higher masseter muscle activity than individuals having moderate and shallow notches. Significant positive correlation was observed between the masseter muscle activity and depth of the antegonial notch, whereas no significant correlation was observed between the cephalometric variables and the depth of the antegonial notch. In the present study, only the correlation between the depth of the notch and masseter muscle activity was studied, but as it is produced by the pull of both masseter and medial petrygoid muscle, further research can be done to correlate the notch with medial pterygoid activity as well. Secondly as is written in literature that notch is seen in cases with arrested growth of the condyle, further study can be conducted in cases showing asymmetric growth of the condyle, to better understand the relation between antegonial notch and growth at the condyle.

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