Masseter Muscle Position Relative to Dentofacial Form

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INTRODUCTION

The differential characteristics of skeletal open bite and closed bite have been well established and reported in the literature. However, a characteristic that has not been clearly established is the anteroposterior position of the masseter muscle. Eschler[2] and Van Zile[10] placed considerable importance on the insertion site of the masseter in the surgical treatment of severe prognathic or retrognathic subjects. Sassouni[6,7] has proposed a relationship between facial proportions and the anatomic position of the musculature; namely, in the skeletal closed-bite subject the posterior chain of muscles, which includes the masseter, would be more vertically positioned, while in the open-bite subject it would be more oblique.

Frischfield[3] reported that the insertion site and angulation of the masseter was significantly different between "mesio-bite" (prognathic) and "deep-bite" subjects. He indicated the muscle was wider, more vertically inclined, and inserted more anteriorly in deep-bite subjects. Peterson[4] studied the position of the masseter in Class I and Class II subjects and found a more anteriorly inclined masseter, relative to sella-nasion plane, in the Class II subjects.

It is the purpose of this investigation to establish a model which will aid in the understanding of the variations which occur in masseter muscle position relative to skeletal open-bite and closed-bite subjects.

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METHODS AND MATERIALS

Lateral cephalograms were taken on the first forty-six consecutive subjects presenting themselves for orthodontic treatment at a university clinic and were used to establish a mean value and standard deviation of sella-nasion to mandibular plane angle. Thirty-four additional subjects were selected with a measurement more than one standard deviation above or below this mean. The age range of all eighty subjects was 10 to 17 years.

Ten measurements from each of the eighty lateral cephalograms (Fig. 1) were submitted to correlation procedures and, of these, five proved to be highly correlated to skeletal open bite and closed bite. They were: 1) sella-nasion-mandibular plane angle, 2) Frankfort-mandibular plane angle, 3) palatal-mandibular plane angle, 4) occlusal-mandibular plane angle, and 5) gonial angle.

The statistical quantity "first principal component" was used to combine these five measurements into one value, this value being computed for each of the eighty subjects. These eighty values were then used to separate the subjects into one of three groups: those at the mean, those more than one standard deviation above the mean, and those more than one standard deviation below the mean. The skeletal open-bite group contained fourteen subjects, the skeletal closed-bite group twelve subjects, and the "normal" group fifty-four subjects.

The location of the anterior border of the superficial portion of the masseter muscle was located by palpation while

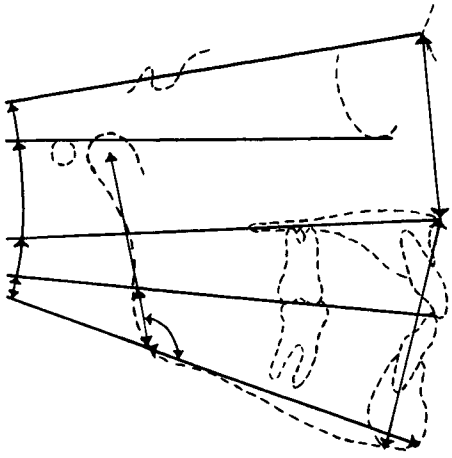

Fig. 1 The various skeletal measurements evaluated for possible use in distinguishing skeletal open bite from closed bite.

the teeth were alternately clenched and relaxed. An .020 inch wire, approximately two inches in length, was then taped into position directly superficial to the muscle border. This was done on both right and left sides prior to exposure of the lateral cephalograms. When tracing the cephalograms the positions of the right and left radiopaque lines were averaged, giving one line which was used as the position for the anterior border of the masseter musculature (Fig. 2).

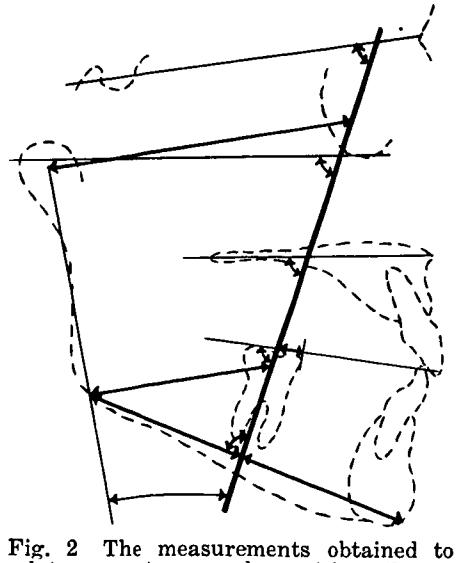

Fig. 2 The measurements obtained to relate masseter muscle position (heavy line) to skeletal elements.

The reproducibility of the muscle locating procedure was determined as follows: A reference line was drawn on one side of the patient's face from the ala of the nose to the tragus of the ear. The angulation of the anterior border of the masseter muscle to this line was determined. Nine subjects selected at random from among clinic patients were used to determine the variation which occurred for a given subject. Subject I was measured, then subject II, etc., until all nine had been measured. This cycle was repeated five times. To determine the anterior-posterior reproducibility a reference point located on the ala-tragus line near the ear was used. Five subjects were used for this procedure and the cycle repeated ten times.

Results

The mean and one standard deviation for various skeletal measurements and masseter muscle position in skeletal open-bite, normal-bite, and closed-bite groups are shown in Tables I and II. Table III shows the results of the test of significance for the differences between mean values when the skeletal open and closed-bite groups are compared.

Comparison of the data representing the two extreme groups indicates differences in the angles formed by the palatal and Frankfort planes with the masseter muscle border. The angles formed by the muscle border and occlusal plane show no significant differences between groups. The sella-nasion plane to muscle border angles have an 8 degree difference which is significant at the 1% level. When the angles formed by the mandibular plane and masseter border are compared, a significant difference is seen. The open-bite group has a mean angle of 14 degrees smaller than

TABLE I

		SN Mand. Plane	F.H. Mand. Plane	Palatal Mand. Plane	Occlusal Mand. Plane	Gonial Angle	Upper Anterior Facial Height	Lower Anterior Facial Height	Ramal Height	Mand. Body Length	Distance from SN to Condyle	Distance from S to SN Condyle*
		deg.	deg.	deg.	deg.	deg.	mm	mm	mm	mm	mm	mm
Skeletal Open Bite	Mean	46.5	33.9	36.6	25.5	130.2	54.0	73.4	46.3	72.6	19.1	15.8
	S.D.	3.7	3.7	4.0	2.9	3.8	2.6	6.7	4.8	5.4	2.8	3.0
Normal Bite	Mean	33.8	23.7	26.9	18.7	122.1	51.5	65.9	49.2	73.5		
	S.D.	4.9	4.3	4.5	2.9	4.8	3.4	4.7	4.5	4.8		
Skeletal Closed Bite	Mean	24.1	14.9	17.4	11.9	113.0	51.5	60.3	53.3	75.9	21.4	16.5
	S.D.	3.8	4.5	4.4	3.7	4.0	3.5	5.8	5.1	3.7	3.0	3.3

S.D. = one standard deviation
* = distance from S to a line perpendicular to SN at center of condyle

TABLE II

MEANS, STANDARD DEVIATIONS AND RANGES OF MEASUREMENTS RELATING MASSETER MUSCLE TO SKELETAL ELEMENTS

Muscle Border to:		SN Plane	F.H. Plane	Palatal Plane	Occlusal Plane	Mand. Plane	Ramal Plane	Gonion*	Condyle**	Gonion**	Lower First Molar	Gonion to Mand. Length
		deg.	deg.	deg.	deg.	deg.	deg.	mm	mm	mm	mm	ratio
Skeletal Open Bite	Mean	48.7	61.3	58.6	69.8	84.7	34.8	40.0	80.4	48.1	-2.2	.54
	S.D.	6.6	5.3	5.3	6.7	5.4	6.5	5.5	8.0	4.6	4.2	.05
Normal Bite	Mean	54.1	64.2	61.0	69.1	92.0	34.1	39.2	80.8	47.0	-2.4	.53
	S.D.	5.9	5.3	6.0	5.9	6.6	6.5	5.9	9.0	5.6	4.8	.06
Skeletal Closed Bite	Mean	57.0	66.3	63.8	69.3	98.7	32.2	40.4	80.9	46.8	-.5	.53
	S.D.	5.2	4.4	4.8	3.9	4.8	3.8	5.2	7.7	6.0	4.5	.06

* = measured on mandibular plane
** = measured perpendicular to ramal plane
S.D. = one standard deviation

the closed-bite group. All measurements comparing muscle position in an anteroposterior direction showed no statistical difference between the two groups.

Analysis of the correlation coefficient matrix agrees with and substantiates the differences between mean values.

The angular variability in locating the anterior border of the masseter muscle, as determined by repeated measurements, on a number of individual subjects always showed a per cent standard deviation less than 3%. The variability in locating the masseter muscle in the anteroposterior dimension was always less than a per cent standard deviation of 4%.

Discussion

Only the anterior border of the superficial portion of the masseter muscle was used in relating masseter muscle inclination to various craniofacial measurements. It should not be assumed that the resultant vector component for the action of the total muscle need be exactly in this direction. This anterior border may approximate the position and inclination of the entire masseter.

Frequently in clinical orthodontics it has been proposed that in skeletal open-bite subjects the inclination of the masseter is more horizontal than in closed-bite subjects. Or stated differently, if the inclination of this muscle were subject to simple vector analysis, the vertical component would be greater in the closed-bite group. This study indicates that there is a statistically significant difference in muscle inclination between skeletal open and closed-bite subjects (Table III). Muscle inclination relative to SN is more horizontal in the open-bite group and more vertical in

TABLE III

	t Value***	Level of Significance
Ramal Plane - Muscle Border Angle	1.22	N.S.
**Condyle - Muscle Border Distance	.15	N.S.
**Gonion - Muscle Border Distance	.61	N.S.
*Gonion - Muscle Border Distance	.19	N.S.
Lower First Molar - Muscle Border	.99	N.S.
Ratio of Gonion - Muscle Border to Total Mandibular Length	.72	N.S.
Occlusal Plane to Muscle Border Angle	.21	N.S.
Palatal Plane - Muscle Border Angle	2.59	5%
Frankfort Plane - Muscle Border Angle	2.61	5%
Sella-Nasion Plane - Muscle Border Angle	3.58	1%
Mandibular Plane to Muscle Border Angle	6.95	1%

* = measured on mandibular plane
** = measured perpendicular to ramal plane
*** = student t test
N.S. = not significant

the closed-bite subjects. But relative to mandibular plane, it might at first appear on examination of the data as though the reverse were true since GoGn - muscle border angle was 85° in the open-bite group and 99° in the closed-bite group. However, this is one expression of the larger gonial angle in the open-bite group. As gonial angle increases from 113° to 130°, GoGn - muscle border passes from the first to the second trigonometric quadrant.

It would not be unreasonable to expect that in closed-bite individuals the masseter would be more anteriorly positioned. This arrangement could impart to the masseter, from a geometrical standpoint, a more efficient force pattern for accomplishing jaw closure and, presumably for preventing open bite. However, the data from this study do not support this contention (Table II). For in the insertion area, the mean difference in the distance from gonion to muscle border is only 0.4 mm and in the region of the origin, the mean difference in distance from condyle to muscle border is only 0.5 mm. This clearly shows that, as far as the anterior border is concerned, the masseter muscle attachment sites are the same in both groups and suggests that relatively constant origin and insertion areas exist regardless of skeletal type. Peterson[4] found the same indication when comparing Class I and Class II cases.

Figure 3 is a full scale model representing some of the craniofacial and masseter muscle relationships which exist between skeletal open and closed bite-groups. All angular and linear measurements, including measurements required to position all planes in this two-dimensional model, represent the mean values obtained. Superposition is at the center of the condyle and parallel to SN.

It is interesting to note that nearly all of the difference in masseter muscle position and inclination relative to craniofacial measurements between the two skeletal types can be explained by the anteroposterior position of the mandible (Fig. 3). These findings agree with and support those of Schudy.[8] It could be said that either the mandible at gonion is anteriorly positioned in the closed-bite group or it is posteriorly positioned in the open-bite group. This observation is further supported in Figure 4, which is the same model except for superposition on SN at S. If this approximately 6° rotation of the mandible (Fig. 3) had not occurred, the statistically significant differences in muscle-skeletal relationships between the two groups (Table III) would not exist. In fact, all muscle-skeletal measurements, excepting muscle border-mandibular plane, would have been surprisingly similar were it not for this rotation of the mandible. Muscle border-mandibular plane differences seem to be an expression of both anteroposterior displacements of the mandible and the large differences in the gonial angles between the two groups. Undoubtedly the size of the gonial angle is an important factor in the skeletal proportion of the face and apparently accounts for the larger part of the difference seen in the size of the angle formed by mandibular plane - muscle border. The different position of the mandible in the open and closed-bite

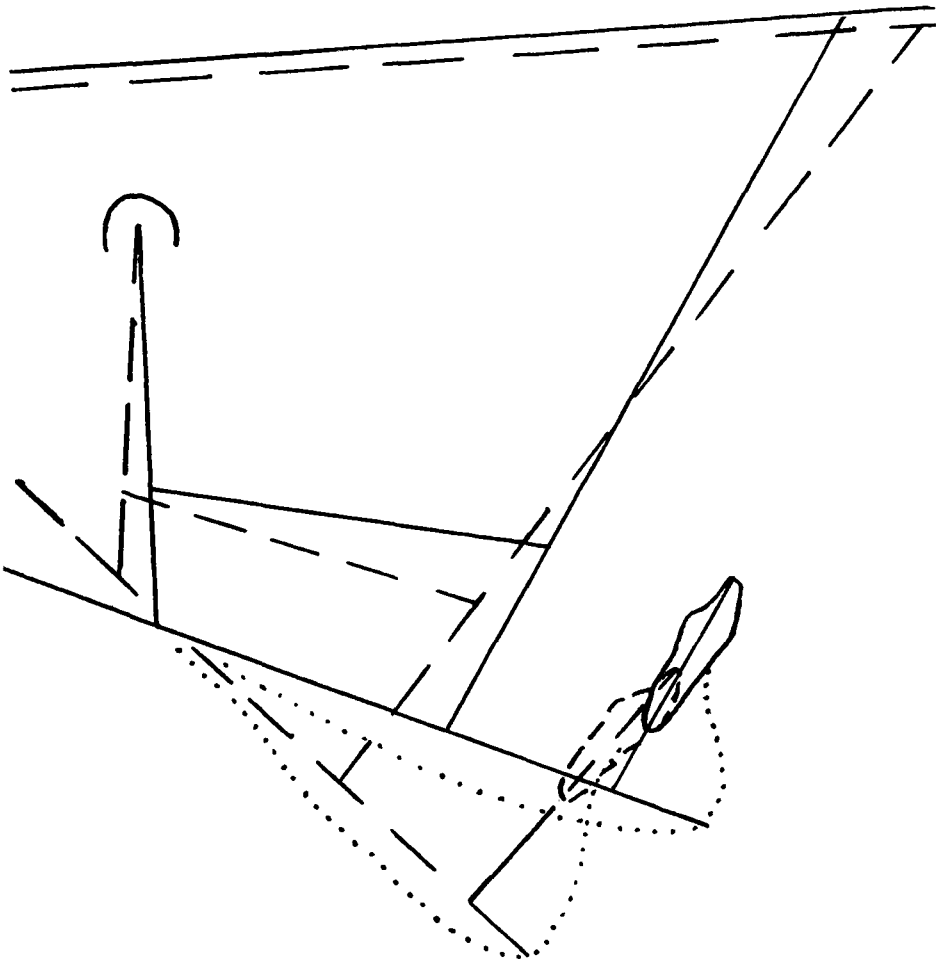

Fig. 3 An actual size model showing anterior border of masseter muscle relative to SN, occlusal and mandibular planes in skeletal open and closed bite. Lower incisal angulation and location for the two groups is also shown. All measurements represent mean values, many of which are presented in Tables I and II. Superposition is on center of condyle parallel to SN.

groups is quite apparent in Figure 4. In the open-bite group, the condyle is anterosuperior, the ramus is shorter, the gonial angle is larger, and the mandible is rotated inferoposteriorly.

In contrast to the relationships just mentioned, close similarities exist in the values of some of the skeletomuscular measurements of the two extreme groups. The angles of muscle to occlusal plane and muscle to ramal plane, the distances of muscle to first molar and to gonion are quite close in value in the two groups. The mean values which showed no significant differences between the two groups are of interest because they may reflect constancy regardless of skeletal type. The constant angular relationship between the muscle border and occlusal plane might suggest a definite relationship between the dentition and muscular forces irrespective of mandibular or maxillary shape or position. This constant relationship

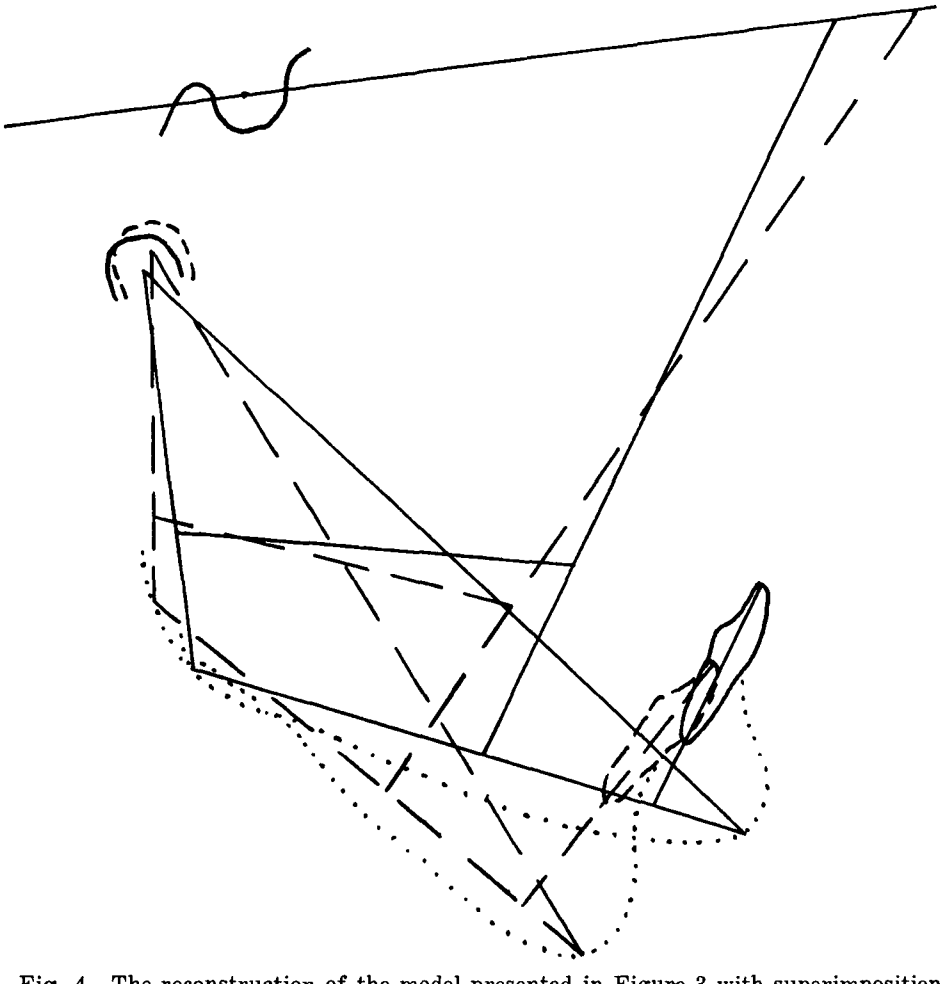

Fig. 4 The reconstruction of the model presented in Figure 3 with superimposition on SN at S. An additional line from center of condyle to gnathion is also present.

may exist in spite of the significant differences seen in the extreme groups when the muscle to SN, Frankfort, palatal, and mandibular planes are compared. This finding is of interest in reference to Sicher's[9] statement, "The superficial portion (masseter muscle) exerts pressure at a right angle to the posteriorly ascending occlusal plane of the molars (curve of Spee)."

This constant relationship of around 69° between occlusal plane and masseter muscle inclination might imply that muscle angulation influences the occlusal plane inclination. If this were true, a closer relationship between these two planes would be expected in the closed-bite group where biting force, being greater, would tend to more clearly affect occlusal plane. It is interesting to note from Table II that the standard deviation in muscle border to occlusal plane is 70% greater in the open-bite group. The range was also about twice as large in this group. Could this suggest that muscle position and/or activity may influence the inclination of the occlusal plane? Downs[1] suggested that when the occlusal plane was tipped as a result of orthodontic

treatment, it tended to return to its original position. If there is a constant relationship between the musculature and the occlusal plane, this return of the occlusal plane to its original position would be expected.

The reproducibility in locating the anteroposterior and angular positions of the masseter was good. Since the muscle positioning technique was quite reproducible, it was of interest to find that seventeen of the eighty subjects (approximately 20% of the sample) showed a muscle angulation difference of more than 6° between the right and left sides. Likewise, the anteroposterior position of the muscle on the left and right sides varied by more than 6 mm in twenty-four (30%) of the subjects. This finding does indicate variability in size and/or position of muscular elements between the two sides of the face. However, part of this difference could be attributed to variations in the roentgenographic-cephalometric technique.

In Table I and Figure 3 are indicated some interesting bony relationships between the skeletal open and closed-bite groups. Mean mandibular body length is only slightly shorter in the open-bite group, 72.6 mm to 75.9 mm, not a statistically significant difference. Ramal length is 7 mm less in the open-bite group and this is significant at the 1% level.

The shorter, total posterior facial height in the open-bite group is a reflection not only of the smaller ramal height but also of the more superior position, by approximately 2.4 mm, of the center of the condyle (Fig. 4). The distance from center of condyle to the SN line, obtained by extending ramal plane to SN, is 12% less in the open-bite group.

Upper anterior facial height is similar in the two groups, with the closed-bite value within 6% of the open-bite value. This is not a statistically significant difference at the 5% confidence level. However, lower facial height is 18% less in the closed-bite group (Table I), significant at the 1% confidence level. The 13 mm difference (Table I) in lower anterior facial height between the two groups was approximately evenly distributed between the mandible and maxilla. For example, the distance from the tip of the mandibular incisor to GoGn was 7 mm less in the closed-bite group. This indicates that the increased lower facial height in the open-bite group is obtained by approximately equal increases in the height of both maxillary and mandibular alveolar processes. Since total maximum biting force is greater in subjects exhibiting closed-bite characteristics,[11] it would appear that muscular forces could have a marked influence on alveolar bone height. The lower incisor-GoGn angle was found to be 99° in the closed-bite group and 88° in the open-bite subjects. Since mandibular length is similar in the two groups, might one expect more anterior crowding in open-bite subjects? If a line were drawn from center of condyle to gnathion and lower incisor angulation measured to this line, the values obtained in the open and closed-bite groups would be surprisingly similar (Fig. 4).

The difference in profile appearance between open and closed-bite individuals is well known. The anteroposterior position of the chin contributes to this profile difference. In Figure 5 (a reproduction of the lower portion of Figure 3) the difference in anteroposterior location of gnathion can be seen. The more posterior position of gnathion in the open-bite group is due to rotation of the mandible posteriorly and to the larger gonial angle, each of these contributing about equally to gnathion position.

Summary and Conclusion

The anterior border of the masseter muscle was located by palpation. A wire

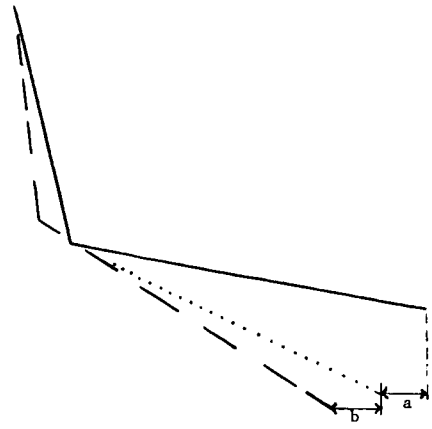

Fig. 5 The accumulative influence of gonial angle and mandibular rotation on the anteroposterior position of gnathion. a) The difference due to gonial angle. b) The difference due to mandibular rotation.

simulating this position was placed on the patient and a lateral cephalogram was taken. Patients were placed in skeletal open-bite, normal-bite, and closed-bite groups and various angular and linear measurements were recorded.

Comparison of the skeletal open-bite and closed-bite groups revealed a more horizontally placed masseter musculature, relative to SN, Frankfort and palatal planes, in the open-bite group. The skeletal open bite had a more vertically inclined musculature related to the mandibular plane. The size of gonial angle and the rotation of the mandible were important contributions to the relationship between mandibular plane and muscle border. Masseter muscle attachment sites, per se, revealed no apparent differences between the two groups. Muscle inclination relative to occlusal plane was the same in skeletal open-bite and closed-bite individuals.

A model was constructed, based on mean values, to illustrate skeletal and muscle differences between the two extreme groups.

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