Maximum Opening and Closing Forces Exerted by Diverse Skeletal Types

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INTRODUCTION

Individuals with skeletal open or closed bite present two extremes in facial proportions. Probably the most frequently cited etiologic factor responsible for these diverse facial types is a difference in the function of mandibular closing muscles. An obvious explanation of the effects of these muscles on facial type would be that strong muscles cause skeletal closed bite since they tend to force the mandible against the anterior cranial base, while weak ones allow more downward and forward facial growth to occur. However, on closer scrutiny it can be seen that forces exerted by yet another group of muscles, namely, those involved in mandibular opening, could also have great influence on facial types. Skeletal open bite could be an expression of relative hyperactivity in this group of muscles, while closed bite would follow their relative hypoactivity. It has been reported[4] that open-bite individuals have shorter rami, more superiorly positioned condyles, and larger gonial angles, all of which would fit nicely the model of hyperactivity of mandibular opening muscles in skeletal open-bite subjects.

Although considerable interest has been shown in the measurements of closing forces exerted during mastication with both natural and artificial dentitions, only Sassouni[6] has attempted to correlate closing muscle force to facial type. No measurements documenting mandibular opening forces have been found in the literature. The purpose of this investigation is to quantitate and compare the opening and closing forces in a selected sample of skeletal open and closed-bite individuals.

METHODS AND MATERIALS

Forty-five individuals with SN-GoGn angles of 42 degrees or more and 25 degrees or less were selected to represent both diverse skeletal types. All force measurements were made within a five-day period (Table I). To measure biting force a gnathodynometer, illustrated in Figure 1, was obtained through the generous help of Viken Sassouni of the School of Dentistry, University of Pittsburgh. Three-sixteenths inch thick polyurethane biting pads were cemented in position on the gnathodynometer by silicone seal to provide comfort and to protect the teeth during biting. This instrument was calibrated on a Detecto scale which had an accuracy of ± 2 ounces in the range of 0-199 pounds. A graph was constructed using Detecto-gnathodynometer units on ordinate and abscissa, respectively, and a curve was drawn which could be used to convert gnathodynometer divisions into pounds.

The gnathodynometer was positioned intraorally as described in Figure 1.

TABLE I

Sample Size and Distribution with Mean and Standard Deviation of Age

Variables	*N*	*Age (year)*
Female Closed Bite	10	15.5±3.2
Female Open Bite	12	15.9±2.2
Male Closed Bite	11	18.3±7.1
Male Open Bite	11	15.1±1.5
Combined Closed Bite	21	17.0±5.6
Combined Open Bite	23	15.5±1.9

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Fig. 1 The quantitation of closing force. Above, each division on the circular scale of the gnathodynometer was approximately equal to 5.5 pounds. Below, the instrument was always positioned so that the upper first molar was in the center of the polyurethane pad with its distal ridge at the distal edge of the appliance.

Extreme care was taken to position the instrument in the same anteroposterior location on each patient. Maximum biting force was measured alternating between the right and left sides. Six total readings were obtained from each patient. This procedure required two technicians. The same technician always

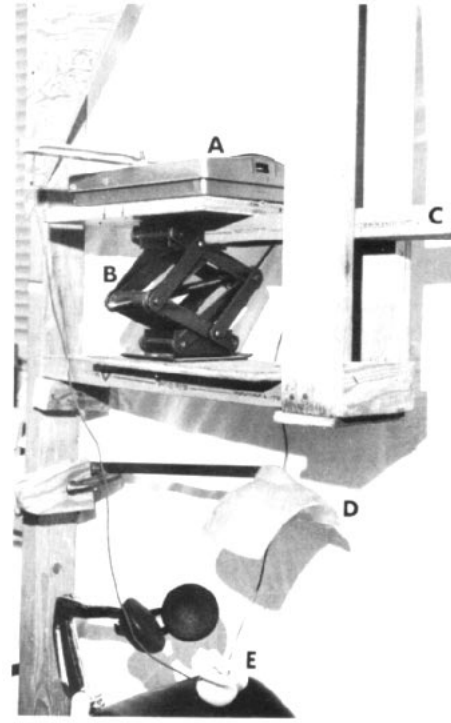

Fig. 2 The quantitation of opening force. A) calibrated bathroom scale, B) scissor jack, C) vertically movable stabilizing arm, D) adjustable, rigid acrylic headcap, and E) foam rubber pad with attached cord.

positioned the gnathodynometer and instructed the subject to bite as hard as possible, while the other always recorded the values obtained to the nearest two units on the scale.

The measurement of opening force was performed with the apparatus shown in Figure 2. The inferior border of the mandible was positioned parallel to the horizontal. The headrest was adjusted to allow the head to fit snugly in the acrylic headcap while the back was supported by the chair. The foam rubber pad was positioned under the mandible so that the anterior surface corresponded to the anterior border of the masseter muscle. The location of the muscle was determined by palpation during alternate clenching and relaxing of the jaw.[4] With the mouth closed the

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pad was made taut by the jack. Increasing amounts of force were applied by the jack until the patient could no longer open his mouth. This force level was recorded from the scale as the maximum opening force. Two technicians were required to operate this apparatus. The same one always operated the jack and scale while the other always checked the position of the mandible and pad and monitored the bite opening ability.

Results

The mean values obtained are shown in Table II and the level of significance between these means is shown in Table III. The mean closing force is greater in the skeletal closed-bite type and this difference is larger among the males. There was no significant difference in closing force between right and left sides.

Extreme closing force values obtained from individuals within the various groups may be of interest. Of the four greatest biting forces recorded among the twenty-two female subjects, two were from skeletal open bites. Of the three highest values from the twenty-two male subjects, one was from a skeletal open bite. The lowest closing force recorded by a female was from a skeletal closed-bite type, but of the four lowest values obtained from males, three were from the skeletal open-bite group.

Opening forces were similar when compared with sex regardless of skeletal type. Also, individuals recording large biting forces tended to record large opening forces as shown by the correlation between opening and closing force for each individual (a correlation coefficient of .4 and a p value of .007).

Linear correlation analysis did not show a statistically significant association between age and measured forces.

TABLE II

Mean and Standard Deviation of Opening and Closing Forces (In Pounds)

Variables	*Average Closing Force* Mean (S.D.)	*Opening Force* Mean (S.D.)
Female Closed Bite (n:10)	104 (35)	32 (8)
Female Open Bite (n:12)	96 (23)	31 (7)
Male Closed Bite (n:11)	130 (29)	38 (6)
Male Open Bite (n:11)	99 (35)	38 (11)
Combined Closed Bite (n:21)	118 (34)	35 (7)
Combined Open Bite (n:23)	97 (28)	34 (9)

TABLE III

Tests of Significance for the Differences Between Means of the Measured Forces

Variables	X_1-X_2	p *Value*
Comb. Closed Bite Closing Comb. Open Bite Closing	20.6	.03
Male Closed Bite Closing Male Open Bite Closing	30.7	.08
Female Closed Bite Closing Female Open Bite Closing	8.1	.5
Comb. Closed Bite Opening Comb. Open Bite Opening	.4	.87
Male Closed Bite Opening Male Open Bite Opening	.2	.96
Female Closed Bite Opening Female Open Bite Opening	1.5	.89

Discussion

Even though a significant difference in closing forces between open and closed-bite facial types has long been assumed by orthodontists, the first attempt to quantitate this relationship was only recently reported.[6] Although mean, standard deviation, and level of significance values were not included in that report, closed-bite individuals "clustered around 150 to 200 pounds" with open-bite subjects "clustering between 50 to 80 pounds." Our data, although supporting these findings, do not show as striking a difference between the two groups (mean closing force for the closed-bite group was 118 lbs. while for the open-bite group it was 97 lbs.). In addition, the magnitude of

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closing force in the two groups of our study was quite different than reported by Sassouni.[6] Of twenty-one closed-bite individuals studied, only six recorded a maximum biting force greater than 150 lbs., while only nine of twenty-three open-bite subjects recorded values less than 80 lbs.

Although the data suggest a relationship between a skeletal type and biting force ($p<.05$), this relationship is not statistically high. This was due to considerable overlapping among individual values obtained within the groups. For instance, of the four highest biting forces recorded among the females, two were from open-bite subjects, and the second highest biting force recorded was on an open-bite male.

When examining the closing-force data on the basis of skeletal type and sex, it was apparent that the difference among females was small (closed-bite mean force was 104 lbs., open-bite mean was 96 lbs.) and not significant, while among males in these two groups the closed-bite mean was 31 pounds greater than the mean for the open-bite type, and this difference gave a p of .08.

The anteroposition of the gnathodynometer can markedly influence the magnitude of the force measured.[3,5,10] With the instrument we used, there was approximately a ten per cent decrease in biting force when the gnathodynometer was moved from the distal of the upper second molar to the distal of the upper first molar, and thirty-five and forty per cent decreases when it was placed at the distal of the second and first bicuspids, respectively. In closed-bite subjects, since the mandibular and palatal planes were somewhat parallel, the gnathodynometer could be positioned as far posteriorly as the third molars. Because of the marked divergence between these planes in open-bite subjects, frequently the instrument could not be positioned farther than the distal marginal ridge of the upper first molar. A change in anteroposterior position of the appliance would markedly influence the results. Extreme care was always taken to position the gnathodynometer to the distal of the upper first molar regardless of skeletal type.

The mandible is vertically balanced between two opposing muscle groups, the opening and closing muscles. It has been suggested that facial type may be an expression of imbalance of these muscle groups rather than the result of closing muscle activity only. Had the open-bite group recorded greater opening force than the closed-bite group, the possible role of opening muscles in the etiology of these two facial types might have been implied. However, our data showed a direct relationship between closing and opening force, regardless of facial types, when figures for male and female subjects were taken together. Though the open-bite type recorded somewhat lesser mean closing force, while the mean opening force was the same for the two groups, the difference does not seem to present enough statistical significance to justify the conclusion that the mandibular opening muscles are relatively more active in open-bite than closed-bite subjects.

Even if muscle function or activity does influence formation of these facial types, it would not have been unreasonable to find no correlation for groups with mean ages greater than fifteen years, since muscle activity patterns may be somewhat transient and force patterns active at 6-10 years of age may not be present at 15-18 years. If the muscle patterns which supposedly cause these diverse facial types exist only at an earlier age, and/or if in the young, growing child only small changes in force magnitude and direction are required to influence ultimate bone shape, then it might be surprising to find a significant difference in muscle activity among our group of subjects. Nevertheless, the relationship between muscle

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activity and facial types found in this study was disappointing. Even though only individuals with these extremes of facial type were selected for study, the mean closing force difference was significant only at the .05 level and there was no difference in opening force.

Although the skeletal closed-bite group as a whole showed stronger closing forces, it is not possible to determine from this study whether the higher closing values produced the skeletal closed-bite type or whether their skeletal type simply enabled the closed-bite groups to bite harder. The skeletal open-bite subject had to open his mouth wider than the closed-bite individual to allow the gnathodynometer to be placed at the distal marginal ridge of the first molar. Since it has been shown that maximum biting force is obtained when the jaws are opened only to the free-way space,[1] the additional opening required by the open-bite patient may have significantly reduced his recorded biting force.

There appears to be a significant relationship between muscle force and skeletal type since a $p<.05$ was obtained. Even higher levels of significance could probably have been obtained by increasing the sample size, using considerably younger patients, and selecting the two extremes of facial type by even wider variations in SN-GoGn and using additional measurements as reported previously.[4] The influence of the anteroposterior position of the gnathodynometer on the degree of mouth opening and hence the magnitude of the closing force between these two groups was not assessed.

The gnathodynometer used in this study was an excellent instrument. It always returned to base line, gave highly reproducible results ($\pm 1\%$) when tested outside the mouth, and was simple to operate. It was a bit bulky and perhaps required skeletal open-bite subjects to open their mouths wider than desirable. The measurement of bite opening forces was more difficult. The anteroposterior position of the foam pad could not be as accurately assessed as the corresponding position using the gnathodynometer. The headcap and neck rest allowed some movement of the chin and the ability of the posterior neck muscles to prevent the head from tilting upward and backward was an uncontrolled variable in this procedure. However, the periodic checking of this instrument on two subjects over a three-month span showed a maximum variation of less than five per cent.

The data from this study indicated that males exert greater maximum closing force than females, which is in agreement with numerous investigators.[7,8,11] That age was not significantly correlated with maximum closing force agrees with White[9] but disagrees with Brawley and Sedwick.[2]

Summary and Conclusions

Maximum opening and closing forces exerted by skeletal open and closed-bite patients were measured. While considerable variation was found among the individuals studied, the mean closing force of the closed-bite group was significantly greater ($p<.05$) than the corresponding value for the open-bite group while there was no significant difference in opening force between the two groups.

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