A Comparison of the Forces Exerted by Class I, Class II and Class II Malocclusions During Maximum Closure

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A COMPARISON OF THE FORCES EXERTED BY CLASS I, CLASS II
AND CLASS III MALOCCLUSIONS DURING MAXIMUM CLOSURE

By

William T. Brown, B.S., D.M.D.

A THESIS SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL OF
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To Mr. Dan Greiner who helped perform the statistical analysis.
AUTOBIOGRAPHY

William T. Brown was born in New York City on February 7, 1941. Elementary education took place in Englewood and Leonia, New Jersey. He attended All Hallows High School, in the Bronx, New York and graduated in June 1959.

Pre-dental studies were completed at Iona College New Rochelle, New York where he received a B.S. degree in Chemistry in 1963.

A D.M.D. degree was conferred upon him by the New Jersey College of Medicine and Dentistry in Jersey City, New Jersey in June 1967.

Upon completion of Dental School, he served for four years in the United States Navy attaining the rank of Lcdr prior to separation from active duty in 1971. He was stationed at the U.S. Naval Training Center, Great Lakes, Illinois for one year and at the U.S. Naval Submarine Base, Pearl Harbor, Hawaii for three years.

In June 1971, he entered graduate school at Loyola Dental School to pursue a clinical specialty certificate in Orthodontics and a M.S. degree in Oral Biology.
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INTRODUCTION AND STATEMENT OF THE PROBLEM

Since the turn of the century and before, many individuals and groups have studied the maximum biting force that can be generated by the muscles of mastication of adults and children.

The purpose of this study is to see if there is a correlation between maximum biting force, the classifications of malocclusion (dental and skeletal) and other variations of the human form such as: sex, weight, height, body type, facial type and muscular development.

In addition, the patients preferred biting area will be studied to see if there is a relationship between it and the maximum force of closure generated by the muscles of mastication.
REVIEW OF THE LITERATURE

A comprehensive review of the dental literature revealed evidence of research conducted by investigators who have utilized an infinite variety of gnathodynamometers to study the efficiency of the muscle of mastication during elevation. Conversely a study was recently conducted to even determine the maximum opening forces of the mandible (Yildurim, De Vincenzo 1971).

The use of a modified gnathodynamometer to record biting forces was introduced by Borelli of Italy (Klaffenbach) in 1681. He employed a spring lever device which enabled him to record values of up to 430 pounds (200 kg).

Dennis (1893) and G.V. Glack (1895) reported the development of a lever arm type device that consisted of a small bite plate, spring, pointer and graduated scale. This instrument was subsequently refined. Black (1895) related the recorded bite forces to the age and physical attributes of the individuals in his study. He also recognized that the various teeth each exert different values with respect to bite force.

Prior research on gnathodynamics was somewhat restricted to the study of force measurements on young adults and children. The first publication was attributed to Dennis (1893) who utilized a spring type instrument to record the vacillating muscle power potential of humans. Other early researchers who have used diverse forms of spring gnathodynamometers were Johnson and Hatfield (1917), Friel (1924), Lancet (1927), Rowlett (1933), Klaffenbach (1936), Black (1936), Klatsky (1936), Taylor (1936), Worner
A condescriptive graph was formulated according to Worner (1944), Figures 1, 2, 3, to summarize the information published by these workers, accentuating the relationship between age and biting force "in the molar region". The "average" results which were plotted have, in several instances, been recalculated since the original investigators did not report mean values. It is probable that the arithmetical mean calculated by Worner (1939) (without the detailed information available to the original workers) did not consistently represent the averages which the researchers would have endorsed. However, results which were not representative of any particular group were eliminated.

In commenting on his observations, Dennis said: "among children whose ages varied from eight to fourteen years a particular fact was noted in that the greater force was applied through the incisor rather than through the molar". This fact when judged against the results of this author and the study of others seemed to indicate that his instrument was very bulky and could not be accommodated properly in the molar region of the smaller mouthed subjects. Dennis' results were the lowest of those which have been recorded.

Johnson and Hatfield's (1917) results using a spring gauge gnathodynamometer showed that there was a positive relationship between handgrip force and biting force on first molars. In addition, their results for the bites on the first permanent molars show an interesting feature in that the curve for girls flattens out in the age range of twelve to
FIGURE 1

BOYS

- WORNER + ANDERSON
- FRIEL
- TAYLOR
- BRAWLEY + SEDWICK
- JOHNSON + HATFIELD
- KLATSKY
- LANCET
- DENNIS
- BLACK

GIRLS

- FRIEL
- TAYLOR
- BRAWLEY + SEDWICK
- JOHNSON + HATFIELD
- KLATSKY
- LANCET
- WORNER + ANDERSON
FIGURE 2

BOYS
FIGURE 3

GIRLS

AGE YEARS

6 8 10 12 14 16 18
fifteen years, the period of pubescence. No such flattening is noted in their curve for boys.

Friel (1924) reported much the same relationship between handgrip and biting pressure; he correlated the biting force on the first molars with sitting height, handgrip and other measurements. The values plotted from his work are probably the most open to question since the age ranges had to be estimated from his sitting height figures.

Lancet (1927) obtained bite force results from a large group of school children up to about fourteen years of age; there was no significant difference between the biting forces of boys and girls.

Rowlett (1933) concluded after his study that "healthy individuals of both sexes were able to record the full measurement of 60 kgms. (132 lbs) about the age of sixteen and often two to three years earlier." His measurements were all taken in the molar region.

The figures quoted by A.D. Black (1936) were obtained on the first permanent molars of both boys and girls using the original G.V. Black spring gnathodynamometer; results of only three age groups (eight, twelve and eighteen years) were given.

Taylor (1936) made a systematic study of the biting forces of Australian children. He stated that he did not attempt to determine "norms" for masticatory pressure, but was "more concerned with observations which might throw light on the incidence of malocclusion and irregularity of the teeth;" no normal values were determined.

Klatsky (1936) recorded biting pressure in the molar region of young
adults; the number of subjects used unfortunately in many instances was small, consisting of groups of four or five subjects each.

Klaffenbach (1936) thought that biting force measurements directly reflected the power of resistance of the periodontal membrane and was not indicative of the power exerted by the closing muscles of mastication.

Brawley and Sedwick's (1937) work was relatively extensive when compared to similar studies of that period. Their results were presented very concisely but, for comparative purposes, it was unfortunate that the instrument they used was designed to measure the closing force of the entire dentition. Surprisingly, their biting force values were not above those of other investigators since their average figures run fairly well in the middle of the results of other workers who state that only one or two opposing molar teeth were utilized in obtaining the measurements.

In summing up their work Brawley and Sedwick said: "the values for biting pressure for both sexes show a gradual increase with age. The total increase in biting pressure over the eleven year period is fifty-eight pounds or slightly over five pounds per year. There is no significant difference between the values for males and females. The variability as shown by the standard deviation is considerable, and increases with age. The deviation for the sixteen year male group is almost twice that of the six year male group. The variability is probably related to variability of skeletal and muscular development."

Worner (1939) used a hydraulic gnathodynamometer to measure biting force on first molars and he concluded that masticatory pressures can be
increased appreciably over a period of a few days with "biting exercises" using the exerciser he had developed.

Baker, Brekhus, and Dowell (1940) utilized the Brinell Hardness principle to measure biting strength.

Brekhus, Armstrong, and Simon (1941) used a hydrostatic gnathodynamometer to demonstrate that the chewing of parafin for one hour per day for fifty days could significantly increase the biting pressure. They concluded that the muscles of mastication can be developed just like most other muscles of the body with exercise.

Howell and Manly (1948) used an electronic strain gauge for the measurement of oral forces; this particular gauge made use of the principle of change in inductance of a coil as a silver plated spring is brought near the coil. A set of four elements were employed to cover the ranges of forces involved. The ranges were 100 to 300 pounds, 30 to 100, 5 to 30, and 1 to 5 pounds; average forces of closure ranged from 24 to 198 pounds for incisors, canines, premolars, and molars.

Heath (1948) using a hydrostatic gnathodynamometer compared two groups of Australian aboriginal children. The first group had eaten a refined diet for over 70 years while the second group subsisted on their traditional ancestral tribal diet. The latter group could bite with 22% more force on the molars and 50% more force on the incisors than could the group that developed more civilized dietary habits (soft foods). Heath also found through the comparison of cephalograms that aboriginal children had more protrusive profiles and lower mandibular plane angles than their white counterparts.
O'Rourke (1949) felt that biting force measurements were more greatly influenced by fear of pain or injury (an opinion shared to some extent by the author) than by muscular power alone. He demonstrated that with maxillary or mandibular block type anesthesia bite force could be increased up to 21%; he found that this was especially true with respect to the incisor region rather than with the molar region.

Yurkstas (1953) employed control groups of dental students and corresponding like subjects to demonstrate that bite force could be increased by "practice chewing". Increases of 13% to 19% were shown after four weeks of chewing.

Anderson (1956) used a strain gauge apparatus incorporated into a dental inlay as a means of measuring the vertical loads taken by a single tooth during mastication. This study centered around the amount of force required to masticate a given food sample and did not reflect maximum bite force.

Boos (1959) employed an intraoral gnathodynamometer to register maximum biting force at various vertical dimensions. Men averaged 60 to 65 pounds of biting force and women produced 25 to 30 pounds. Physiologic rest position and the vertical dimension that permitted maximum biting force were the same according to Boos. Although his study was restricted to the artificial dentition he did determine that bite force varied with a given vertical dimension.

Storey (1963) wrote from his study on changing vertical dimensions that there existed a position of maximal closing force at an optimal
vertical dimension for every individual.

Jerge (1963) proposed the existence of two functional type pressorceptors in the periodontal membrane that responded to light (1-3 gms.) and increased pressure (2-6 gms.); the light pressorceptors responded to pressure on one tooth only; while the more moderate pressorceptors involved pressure on two or more adjacent teeth.

Kawamura (1967) demonstrated inhibition of the motor neurons in the trigeminal nucleus of the closing muscles of mastication through stimulation of the periodontal pressorceptors. Griffin and Murro (1969) observed inhibition of the closing muscles of mastication as occlusal contact was approached during jaw closure. In essence, the results of Kawamura and Murro tend to substantiate the ideas expressed earlier by Black and Klaffenbach that the periodontal ligament plays a key role in force regulation during mastication and that a corresponding protective reflex mechanism is actively present.

It is now known (Kawamura) that afferent nerve impulses travel via receptors located in the periodontal membrane to the superior and inferior alveolar nerves and then on to the mesencephalic nucleus. Internucial neurons (relay in nature) in the nucleus supratrigeminalis were alleged to inhibit motorneurons of the mandibular elevators, arresting the closing movement of the lower jaw.

White (1967) utilized the principle of the electrical strain gauge with a gnathodynamometer to correlate maximum biting force and the mandibular plane angle. He felt that as the gonial angle increases, the biting force
decreases and as overbite increases, the maximum biting force increases. White also thought that the mandibular plane angle varied inversely with the biting force.

Sassouni (1969) used a gnathodynamometer to determine if open-bite and deep bite skeletal type persons show a different degree or different level of masticating force. His tests showed that open-bite facial type persons have a biting force clustering between 50 and 80 pounds at the molar level, whereas deep-bite skeletal type persons cluster around 150 to 200 pounds when tested for bite force. As can be seen White's and Sassouni's findings tend to substantiate each other.

Bonaguro, Dusza, and Bowman (1969) measured the subjective ability of patients to discriminate differences in intensity of forces applied to maxillary canines, and to mandibular incisors, canines and first premolars. The force producing instrumentation (torque wrench) and the technique used were the same as reported by Bowman and Nakfoor (1968). Bite force values were not determined per se, but the relative ability of the teeth to distinguish between forces of different intensity was investigated. They concluded that: (1) the ability to discriminate differences between light forces is best accomplished through the maxillary incisors. (2) The ability to discriminate the least relative difference between intensity of forces is associated with maxillary canines, although they have a higher optimal functioning range than do maxillary incisors. Finally (3), that the ability to discriminate differences in intensity of force application is essentially the same in mandibular incisors, canines and first premolars.
Proctor and De Vincenzo (1970) studied masseter muscle position relative to dentofacial form. The anterior border of the masseter muscle was located by palpation of the contracted musculature directly. A wire simulating this position was taped into position directly superficial to the muscle boarder while lateral cephalograms were taken. 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.

Again, Ylidirim and De Vincenzo (1971) investigated maximum opening and closing forces as exerted by diverse skeletal types. Using a gnathodynometer almost identical to the one employed in this study they felt that 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.
Fifty seven young adults were selected for this study and were divided into three groups according to the different classifications of dental malocclusions (Angle I, II, III).

A gnathodynamometer (an instrument capable of measuring bite force intraorally) was obtained from the OIS Company on loan for this study (Figures 4,5). It was very similar in design to the one used by Sassouni (1969), Yildruim and De Vincenzo (1971) and Stewart (1972) in their studies on bite force. A steel casing between the baseplate and lever arm contained a gauge assembly which registered the amount of deflection of the lever arm when it was subjected to a compressive force. This instrument was received in non-working condition. It was repaired and then calibrated in kilograms by the Robert W. Hunt Company, Chicago. As can be seen from the graph (Figure 6), the readings on the dial of the force gauge and the load in kilograms have an almost straight line relationship when plotted. The values as read from the graph differ considerably from the fixed value 3.41 kg for each division on the scale as reported previously for the same instrument (Stewart 1972). For example, as can be seen from the graph a load of 3 kg will cause a deflection of one unit on the dial of the force gauge; a heavier load of 88.2 kg will cause a deflection of only 20 units on the force gauge. This represents a proportional change with the heavier load from 3 kg/deflection to 4 kg/deflection within the range specified on the graph.
FIGURE 4
FRONTAL VIEW OF GNATHODYNOMETER
LATERAL VIEW OF GNATHODYNOMETER
FIGURE 5

LATERAL VIEW OF GNATHODYNOMETER
FIGURE 6

CALIBRATION OF THE GNATHODYNOMETER

(October 15, 1972)
A pilot study was initially conducted on seven young adult males. The pilot study was similar in all respects to the main study. Measurements taken in pilot study showed no significant change in value after a four day interval.

A clinical examination was given to each patient (Figure 7) prior to participation in the bite exercise. A maximum effort was made to explain the measurement procedure to the patient in order to minimize the amount of anxiety reaction that a particular patient might undergo; patient anxiety presented a problem in some cases.

The instrument was placed intraorally on the selected teeth after allowing as much time as practical for the patient to become relaxed. A disposable cotton bite pad 4 mm thick was placed on the metal bite table of the gnathodynamometer and secured with adhesive. This cushion prevented injury to the cusps and incisal edges of the teeth. The total thickness of the instrument table including the cotton pads was 14 mm. The subject was then instructed to close until the teeth being tested in both arches were just touching the bite table (Figure 8). This was done to insure proper positioning of the instrument. When the bite table was in the proper position, the patient was instructed to exert as much bite force as possible on the cushion of the bite table. The instrument was confined to the teeth involved in each instance. The measurements were recorded from right to left sides in all cases. Two separate measurements were performed for each area in order to insure the reproducibility of the results as much as possible for that particular measurement. These measurements were averaged to determine a single value for each tooth region: incisor, canine, premolar
FIGURE 7

CLINICAL EXAMINATION FORM
(COMPLETED FOR EACH SUBJECT)

Examination Date ____________

Patients Name __________________ Sex ______ Race ________________

Weight ____________ Height ____________ Birth date and age ________________

A. Patient's Health History (Positive + Negative)

Comments: ____________________________________________________________

B. Dental Examination:
1. Molar Relation (Angle) I, II, or III
2. Canine Relation I, II, or III

C. DMF Findings
1. Decayed Teeth ____________
2. Missing Teeth ____________
3. Filled Teeth ____________

D. Dento-Skeletal Analysis:
1. ANB in degrees ____________
2. ANB in mm. ____________

E. Periodontal Findings:
1. Clinical _____________________________________________________________
2. Roentgenographic _________________________________________________

F. Body Type: R Teeth and Corresponding Measurements L
1. Endomorph
2. Mesomorph
3. Ectomorph

7 6 5 4 3 2 1 1 2 3 4 5 6 7

G. Facial Type:
1. Brachycephalic
2. Doliocephalic
3. Mesocephalic

H. Generalized Muscular Development
1. Slight
2. Medium
3. Heavyset

I. Patient's preferred biting area.
and molar. The patient was instructed to indicate to the examiner if there was any pain or other incident during the testing procedure. The values obtained were all recorded on the clinical examination form.

Finally, the patient was given the gnathodynometer and asked to place it in the area of his choice intraorally and close as hard as possible (Figure 8). This value was recorded.

established. An apical base appraisal was made by measuring the angle ANB (Figure 11). The average ANB angle is 2°, an angle in excess of 4° of a negative angle would be indicative of a Class II or Class III skeletal relationship respectively.
and molar. The patient was instructed to indicate to the examiner any pain
or other incident during the testing procedure. The values obtained were
all recorded on the clinical evaluation form.

Finally, the patient was given the gnathodynamometer and asked to place
it in the area of his choice intraorally and close as hard as possible
(Figure 9). This value was recorded.

ROENTGENOGRAPH ANALYSIS

After completion of the clinical aspect of the biting force test, each
patient received a lateral centric head film and a panorex radiograph. A
headplate tracing was made in pencil for each of the lateral centric radiographs on acetate tracing paper depicting the pertinent anatomical landmarks in the ANB analysis (Figures 10, 11). An ANB skeletal analysis (Riedel) was completed for each case with a lateral centric radiograph. The purpose of the skeletal analysis was to obtain an appraisal of the anteroposterior apical base relationship. The anteroposterior apical base relationship was recorded by relating the maxilla and the mandible to each other and to the cranial base. The simplest way was to make angular measurements from points "A" on the maxilla and "B" on the mandible to a cranial base line such as S-N. By taking the difference between the angles S-N-A and S-N-B (Riedel) the magnitude of anteroposterior base difference was established. An apical base appraisal was made by measuring the angle ANB (Figure 11). The average ANB angle is 2° an angle in excess of 4° or a negative angle would be indicative of a Class II or Class III skeletal relationship respectively.
FIGURE 9

PATIENTS' PREFERRED BITING AREA

(PATIENT POSITIONING GNATHODYNOMETER)
FIGURE 10

CEPHALOMETRIC LANDMARKS

S  Sella turcica. The midpoint of sella turcica, determined by inspection.
A  (A point) Subspinale. The deepest point on the maxilla between the anterior nasal spine and prosthion (Downs).
N  (Na Nasion). The intersection of the internasal suture with the nasofrontal suture in the midsagittal plane.
B  (B point) Supramentale. The most posterior point in the concavity between infradentale and pogonion (Downs).
ANB Angle relating the apical base of the maxilla to the apical base of the mandible. The normal value is 2°.
LATERAL CENTRIC HEADPLATE TRACING DEPICTING THE ANB ANGLE
A panorex radiograph was taken on the subjects in order to assess the following factors: height and texture of the supporting bone, periapical pathology, deep caries, extensive restorations, thickness of the periodontal membrane space, continuity of the lamina dura and any other factor that could conceivably influence bite force.

All patients with a negative health history (past medical history of extensive debilitating diseases) or an extensive number of decayed, missing or filled teeth were eliminated from the study.
EXPERIMENTAL RESULTS

STATISTICS

The statistical analysis (Statistical Packet for the Social Sciences) performed on the results consisted of a coefficient of correlation on ratio data (data expressed numerically only) and a cross tabulation on nomina data (data expressed numerically and verbally). The ANB analysis (ratio data) was analyzed by a coefficient of correlation; the remaining nomina data was evaluated by cross tabulation. From high percentage clusters of data in the cross tabulation, graphs representing the findings were constructed. The graphs in this section represent a description of both the population and the results in terms of functions that comprised the examination forms (Figure 7).

POPULATION DESCRIPTION

The population in this study consisted of 57 young adult caucasians with a mean age of 27 years. There were 54 males and 3 females. The subjects ranged in weight from 120 to 256 pounds with a mode weight of 170 pounds. The height of those in this group ranged from 63 inches to 77 inches with a mode height of 70 inches. All subjects used in this investigation enjoyed good health at the time the study took place.

The following percentages describe the composition of the population according to Angle's classification of malocclusions with respect to the first molar relationships: Class I = 45.6%, Class II = 29.8% and Class III = 24.6% (Figure 12).
FIGURE 12

THE DIFFERENT MOLAR RELATIONSHIPS
(CLASSIFICATION: ANGLE) AS PERCENTAGES OF THE
ENTIRE POPULATION OF SUBJECTS

MOLAR RELATIONSHIPS (CLASSIFICATION: ANGLE)

POPULATION PERCENTAGE

I

II

III

45.6

29.8

24.6
Similarly, the canine relationships for the entire population of subjects can be described as comprising the following percentages of the population: Class I = 49.1%, Class II = 26.3% and Class III = 24.6% (Figure 13).

The ANB angle in degrees expressed as percentages of the population is described in (Figure 14). As can be seen from (Figure 14), the graph has basically three modes: +4°, -4° and +6° corresponding to 12.4%, 7% and 5.4% of the population respectively. The population had a range of ANB angles from -6° to +11°. Only one subject in the population had an ANB angle in excess of +6° (Figure 14). This was due to the fact that only one member of the randomly selected population had an extremely excessive positive (Class II skeletal) apical base discrepancy (ANB = +11°); the upper jaw extended severely out in a horizontal direction over the lower jaw in this particular patient giving him the classical "buck tooth" appearance.

DESCRIPTION OF EXPERIMENTAL RESULTS

The mean bite force in kilograms at the level of the right first molar region for the different Angle molar classifications can be seen in (Figure 15). As can be noted, Class I malocclusions have the highest mean bite force in this region (65 kg), followed by Class II malocclusions (58 kg); Class III malocclusions exerted the least amount of bite force in this region (36 kg).

With respect to the left side, the mean bite force in kilograms at the level of the left first molar region for the different Angle molar classifications can be seen in (Figure 16). Here again, the Class I malocclusions have the highest mean bite force for
FIGURE 13
THE DIFFERENT CANINE RELATIONSHIPS
(CLASSIFICATION: ANGLE) AS PERCENTAGES OF THE ENTIRE POPULATION OF SUBJECTS

CANINE RELATIONSHIP (CLASSIFICATION: ANGLE)
FIGURE 14
ANB ANGLE IN DEGREES AS PERCENTAGES OF THE POPULATION
FIGURE 15
MEAN BITE FORCE (Kg) AT THE LEVEL OF THE
RIGHT FIRST MOLAR REGION FOR THE DIFFERENT ANGLE MOLAR CLASSIFICATIONS
FIGURE 16

MEAN BITE FORCE (Kg) AT THE LEVEL OF THE LEFT FIRST MOLAR REGION FOR THE DIFFERENT ANGLE MOLAR CLASSIFICATIONS

LEFT FIRST MOLAR RELATIONSHIP (CLASSIFICATION: ANGLE)
the region (64 kg), followed by the Class II malocclusions (61 kg); here too the Class III malocclusions exerted the least amount of bite force in this region (35.5 kg).

Very similar results were obtained for the same measurements conducted in the canine region. The mean bite force in kilograms at the level of the right canine region for the different canine classifications can be seen in (Figure 17). As with the right first molar relationships, the patients with Class I canine relationships had the highest mean bite force (65 kg), followed by the Class II (62 kg); again the Class III was least with (36 kg).

Measurements taken on the left side were markedly similar. The mean bite force in kilograms at the level of the left canine region for the different canine classifications can be seen in (Figure 18). The patients with Class I canine relationships had the highest mean bite force (65.5 kg), followed by the Class II (60 kg); the Class III was again least with (39 kg).

Perhaps one of the most interesting results of this investigation were obtained from the correlation of the ANB angle with the biting force for various regions (Figure 19). The coefficient of correlation was considerably higher in the right and left molar areas, .20 and .14 respectively, than in any other region, although not statistically significant for a sample of this size (the significant r value at p<.05 is .256).

Another interesting aspect of this study concerned the determination of the preferred biting region of the population. As can be seen from (Figure 20) the predominately preferred region was the right and left first
FIGURE 17

MEAN BITE FORCE (Kg) AT THE LEVEL OF THE RIGHT CANINE REGION FOR THE DIFFERENT ANGLE CANINE CLASSIFICATIONS

MEAN BITING FORCE (Kg) RIGHT CANINE REGION

65.0
62.0
36.0

RIGHT CANINE RELATIONSHIP (CLASSIFICATION: ANGLE)
FIGURE 18
MEAN BITE FORCE (Kg) AT THE LEVEL OF THE
LEFT CANINE REGION FOR THE
DIFFERENT ANGLE
CANINE CLASSIFICATIONS

LEFT CANINE RELATIONSHIP
(CLASSIFICATION: ANGLE)
Figure 19

Correlation of ANB angle with biting force for the various biting regions (teeth)

For N of 57 significant.

Coefficient of correlation is .256

Significant at .05% level
FIGURE 20

PREFERRED BITING REGION OF POPULATION

PREFERRED BITING REGION AS CHOSEN BY SUBJECTS
molar regions (mean values 65 and 64 kg respectively); 73.7% of the population irrespective of dental classification chose this area. Since this was a sample of the general population of available young adults (sufficient for comparison) one would imagine that a relatively large percentage of these people would be right handed and would hence be expected to position the gnathodynamometer in the right side of the mouth.

In over 90% of the subjects tested the preferred biting region corresponded to the region in which the maximum forces of closure were exerted suggesting that most patients were intuitively aware of the region in which they could exert a maximum force and could also readily locate that region during function.

The mean bite force in kilograms at the level of the first molars (right and left) vs body type is shown in Figures 21, 22. According to the results obtained from this study, the mesomorphs were capable of exerting the greatest amount of bite force, 64 kg and 54 kg respectively for right and left sides. The endomorphs were capable of exerting an intermediate force with respect to the three groups of 59 kg and 53 kg for the right and left first molar regions respectively. Finally, the ectomorphs were capable of exerting the least amount of bite force among the three body types registering a force of only 38 kg and 32.5 kg in the right and left first molar regions.

Due to the relatively small number of brachycephalic and dolicocephalic individuals in the population sample as compared to the number of mesocephalics the findings in this category were deemed inconclusive.
MEAN BITE FORCE AT THE LEVEL OF THE RIGHT FIRST MOLAR REGION VS BODY TYPE

MEAN BITING FORCE (kg) RIGHT FIRST MOLAR REGION

ENDOMORPH  MESOMORPH  ECTOMORPH

BODY TYPE
FIGURE 22

MEAN BITE FORCE (Kg) AT THE LEVEL OF THE LEFT
FIRST MOLAR REGION VS BODY TYPE

ENDOMORPH  MESOMORPH  ECTOMORPH

BODY TYPE
DISCUSSION

It is commonly thought by clinical dental specialists and general practitioners alike that bite force is directly influenced by dental occlusion. If it could be demonstrated that all other factors being equal, persons with ideal or nearly ideal occlusions (slight Class I malocclusions) were capable of exerting greater bite force than those with malocclusions (Class II, Class III,) then a rationale based on function could be presented to a prospective patient in order to motivate him to undergo corrective treatment. Of course the most apparent problem encountered in a study of this type is the almost limitless number of variables other than the occlusion presented by each individual. Some of these variables are significant others are not. The examination form used takes into account many of these variables (Figure 7). An attempt was made in this study to relate some of these variables to bite force as measured by the gnathodynamometer.

A strict comparison of the maximum bite force values obtained in this study with those of earlier investigators is not possible since earlier studies did not distinguish subjects according to the classifications of malocclusions. Therefore the values obtained in this study had to be contrasted with results obtained from populations that were subdivided for the most part according to age, sex, skeletal type and so on but not malocclusion.

The bite force values obtained in this study for Class I malocclusions were clearly higher than those obtained by such early investigators as Dennis (1893), Lancet (1927), Taylor (1936) and Worner and Anderson (1944). These men generally studied a younger population in which a detailed
description of the subjects was lacking. No information was available concerning the occlusion or the number of decayed, missing, filled teeth, skeletal type, periodontal condition, body type, facial type or generalized muscular development. The bite force values for Class I malocclusions obtained in this study were somewhat higher than those of A.D. Black (1895); he determined that the force of closure for his adolescent subjects was in the range of 34 to 45 kg.

Rowlett (1933) studied the bite force of children in the molar region and stated that, "healthy individuals of both sexes are able to record the full measurement of 60 kg at about the age of 16 and often two or three years earlier." His results among those of early investigators were very close to the measurements obtained in this study for Class I and Class II malocclusions.

The results of Klaffenbach (1936) and Klatsky (1936) were in general lower than the ones obtained in this study; their population of subjects consisted mainly of children some of which had very large dental restorations.

In Klatsky's later study (1942) on adults of both sexes he obtained higher bite force values in the molar regions. He found that males with an average age of 27 years and 28 teeth could exert 55 kg of closing force on the right side and 50 kg on the left side. Females in the same study with an average age of 25 years and 29 teeth provided closing force values of 38 kg and 37 kg for the right and left molar areas respectively. His values for young adult males are close to the ones determined in this study.

Yildruim and De Vincenzo (1971) found a range of 45 to 48 kg in their
study, but their patients were of a younger age group (15 - 18 years) than the present study. It would be logical to assume that except for the age difference and sample variation a closer series of values should exist due to the similarity of instrumentation for the two experiments.

Howell and Manley (1948) and Sassouni (1969) obtained higher ranges of values than did this author for the molar teeth (68 to 91 kg). Sassouni obtained especially high values for his deep bite skeletal type persons (up to 91 kg). These high values may be attributed to the comparatively minor impingement upon the free way space caused by their narrow bite element gnathodynometers. As was pointed out by Boos (1959) and Storey (1963), a patient's ability to exert a closing force on his dentition will decrease to a submaximal level if the established vertical dimension exceeds his normal physiological rest position. Since the vertical dimension required for the bite table and cotton pads was 14 mm., it is quite probable that, at least in some cases, the amount of opening required by the patients to accommodate the instrument exceeded physiological rest thus insuring the registration of a submaximal force upon closure. However, a possibility exists that the other investigators achieved a higher degree of rapport with their patients, thereby convincing their patients to exert more effort on the gnathodynometer. Apprehension on the part of the patients probably affected results, since this was a study involving the voluntary exertion of bite force by these patients.

The gnathodynometer utilized for this study proved to be a reliable instrument. It always returned to the baseline after a measurement was
made and generally yielded reproducible results. The greatest shortcoming of the instrument was its bulk which necessitated a wider opening of the mandible than was usually desirable. It should also be noted that the anteroposterior placement of the instrument especially in the posterior regions was most critical. If for example, while measuring the maximum forces of closure in the first molar region the instrument was inadvertently placed more distally than usual, the already taxed optimal vertical dimension would be further impinged upon and a smaller force value would be observed.

An additional problem which was impossible to quantitate was that of patient anxiety and competitiveness. Some patients were actually fearful of fracturing a tooth (one subject did even cause a slight fracture of a bicuspid tooth) and consequently did not bite as hard as they could have. Several other subjects tended to look upon the experiment as a competitive exercise and tended to overexert themselves. Still others felt discomfort and did not bite as hard as they might have. Since this study was based on the patients voluntary cooperation, anxiety was regarded in particular as a most undesirable reaction; it was impossible to eliminate in some cases.

An interesting aspect of this study concerned the determination of the preferred biting region of the population. As can be seen from (Figure 20), the predominately preferred region was the right and left first molar areas; 73.7% of this population irrespective of dental classification chose this area. Since this was a random sample of the general population of available young adults one would imagine that a relatively large percentage of these
people would be right handed and would hence be expected to position the gnathodynamometer in the right side of the mouth. The results of this study do not substantiate this supposition since an almost equal number of patients (47% vs 52.6%) chose to position the instrument in the left side of the mouth. This fact would tend to suggest a considerable adaptability on the part of some individuals.

It is interesting to speculate on the possible reasons for this apparent adaptability on the part of these patients. A right handed adult for example, might be forced to masticate on the left side of his mouth due to numerous local factors that might necessarily preclude active mastication on the right side. Some of these local factors could be the following: deep caries, traumatic occlusion, periodontal disease, high dental restorations, pericoronitis, or missing teeth. With children of mixed dentition age, for instance, this observation could be explained by a unilateral eruption pattern although this would probably be a rare occurrence. Quite possibly some individuals might alternate their favorite masticating side several times throughout a lifetime while still others might maintain a consistent unchanging unilateral chewing pattern for an indefinite period.

This study demonstrated that the greatest closing force could be generated in the first molar region followed by the canine region; the premolar and incisor regions elicited the least amount of force respectively. This factor could partially be explained by the examination of several of the anatomical facts associated with these teeth. The molar teeth and the incisor teeth represent the proximate and distal points with respect to
the fulcrum generated by the closing muscles of mastication. Since the molar teeth are the closest to the fulcrum they are aided in reflecting the maximum force of closure for all of the teeth measured. In addition, from the point of view of bite force the individual anatomy of the teeth favors the molars; they have the largest total amount of crown (occlusal) and root surface area. Also, as can be observed from the examination of cross sections through the body of the mandible at the first molar area the supporting cortical bone is thickest here. In addition, some patients are probably less apprehensive about closing forcefully on posterior teeth since the danger of tooth fracture is decidedly less in this region. Here again, the spector of a visibly fractured anterior tooth might tend to dissuade some from exerting a maximum force in the anterior region (O'Rourke).

Perhaps one of the most interesting findings of this investigation was obtained from the correlation of the ANB angle with the biting force region (Figure 19). The coefficient of correlation was considerably higher in the right and left molar areas, .20 and .14 respectively, than in any other region, although not statistically significant for a sample of this size (the significant r value at p<.05 is .256).

It should be noted that in all other regions of the oral cavity analyzed with respect to the ANB angle and bite force region this coefficient did not nearly approach a significant value (Figure 19). Class I dental and Class I skeletal subjects represented the largest single category of patients studied in this investigation. Normal ANB values (+2°) are almost always associated with a Class I skeletal and hence usually with a Class I dental relationship.
Class I molar relationships, according to the results of this study, represent an efficient relatively more forceful masticatory apparatus with respect to the other tooth regions measured. Perhaps herein lies the obscure relationship between these two apparently unrelated factors, ANB angle and bite force.

Many of the subjects in this study that had ectomorphic body types also had Class III malocclusions; Class III patients almost always recorded the least amount of bite force (Figures 15, 16, 17, 18). This fact helps to explain why the ectomorphs in this study were able to generate the least amount of bite force when compared to the other body types, mesomorphs and endomorphs (Figures 21, 22).


APPENDIX
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*See Figure 6 for conversion to kilograms

**Clinical data in D deflection units**

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**SEE FIGURE 6 FOR CONVERSION TO KILOGRAMS**

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*See Figure 6 for conversion to Kilograms

**CLASS II DIVISION II**
The thesis submitted by Dr. William T. Brown has been read and approved by three members of the Oral Biology Department, Loyola University School of Dentistry, Chicago, Illinois.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form and mechanical accuracy.

The thesis is therefore accepted in partial fulfillment of the requirements for the Degree of Master of Science.

7/3/73

Date

William T. Brown

Signature of Advisor