Dental and Skeletal Relationships to Attritional Occlusion

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The relationship of dental morphology to maxillary and mandibular arch forms has long been of interest to investigators and clinicians. Much attention has also been directed toward the interrelationships between muscle forces and arch forms. Dental anatomy and arch form have been studied extensively in relation to function. Orthodontists, in particular, have been concerned with the proper orientation of dentures within the craniofacial complex. Significance has therefore been attached to the anatomy of individual and grouped teeth, the direct environmental factors influencing the position of these teeth, and proper relationships of the teeth to supporting skeletal structures.

The modern-day concept of a normal occlusion is much oriented toward specific anatomical characteristics of the teeth. Cuspal relationships are used to describe and treat normal occlusions and malocclusions. The clinician has established the Angle Class I molar relationship as an ideal toward which to work. Every phase of dental therapy is concerned with the restoration, alteration, or orientation of cusps on the occlusal surfaces of teeth.

Man did not always demonstrate marked occlusal-cusped anatomy. Civilized man exhibits relatively little dental attrition, but more primitive societies possessed teeth with marked degrees of wear. This attrition was due to many factors, primarily the abrasiveness of the food consumed. This erosive quality was caused by the type of food, lack of food refinement, and the nature of the cooking and eating utensils. Pieces of clay easily became disengaged from the cooking utensils. Small heated stones were often placed in the pots to facilitate heating the food. In some situations teeth were also utilized for performing tasks such as the working of animal hides.

Civilized man demonstrates an innumerable amount of problems related to tooth alignment. Malocclusion associated with inadequacy of arch length to accommodate full dentitions is common. Even in mouths demonstrating well-aligned arches, problems often exist with the inability of the third molars to take their proper places at the distal ends of the arches.

Malocclusion has been demonstrated in prehistoric man, but many investigations have reported on the surprisingly large incidence of occlusions that demonstrate no form of malocclusion.

Study of occlusions demonstrating significant degrees of occlusal and proximal attrition deserves attention. The purpose of this paper is to better understand the influence attrition has on the adequacy of dental arch length, maxillary and mandibular arch forms, and the facial skeleton.

Review of Literature

Many investigators have examined attrition as it relates to early man. There has been considerable interest in regard to the difference in arch length between an attritive society and modern man. Attempts have been made to correlate attrition with alterations in tooth position, arch form, and its relationship to supporting skeletal bone.

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Begg[1-5] has investigated occlusions found in Australian aboriginals and has reported extensively on these findings. He is convinced that in the normal development of the dentition an extensive amount of attrition is necessary to compensate for an excess amount of tooth material. He feels this is the primary reason why so much malocclusion associated with crowding exists in modern man. In fact, the underlying philosophy of the orthodontic treatment technique that Begg has fostered is supposedly based on this premise.

Begg maintains that teeth migrate occlusally and mesially as attrition progresses. The modern-day concept of a normal cusp in fossa occlusion is supposedly erroneous. Attritional occlusion allows for the changing anatomy of teeth which is essential for correct occlusion. The function of cusps is to guide the eruption of teeth in early years. Modern man's jaws are supposedly too far apart.

In civilized man, first permanent molars cannot erupt into proper occlusion because of lack of deciduous molar attrition. The deciduous and permanent incisors erupt in an overbite relationship and then gradually become edge-to-edge as attrition progresses and the lower teeth migrate forward. Begg feels the lower incisors become more procumbent and the upper incisors more upright. The incisors at first demonstrate downward and forward planes of wear which become horizontal as attrition progresses. Overbite was rarely found, even in Class II cases exhibiting incisal overjet.

Begg contends that, after wear extends below the proximal contact areas, arch length is markedly reduced.[1,2] The molars establish a Class III relationship to each other. He found the difference in total arch length between worn and unworn groups to be at least 10.6 mm in the mandibular arch and slightly less in the maxillary. It should be pointed out that these measurements were derived from measuring only nine skulls.

Begg demonstrates how the teeth are designed to resist attrition so that time is available for the formation of secondary dentin as a defense mechanism. The greatest amount of enamel and dentin is on the occlusal, incisal, and proximal surfaces. Before occlusal attrition progresses far, the posterior plane of occlusion slopes downward from the buccal to lingual surfaces, then becomes horizontal because of the resistance afforded by the cusp of Carabelli, and then eventually slopes downward from the lingual to buccal.

Brodie[3] has investigated in aboriginal jaws the patterns of wear as related to mandibular paths of movement. He noticed movement of the mandible in three arcs, horizontal, vertical and frontal. The occlusal surfaces of all the posterior teeth became more concave and more tooth structure was lost on the lingual half of the upper teeth and buccal half of the lower teeth. Interproximal wear was extensive indicating independent movement of the teeth.

Eskimo crania were examined by Leigh.[4] He showed that the lingual margins of the maxillary teeth wore deeper than the facial. As attrition progressed, this plane of wear reversed direction. Concave areas were often found in the mandibular teeth. As attrition progressed, the mandibular plane of occlusion slanted from the lingual to the buccal surface. This agrees with Begg's findings. Leigh also noted that in very advanced attrition the apices of the teeth were displaced buccally, sometimes resorbing the buccal plate.

Begg states that malocclusion in precivilized man was not as much a handicap since mandibular excursions were easily made with flat occlusal surfaces.

He states that it is not necessarily true that evolution has been responsible for the gradual lengthening and lateral narrowing of the face. These changes may be due in large part to the absence of attritional occlusion.

Björk[5] discusses the effects evolution has had on the shortening of the dental arches. He considers the reduction of facial prognathism to be the most significant change associated with the decrease in arch length.

Pre-Columbian Arkansas Indian skulls, 3-5,000 years old, were measured by Mehta and Carnot to determine the exact amount of attrition that existed.[6] Buccal and lingual crown heights and mesiodistal widths were measured and compared with modern man. Occlusal heights were less in the attrition group, but mesiodistal widths did not differ. The widths between the maxillary premolars were greater than the canine fossa measurements indicating the probability that these Indians had an inherent excess of tooth material over basal bone. Malocclusion was rare.

Lysell[7] examined medieval skull material from northern Sweden. He measured the width of the dental arches between first premolars and first molars, the length and height of the arches, incisor inclination, and evaluated available arch length. Overjet, overbite, and molar relation were also examined. The skulls exhibited marked attrition. Their widths were less than similar measurements on present-day material, although the validity of this conclusion is questionable. The juvenile skull exhibited more overbite and overjet than the mature skulls.

Using the same material from Sweden, Lysell[8] investigated the effects of attrition to a greater degree. He studied the relation of attrition to age and sex, the distribution of attrition within the dentition, the degree of proximal tooth reduction and the amount of tooth migration. He determined the mesiodistal widths of the teeth prior to attrition by means of the existing buccal-lingual widths which were not particularly subjected to the forces of attrition.

Lysell's results revealed that attrition increased with age with no sex differences. The incisors demonstrated the most attrition, the third molars the least. The mandibular molars and incisors showed more attrition than the maxillary teeth. He found the loss in total arch length to be approximately 8.28 mm in the lower jaw and 7.6 mm in the maxilla. These values are somewhat less than those found by Begg. Those skulls possessing a large amount of attrition did not demonstrate spacing. The upper incisor tipped lingually in the severe attrition group, rather than the molars drifting mesially. The upper incisor to the SN plane decreased from approximately 93.0 to 80.5 degrees. Lysell postulated the cause of this change in incisal inclination to be due to an increased use in the perioral musculature, because food was more difficult to tear as the incisors became shorter through attrition.

Lundstrom and Lysell[9] studied a group of medieval Danish skulls. In addition to measurements similar to the previous study, anthropological measurements of cranial width, facial width and height, and mandibular width were taken. Overbite was less in the mature skulls and this was felt to be related to the additional attrition in the older group. Arch width was found to be wider in the medieval skull group as compared with present-day material.

Murphy[10] noticed that Begg's measurements of arch length reduction were made on immature Australian aboriginal groups. Murphy investigated adult Australian aboriginal skulls, but limited his attention to only the posterior

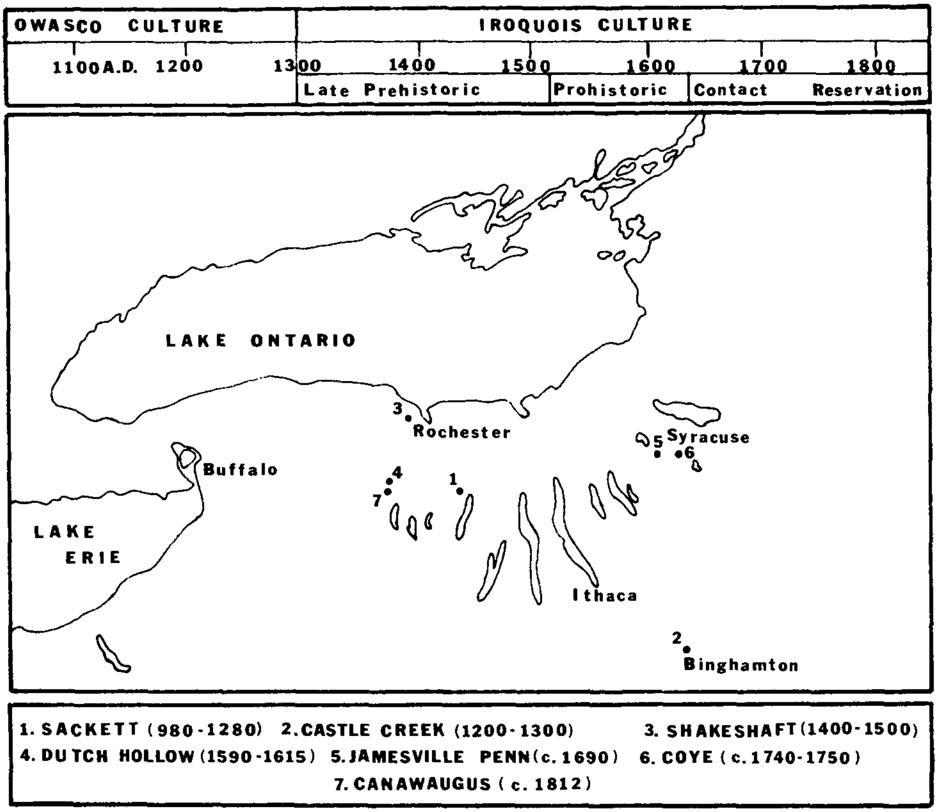

Fig 1

teeth. The length of the buccal segment, and arch width between the first molars were measured. These findings were then compared with present-day aboriginal communities. Approximately 3.5 mm of arch-length reduction was found in the buccal segments. Arch width was found to increase slightly.

Methods and Materials

For the purpose of this study American Indian crania were utilized. These skulls were derived from excavations of the central regions of New York state. As seen in Figure 1, the material came from seven excavation sites, the location and age of which are designated on the chart. The crania from the Jamesville Penn and Coye sites were provided by Mr. William Ennis of Brewerton, New York, being part of his private collection. The balance of the skulls, together with a large additional amount of material not used in this particular study, was provided by the Rochester Museum of Science and History through the courtesy of the museum director, Mr. Edward Hayes III, and his staff. The carbon-14 anthropologic dating technique was used for dating most of the sites. Identification of artifacts found with the skeletal material provided the ages of the remaining sites.

Approximately an eight hundred-year span was represented in this study. Thirty skulls were selected from a total of fifty-six. They represented all available skulls that were structurally intact and possessed full permanent dentitions including third molars. Some of the dentitions were missing several teeth

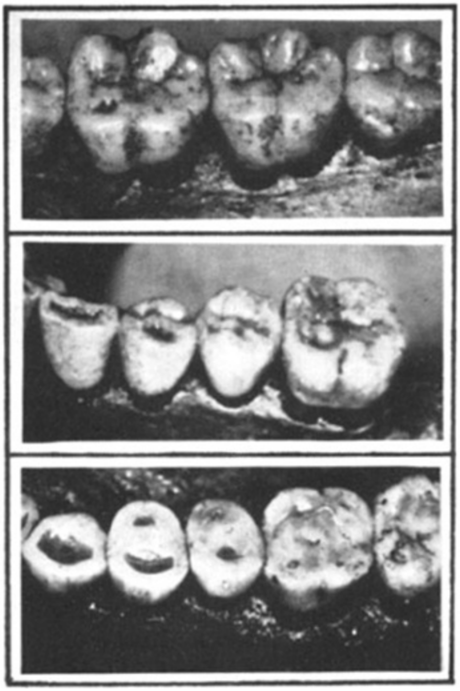

Fig. 2 Top, Group 1; middle, Group 2; bottom, Group 3.

due to loss during excavation. Some third molars were not completely erupted, but were clinically visible and near eruption.

The total was divided into three main groups dependent on the degree of existing attrition. Each site yielded skull material that represented more than one attrition group. The following group classification of attrition was used:

0—no attrition

1—some cuspal attrition, but cuspal anatomy maintained

2—practically all cuspal anatomy eliminated with some occlusal grooves and fissures remaining

3—no cuspal anatomy remaining, but attrition not having progressed to the cemento-enamel junction

4—attrition of the entire crown.

Group 1 numbered sixteen, Group 2 seven and Group 3 seven. Since both Group 2 and 3 skulls demonstrated flat occlusal surfaces, they were also combined into a fourth group of fourteen to be evaluated collectively. Figure 2 demonstrates the differences between the attrition groups in terms of occlusal anatomy and in respect to flatness of the occlusal table.

Alginate impressions were taken of the upper and lower dentitions and plaster study models fabricated. All skulls and teeth were photographed.

Both portable and fixed x-ray units were utilized. A Wehmer counter-balanced cephalometer with 90 KV S.S. White tubehead was used for the fixed location radiographs. A portable cephalostat mounted on a standard photographic tripod was constructed and used with a tripod-mounted 65 KV Minimax radiographic unit for the museum work. Although the anode to film distance was standardized at five feet in both set-ups, image magnification did vary because of the inherent variations in x-ray beam configuration, and due to the variations between skull to film distances using the two cephalostats. Magnifications were calculated and compensated for. The skulls were positioned within the cephalostats in five basic positions: lateral, occlusal surface of the maxillary teeth parallel to the film, frontal, and right and left obliques but only the first two skull positions were utilized for this study. The following angular measurements were made from the lateral cephalometric film (Fig. 3):

S-Na-Pr, the anteroposterior relationship of the upper incisors;

Na-S-Ar, the degree of cranial base flexion;

S-Ar-Go, the angle formed between ramus and body of mandible;

Ar-Go-Gn′ represents changes in the angle formed by the ramus and body of the mandible. Gn′ is formed by the intersection of the mandibular plane and the plane formed by infradentale and pogonion;

Go-Gn′-Id, the anteroposterior relationship of the lower incisors;

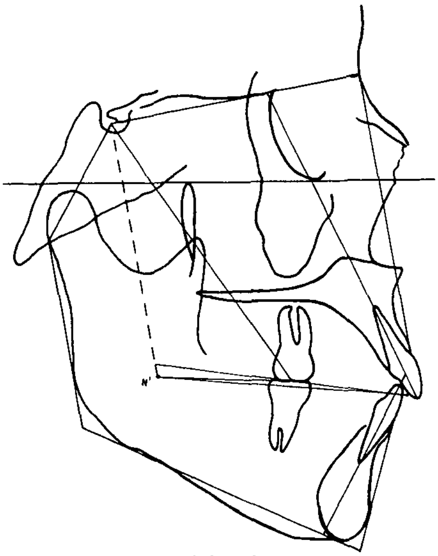

Fig. 3

U1-SNa, the labiolingual axial inclination of upper incisors;

L1-MP, the labiolingual axial inclination of the lower incisors;

U1-L1, the amount of inclination between upper and lower incisors;

Na-S-6, the anteroposterior relationship of the upper and lower first permanent molars;

Molar angle, the vertical relationship of the first molars. Point N′ was constructed by making S-N′ perpendicular and equidistant to Na-S. The molar point was marked by first locating for each molar the points half way between the mesial and distal surfaces and then bisecting the distance between the points;

Incisal angle represents the vertical relationship of the incisors. Construction of the angle performed in the same manner as molar angle;

Occlusal plane angle represents the cant of the occlusal plane distinguishing the relative variations in vertical change between the incisors and molars.

Mean and standard deviation measurements were calculated for the three attrition groups plus Groups 2 and 3 combined. The results were tested for statistical significance using the one-tail "t" test.

The study models were analyzed in two general ways. Differences in general arch configuration and variations in tooth size and associated arch length were tested.

In respect to evaluating differences in arch length and width between the attrition groups, it was felt best to first determine what measurements would be valid to utilize. To do this, models of twelve skull dentitions that demonstrated ideal occlusions were selected from the same sample groups. They were carefully selected in terms of arch alignment and interarch occlusion. No crowding, spacing or rotations were evident. All possessed complete adult dentitions including third molars.

As seen in Figure 4, four different intra-arch measurements were taken on the maxillary models. In addition to this, millimetric measurements of the total maxillary arch length were taken between the marginal ridges of the first molars. Intra-arch measurements that were significantly correlated to arch length in the ideal model series were considered to be more valid to use in measuring differences between the attrition groups.

Measurement A was a linear measurement of midsagittal arch length. The posterior point of reference was determined by bisecting a line drawn tangent to the distal surfaces of the first molars. The anterior point of ref-

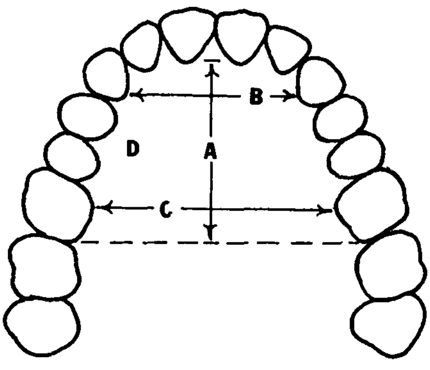

Fig. 4

erence was determined by bisecting the distance between the lingual alveolar ridges of the central incisor bony sockets. Measurements B and C were the distances between the linguo-alveolar ridges of the cuspid and first molar tooth sockets, respectively. The lingual ridges of the tooth sockets were used instead of the teeth themselves because occasionally a tooth was lost during archeologic excavation. It was also noted that the cingulum area and lingual margin of the alveolar socket occupied very similar positional relationships. Measurement D was a planimetric measurement that determined the square millimetric area encompassed within the lingual surfaces of all teeth, exclusive of the second and third molars. The posterior border of this two-dimensional planimetric area was determined by the same construction plane utilized for measurement A. A Dietzgen model D-1802 polar planimeter was used for the measurements. Vernier units were converted into square millimetric values. The planimetric measurements were determined from tracings of the occlusal skull radiographs. Mean and standard deviation values were calculated for measurements A, B, C, and D. Coefficient of correlation (r) values of these measurements were determined as compared with total arch length values. The standard error of "r" and the ratio of "r" to its standard error were calculated to determine the confidence in coefficient of correlation values.

The measurements found to be significantly correlated with ideal occlusion were then used to make comparisons between the three occlusion groups and Groups 2 and 3 combined. Mean and standard deviation values were determined. Percentage changes in these measurements between the groups were calculated. Planimetric measurements were also taken of the mandibular

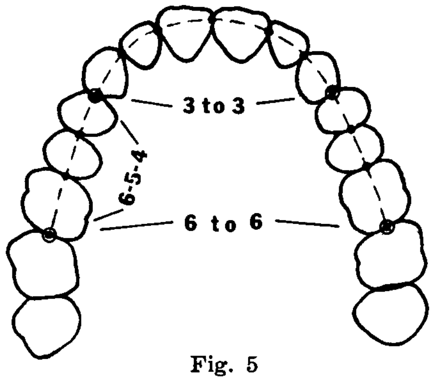

Fig. 5

dentitions in the attrition series. This was accomplished by taking radiographs of the mandibular models keeping the occlusal plane parallel to the film and subsequently correcting for magnification.

Mesiodistal widths of all the maxillary and mandibular teeth exclusive of the second and third molars were measured in millimeters for each of the attrition groups. If crowding or proximal spacing was evident, its amount was recorded. As seen in Figure 5, besides the individual tooth measurements, total first molar to first molar measurements of arch length were recorded along with subtotal measurements of the posterior segments (mesial of first premolar to distal of first molar) and the subtotal measurement of the anterior segment (distal of cuspid to distal of cuspid).

Mean and standard deviation values were determined for the widths of each maxillary and mandibular tooth; in addition the subtotal and total arch length groups were determined. If crowding existed, the amount was subtracted from the total mesiodistal widths of the teeth to yield more valid arch length values. Interproximal spacing was added to the mesiodistal widths of the teeth to yield truer arch length values.

All of the dentitions from the three

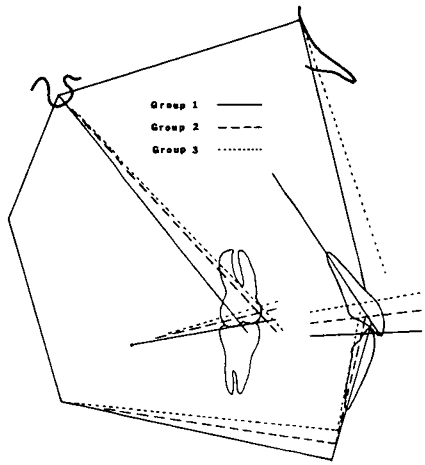

Fig. 6

attrition groups were classified according to the Angle classification of occlusion. The degrees of arch length insufficiency, overbite and overjet incidence were also recorded.

Results

Six of the cephalometric measurements demonstrated results that expressed levels of significance at the five percent level or better. As seen on Figure 6, the sella-nasion-prosthion (S-Na-Pr) angle increased 3.9 degrees between Groups one and three, demonstrating a forward positioning of the upper incisors as attrition became more severe. This forward positioning seemed to be more a bodily form of movement rather than tipping, since the inclination of the upper incisor to SN did not change significantly.

The gonial angle (Ar-Go-Gn′) decreased as the degree of attrition became more severe. This occurred without any significant change in the inclination of the lower incisor to the mandibular plane. The gonial angle decreased 3.4 degrees between Groups one and two, 6.1 degrees between Groups one and three, and 4.7 degrees between Group one and Groups two and three combined.

The interincisal angle (U1-L1) increased as the degree of attrition increased. As mentioned before, this was not due to any uprighting of the incisors in relation to their skeletal bases but apparently to the decrease in the gonial angle. The interincisal angle increased 6.2 degrees between attrition Groups one and two, 10.7 degrees between Groups one and Groups two and three combined.

The incisal angle expressing vertical changes in the incisors decreased significantly as the degree of attrition increased. Similar to the first molars, this indicates a superior repositioning of these teeth. The cant of the occlusal plane did not alter significantly indicating a proportional relationship between the superior vertical movement of the incisors and molars. Between Groups one and two the incisal vertical angle decreased 3.9 degrees, decreased 6.6 degrees between Groups one and three, and decreased 5.0 degrees between Group one and Groups two and three combined.

The nasion-sella-first molar angle (Na-S-U6) representing the anteroposterior relationship of the first molars decreased as the degree of attrition increased. This means the first molars moved anteriorly as attrition increased. The angle decreased 4.5 degrees between Groups one and two, 5.2 degrees between Groups one and three, and 4.8 degrees between Group one and Groups two and three combined.

In reference to the four model measurements of arch width, length, and area encompassed within the teeth, all of them demonstrate a significant correlation to the arch length found in the ideal occlusion sample. Planimetric measurements were best correlated (.94). The anteroposterior midsagittal measurements (.83) and the cuspid to cuspid (.78) and molar to molar (.75)

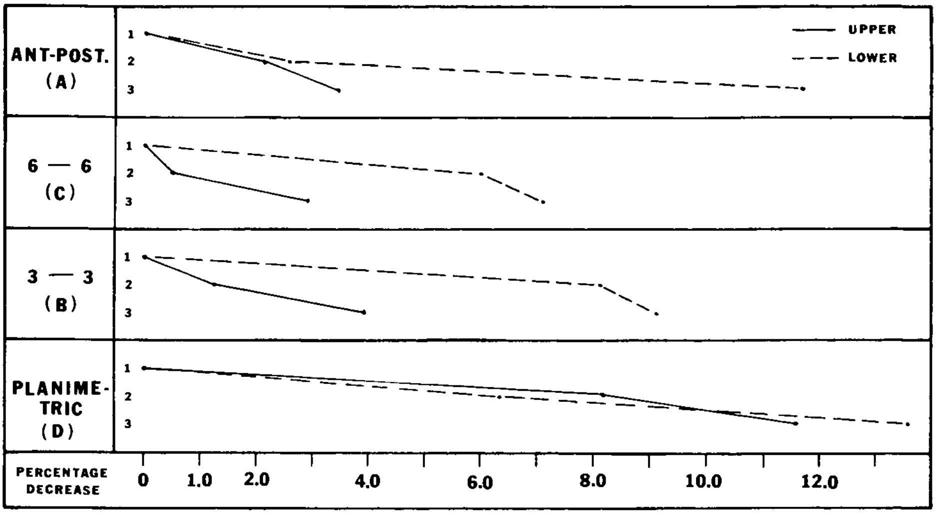

Fig. 7

arch width measurements followed in order of decreasing significance. Since all of these measurements were considered valid to use, they were applied to the three attrition groups.

As seen on Figure 7, all dimensions decreased as the degree of attrition increased. This was irrespective of whether it was the maxillary or mandibular dentition. All of the lower dimensions decreased more than the upper as expressed in terms of percentage decrease.

In the maxilla the anteroposterior and planimetric measurements decreased most between attrition Groups one and two. The mean value for the anteroposterior measurement decreased from 29.4 mm in Group one, to 28.8 mm in Group two. The planimetric measurement decreased from 12.08 square cm in attrition Group one, to 11.1 square cm in Group two. The molar to molar and cuspid to cuspid arch width measurements decreased most between Groups two and three. The mean maxillary intramolar measurement decreased from 38.4 mm in Group two, to 37.8 in Group three. Between the same two samples the intracuspid measurement decreased from 26.5 mm to 25.9.

In the mandible the opposite occurred in that the molar to molar and cuspid to cuspid arch length measurements decreased more between attrition Groups one and two. The intramolar dimensions decreased from 38.3 mm in Group one to 36.0 mm in Group two. The intracuspid measurement changed from 21.0 mm in Group one to 19.3 in Group two. The anteroposterior and planimetric measurements decreased most between Groups two and three. The anteroposterior measurement changed from 26.7 mm in Group two to 24.2 mm in Group three. The decrease in the planimetric values between the same two samples changed from 11.1 square cm to 10.7 square cm.

In both the maxilla and mandible the intracuspid dimension decreased more proportionally than the intramolar dimension. In both of these arch width measurements the mandibular percentage decrease was approximately twice the maxillary. The mandibular decrease in midsagittal arch length approximated four times the magnitude of the maxillary decrease.

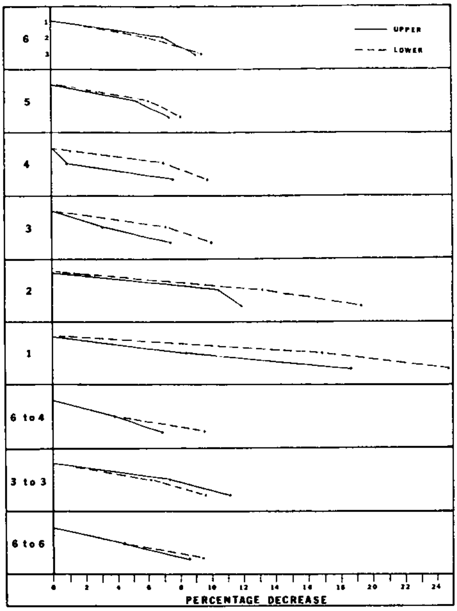

Fig. 8

Measurements of the mesiodistal dimensions of the teeth revealed a consistent decrease in size for all the teeth as attrition increased. As seen in Figure 8, the lateral incisors showed approximately twice the amount of proximal reduction as the cuspids, premolars and first molars. The central incisors demonstrated even more reduction. All of the mandibular teeth exhibited more proximal reduction than their respective maxillary teeth.

For all the mandibular teeth, most of the proximal attrition occurred between Groups one and two. The maxillary first molars, second premolars and lateral incisors showed more attrition between Groups one and two. The first premolars, cuspids and central incisors exhibited more reduction between Groups two and three.

The total mean values of the mandibular mesiodistal widths for all the teeth was 91.3 mm for Group one, 85.1 mm for Group two, and 81.5 mm for Group three. This represents a 9.8 mm mandibular decrease in tooth size between attrition Groups one and three. Mean values for the maxillary posterior segments measured 51.1 mm for Group one, 49.9 mm for Group two, and 48.3 mm for Group three. The maxillary anterior segments measured mean values of 40.3 mm for Group one, 35.2 mm for Group two, and 33.2 mm for Group three.

As seen on Figure 8, the total and subtotal arch length measurements did not agree completely with percent decreases in mesiodistal tooth widths. This was particularly true in the cuspid to cuspid arch length measurement. It reflects the fact that, although the incisors exhibited the most attrition, the proximal surfaces did not maintain a contact relationship to each other and resulted in interproximal spacing. The maxillary cuspid to cuspid measurement of arch length was 49.8, 46.2, and 44.3 mm in Groups one, two and three, respectively.

This represents an average of .9 mm of arch length due to spacing. The mandibular difference was more significant demonstrating an average of 1.5 mm of spacing in the anterior region. It is interesting to note that the lower six anterior teeth averaged 40.3 mm of tooth size in Group one, but only 38.8 mm of arch length was available. This was also found in the total molar to molar measurement for the same reason. The posterior maxillary segments measured 53.0 mm of arch length in Group one, 51.0 mm in Group two, and 48.0 mm in Group three. This represents an average of only .7 mm difference due to spacing. As seen in the anterior segment measurements, the posterior teeth demonstrated 1.9 mm more tooth material than available arch length in attrition Group one. The mandibular cuspid to cuspid measurement demonstrated less arch length decrease than the maxillary

	CLASS I MOLAR RELATION					CLASS II MOLAR RELATION				
	no crowding	crowding	xs space	overjet	overbite	no crowding	crowding	xs space	overjet	overbite
GROUP 1	55.5 %	33.3		33.3		11.2		5.6	5.6	
GROUP 2	57.1	14.3	28.6	28.6		14.3	14.3	14.3		14.3
GROUP 3	28.6	42.9	14.3	57.1		28.6		14.3	28.6	
GROUP 2 - 3	42.9	28.6	21.4	42.9		21.4	7.1	14.3	14.3	7.1
% OF TOTAL	50.0	31.3	9.4	37.5		15.6	3.1	9.4	9.4	3.1

Fig. 9

measurement indicating proportionally more interproximal spacing in the mandibular anterior teeth.

The general analysis of the occlusion (Fig. 9) reveals that 81.2 percent of the total sample demonstrated Class I molar relationships. The remaining 18.8 percent had Class II molar relationships. Molar relations did not change as attrition progressed. Two-thirds (66.7%) of the total Group one sample showed crowding, defined as the proximal overlapping of adjacent teeth. As the severity of attrition increased, more Class I dentitions demonstrated dental crowding. Group three Class I molar cases exhibited 42.9 percent with crowding and 28.6 percent with no crowding. Class II cases also demonstrated crowding in attrition Group two. No Group one Class I molar dentitions demonstrated excess arch length. This agrees with the arch length findings where most of the same group demonstrated crowding. As attrition became more severe, excess space became more prevalent.

It is interesting to note that a large percentage of all the skulls demonstrated overjet, but no Class I molar cases demonstrated any overbite. The incidence of overjet increased markedly as attrition became more severe. In the Group one cases 38.9 percent of the Class I dentitions demonstrated overjet. In the Group three Class I cases 85.7 percent of them showed overjet. In the Group one cases 5.6 percent of the Class II molar dentitions exhibited overjet with 14.3 percent of the Group three cases showing overjet.

Discussion

The effects of dental attrition certainly are not limited to the reduction of individual tooth dimensions. Skeletal changes are evident, dental arch morphology is altered, and the associated interrelationships between the two jaws and their supporting structures are modified.

As attrition progressed, the occlusal anatomy became obliterated and flat occlusal planes developed. In the posterior areas of the mouth, the occlusal surfaces sloped downward from the lingual to the buccal surfaces in the severe attrition cases. This is opposite to that found in skulls demonstrating little attrition. The incisors changed from a downward and forward plane of wear seen in the skulls with little attrition to a horizontal or downward and posterior plane in severe attrition cases. These findings confirm those found by other investigators mentioned before.

The mesial and distal surfaces of the teeth became flatter and the arch length was altered. Both the maxillary and mandibular molars drifted anteriorly. Midsagittal arch length decreased for both arches, but less for the uppers. As arch length decreased, proximal contact relationships did not always maintain themselves, often spacing developed, particularly in the anterior regions. Lysell observed the opposite result describing no spacing interproximally. The upper incisors moved anteriorly as the degree of attrition progressed. The lower incisors maintained a more stable relationship. An increase in lower incisor procumbency and an uprighting of the upper incisors was not seen, as observed by Begg and Lysell. The upper incisor to a cranial base angle increased significantly.

The intra-arch width dimensions decreased as attrition progressed. This is in contradiction to observations by Lundstrom and Murphy. The intraoral area at the level of the dentition decreased in magnitude as attrition developed. The mandibular dentition exceeded the maxillary in its overall size reduction resulting in posterior overjet. The excess mandibular reduction resulted in what at first appears to be a disproportionality between the maxillary and mandibular dental arch dimensions. This conclusion may not be valid as the functional movements of the mandible may be aided by the flat occlusal plane seen in more advanced attrition. In the attritional occlusion, with the flat but angled occlusal surfaces, anterior and posterior overjet may be more compatible with an efficient functional system than that seen in present-day civilized man.

As the occlusal and proximal attrition progressed, the occlusal plane moved more vertically within the craniofacial complex. Concomitant with this, the mandibular gonial angle decreased and total facial height decreased. This seems to be in agreement with Begg's observations.

Normal tooth alignment was certainly evident in the study sample. Malocclusion was also present although not severe. Begg's contention that attritional occlusion is more normal and that lack of attrition in civilized society is the primary etiologic factor in malocclusion, is worthy of consideration although this conclusion is not clearly evident in this study. Many excellent occlusions existed in skulls that demonstrated both slight and advanced attrition. It does, though, seem to be an indisputable point that attrition does generally provide additional arch length to accommodate teeth at the distal extremities of the arches.

The relatively large amount of anterior overjet found without associated overbite is of particular interest. This observation is in contradiction with what is generally found in modern man. Malocclusions found in present-day man almost always exhibit overbite as being closely associated with overjet. Because of the nature of this study, it seems valid to theorize that the flat occlusal plane seen in the more advanced attritional occlusion permitted functional mandibular excursions that were more extensive in magnitude of distance covered. In all probability the incisors were not allowed to supererupt because of this.

The decrease of the gonial angle as attrition became more severe implies that this decrease occurred in the same individual. The individuals who demonstrated severe adult attrition possessed full cuspal anatomy at younger ages. More understanding of this type of skeletal change is needed.

Begg's contention that normal occlusion is the severe attrition type of dentition is a point that bears little relevance with present-day man. Although it has been shown that severe attritional occlusion does provide more space for eruption of some posterior teeth, many problems are not eliminated by it. Modern-day man does not and in all probability will not exhibit severe attrition. Any concept of a normal occlusion today cannot include most of Begg's thought regarding attritional occlusion.

Conclusions

Dental attrition has been investigated in depth. Besides alterations in arch length due to attrition, skeletal and intra-arch differences were discovered. It is felt that these findings do have value in helping us realize that present-day concepts of proper occlusion cannot necessarily be applied to dentitions that existed at another time. A more thorough knowledge of occlusions exhibiting dental attrition provides information that is helpful in understanding more fully the nature of tooth eruption and associated dental arch occlusion and the interrelationships of these factors with supporting skeletal structures.

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