A Study Of Attrition Of Teeth In The Arkansas Indian Skulls

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A considerable amount of attrition of teeth is observed in Australian Aborigines' skulls.[4] Compared with this the occurrence of attrition seems to be negligible in modern man. Several observers have examined anthropological skulls and the mouths of Australian Aborigines[6-12,17,20,24] and have reported on the condition of their dentition. The studies dealt mostly with carious activity in these individuals and the attrition was evaluated only according to Broca's classification into four stages. It seems that actual calculation of the amount of attrition by measuring the crown heights, both buccally and lingually, and comparing these figures with the crown heights of modern man has never been performed.

The purpose of this investigation is to determine the exact amount of attrition of teeth in Arkansas Indian Skulls. This is achieved by measuring the mesiodistal diameter of all teeth to determine the proximal wear and by measuring the crown height to determine the occlusal wear. Crown height is measured on both buccal or labial and lingual or palatal surfaces. The statistical data obtained from this sample are compared with those of Black[5] and Begg.[4] By noting the differences in the measurements between the modern and prehistoric man a better understanding of the dentition of the two groups can be obtained.

According to Begg[3,4] the extensive attrition of Australian Aborigines' teeth, coupled with mesial migration, leaves enough room in their dental arches to accommodate a full complement of teeth. Our present diet, seemingly not being capable of producing this phenomenon, is partly responsible for third molar impactions and malocclusions so prevalent in modern man. It might be mentioned that various studies show that about one half of all children are potential orthodontic patients.[18,21] Studies of Massler and Frankel[15,16] and Altemus[1] indicate that as many as eighty percent of American children have malocclusions. This great variation in the percentage of malocclusion between modern and ancient civilization requires closer examination. In this study an attempt is made to investigate this problem.

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SAMPLE

Twenty-one well preserved brachycephalic Post-Columbian Arkansas Indian Skulls of an average age of 26.8 years were selected from the collections of the Division of Physical Anthropology of the Smithsonian Institution in Washington, D.C. These skulls were used because they represent the largest group of skulls with nearly a full complement of measurable teeth.

In fifteen skulls the third molars were in normal occlusion and in one they were not in full occlusion. In the remaining five skulls the occlusion of third molars could not be determined due to loss of opposing teeth.

Thirteen of the skulls were from

Pecan Point, Mississippi county, Arkansas. The rest were divided between Rhodes Place, Crittenden county; Poinsett county; Cross county and Boyt's field, Union county; all from the state of Arkansas.

Instruments

All measurements on teeth were made with a pair of modified Boley gauges in tenths of a millimeter. The beaks of the Boley gauges were sharpened to a point for better access and accuracy. The fixed prong of one of the Boley gauges was also shortened by 2.5 mm to facilitate measuring crown heights (Fig. 1).

Measurements, Nomenclature and Landmarks

A total of approximately four thousand measurements was recorded on twenty-one skulls with a total of 616 teeth. The crown height of all teeth was measured both buccally and lingually. It was measured from the cemento-enamel junction to the cusp tip or the occlusal surface. In case of a discrepancy between the mesial and distal crown height, a mean reading was recorded. The width between the maxillary first bicuspids was taken between the summits of the buccal cusps or the buccal surfaces in order to compare this with a previous study by Howes.[14] The distance of the mental foramen from the mesial surface of the crown of the mandibular first molar was measured parallel to the occlusal plane.

The degree of the tooth attrition was classified into Broca's four stages:

First — Enamel worn without cusp obliteration or exposure of dentin.

Second — Cusps worn down and dentin exposed.

Third — Quite an appreciable amount of crown wear.

Fourth — Extreme wear. Most of the crown disappeared.

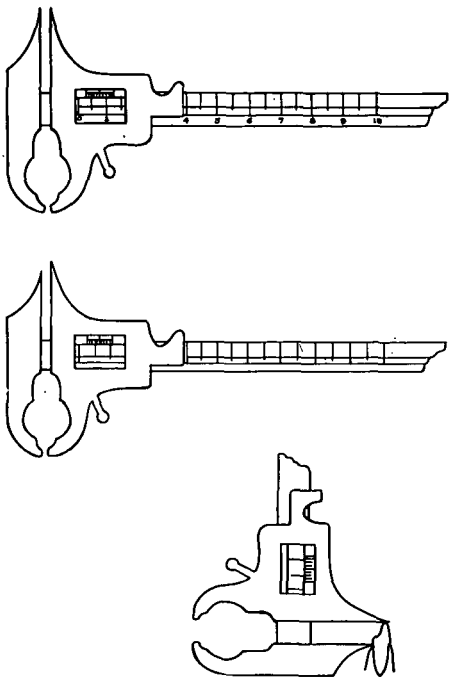

Fig. 1 Modified beaks of Boley gauge.

The malocclusion was classified according to Angle's classification.[2]

Previous Work on Attrition of Teeth

Begg[4] and several observers[6-12,17,20,24] have examined the skulls and the mouths of Australian Aborigines and have recorded attrition of their teeth. But it was Begg who pointed out its possible significance in the production of normal occlusion.

Gottlieb[13] seems to have been the first to propose the theory of continual tooth eruption according to which throughout life the teeth migrate in two directions, horizontal and vertical. The former is called mesial migration and the latter continual eruption. During life there is dynamic change in occlusion and an anatomically correct occlusion is never static.

Begg has observed extensive inter-

TABLE 1

MAXILLARY MESIODISTAL TOOTH MATERIAL

Tooth	Number	Mean	Max.	Min.
Central Incisor	31	8.75	9.8	7.3
Lateral Incisor	37	7.25	9.5	5.5
Canine	42	7.95	8.9	6.9
First Premolar	41	6.75	8.2	5.1
Second Premolar	41	6.95	7.6	5.2
First Molar	40	10.25	12.2	6.5
Second Molar	40	9.45	11.5	7.4
Third Molar	30	8.75	10.0	6.5

proximal wear in Australian Aborigines. In these skulls the overall mesiodistal lengths of both maxillary and mandibular dental arches were reduced with molars erupting farther mesially than in the jaws of civilized man.

According to Begg the inherent size of all teeth in the Stone Age man is greater than the supporting jaw bones. This excess of tooth substance is to compensate for the extensive attrition of teeth. If this excess of tooth material did not exist, the Stone Age man would ultimately have insufficient tooth substance to fully occupy the tooth-bearing areas of the jaws and to have an efficient masticatory apparatus.

The proximal wear increases the contact between the teeth from a point to an area contact. As the interproximal and occlusal wear progresses, the amount of space required (the basal bone) to accommodate the teeth is greatly reduced. In modern man with similar ratio of tooth material to supporting bone, as in Australian Aborigines, the lesser amount of attrition results in malocclusion. This is because the lack of attrition fails to bring about a delicate balance between the amount of tooth material and the basal bone.

According to the research findings of Begg, an average of 5.28 mm of tooth substance is lost in one quadrant of the mandibular dental arch before the third molars erupt. Therefore the total amount of attritional reduction, just prior to the eruption of the third molars, in the mesiodistal dental arch length is 10.56 mm. At this stage the total amount of mesiodistal attritional wear in the maxilla is about one millimeter less than that in the mandible. These figures, however, are misleading because the canines, premolars and second molars have undergone a minimal attrition and the third molars, when in function, will further reduce the overall arch length.

The relatively low incidence of malocclusion in Australian Aborigines, according to Begg, is very largely due to a reduction of the total dental arch length by more than half an inch (more than 12.7 mm) in both the maxillary and mandibular arches. Also, since the Australian Aborigines' dental arches were reduced on each side by over five millimeters, the orthodontist is justified, in crowded cases, of artificially reducing the arch length by extracting a premolar or an equivalent tooth from each quadrant.

Begg further claims that flat-worn occlusal surfaces with sharp-edged rim of enamel are more efficient in mastication. The blunt rounded cusp tips fitting into sharp deep grooves and fossas are less efficient. The overbite and deep cusp and groove relationship in civilized man restricts the lateral and protrusive excursions of the mandible and the high

unworn cusps prevent mesial migration. On the other hand, the flat occlusal surfaces and an end-to-end bite in the Australian Aborigines eliminate lateral forces on the periodontium.

Begg explains the evolution of the form and the shape of the teeth on the basis of his observations on Australian Aborigines' skulls. According to this, the greatest amount of enamel and dentin covering the pulp is on the incisal, occlusal, mesial and distal surfaces, whereas, the lingual, buccal and labial surfaces which are not subjected to the forces of attrition are thinner. For similar reasons, he explains, the buccal cusps of the mandibular first molar and the lingual cusps of the maxillary first molars have a greater thickness of dentin and enamel.

Further, according to Begg, the greater mesiodistal width of the deciduous molars was a great adaptive evolutionary allowance. If the mesiodistal widths of the deciduous molars were not greater than the premolars, the interproximal attrition and mesial migration of the molars would have left insufficient room for the eruption of the premolars thus producing a malocclusion.

Begg explains the difference in the occlusocervical lengths of different teeth as follows: The occlusocervical length of the crown of an unworn first permanent molar is greater than that of the second permanent molar, because it starts to undergo attrition six years prior to the eruption of the second permanent molar. For the same reason the occlusocervical length of the third molar is less than that of the second molar and the crown height of the second premolar smaller than that of the first premolar.

Besides Begg, Campbell[12] has done extensive work with Australian Aborigines. In a comparative age group, that is, between the ages of twenty and twenty-nine years, he found that nine out of fifteen cases fell into stage II of Broca. In other words in 60 per cent of cases the cusps were worn down and dentin was exposed.

Findings

The canine fossa measurement and the width between the maxillary premolars, as suggested by Howes, were measured on all the skulls which had a normal occlusion and no crowding. This was done to re-evaluate the concept that every tooth has to be supported directly over the basal bone and that the measured width between the premolars should never exceed the width of the canine fossa, measured just above the apices of the first premolars. Exactly the opposite was found to be the case in this sample of twenty-one skulls with normal occlusion. Only in one case the canine fossa measurement was greater than the width of the premolars by two millimeters. In one case they were equal. On an average, the premolar width was greater than the canine fossa measurement by 5.4 mm.

The means on measurements on teeth were obtained from a sample which consisted of a maximum of forty-two teeth to a minimum of twenty-nine teeth for each measurement. The maxillary and mandibular mesiodistal tooth material and buccal and lingual crown heights are recorded in Tables 1 to 6.

The sum of the mean buccal crown heights in the maxilla was 58.15 millimeters and in the mandible 50.25 millimeters. The sum of the mean buccal crown height of Black's[5] measurement is 65.2 mm in the maxilla and 65.7 mm in the mandible. By determining the difference in the sum of crown heights of these two studies, a difference of 7.05 mm in the maxilla and of 15.45 mm in the mandible is demonstrated. These, of course, represent one-half side of the mouth or skull; the total difference would be double.

TABLE 2

MANDIBULAR MESIODISTAL TOOTH MATERIAL

Tooth	Number	Mean	Max.	Min.
Central Incisor	31	4.85	6.1	3.3
Lateral Incisor	39	5.85	7.4	3.7
Canine	40	6.95	8.2	6.0
First Premolar	40	6.75	7.9	5.8
Second Premolar	42	7.15	8.5	5.5
First Molar	38	11.10	12.6	9.8
Second Molar	40	10.65	12.8	9.4
Third Molar	34	10.65	13.3	8.7

TABLE 3

MAXILLARY BUCCAL CROWN HEIGHT

Tooth	Number	Mean	Max.	Min.
Central Incisor	37	8.50	10.9	6.1
Lateral Incisor	39	7.95	10.5	5.0
Canine	42	8.65	11.2	5.2
First Premolar	41	7.15	9.6	5.1
Second Premolar	41	6.65	8.9	3.7
First Molar	40	6.30	8.0	3.4
Second Molar	40	6.50	8.0	3.4
Third Molar	29	6.45	12.6	3.3

TABLE 4

MAXILLARY LINGUAL CROWN HEIGHT

Tooth	Number	Mean	Max.	Min.
Central Incisor	37	8.60	11.3	5.1
Lateral Incisor	39	7.75	10.5	4.0
Canine	42	8.45	11.1	3.0
First Premolar	41	5.70	7.7	2.5
Second Premolar	41	5.20	7.2	2.8
First Molar	40	5.00	6.6	3.5
Second Molar	40	5.00	7.0	2.8
Third Molar	31	5.05	7.0	2.6

TABLE 5

MANDIBULAR BUCCAL CROWN HEIGHT

Tooth	Number	Mean	Max.	Min.
Central Incisor	31	5.85	8.4	1.5
Lateral Incisor	39	6.40	8.7	1.5
Canine	39	8.40	12.3	4.8
First Premolar	40	6.70	9.7	4.0
Second Premolar	42	6.15	9.1	4.1
First Molar	38	5.65	7.1	3.3
Second Molar	41	5.70	8.0	2.4
Third Molar	35	5.40	7.8	3.8

TABLE 6

MANDIBULAR LINGUAL CROWN HEIGHT

Tooth	Number	Mean	Max.	Min.
Central Incisor	31	5.85	8.5	1.7
Lateral Incisor	39	6.55	9.1	1.7
Canine	39	7.05	9.2	2.7
First Premolar	40	4.50	6.0	3.2
Second Premolar	41	4.70	6.7	3.7
First Molar	38	5.45	6.7	3.3
Second Molar	41	5.40	6.7	3.3
Third Molar	35	5.25	6.7	2.8

TABLE 7

ATTRITION OF TEETH ACCORDING TO BROCA

Total number of teeth examined: 616

Stage	No. of Teeth	Percentage
I	158	25.65
II	381	61.85
III	73	11.85
IV	4	.65

TABLE 8

COMPARISON BETWEEN THE AVERAGE MESIODISTAL WIDTHS OF MANDIBULAR TEETH OF THE AUSTRALIAN ABORIGINES (BEGG) AND THE ARKANSAS INDIANS (CURRENT STUDY)

	Australian Aborigines		Arkansas Indians	
Tooth	No. of Teeth Measured	Average M-D Measurement in Millimeters	No. of Teeth Measured	Average M-D Measurement in Millimeters
Central	18	5.72	31	4.85
Lateral	18	6.27	39	5.85
Cuspid	18	7.18	37	7.00
First Premolar	18	7.25	40	6.75
Second Premolar	18	7.46	42	7.15
First Molar	18	10.78	38	11.10
Second Molar	18	12.12	40	10.65
Total		56.78		53.35

The low incidence of malocclusion prompted the comparison of the mesiodistal arch length of the two cases exhibiting crowding with the mean mesiodistal arch length. In one skull where there was a mild crowding in the maxilla, the overall mesiodistal arch length was 3.7 mm greater than the mean for the same measurement. In another skull exhibiting a lack of space both in the maxilla and the mandible, the excess of tooth material was 15.5 mm in the maxilla and 17.4 in the mandible.

One of the outstanding observations was that malocclusion was rather rare in these skulls, except for very mild and tolerable crowding of the anterior teeth in two of the cases and linguoversion of two bicuspids. Only one case showed a very mild overjet. The overbite was never deep.

There was a considerable amount of attrition on all of the teeth observed as is indicated in Table 7. In one specimen the crowns of all four mandibular incisors were completely worn down. On an average, the distance between the mesial surface of the crown of the lower first molar and the mental foramen was 2.4 mm. In modern man, on an average, the mental foramen is located between the two bicuspids at a distance of about 7.9 mm. According to these figures, the molars in this study have drifted forward by an average of 5.5 mm. This is only two millimeters less than the width of a lower bicuspid in modern man. However, it must be mentioned that in one study of 100 unselected, unsexed, adult dentulous mandibles of modern man, the more common position of the mental foramen was found to be at the apex of the lower second bicuspid.[23] The amount of proximal wear could also be realized by the fact that in two cases the buccolingual length of the contact area was as large as 6.4 mm. One was between the right maxillary second bicuspid and first molar, and the other between the maxillary right second and third molars. The proximal wear and concomitant cuspal arrangement made most of the teeth rather constricted at the contact area. Frequently the third molars were larger mesiodistally than the second molars by as much as 1.8 mm. The difference between the largest maxillary third molar and smallest maxillary second molar was 2.5 mm while the same difference in the mandible was 2.9 mm.

Interpretation

It is highly probable that the coarse nature of the diet of the Arkansas Indians, which often contained a large amount of soil and sand,[22] was mainly responsible for the extensive attrition observed on these teeth.

It should be realized that the occlusal wear, when progressed beyond the contact point, brings about the reduction in the mesiodistal diameter of the teeth, thereby reducing the arch length.

The majority of teeth (381 out of 616, or 61.85 percent) were in the second stage of attrition; that is, the cusps were worn down and the dentin was exposed. This compares very favorably with Campbell's findings[12] that 60 percent (9 out of 15) of Australian Aborigines of Cockatoo Creek, Central Australia, were in the second stage of Broca's classification. These young Australian Aborigines were of a comparable age group, namely twenty to twenty-nine years.

Even though the current findings are in agreement with the previous work on the subject, it must be said that Broca's classification of attrition seems to be arbitrary, ambiguous and subjective. Any conclusions based simply on these findings should be evaluated very carefully. The distinction between the various stages is relative. The terms "quite an appreciable wear and extreme wear" may mean different things to different

people.

A comparison between the sum of the average mesiodistal widths of mandibular teeth of the Australian Aborigines and Arkansas Indians (Table 8) reveals a decrease of mesiodistal arch length of the Arkansas skulls by an average of 6.86 millimeters from one second molar to the other. This is probably due to the age factor. The measurements on Australian Aborigines were carried out just prior to the eruption of third molars, while the average age of Arkansas Indians was 26.8 years. The smaller mesiodistal arch length may also be due to the possible differences in diet, environment and the inherent size of teeth.

The presence of crowding in cases exhibiting a mesiodistal arch length which exceeds the mean value for this measurement indicates a possibility that larger-sized teeth are responsible for crowding of teeth.

There was a little difference in measuring the crown height between Black who measured teeth of modern man, and this investigator. Black measured the crown height up to the gingival line while this investigator measured the anatomical crown height up to the cemento-enamel junction. This is definitely a difference, but should in no way impair the conclusions of this study provided it could reasonably be assumed that in Black's sample the majority of teeth did not present a gingival line lower than the cemento-enamel junction. If this is true, then the difference should be greater between Black's findings on crown height and the present findings. In other words, the actual amount of occlusal attrition could be greater in these Indian skulls than is depicted by the figure — 7.05 mm in the maxilla and 15.45 mm in the mandible. Moreover, here a comparison has been made between the smaller-sized modern man's teeth and the larger-sized teeth of Arkansas Indians. It is obvious that the Arkansas teeth were originally larger because the sum of the mesiodistal crown width of the extremely worn Arkansas Indian teeth was identical with the crown width of the very slightly worn teeth in Black's sample, both in mandibular and maxillary arches. In Black's sample as well as in the current study the sum of maxillary mesiodistal diameters was 65.5 mm and mandibular mesiodistal diameters was 64.8 mm.

It was observed that in the same skulls the third molars were sometimes larger than the second molars mesiodistally. The largest such difference was 1.8 mm. This can be explained by at least two reasons. First, they arrive late and are therefore subjected to less attrition, and secondly, they undergo no attrition on their distal surface. For the same reason, that is, their early arrival, the first permanent molars exhibit a greater occlusogingival wear than the second molars. On an average the maxillary third molars were smaller than second molars by .7 mm and the mandibular second and third molars were of the same size.

In eighteen out of twenty specimens the width between the maxillary premolars was greater than the canine fossa measurement. On an average the premolar width was greater than the canine fossa measurement by 5.4 mm. This could be partly attributed to two things. One, these bicuspids underwent somewhat greater attrition than those in Howes' study. Greater increase in width is recorded with cuspal wear. Two, the canine fossa measurement was made on dry skulls in this study. Howes measured the modern human mouth with soft tissues intact. It is possible that, if allowance for soft tissue is made, there may be no real difference between Howes' study and this one. In any case, in reality, the bony measure-

ment was certainly smaller than the tooth measurement; or in other words, the teeth lay outside the bony arch.

Conclusions

The dentition of the Arkansas Indian skull which has undergone attrition presents an overall mesiodistal diameter of teeth which is not smaller than the same in modern man.

The average mesiodistal width of the teeth of the Arkansas Indian was smaller than that of the Australian Aborigine.

A tendency toward crowding was observed when the mesiodistal arch length exceeded its mean value.

The extensive attrition of teeth and their subsequent accommodation just within the basal bone leads us to conclude that the Arkansas Indian skulls of this sample had an inherent excessive tooth material over the basal bone.

About sixty percent of teeth in this sample exhibited tooth attrition which was in the second stage of Broca's classification. This means that in these teeth the cusps were worn down and the dentin was exposed.

The average buccal crown height of the Arkansas Indians was smaller than that of Black's sample, while the average mesiodistal width of the two samples was identical.

On an average, the width between the maxillary premolars was greater than the canine fossa measurement.

Malocclusion was rare in these Arkansas Indian skulls.

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