Orthodontic Aspects of Dental Anthropology

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Dental anthropology is a term introduced about a decade and a half ago to recognize the growing body of literature describing the most indestructible and most morphologically revealing part of the human skeleton, the teeth. Variation in the size, shape, number, arrangement, and wear pattern of the teeth of man has long been an area of great interest to physical anthropologists. Since the orthodontist ponders many of these same variables in his daily battle with malocclusion, many aspects of dental anthropology can prove helpful in understanding orthodontic problems and in formulating their successful treatment. It is the purpose of this paper to present a brief survey of clinically useful information which lies at the interface of orthodontics and anthropology.

Orthodontic odontometry

The anthropologic science of measuring the size and proportion of teeth is called odontometry. Many orthodontists today practice some form of odontometry, perhaps unknowingly, as part of their routine case diagnoses. Traditionally, orthodontic odontometry has been limited to the determination of the amount of dental arch space deficiency. Typically, the mesiodistal crown widths of all the teeth from molar to molar are measured. Then the arch space available is determined by laying a brass wire along the arch perimeter, a ritual of questionable accuracy.

It is worth noting that, historically, all orthodontic diagnostic analyses utilize only mesiodistal tooth measurements in their construction. In contrast, tooth-size indices incorporating both faciolingual and mesiodistal dimensions have been found quite useful by physical anthropologists. In some recent odontometric studies[1,2] *crown shape* has been found to be a determining factor in the presence and absence of mandibular incisor crowding. As a numerical expression of crown shape, an index is constructed using the mesiodistal (MD) and faciolingual (FL) dimensions in the form of an MD/FL ratio. The index equals the mesiodistal crown diameter in millimeters divided by the faciolingual crown diameter in millimeters and multiplied by 100 (Index = 100 MD/FL).

In clinical practice one can advantageously apply this index to detect tooth shape deviations which influence and contribute to pretreatment and posttreatment mandibular incisor crowding problems. Characteristically, well-aligned lower incisors possess MD/FL indices in the low 90's or less. That is to say, the mesiodistal diameters of these teeth are usually about 90 per cent or less than their faciolingual diameters. From our published work and continuing studies the opposite proportion appears equally characteristic of severely crowded mandibular incisors. For these incisors the MD/FL index commonly exceeds 100 indicating that the mesiodistal dimension is greater than the faciolingual dimension.

From our odontometric studies utilizing two samples of Caucasian women, one sample selected for their perfect lower incisor alignments, and the other sample a reference population group, clinical standards have been adapted to determine whether a lower incisor is

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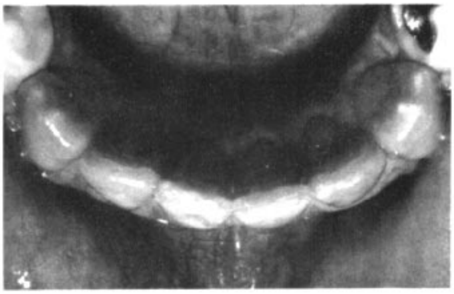
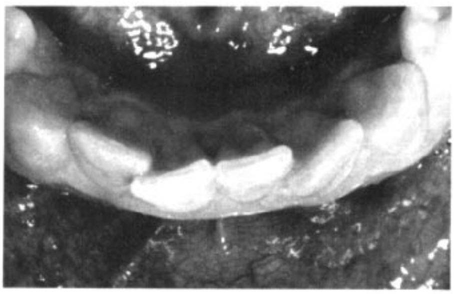


Tooth	MD	FL	MD/FL Index	MD/FL Index Standards
2⌉	5.3	6.4	83	90-95
1⌉	5.2	5.8	90	88-92
⌈1	5.2	5.7	91	88-92
⌈2	5.5	6.3	87	90-95



Tooth	MD	FL	MD/FL Index	MD/FL Index Standards
2⌉	5.8	5.9	98	90-95
1⌉	5.4	5.3	101	88-92
⌈1	5.2	5.4	96	88-92
⌈2	6.3	5.6	111	90-95

Fig. 1 Relationship between mandibular incisor shape and the presence and absence of mandibular incisor crowding. Pictured are the lower incisors of two untreated adults. Tables indicate the mesiodistal (MD) and faciolingual (FL) crown diameters, and the computed MD/FL indices. From studying the above photographs and tables it becomes apparent that (1) MD and FL crown dimensions and incisor shape are highly variable, (2) incisor shape and incisor alignment are closely related variables, and (3) low MD/FL index values are characteristic of well-aligned incisors, while high MD/FL index values are characteristic of crowded incisors.

favorably or unfavorably shaped relative to good alignment. The ranges employed as clinical guidelines for the maximum limit of desirable MD/FL index values for the lower incisors are: 88-92 for the mandibular central incisors and 90-95 for the mandibular lateral incisors. The lower limit of each range represents approximately the mean value of the MD/FL index of naturally well-aligned incisors. The upper limit of each range is derived from the lower limit plus one standard deviation.

Lower incisors within or below these ranges may be considered favorably shaped. Any lower incisor with an MD/FL index above these ranges, however, possesses a crown shape deviation which may influence or contribute to the crowding phenomenon (Fig. 1).

The clinical implications of this relationship between tooth shape and lower incisor alignment are manifold. Mesiodistal enamel "stripping" or *reproximation* now has a legitimate role in orthodontics as a clinical procedure for modifying tooth shape and more specifically for correcting tooth shape deviations.[3] Reproximation is defined as a clinical procedure involving the reduction, anatomical recontouring, and protection of the mesial and/or distal enamel surfaces of a permanent tooth. Clinically, gross enamel removal is performed using abrasive steel strips and discs. This is followed by anatomical recontouring using green stones. And then after light polishing with finishing strips, acidulated phosphate-fluoride is applied as a prophylactic measure.

All orthodontists are somewhat familiar with tooth shape deviations simply from their lower incisor band fitting experiences. Most practitioners can easily recall the lower incisor on which a preformed band fits very tightly at

Fig. 2 Mandibular incisor shape variations associated with anomalies of tooth number. Both cases exhibit the same condition, a missing mandibular lateral incisor, but for different reasons. Above, mandibular left lateral incisor was extracted as part of orthodontic treatment. The remaining incisors have MD/FL indices in excess of 100 confirming iatrogenic, as opposed to congenital, hypodontia. Below, mandibular right lateral incisor congenitally absent. Remaining incisors possess remarkably low MD/FL indices (below 90) which is a common distinguishing feature in cases of true hypodontia.

the contact level, but with slightly more seating pressure drops quickly to the gingival level resulting in a frustratingly poor fit. Incisors demonstrating this facility inherently have a greater crown perimeter at the incisal edge than at the gingival margin. These teeth possess gross shape deviations with MD/FL indices well over 100 and sometimes over 110. Deviations of this intensity should be corrected or at least partially corrected before banding. Otherwise, there is a great potential for food accumulation and decalcification at the flabby gingival margin of the band. Furthermore, reproximation at this time will make the banding procedure much easier for both doctor and patient.

Tooth shape analysis may be employed to help differentiate anomalies of tooth number. A comparison of the mandibular incisors of two males illustrates this fact. One young man had a mandibular lateral incisor extracted as part of orthodontic treatment attempting to resolve incisor crowding. Following active therapy, a canine to canine fixed retainer was worn for several years before removal. The three remaining incisors have MD/FL indices exceeding 100 (Fig. 2, above). With crown shape deviations of this intensity, postretention stability becomes severely jeopardized.

In contrast, another instance of three mandibular incisors is distinctly the product of tooth agenesis. The lower right lateral incisor is congenitally absent in the case illustrated (Fig. 2, below). The MD/FL indices of the remaining lower incisors are all less than 90 which is a distinguishing characteristic in cases of hypodontia. It follows from this comparison that information derived from tooth shape analysis can be uniquely revealing diagnostically and forensically as well.

Tooth shape deviations are not confined to the mandibular incisors. The mandibular premolars are often just as variable in shape. Frequently, these variations are associated with tooth shape deviations of the anterior teeth. Normally the mandibular premolars possess MD/FL indices of less than 100. Gross tooth shape deviations of the mandibular first premolars and/or the mandibular second premolars are usually expressed bilaterally (Fig. 3). In all cases, reduced faciolingual diameters and enlarged mesiodistal diameters characterize the teeth. The shape-deviated premolars do not demonstrate positional irregularity as often as simi-

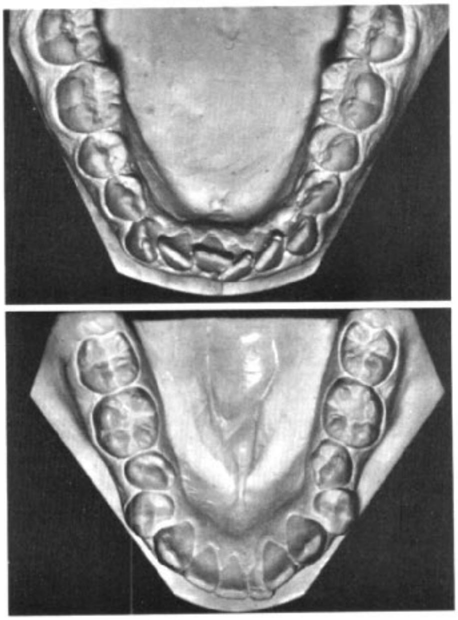


Fig. 3 Tooth shape deviations of the mandibular premolars (MD/FL index > 100). Normally, the MD/FL index for the mandibular first premolar averages 90 ± 5, while the average MD/FL index for the mandibular second premolar is 85 ± 5. Above, first premolar deviations. MD/FL indices: 5⌉ = 88; 4⌉ = 122; ⌈4 = 122; ⌈5 = 84. The four lower incisors also possess gross shape deviations (MD/FL > 100). Below, second premolar deviations. MD/FL indices: 5⌉ = 127; 4⌉ = 93; ⌈4 = 92; ⌈5 = 120.

larly deviated incisors because of their more robust approximal anatomy. These deviated premolars are choice candidates for orthodontic extraction, while the incisors, in these cases, should be reproximated as necessary to correct their tooth shape deviations.

Another odontometric method favored by many orthodontists is the anterior intermaxillary index described by Lundström[4] and introduced clinically by Bolton.[5] This index is constructed by dividing the sum of the mesiodistal widths of the six mandibular anterior teeth by the sum of the mesiodistal widths of the six maxillary anterior teeth and multiplying by 100. This produces a percentage ratio of the mandibular anterior tooth material relative to the maxillary anterior tooth material. The rationale is that, if the dentition is considered as a finely meshing assembly, it should be easy to conceive minor deviations in mesiodistal tooth size relationship disrupting the occlusion, particularly overbite and overjet. Since overbite and overjet are anterior phenomena, the anterior ratio would seem more relevant than the over-all molar to molar intermaxillary ratio.

Two studies of the anterior intermaxillary index utilizing excellent occlusions have been reported, one by Bolton[5] on North Americans and the other by Tsubura[6] on Japanese. Both samples demonstrated the same range of the anterior intermaxillary index, 74-81. In other words, in excellent Class I (Angle) occlusions the mandibular mesiodistal tooth size from canine to canine is 74% to 81% of the maxillary mesiodistal tooth size from canine to canine.

Recent studies by Geigerich[7] and Lombardi[8] conclude that the intermaxillary index is *not* significantly related to treatment outcome. Therefore, its active use to avert crowding or refine overbite or overjet is unfounded. However, the index still has a role in clinical orthodontics as an important diagnostic guide to *prevent* anterior intermaxillary discrepancies from being created by an injudicious incisor extraction or by overzealous reproximation. In these situations clinical experience has shown a pretreatment Bolton analysis to be much more reliable than a plaster cast diagnostic setup.

Winged and shovel-shaped incisors

A peculiar arrangement often seen between central incisors, both maxillary and mandibular, has been noted by many dental anthropologists beginning with Leigh[9] in 1925. The arrange-

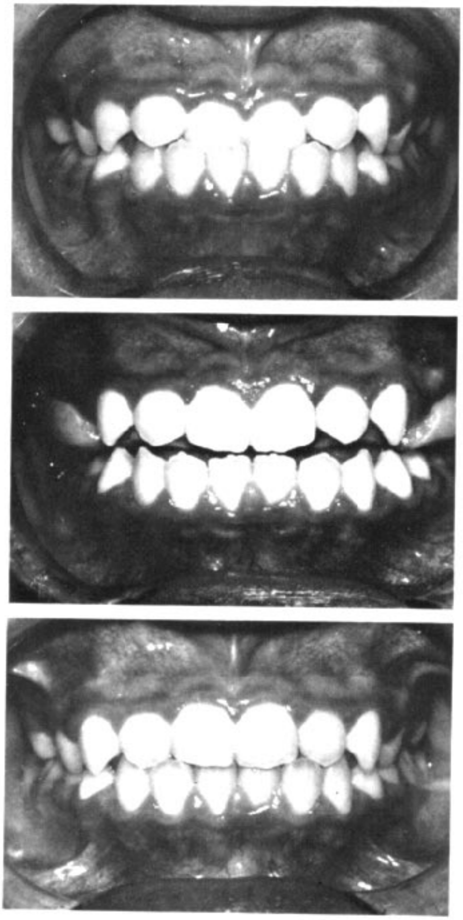


Fig. 4 Top and middle, incisor crossbite in a Chinese-American girl with maxillary and mandibular central incisor winging (mesiolinguoversion). Treatment objective was to correct only the crossbite. A removable appliance with a posterior bite plane and recurved finger springs lingual to the central incisors was used for two months. The appliance was then discarded and the patient simply "chewed-in" her new bite. Below, the incisor winging remains untreated because of its usually unfavorable prognosis for permanent correction.

ment has been called *incisor winging* by Dahlberg.[10] It is characterized by mesiolinguoversion of the central incisors creating a V-shaped notch in the arch at the midline. This trait is most frequently noted in Mongoloid dentitions. It has, however, been detected to varying degrees in almost every population. Population affinity studies strongly suggest the incisor winging trait to have some genetic determinants. Therefore, this condition would usually be rather resistant to conventional orthodontic correction. Clinical experience, we may add, has shown this to be the rule. In this light it would be prudent for the orthodontist routinely to inform patients with winged incisors of their unfavorable prognosis for permanent orthodontic correction (Fig. 4).

Shovel-shaped incisors present another variation of incisor morphology with orthodontic implications. Shovel-shape refers to the peculiar prominence of the mesial and distal marginal ridges enclosing the central fossa in the lingual surface of incisor teeth. Shovel-shaped incisors are much more frequently found in the maxilla than in the mandible. The trait is most frequently expressed in Mongoloid populations but also appears among others. Since Hrdlička's classic paper[11] on the subject, this morphologic trait has been used extensively by anthropologists as a criterion for the assessment of population affinities. To the clinical orthodontist shovel-shaped incisors often present a problem in overjet correction. The prominent marginal ridges sometimes restrict full retraction of the maxillary incisors. In these cases, reducing the prominence of the marginal ridges by stoning is an indicated, and usually fruitful, procedure. The marginal ridges consist almost entirely of enamel, thereby making the ridge reduction an innocuous procedure.

Sometimes a single aberrant marginal ridge will prevent the alignment correction of one tooth, commonly the maxillary lateral incisor. Again, selective grinding of the hypertrophied enamel is indicated.

Theory of overbite

Overbite, or vertical overlap of anterior teeth in occlusion, is present in greatly varying degrees among modern populations. Primitive peoples, past and present, tend to display edge-to-edge anterior bites (labidonty), or at most, slight scissor bites (psalidonty) of less than two millimeters. Overbites in excess of two millimeters are largely limited to those living in relatively civilized environments.

It is generally reasoned that overbite has accrued among the civilized because substantial tooth wear is no longer present to compensate for natural incisor eruption.[12-14] Therefore, to combat overbite, orthodontists might logically consider grinding off incisal edges as necessary. This approach, however, would scarcely pass a twentieth century esthetics test. So, regrettably, the attritional theory of overbite, while defensible, is hardly applicable.

Another insight into the origins of overbite in man has been suggested by Brace and Mahler.[15] They observe overbite as a fairly recent development, widely expressed among Europeans, only after the Middle Ages (ca. 15th century A.D.). At that time, also, the table fork was introduced in Italy, and it gained rapid popularity as the Renaissance ascended in Europe. The introduction of individual table forks (as distinct from the serving utensils) and the accompanying new eating style had a devastating effect on overbite according to Brace and Mahler. The personal fork and knife took the functions of holding and shearing food away from the incisors and placed them on the table. Protrusive function, essential to the holding and shearing process, swiftly became obsolete, and deep overbite and its related occlusal deviations (notably Class II malocclusion) have since proliferated unchecked.

However simplistic, this anthropologic theory seems too plausible to be totally disregarded. Recurring overbite is an almost universal postorthodontic sequela. Deep overbite correction may be nicely maintained through the retainer period, but it commonly deteriorates as soon as retaining appliances are removed.

Assuming the fact of this new explanation, what can an orthodontist do to maintain overbite correction in a deep bite case? The answer is not too hopeful. Short of wearing a bite plane appliance indefinitely, very little can be done. So long as our peculiar eating mannerisms continue to relax the very mechanism—protrusive function—naturally limiting overbite, we may have to live with some overbite relapse in spite of the best mechanotherapy.

Buccal segment reproximation

Now we would like to touch upon an idea derived from dental anthropology whose time we feel has come. For decades anthropologists have written about the changes in the human dentition associated with natural tooth wear. The orthodontic community has known of this largely through the work of Raymond Begg[13] on the Australian aboriginal population. Briefly stated, all teeth become smaller mesiodistally as they wear down with age. In addition, the contact areas between the teeth become flatter and broader. Theoretically, mesiodistal enamel reduction of all permanent teeth in the developing adolescent dentition would be a logical method to produce artificial tooth wear mimicking the natural wear pattern of primitive populations. More importantly, precious arch space may be derived by this method.

A further indication for reproximation of posterior teeth is provoked by the ingrained discipline in operative dentistry of overcontouring approximal restorations. The cumulative effect of this questionable practice in the adolescent dentition no doubt contributes to vanishing arch length and intensified crowding.

Case report

A fourteen-year-old girl presented a Class I facial pattern and Class I occlusion, slight anterior open bite, and orthognathic profile (Fig. 5a). Maxillary anterior crowding was present with lingually displaced lateral incisors. Mild mandibular anterior crowding was also present. The maxillary right first molar had a cemented copper band as part of endodontic therapy. In the treatment of this case we were hesitant to extract teeth due to the patient's fine skeletal pattern. To resolve the arch space deficiency, we decided instead to reproximate the posterior teeth. The fact that this patient had eighteen approximal surfaces of amalgam in the posterior teeth was a key factor influencing this treatment plan.

Each quadrant was reproximated separately, and maxillary and mandibular "ACCO" appliances were constructed to move the buccal segments distally into the newly created interproximal spacing (Fig. 5b). (The ACCO is a removable appliance, originally designed by Dr. Herbert Margolis utilizing a bite plane, finger springs, and extraoral anchorage to distalize teeth and harness growth.) Only one quadrant was distalized at a time to prevent strain on the anterior anchorage. Upon conclusion of buccal segment reproximation and distalization, the case took on an obviously nonextraction character (Fig. 5c).

The mandibular incisors then were reproximated to correct tooth shape deviations and were immediately banded. The maxillary four incisors were banded and a sectional arch employed.

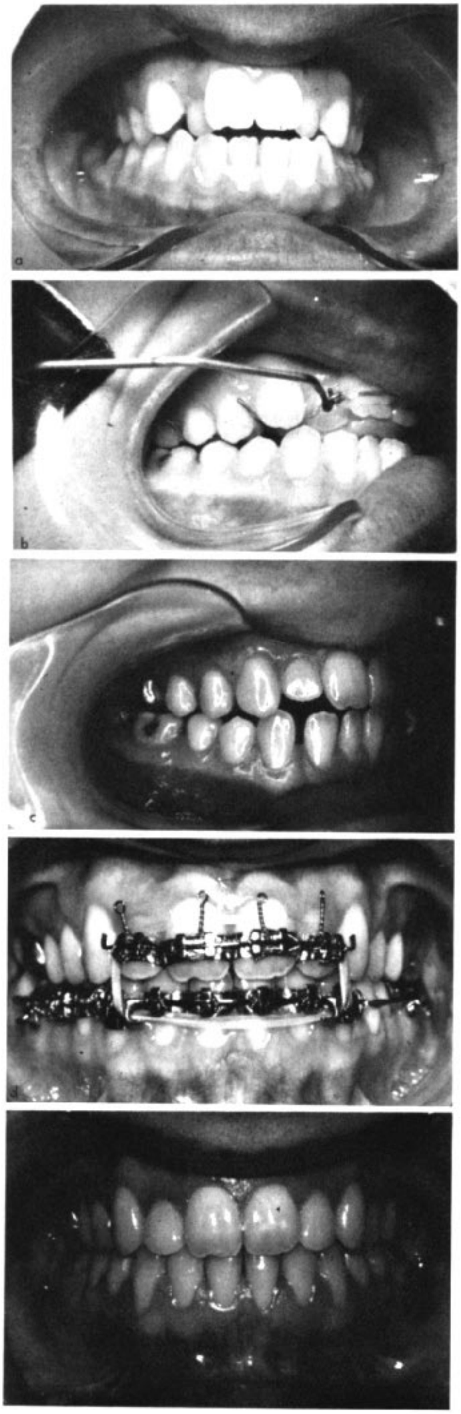


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Fig. 5 Original occlusion (a); distalizing buccal segments with "ACCO" appliance (b); after reproximation (c); segmental banding with anterior vertical elastics to conclude treatment (d); final occlusion, eighteen months post-treatment (e).

Vertical elastics were utilized to close the slight anterior open bite (Fig. 5d). Bands were removed after seventeen months of active treatment. Maxillary and mandibular retainers were used for six months; thereafter, the maxillary retainer was worn as needed at night, and the mandibular retainer discontinued. The corrected occlusion one and one-half years out of treatment is shown in Figure 5e.

Summary

Variation in the size, shape, number, arrangement, and wear pattern of the teeth of man has long been an area of great interest to physical anthropologists. In this paper some of the remarkable variations to be found in the human dentition are identified and translated in orthodontic terms.

Teeth are by nature imperfect structures, often just as disfigured individually as the malocclusions they form collectively. It is important that the orthodontist cultivates an anthropologist's eye for tooth variations. With this sensitivity he shall surely enlarge his understanding of the limitations of orthodontic therapy and shall appreciate the valuable role of tooth altering procedures in achieving treatment success.

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References

1. Peck, S. and Peck H. Crown dimensions and mandibular incisor alignment. *Angle Orthod.*, 42:148-153, 1972.
2. Peck, H. and Peck, S. An index for assessing tooth shape deviations as applied to the mandibular incisors. *Am. J. Orthod.*, 61:384-402, 1972.
3. ———. Reproximation as an essential orthodontic treatment ingredient. Transactions Third Int. Orthod. Congress, London (in press).
4. Lundström, A. Intermaxillary tooth width ratio and tooth alignment and occlusion. *Acta Odont. Scand.*, 12: 265-292, 1954.
5. Bolton, W. A. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. *Angle Orthod.*, 28:113-130, 1958.
6. Tsubura, T. Tooth-size ratio in Japanese. *Odontology* (Tokyo), 59:567-577, 1972.
7. Geigerich, T. A. Intermaxillary tooth mass discrepancy: its incidence and effects on the treated case. M.S. thesis, *Case Western Reserve Univ.*, 1971.
8. Lombardi, A. Mandibular incisor crowding in completed cases. *Am. J. Orthod.*, 61:374-383, 1972.
9. Leigh, R. W. Dental pathology of Indian tribes of varied environmental and food conditions. *Am. J. Phys. Anthrop.*, 8:179-199, 1925.
10. Dahlberg, A. A. A wing-like appearance of upper incisors among American Indians. *J. Dent. Res.*, 38:203-204, 1959.
11. Hrdlička, A. Shovel-shaped teeth. *Am. J. Phys. Anthrop.*, 3:429-465, 1920.
12. Campbell, T. D. Food, food values and food habits of the Australian aborigines in relation to their dental conditions. *Austral. Dent. J.*, 43:1, 45:73, 141, 177, 1939.
13. Begg, P. R. Stone age man's dentition. *Am. J. Orthod.*, 40:298-312, 373-383, 462-475, 1954.
14. Smith, P. Studies in tooth wear. *Israel J. Dent. Med.*, 21:75-78, 1972.
15. Brace, C. L. and Mahler, P. E. Post-Pleistocene changes in the human dentition. *Am. J. Phys. Anthrop.*, 34: 191-204, 1971.