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Occlusal variation in the Zuni: a pre-contact North American population

Aidan McKeever* and Paul Sutcliffe†

Aidan McKeever, Whitetree Specialist Centre, Bristol* and Health Sciences Research Institute, Warwick Medical School, University of Warwick, Coventry,† United Kingdom

Background: Reports of occlusal variation in ancient populations consistently show a low prevalence of malocclusion coupled with heavy attritive wear.

Materials and methods: The dentitions of 28 individual remains from a pre-contact native North American population were examined and the extent and nature of occlusal variation recorded.

Results: The prevalence of malocclusion was low (mean IOTN = 2.14) and where crowding existed, was limited to intra-arch variability as opposed to inter-arch discrepancies. Increased overbites, overjets and other classical features of Class II malocclusions were almost entirely absent. These findings suggest that the ideal mutually protected Class I occlusion occurs only as a transient juvenile arrangement in nature, where, due to rapid attrition following establishment of the occlusion, there is an increasing tendency towards mild Class III, edge-to-edge incisor and buccal segment relationships.

Conclusion: Whilst of limited therapeutic benefit, an understanding of the anthropology of malocclusion provides an insightful perspective, and suggests that function may be of more importance than heredity in its aetiology. It is suggested that future occlusal studies in ancestral populations would benefit from the use of a standard methodology.

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Aidan Mckeever: aidanmckeever@outlook.com; Paul Sutcliffe: P.A.Sutcliffe@warwick.ac.uk

Introduction

Malocclusion has been described as a 'disease of civilization',[1] due to its ubiquity in the developed world, and almost complete absence in non-industrialised populations.[2,3] The few existing studies of malocclusion or 'occlusal variation' in ancient populations available corroborate this remarkable polarity,[4-9] and place malocclusion into context as an extremely recent phenomenon in the natural history of Man.

The relevance of archeological and anthropological research to modern clinical orthodontics may not be immediately obvious. However, the work of Begg was grounded in his theories on the anatomical basis of malocclusion, as demonstrated in his comparative studies of Stone Age and modern Australian Aboriginal dentitions.[10] Noting that, in the ancestral environment, these populations were seldom crowded, the Begg orthodontic philosophy was developed, of which a basic principle was the extraction of teeth as a form of surrogate for the high level of tooth wear experienced in nature. There is, therefore, an important precedent of reference to physical anthropology as an aid to understanding the aetiology, and a rationale for the treatment of malocclusion. For Begg, the concept of 'attritional occlusion' in a high-wear environment was crucial, although reduced functional stimulation of the masticatory apparatus or 'disuse', as well as genetic admixture and inbreeding have been proposed elsewhere as major factors in the modern rise of malocclusion.[11,12] Of the latter theories, there is currently good evidence to support changing diets and reduced functional demands on the masticatory system as a more likely cause of reduced mandibular dimensions, and hence malocclusion, than genetic admixture, at least in the anthropological literature.[13]

Studies reporting levels of occlusal variation in ancient human populations are rare. This may be due to the practical difficulties associated with handling archaeologically-recovered human dental structures, which are often friable and delicate. Alternatively, the scarcity of sufficiently well-preserved structures may present methodological challenges in gathering enough data to provide a statistically representative cross-section of the study population. Whilst physical anthropologists have reported extensively on secular changes in specific aspects of tooth morphology and third molar eruption,[14-16] occlusal variation and malocclusion are poorly reported in the literature. The few existing studies which have appeared in either the dental or anthropological literature (Table I) have repeatedly shown that malocclusions requiring treatment by today's standards were almost completely absent in pre-industrial civilisations, and that their incidence appears to increase rapidly as societies industrialise and move away from traditional hunter-gatherer food habits. Exceptions to this observation have been documented by Inoue et al.[17] in which one ancestral Japanese population experienced a higher than average incidence of skeletal Class III malocclusions, and also by Campbell-Wilson[18] in which a high incidence of Class II malocclusions was observed in a (very small and statistically insignificant) Scottish sample. Mockers et al.[19] also reported high levels of intra-arch crowding in unarticulated French Copper-Age specimens, without reporting specifically on occlusal relationships.

Of the 10 studies in Table I, 44 unique outcome measures were reported, of which only one (Angle's Classification) was common to at least three studies.[7,8,20] Where studies reported the same outcome, comparison was complicated by the use of different units or parameters for the definition of a trait. Corruccini has cited the problem of heterogeneity of outcomes, as illustrated here, to justify the need for a standardised assessment method in anthropological occlusal studies.[15]

The most reliable evidence for the increasing tendency to malocclusion with increasing acculturation is a series of cohort studies by Corruccini et al.[4,20,21] Comparisons of the prevalence and severity of malocclusions in successive generations living in isolated communities before and after the effects of rapid 'westernisation', resulted in Corruccini's observation that occlusal variation was likely to be significantly higher within one or two generations of the adoption of western food habits in otherwise genetically stable populations, and where potential confounding factors were reliably controlled. These findings suggested that environmental factors play a larger part in the aetiology of malocclusion than heredity, at least in the short term.

The aim of the current study was to contribute to the existing body of evidence on ancestral occlusal variation by providing qualitative and quantitative data on the incidence and types of malocclusion observed in a previously unreported sample of human

Table I. Summary of the findings of studies of ancestral malocclusion.

Author	Population	N	Main findings
Inoue 1994	Ancient, West Japan 3 locations	218	Low prevalence of malocclusion, increasing in incidence over time. High prevalence of skeletal class III in one location
Corruccini 1989	Etruscans	50	Low prevalence of malocclusion
Mockers 2004	Copper Age, France	43	High prevalence of intra-arch crowding. Occlusion not reported
Campbell-Wilson, 1969	Dark Ages, Scotland	14	High Prevalence of Class II
Mohlin, 1978	Medieval, Sweden	81	Low prevalence of malocclusion
Varrela 1989	Medieval, Finland	49-93	Low prevalence of malocclusion
Helm, 1979	Medieval, Denmark	278	Low prevalence of malocclusion
Evensen, 2007	Medieval, Norway	146	Low prevalence of malocclusion
Weiland, 1997	C19th, Austria	94	Low prevalence of malocclusion
Corruccini, 1983	Melanesians	119/87	Malocclusion increases with Western contact

archaeological remains, representative of a pre-contact North American aboriginal population. The results were compared with those obtained from similar studies by previous authors and the relevance to clinical orthodontics of the anthropological evidence base is discussed.

Materials and methods

Ketchipawan is a ruin of one of several abandoned pueblos of the Zuni tribe, situated in western New Mexico. Ketchipawan and its more famous neighbour, Hawikuh, were two of the fabled 'Seven Cities of Cibola', or 'Seven Cities of Gold' as they came to be known by the invading Spanish around 1540. It was here that the very first contact between Europeans and Native Americans occurred. Conquest and occupation lasting 140 years followed until the Pueblo revolt of 1680, after which many of the outlying pueblos were abandoned as the Zuni consolidated to a single larger settlement, where they remain today.[22,23] The area has since been of interest to historians, anthropologists and archaeologists.

Between 1919 and 1923, a joint expedition of the Museum of the American Indian, Heye Foundation, and the Museum of Archaeology and Ethnology, University of Cambridge (known as the Hendricks-Hodge Expedition) carried out excavations at the Ketchipawan site, and of 266 excavated burials, 54 individuals were and are currently housed in the Duckworth Laboratory, The Leverhulme Centre for Human Evolutionary Studies, University of Cambridge. Accurate dating of the burials has been difficult and largely deduced from cultural evidence such as the geographical orientation of burials (e.g. east-west) and burial artifacts which represented known contemporary practices and therefore enabled approximate dating. It has been estimated that most of the burials at Ketchipawan post-date 1300 AD, and it is known that the pueblo was abandoned by the time of the pueblo revolt in 1680. There is, therefore, an overlap of approximately 140 years during which European contact was documented following the Spanish conquest. However contemporary Spanish reports suggest that the pueblo was already gradually being abandoned between the arrival of the Europeans in 1540 and 1582. It is difficult to say with certainty that all of the burials represent pre-European contact individuals. Since the nature of the contact during this period was of imperial conquest and mutual aggression rather than cultural assimilation, it is unlikely that during the 140-year contact period, the way of life of the Zuni was changed to any great extent. This population can therefore be considered representative of an ancestral pre-contact North American aboriginal people.

It was decided that a methodology proposed by Corruccini[3] would be employed for the study, for two reasons:

1. To enable meaningful comparison with the series of Corruccini studies, which currently represent the best quality work with the most clearly defined outcomes in this area.
2. Similar studies by other authors have used alternative outcome measures such as locally-used treatment need indices.[5,21] Although Corruccini's method is based on the Treatment Priority Index used in the USA, the measurements used for its formulation are relatively low level. This however, facilitates re-interpretation to fit alternative indices with subsequent forward compatibility and consequently meaningful future comparison with a wider range of studies. The problem of heterogeneity in occlusal studies has been discussed earlier.

The variables recorded as part of the Corruccini methodology are shown in Table II. This methodology also recommends the specific inclusion criterion that only samples with no missing teeth and all but one permanent tooth (excluding third molars) should be included in the study. Finally, in addition to these requirements all samples were assessed according to the UK Index of Treatment Need (IOTN).

Data collection

Methodological difficulties in collecting occlusal data from archeological samples have been documented;[24] however, single-examiner consistency in recording occlusal variables for epidemiological studies has been shown to be highly reliable. Consistency ratios (CR - the number of subjects with a trait divided by the total number of subjects) have been shown to be approximately 90% for single-examiner occlusal studies.[25] The majority of traits in the present study were considered to be consistent, with the exception of rotation, which has a CR of 72%. Data were recorded using a data collection sheet, by one examiner using digital dividers, which, in providing readings to the

Table II. Corruccini's methodology for comparative occlusal studies.

Variable	Unit
Overjet	Millimetres
Overbite	Fraction of lower incisal crown coverage, and millimetres
Posterior crossbite	Fraction of bucco-lingual displacement of mesiolingual cusp of upper first molar, and millimetres
Buccal segment relationship	Fraction of mesio-distal displacement of mesio-buccal cusp of upper first molar, and millimetres
Maxillary arch length	Chord of interincisal point to distal margin of left first molar - millimetres
Maxillary arch breadth	Maximum transverse dimension between buccal surfaces of first molars - millimetres
Rotation/Displacement score	Sum of rotated or displaced teeth (rotations >45 degrees, impactions and displacements >2mm are counted twice)
Treatment priority Index	IOTN used here instead

nearest hundredth of a millimetre, were more than adequate for this study. Certain specimens were initially considered to be of poor quality as they were highly fragmented, but with the assistance of a desktop clamp it was often possible to reconstruct the damaged mandibles and maxillae so that a definite inter-arch articulation was achievable. In many cases some or all teeth had become dislodged from the alveolus post mortem, and if present, were stored separately from the main cranial and mandibular bones. This circumstance required the reinsertion of the teeth into the correct sockets in order to reconstruct the occlusion. This necessitated familiarity with dental structures, and there were instances when it was apparent that teeth had been replaced with adhesive into incorrect sockets by previous investigators, making examination more difficult. Such instances were corrected or taken into account where appropriate.

Results

From a total collection of 54 sets of individual remains, 28 met the inclusion criteria. The findings are summarised in Table III.

Negative values, where applicable, denote reverse overjet, reduced overbite (anterior open bite), lingual crossbite (scissor bite), and pre-normal buccal segment relationships (Class III).

The results show that the study sample displayed a tendency for small overjets and overbites, a slight tendency toward buccal crossbite (or reduced buccal overjet) and Class III buccal segments, a low average need for orthodontic treatment according to the IOTN, but a notable rotation and displacement score.

Discussion

Main findings

The results were in keeping with the general trend observed in similar studies in non-acculturated populations about which the same variables were reported. Apart from buccal crossbite, the qualitative trend observed in previously studied archaeologically-recovered samples, was confirmed. Furthermore, the results retrospectively corroborate Corruccini's observations that modern pre-contact and non-acculturated populations exhibited levels of occlusal variation similar to those of ancient populations. Table IV shows how the results compare with the combined averages of those obtained from four other pre-industrial populations studied by Corruccini, the originator of the methodology.[22,23,26] These cohort studies involved older and younger generations of the same living populations (rural Kentuckians, Chinese immigrants to Liverpool, Pima Amerinds and Australian Aboriginals), as opposed to archaeological material from deceased individuals. Right and left crossbite and buccal segment relationships have been combined and the average taken, to reflect their common presentation in the comparison studies. Only those values are compared which were reported in all four Corruccini studies.

The ancestral occlusion as typified by the current study sample exhibits a combination of the following traits:

- Heavy attritive wear
- Class I or Class III incisor and buccal segment relationships

Figure 1. Minimal posterior contact in centric occlusion (left) and maximal contact in right-sided laterotrusion (right). Reproduced with permission from the Duckworth Collection.

Figure 2. Differential molar wear. Reproduced with permission from the Duckworth Collection.

Figure 3. Compensatory overeruption in a retained deciduous molar. Reproduced with permission from the Duckworth Collection.

Table III. Summary of occlusal variables in Ketchipawan sample.

Variable	Mean	SD
Overjet (mm)	1.19	3.13
Overbite (fraction)	1/5	1/5
Overbite (mm)	1.33	1.20
Right posterior crossbite (fraction)	1/5	3/8
Right posterior crossbite (mm)	0.68	1.14
Left posterior crossbite (fraction)	1/5	3/8
Left posterior crossbite (mm)	0.78	1.34
Right buccal segment (fraction)	-1/4	5/7
Right buccal segment (mm)	-1.18	3.73
Left buccal segment (fraction)	-1/6	3/5
Left buccal segment (mm)	-1.16	2.41
Arch breadth (mm)	60.99	3.02
Arch length (mm)	52.52	3.16
Rotation/Displacement score	5.21	3.60
IOTN	2.14	1.61

Figure 4. Anterior view: centric occlusion (left) and group function in protrusion (right). Reproduced with permission from the Duckworth Collection.

- A flat curve of Spee and normal or reduced overbites
- A tendency to posterior crossbites or edge-to-edge buccal segment relationships
- Varying degrees of crowding, rotations and displacements.

The severe wear observed in the specimens makes occlusal diagnosis according to today's clinical parameters difficult, since much of the occlusal anatomy was lost. Classification of the buccal segment relationships would usually require a determination of the position of the upper first molar mesiobuccal cusp tip with respect to the lower first molar buccal groove. As seen in Figure 1 this landmark may be lost in the upper molar.

Figure 2 demonstrates the rate of wear in permanent molars over a lifetime. Severe wear was evident in a lower first molar, moderate wear in the adjacent second molar and minimal wear in the third molar, directly proportional to their chronological eruption sequences. In this way, it may be deduced that, probably by the early twenties (this specimen was estimated to be 23-35 at death), severe wear of the longest established teeth was well underway.

It has been suggested by various authors[27] that there exists a compensatory mechanism of over-eruption which acts to maintain the occlusal plane in dentitions with various levels of wear. Figure 3 shows a specimen with a retained second deciduous molar and it can be observed that, as the crown heights from cemento-enamel junction to occlusal surface were successively reduced from second molar to deciduous molar, there was a proportional increase in the level of supra-crestal root surface exposure.

A consequence of the heavy wear as observed in this type of attritional occlusion was that excursive contacts follow a 'group function' pattern as opposed to the gnathological arrangement of canine and incisor guidance, which are used in modern dentistry as clinically and anatomically ideal occlusal references. This can be seen in Figure 1, which shows a typical buccal view in centric relation and in right-sided excursion, respectively, and demonstrates maximal contact only in laterotrusion. Despite having recorded an average reduction in buccal overjet, this feature corresponds to the functional description of alternate intercuspation (X-occlusion).[28]

Figure 4 shows an anterior view of the same individual in centric occlusion and protrusive excursion respectively, and indicates anterior group function. It is considered that protrusive incisal 'lift' and posterior disclusion was not possible without the presence of a positive overbite.

While average overjets were smaller in this study, overbites were slightly larger (1.03 mm compared to 0.25 mm). However, it was noted that strictly-defined, clinically-increased overbite – where the lower incisal edge occluded beyond the vertical limit defined by the upper incisal cingulum plateau – was completely absent in this sample. Observed overbites were generally due to the variation in type and extent of oblique labio-palatal incisal wear of the upper and lower incisal edges, which meant that the labial surface of an upper central incisor could vertically overlap the lower incisor crown significantly when viewed facially, while the subject still retained a functional edge-to-edge occlusion as illustrated in Figure 5.

The measurement of overbite in worn occlusions was therefore greatly dependent upon the parts of the tooth used as the measurement landmarks, and can produce illusory results that defy comparison with modern concepts of overbite. A similar observation can be made about overjet. Because attritive wear can result in upper incisors worn as far as the level of the cingulum plateau, producing broad flat or oblique incisal edges, there may be a difference of several millimeters between the palatal and labial surfaces of an upper incisor at the incisal edge. This results in an apparent overjet in a subject with an edge-to-edge occlusion. In essence, the overbites and overjets observed in this sample were taxonomic rather than functional.

In the present study, all objective indicators of occlusal health were sound. Arches were broad and overjet, overbite, buccal segment discrepancies, posterior crossbite, and rotation and displacement scores, were low. Accordingly, when applying a clinical assessment of objective treatment need such as the IOTN, the scores were also low. As with examples from Table 1, a clinically significant malocclusion was not completely absent; however, where present, it was limited to intra-arch crowding. There was no evidence of any malocclusion associated with increased overbite, mandibular retrognathia, narrow maxillary arches or other classical features of Class II malocclusions. Occlusal variation was largely confined to intra-arch discrepancies, although one skeletal Class III case was observed.

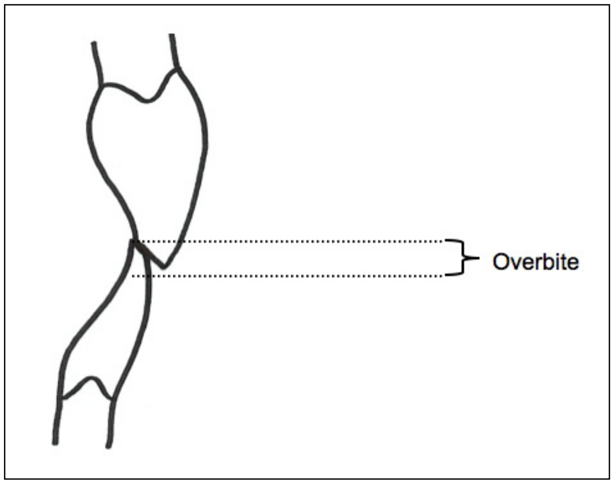

Figure 5. How oblique wear can result in apparent overbite.

Limitations of the study

The adoption of the Corruccini methodology for use in the current study was an attempt at establishing the importance of a standardised approach to studies of occlusal variation, and also to enable meaningful comparison with similar studies. However, some modification of this methodology was required. According to Corruccini,[3] only samples with no missing teeth and all but one permanent tooth erupted (excluding third molars) should be included, as this would represent an intact adult dentition (should this present a problem obtaining an adequate sample size, specimens with unilaterally missing teeth were an acceptable concession). It must be noted however, that the majority of Corruccini's work involved living subjects from relatively large communities in which gathering an adequate sample size was presumably not difficult. It was considered that it was unrealistic to apply this specific selection criterion to a study involving ancient skull material, as it would be very unlikely that a sample of suitable size would be available. Early during the sample selection process, it became clear that this was the case. For this reason 'no missing teeth' was changed to include 'no more than one missing tooth *in each quadrant*, excluding third molars', since even with a missing tooth in a quadrant it was possible to measure all of the variables described in Table II. This would be complicated if the missing tooth was a first molar, as it can be seen that the variables 'buccal segment relationship' and 'posterior crossbite' both require measurements relative to specific anatomical loci on this tooth. Therefore, in cases of missing first molars, the second premolar or second molar was substituted for the measurement of those variables. This concession introduced a potential source of error related to the common finding that ancestral dentitions usually possessed a helicoidal plane of occlusion.[29] This concept described the variation in the angles of the bucco-lingual wear planes produced on the occlusal surfaces of the posterior teeth as a consequence of changing arch breadth dominance – from maxillary to mandibular – with increasing posteriority. Although there is a compensatory increase in axial tilt that mitigates this effect to some extent, it may be observed that there is an increase in crossbite tendency with increasing posteriority, and that the substitution of a second molar for a missing first molar could introduce an overestimation of posterior crossbite tendency. The sample did demonstrate a generalised tendency towards mild posterior crossbite, which is

Table IV. Differences between current and similar studies.

Variable	Corruccini combined Mean	Ketchipawan sample Mean (Difference)
Overjet (mm)	2.18	-0.99
Overbite (fraction)	1/5	0
Overbite (mm)	0.25	1.08
Crossbite (mm)	0.29	0.44
Buccal segment relationship (mm)	0.27	-1.44
Arch breadth (mm)	56.95	4.04
Arch length (mm)	38.97	13.55
Rotation/displacement score	2.54	2.67

contrary to many documented observations in similar populations in which an increased buccal overjet (alternate intercuspation or 'X-occlusion') is the norm, and is otherwise difficult to explain. For determining linear sagittal and transverse measurements where substitution of a premolar or second molar was inappropriate (i.e. maxillary breadth and arch length), the mesio-buccal and distal socket borders were used, respectively. In cases of unilaterally missing central incisors, overjet and overbite were measured using the contralateral tooth.

The methodological compromises described above, as well as other criticisms such as the crude use of arch length and the inherent imprecision of reporting occlusal variables as fractions, highlight the fact that the use of the Corruccini method as the benchmark for this type of work, remains open to question.

Table IV shows a comparison between the average results in the current study sample and those obtained from other similar studies, in which there appeared to be a large discrepancy in average maxillary arch lengths. Examining this further, some ambiguity in the description of the landmarks used by Corruccini was noted, and it was likely that, in those studies, arch length was described with reference to the mandible rather than the maxilla. Therefore, the comparison of average arch lengths should be disregarded. Another notable deviation from Corruccini's results was the trait of rotation/displacement; however, due to the lower than expected CR for rotation, caution may be needed when interpreting this finding.

Analysis

The findings of the current study are consistent with those made by other authors, in that occlusal variation in pre-industrial populations was rare but not entirely absent. However, where present it generally took the form of intra-arch variability as opposed to inter-arch antero-posterior, transverse or vertical discrepancies. Where crowding was present, occlusions remained acceptable by most objective indicators. Malocclusions were therefore qualitatively different from the majority of those seen in the clinical setting today, where skeletal Class II malocclusions and increased overbites are comparatively frequent. Features of Class II malocclusions were entirely absent from this study population and there was a general tendency towards slightly Class III incisor relationships, Class III buccal segments and posterior crossbites. Heavy generalised wear of the dentition was a feature common to all samples.

While it seems intuitively crucial to attempt to understand the disproportionately high prevalence of malocclusion in modern urban populations, any new insights gained from anthropological studies may ultimately prove futile – at least from a therapeutic point of view. While most of the evidence from anthropology seems to support the 'disuse' theory (i.e. that malocclusions arise due to reduced functional stimulation of the masticatory system during growth, reduced jaw size, and therefore resultant tooth size/jaw size discrepancies), it would be unscientific to attempt to categorise a clinical application based on this principle. It is tempting to extrapolate from the disuse theory that using functional appliances to correct skeletal Class II malocclusions by encouraging mandibular growth rather than accommodating the teeth by extractions, represents the ideal approach to treatment, since according to this paradigm, it would be effectively 'treating the cause' of the malocclusion. However, by this reasoning, if the treatment objective was to correct the malocclusion by returning the dentition to an atavistic state, it would be necessary to reproduce the very heavy wear that was ubiquitous in the ancestral environment; the characteristic Class I/Class III occlusal relationship of pre-industrial man was absolutely dependent on this attritive morphology and the two features were intimately related. This may therefore be an unrealistic reference for a modern anatomical ideal. Indeed, it has been discussed elsewhere and in greater detail[27-29] that the ideally intercuspated Class I occlusion to which clinicians aspire today, is in nature a juvenile arrangement, rapidly lost as the teeth and jaws dynamically accommodate to rapid occlusal and interproximal wear.

While most of the discussion in this and other similar studies centres on occlusal wear, the importance of interproximal wear should not be overlooked, as this was the trait noted by Begg to provide sufficient arch length to accommodate all thirty-two teeth in the Aboriginal and Stone-Age dentitions. Aboriginal subjects have been observed to routinely display crowded arches during childhood, which were soon relieved by a combination of interproximal wear and occupation of the space of Nance, both of which were considerable in these populations.[28] This 'dynamic' occlusion model also suggested a phenomenon of lifelong mesial migration of the dentition – facilitated by interproximal wear – which, in a heavily worn Class I occlusion, served not only to relieve crowding but also maintain the incisor relationship. If this ancestral feature was somehow retained as an intrinsic property of the physiology of the dentition, even in the absence of attritive wear, this may have implications for late lower incisor crowding, third molar eruption and post-treatment retention. However, since the dynamic occlusion/mesial drift model posits an unproven and somewhat speculative phenomenon, it would be inappropriate to attempt to credit it with any clinical value at this stage (the most obvious being theoretical support for extraction treatments as in Begg,[10]) in the same way that it would be erroneous to justify non-extraction functional treatments by citation of the disuse theory.

In clinical orthodontics, it is still a requirement to base diagnoses and treatment plans on the limited parameters of the patient's presenting skeletal and dental relationships, irrespective of whatever may be the supposed phylogenic cause of their deviation from the ancestral anatomical ideal. In this regard, proximate ontogenic causes for malocclusion are of more immediate interest to the clinician, and it would be wise to avoid deriving empirical conclusions from hypothetical paradigms.

For now, anthropological evidence suggests that the challenge of clinical orthodontics is to retain for life what is, in nature, a temporary childhood arrangement, which may be a useful perspective for those whose research involves stability, retention and the long-term follow-up of orthodontic patients. Furthermore, an understanding of the anthropology of orthodontics places malocclusion in the category of afflictions attributable to human mal-adaptation, whereby the great divergence between the environment, for which humans are primarily adapted and that which those of us in industrialised nations inhabit, brings about novel clinical phenomena, the so called 'diseases of civilization'. These are much better understood when considered through the lens of the growing and topical field of evolutionary medicine, which already adds a novel perspective to the study of various metabolic, autoimmune and psychological disorders.[30,31]

Conclusion

Using careful selection criteria and a standard methodology in a hitherto unreported sample, the present study was successful in its aim of contributing to the body of evidence on occlusal variation in pre-industrial populations. The main findings were similar to those of earlier studies and support the characterisation of malocclusion as a 'disease of civilization'. A necessary modification of the planned inclusion criteria highlighted a difficulty in occlusal studies of ancient materials, and this modified methodology is offered as a model for those wishing to undertake similar future studies.

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Conflicts of Interest

None declared.

Corresponding author

Dr Aidan McKeever
Whitetree Specialist Centre
1-3 North View
Bristol BS6 7PU
United Kingdom

Email: aidanmckeever@outlook.com

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