Palate morphology of bruxist children with mixed dentition. A pilot study

C. C. RESTREPO*, C. SFORZA†, A. COLOMBO†, A. PELÁEZ-VARGAS* & V. F. FERRARIO†
*CES-LPH Research Group, Medellín, CES University, Colombia and †Laboratory of Functional Anatomy of the Stomatognathic Apparatus, Department of Human Morphology, University of Milan, Milan, Italy

SUMMARY The objective of the study was to analyse quantitatively palatal morphology in bruxist and non-bruxist children with mixed dentition. Twenty-three children with mixed dentition were classified as bruxist according to their anxiety level, audible occlusal sounds related by the parents and signs of temporomandibular disorders; 23 children were control subjects matched for gender, age, and dental formula. The maxillary dental arches of all subjects were reproduced from alginate impressions cast in dental stone with a standardized technique. The casts were digitalized and mathematical equations were used to obtain the form of the palate in the sagittal, frontal and horizontal planes. Bruxist children had a statistically significant longer palate in the sagittal plane than control children; palatal shape differed especially in correspondence of the third, fourth and fifth teeth, bruxist children showing a relatively higher palate than control children.

In this pilot study, sagittal plane differences in the palate between bruxist and non-bruxist children matched for age and gender were found. Further investigations are needed to understand better the clinical implications of the findings. Results should be taken into account in the diagnosis of the occlusal development in children with parafunctions to prevent future abnormalities: a bruxist child may have bigger dental arches than a normal child.

KEYWORDS: palate, bruxism, growth and development, morphometry

Accepted for publication December 9 2007

Introduction

The aetiology of bruxism has been defined as multifactorial (1). It is mainly regulated centrally, but influenced peripherally (2). Oral habits (3), temporomandibular disorders (TMD) (4–7), malocclusions (8, 9), hypopnoea (10), high anxiety levels (11) and stress (12) among others (13) could influence the peripheral occurrence of bruxism. These factors act as a motion stimulus to the central nervous system, which reacts with an alteration in the neurotransmission of dopamine (14, 15) and the answer is the clenching or grinding of the teeth.

The effects of bruxism on teeth (16, 17) as well as on facial morphology (18–20) have been widely studied, but its relationship with the function and/or the shape of the upper maxilla or jaw has not been reported in children, although alterations in the hard palate of adult bruxists, such as torus palatinus have been reported (21).

In particular, the analysis of palatal normal morphology in bruxist children appears to have been neglected so far. Quantitative investigations of normal palatal size and shape are infrequent. As reviewed elsewhere (22, 23), the main shortcoming seems to be technical: direct techniques in which several standardized landmarks are used as endpoints for caliper measurements are time-consuming and prone to error and cannot be used with the current computerized methods of treatment planning. Indirect analyses with the use of two-dimensional projections (radiographs, photographs or photocopies) are insufficient for the
palate, while the loss of the third dimension does not significantly influence dental arch form in the horizontal plane; it hinders most investigations of palatal morphology.

Currently, technology provides three-dimensional digitizers that can be directly used on dental casts to supply the metric coordinates of selected landmarks. The coordinates can be used for any kind of mathematical modelling. Optical devices, electromechanical instruments, electromagnetic digitizers have all been used to collect three-dimensional data on the human palate in both normal individuals and patients with alterations in craniofacial structures (22–25). In contrast, quantitative three-dimensional methods have never been used for the assessment of palatal characteristics in bruxist children.

The quality and hardness of the food had become more processed and soft from time to time. The dietary consistency affects craniofacial growth (26). When the food is not hard enough, the teeth do not wear naturally, with a resulting insufficient growth of the alveolar base in children. Lacking the adequate stimuli, arch size is not sufficient for teeth eruption (27). When bruxism occurs, the dental wear is higher, so the contacts between the upper and the lower teeth are bigger and flatter than with natural chewing. Those contacts allow the horizontal movements of the mandible against the upper jaw and the stimuli to the alveolar bone is higher (27, 28).

The aim of this investigation was to analyse quantitatively palatal morphology in bruxist and non-bruxist children with mixed dentition. Bruxism involves a higher activity of the masticatory muscles in the affected children (1) and higher size of dental wear (29), and this may provoke alterations in hard tissue structures, which could lead to higher size of palate in the bruxist children.

This study was developed as a first approach to accomplish the hypothesis that a higher activity of the muscles previously reported in animal models (30) could modulate the sagittal growth of the maxillary arch. The reason is that the palatine raphe acts as a fulcrum and produces an expansion of the arch when a labialization of the alveolar process occurs.

Materials and methods

A case–control study was performed. The procedures, possible discomforts or risks, as well as possible benefits were fully explained to the participating patients and their parents and the informed consent from the parents was obtained prior to the investigation. Institutional Ethics Committee of the CES University approved the study.

Subjects

Participating children were Colombian (mean age bruxist children 9·3 years, s.d. 0·8; control children 9·4 years, s.d. 0·7) and they were required to be healthy with normal facial morphology, complete primary teeth, presence of dental wear, no history of trauma present and absence of other types of oral habits, such as mouth breathing, tongue thrusting or sucking habits. The sample size was calculated with a confidence of 95% and a statistical power of 80%. The number of subjects required in each group to make comparisons was 19.

Inclusion criteria

An evaluation of the temporomandibular joint (TMJ) was performed on all the children together with a questionnaire and a clinical examination according to Bernal and Tsamtsouris (31).

Children’s anxiety was measured using the Conners’ Parents Rating Scales (CPRS; 32). Both instruments, the Tsamtsouris and Bernal and CPRS tests had been previously used to diagnose bruxism in children.

Children were included in the bruxist group \((n = 23)\) when their anxiety level was above 0·75% according to the CPRS, presented two or more signs of TMD according to Bernal and Tsamtsouris and they accomplished the classification criteria proposed by the American Academy of Sleep Medicine (AASM; 33) for bruxism. The AASM criteria for bruxism are the following:

1. The parents of the children indicated the occurrence of tooth-grinding or tooth-clenching during sleep.
2. No other medical or mental disorders (e.g., sleep-related epilepsy, accounts for the abnormal movements during sleep).
3. Other sleep disorders (e.g., obstructive sleep apnea syndrome) were absent.

All the parents were required to sleep close to their children for at least 2 weeks before the beginning of the study.
The children in the control group \((n = 23)\) accomplished the second and third criteria of the AASM, but not the first one.

One hundred and eighty eight Colombian children aged 8 to 11 years were initially evaluated. Forty-six individuals were finally selected and included in the study. Standardizations of the examiners and calibration of the techniques were made in 10 subjects. The methods were highly reproducible without statistically significant intra-tester and inter-tester errors (ICC\(^>0.9\), and Kappa >0.7).

**Techniques**

The maxillary dental arches of all subjects were reproduced from alginate impressions cast in dental stone. The models were stored for a week to avoid dimensional changes. For technical reasons, the models of two bruxist and seven control children were discarded, thus leaving a total of 23 children for each group.

All subjects had a mixed dentition in their maxillary arch, with permanent first molars, central and lateral incisors. In the control group, two children had second premolars, 12 children had first premolars and five children had permanent canines. In the bruxist group, one child had second premolars and six children had first premolars.

**Digitization of palates and mathematical equation**

The method has been described elsewhere (22, 23, 34, 35). In brief, on each cast, the intersections of the palatal sulci of the right and left sixth (first permanent molars in all occasions), fifth, fourth and third teeth with the gingival margin (landmarks 6R, 6L, 5R, 5L, 4R, 4L, 3R, 3L in Fig. 1), the incisive papilla (IP) and the most posterior limit of the palatal raphe (RP) were identified and marked. The intermolar 6R-6L line and its perpendicular starting from IP were traced and their intersection point was marked as M. On the IP-M, 6R-6L, 5R-5L, 4R-4L and 3R-3L lines, approximately 12–20 nearly equidistant points were then marked. The \(x, y, z\) coordinates of the landmarks were obtained with an electromagnetic three-dimensional digitizer (3Draw)† interfaced with a computer (15). Digitization of landmarks was performed by a single operator.

Computer programs devised and written by one of the authors were used for all the following calculations.

A common orientation for all palates was obtained by mathematically setting the plane described by IP, 6R, and 6L as horizontal \(x\)-axis, corresponding to the 6R-6L line, right-left; \(y\)-axis, anterior-posterior; and \(z\)-axis, caudo-cranial). Actually, this plane is tilted forward, no assessment of the spatial relationships between palate

---

*Intraclass Correlation Coefficient.

†Polhemus Inc., Colchester, VT, USA.

© 2008 The Authors. Journal compilation © 2008 Blackwell Publishing Ltd
and craniofacial structures was performed. For each palate, the following measurements were obtained:  
*Sagittal plane:*  
Palatal length, horizontal projection of the IP-M line (unit: mm).  
Palatal slope, slope of the maximum palatal height versus the horizontal axis (degrees).  
Maximum palatal height (mm).  
*Horizontal plane:*  
Angle between the IP-RP and the IP-M lines (RP, degrees).  
*Frontal plane:*  
Palatal widths and maximum palatal heights at the first permanent molars, fifth, fourth and third teeth (6R-6L, 5R-5L, 4R-4L and 3R-3L distances in mm).  
All coordinates were then standardized in the frontal plane as percentages of the intermolar distance 6R-6L (x coordinate) and in the sagittal plane as percentages of the horizontal projection of the IP-M distance (y coordinate).  
The curve of the palatal surface was fitted to a fourth-degree polynomial (13, 21): \[ y = a x + bx^2 + cx^3 + dx^4, \]
separately for the sagittal and the frontal (four curves corresponding to 6R-6L, 5R-5L, 4R-4L and 3R-3L) plane projections of the three-dimensional standardized (i.e., size-independent) coordinates of the digitized landmarks. In the frontal plane projection, the origin of axes was set at 6R, the \(x\)-axis corresponded to the right-left transverse line, and the \(y\)-axis to its vertical perpendicular. In the sagittal plane projection, the origin of axes was set at IP, the \(x\)-axis corresponded to the horizontal projection of the IP-M distance, and the \(y\)-axis to its vertical perpendicular. The four coefficients of the polynomial equation were computed using the least-square method, and the correlation coefficient \(r\) of the curve was also assessed (21).

**Statistical analyses**  
For each palatal measurement, descriptive statistics for each group (bruxists, control children) were calculated. Statistics for angular variables were computed using the rectangular components of the angles. In both groups, male and female data did not differ (Student’s \(t\)-test for independent samples) and pooled values were considered.  
The values obtained in the two groups were compared by Student’s \(t\)-test for independent samples; categorical variables were compared by Chi-squared test. In all cases, two-tailed tests were used with a level of significance set at 5%.

**Error of method**  
The intra-operator repeatability of the measurements was assessed by Ferrario et al. (13) by repeated tracings (landmark identification) and digitizations of the same casts. For each variable, the error of the method (error percentage) was calculated as the percentage ratio between the variance of the method error (squared Dahlberg’s error) and the population variance of that measurement (squared standard deviation). For landmark identification, the error percentage was always less than 10% of the total biological variance. For landmark digitization, the error percentage ranged between 1.76% and 8.26%.

**Results**  
The two groups of children (bruxist and control children) were matched for age (mean age bruxist children 9.3 years, s.d. 0.8; control children 9.4 years, s.d. = 0.7, \(P > 0.05\), Student’s \(t\)-test for paired samples) and sex (no differences in the sex distribution, \(P > 0.05\), Chi-square test).  
The sagittal length (IP-M in mm) and the raphe angle (angle between the IP-RP and the IP-M lines) were somewhat higher in the palate of the bruxist children than in the non-bruxist children (Table 1). Both measurements showed statistically significant differences when comparisons were performed including only the children with primary deciduous canines (five control children excluded). In contrast, when the children with permanent canines (late mixed dentition) were included in the analysis, only sagittal palatal height remained significantly longer in bruxist children.  
All palatal heights (in both the sagittal and frontal planes) were somewhat higher in bruxist than in control children, but the differences did not reach statistical significance.

Palatal shape independently from size in both the sagittal and frontal planes was well reconstructed by the four-order polynomials, with coefficients of correlation \(r\) ranging between 0.92 and 0.99.  
In both groups, palatal shape independently from size peaked in correspondence of the fifth teeth, and it decreased progressively in the fourth and third teeth.
area (Fig. 2). In the first permanent molar area, palatal shape was somewhat lower than in correspondence of the deciduous molar/premolar teeth. No differences between the two groups of children were observed in the sagittal plane. Overall, bruxist children had higher palate in the frontal plane than control children, especially in correspondence of the third, fourth and fifth teeth.

Analyses were also performed separately for the 15 control and 14 bruxist children who had no permanent teeth apart from the first molars (deciduous central and lateral incisors, canines, molars, permanent first molars); the same pattern of differences observed in the complete groups was found (data not shown).

### Discussion

It is difficult to compare the present findings with those of literature reports, because quantitative investigations of normal palatal size and shape are uncommon. Only three-dimensional computerized analyses can correctly assess palatal morphology (22, 36). Both surface-based and landmark-based methods have been used. Indeed, most surface-based approaches are time-consuming, requiring several scans for each cast, and they seem best suited for the analysis of selected patients (for instance, cleft-palate children), they are of difficult application for a wide-scale collection of data.

The major limitation of landmark-based methods seems to be the reduced number of digitized landmarks, which approximates the analysed structure neglecting most information (22, 24). In this investigation, palatal morphology was analysed along four left-right curves (third, fourth, fifth and sixth teeth) and one anterior-posterior curve (approximately corresponding to the palatal midline), thus supplying a sufficient approximation of its size and shape characteristics (23, 24).

**Fig. 2.** Palatal shape independently from size in bruxist and control children. Upper panel: sagittal plane projection; lower panel: frontal plane projection (all four curves are drawn). x-axis unit: % of 6R-6L distance; y-axis unit: % of IP-M distance.
The width of the upper arch had been previously estimated with single measurements like the intercanine distance (37), and correlated to habits and some para-functionalities, such as dummy-sucking, finger-sucking habit, oral breathing (38), breast and bottle sucking (37), but not with bruxism. In the sucking cases, the intercanine distance was reduced in the children who practiced para-functional activities. According to the present research, bruxism seems to have no effect on the palatal width when the bruxist children were compared with the control children.

In contrast, this para-function had some effect on both the length and the raphe angle of the palate when comparisons between the bruxist and the control group included in the analysis only the children with primary deciduous canines. Also, palatal shape modified with a relatively higher palate in bruxist than in non-bruxist children.

Both intercanine and inter-fourth teeth width were slightly larger in the bruxist children than in the control children, with mean differences of 0.8–0.9 mm. It is well known that the intercanine distance of the upper arch increases when primary canines exfoliate and the permanent canines erupt (39). It is possible that the higher muscular activity (40), the increased movements of the mandible (41, 42) and the higher bite force (43) through the upper arch during bruxism might have accelerated the modifications in palatal shape in the bruxist children. These bruxist forces stimulate the proprioception of the periodontal ligament (44) and the process of apposition – resorption (45) of the upper alveolar bone that leads the arch to growth both in length and in height. As the roots of the deciduous canines are shorter than those of the relevant permanent teeth, the dental structures present less resistance to movement.

The natural characteristics of the occlusal plane have been described elsewhere (46). Specific changes can be seen when the dentition grinds (47–49), not only occlusal changes (50, 51) (shortening and widening of the dental is seen, creating space for erupting and migrating teeth) but also cephalometric changes (52). In fact, dramatic transformations in the craniofacial morphology and the dentoalveolar development can be seen when pre-historic and present day populations are compared. This could be a possible explanation for the significantly longer palate in bruxist children than in control children.

In this study, the two analysed groups (bruxist and non-bruxist children) were matched for gender and age. When boys and girls were separately analysed, no gender-related patterns were found. Indeed, Slaj et al. (53) showed that in the early mixed dentition, longitudinal comparisons of width, depth and dental arch segment–length changes between male and female subjects did not yield any statistically significant difference in a 2-year period. Also, no effect of the exfoliation of deciduous molars/eruption of premolars was observed.

Conclusions

This investigation showed sagittal plane differences in the palate between bruxist and non-bruxist children matched for age and gender. In bruxist children, the higher muscular activity (19, 20, 54, 55) and the dental wear may have accelerated the normal developmental modifications in the palatal shape. This finding has to be taken into account in the diagnosis of the occlusal development in children with para-functions, because if a child has bruxism, then his/her arches could be bigger than the ones of a child without bruxism.

This was a pilot study, and accordingly, data interpretation and conclusions should be judicious until further studies are conducted. The differences in palatal proportions found in this study were small, although some of them were statistically significant, and may therefore not be so clinically significant.

References

6. Magnusson T, Egermark I, Carlsson GE. A prospective investigation over two decades on signs and symptoms of
temporomandibular disorders and associated variables. A final
8. Demir A, Uysal T, Guray E, Basciftci FA. The relationship between bruxism and occlusal factors among seven-
9. Sari S, Sonmez H. The relationship between occlusal factors and bruxism in permanent and mixed dentition in Turkish
10. Oksenberg A, Arons E. Sleep bruxism-related to obstructive
sleep apnea: the effect of continuous positive airway pressure.
11. Manfredini D, Landi N, Fantoni F, Segui M, Bosco M. Anxiety
12. Tsai CM, Chou SL, Gale EN, Mccall JR. Human masticatory
muscle activity and jaw position under experimental stress.
14. Lobbezoo F, Soucy JP, Montplaisir JY, Lavigne GJ. Striatal d2
receptor binding in sleep Bruxism: a controlled study with
iodine-123-iodobenzamide and single-photon-emission com-
15. Lobbezoo F, Soucy JP, Hartman NG, Montplaisir JY, Lavigne GJ. Effects of the d2 receptor agonist bromocriptine on sleep
1997;76:1610–1614.
3-D device for the detection of wear. J Dent Res. 1997;
76:1799–1807.
17. Kerstein R. Disclosure time measurement studies: stability of
disclosure time – a 1-year follow-up. J Prosthet Dent.
18. Krosgstad O, Dahl BL. Dento-facial morphology in patients with
19. Waltimo A, Nystrom M, Kononen M. Bite force and dento-
facial morphology in men with severe dental attrition. Scand J
Craniofacial morphology, occlusal traits, and bite force in
persons with advanced occlusal tooth wear. Am J Orthod
21. Kerdpon D, Sirirungrojying S. A clinical study of oral tori in
southern Thailand: prevalence and the relation to parafunc-
22. Ferrario VF, Sforza C, Schnitz JH, Colombo A. Quantitative
description of the morphology of the human palate by a
mathematical equation. Cleft Palate Craniofac J. 1998;35:396–
401.
23. Ferrario VF, Sforza C, Colombo A, Dellavia C, Dimaggio FR.
Three-dimensional hard tissue palatal size and shape in
141–147.
24. Ciusa V, Dimaggio FR, Sforza C, Ferrario VF. Three-dimen-
sional palatal development between 3–6 years of age. Angle
25. Ferrario VF, Sforza C, Tartaglia GM, Sozzi D, Caru A. Three-
dimensional lip morphometry in adults operated on for
of dietary consistency on the mandible of rats at the growth
stage: computed X-ray densitometric and cephalometric
27. Simoes WA. Selective grinding and Planas’ direct tracks as a
28. Simoes WA. Better oral neurophysiology information gives
imaging of patterns of dental wear to diagnose bruxism in
30. Tuxen A, Rostrup E. Histochemical characterization of pig
31. Bernal M, Tsamtsouris A. Signs and symptoms of temporom-
andibular joint dysfunction in 3 to 5 year old children.
32. Conners CK, Sitarenios G, Parker JD, Epstein JN. The revised
Conners’ Parent Rating Scale (CPRS-R): factor structure,
33. Buysse DJ, Young T, Edinger JD, Carroll J, Kotagal S. Clinicians’ use of the international classification of sleep
34. Ferrario VF, Sforza C, Colombo A, Tartaglia GM, Carvajal R,
Palomino H. The effect of ethnicity and age on palatal size and
shape: a study in a northern Chilean healthy population. Int J
35. Ferrario VF, Garattini G, Colombo A, Filippi V, Pozzoli S,
Sforza C. Quantitative effects of a nickel-titanium palatal
expander on skeletal and dental structures in the primary and
definition of the shape of dental arches in human permanent
37. Ogaard B, Larsson E, Lindsten R. The effect of sucking habits,
cohort, sex, intercanine arch widths, and breast or bottle
feeding on posterior crossbite in Norwegian and Swedish
38. Valera FC, Travitizki LV, Mattar SE, Matsumoto MA, Elias AM,
Anselmo-Lima WT. Muscular, functional and orthodontic
changes in pre school children with enlarged adenoids and
39. Moortrees CF, Reed RB. Changes in dental arch dimensions
expressed on the basis of tooth eruption as a measure of
40. Cosme DC, Baldisserotto SM, Canaharro Sde A, Shinkai RS.
Bruxism and voluntary maximal bite force in young dentate

Correspondence: Claudia C. Restrepo, Carrera 38 No. 6 B Sur 25, Apartamento 1002, Medellin, Columbia.
E-mail: martinezrestrepo@une.net.co, rarestre@une.net.co