Symmetry Analyses of the Palate and Maxillary Dental Arch*

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Asymmetry, deliberately reproduced in ancient Greek art as a naturally occurring phenomenon, was demonstrated by Hasse[1] in 1887 to be a feature of every human face. In fact, a perfectly symmetrical face would have an unpleasant, mask-like appearance, with the unreality of a window-display mannequin,[2] as Hallervorden[3] graphically showed by means of composite photographs of each side of a face with its mirror image.

Yet a subjectively determined point exists at which orofacial asymmetry becomes clinically significant because it is to some extent disfiguring. As such, dental arch shape and its relationship to facial asymmetry must be evaluated by the orthodontist, but the planning and prognosis of treatment are often hampered because the origin of the asymmetry is unknown.

It is commonly alleged[4-6] that muscle activity plays an important role in determining the shape of the dental arches, and an accurate method for assessing contour, symmetry and stability of the dental arches is a prerequisite for investigations[7-9] of this form-function relationship. Various approaches to the study of arch shape have been described but they were either best suited for simple visual analysis or, when maximal accuracy was desired, techniques and equipment were employed whose cost and complexity preclude their general application.

This paper describes a method for graphic and metric appraisal of arch and palate form, using a relatively simple procedure. Additionally, some difficulties inherent in the study of symmetry are discussed.

The initial problem lies in adequately defining symmetry. For instance, Stein[10] points out that the term may imply both "regularity of form or arrangement with reference to corresponding parts," and, more comprehensively, "correspondence in size, form and arrangement of parts with reference to their position on opposite sides of a plane, line, or point."

It follows therefore that in symmetry studies, consideration should be given to (a) correspondence in the contours of left and right sides of the dental arch, and (b) the relationship of these contours to a predetermined midplane. While independent consideration of these two interrelated concepts assists in locating discrepancies, it should be acknowledged that the *midplane* itself is an abstraction determined by the "best fit" between centrally located anatomic points. The investigator has thereby arbitrarily ascribed greater stability to such median reference points than to the bilateral structures that are examined.

In a biological complex so variable and intricate as the human orofacial region, no reference system is likely to meet all requirements or satisfy all critics. Nevertheless, traditional studies of maxillary symmetry have used the raphe palatinus plane, which was also employed in the present study because of its ease of location directly on the dental cast. Additionally, Lundstrom[11] has indicated that the midpalatal plane is no less reliable than other orientation systems.

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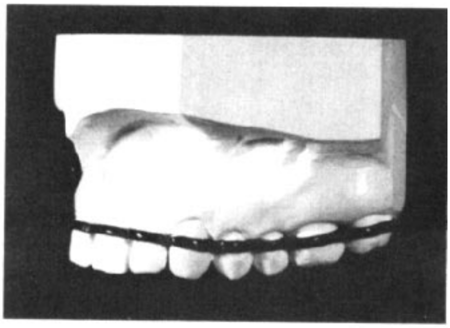

Fig. 1 Maxillary dental cast with strip of casting wax extending buccally from the left second molar to its antimere, at the level of the crests of the interdental papillae.

The photographic technique described below reveals the extent to which left and right maxillary dental arches and the transverse palatal outlines have similar contours. It also shows the relation of these segments to the raphe midplane.

Materials and Methods

Assessment of dental arch symmetry:

A continuous clasp was waxed to the buccal surfaces of the teeth on an investment maxillary dental cast. The wax strip ran at the level of the interdental papillary crests, from the left second molar to the corresponding point on its antimere (Fig. 1). The wax pattern was cast in technique metal, the sprues to a central reservoir being retained for stabilization. Each casting was taped to a cassette and radiographed in a Broadbent-Bolton cephalometer, the resulting silhouette being used to produce positive transparencies (Fig. 2).

In order to compare the contours of right and left arch segments, the transparency was folded and cut in two, the line of division running between the central incisor contours. The halves were superposed to obtain the "best fit" of the buccolabial aspects of the central incisors and the first molars. While maintaining this relationship, marker patterns in register were affixed to each half. Thus, visual or metrical comparison of the contours of left and right maxillary arch segments could be made at any time simply by placing the marks in register. However, differences between the arch contours could be appreciated better by making a single print on which left and right segments had different color contrasts. For this purpose separate negatives were made from each half of the transparency. These negatives were superposed on the registration marks and their margins trimmed at 90°.

A sheet of contact printing paper was trimmed to exactly the same size and shape as the negatives. The negative from the right arch segment and the contact paper were held with their edges against a right-angled guide, and a one second exposure was made. The negative of the right side was removed, replaced with the negative of the left segment, and a two second exposure was given to the same sheet of printing paper. After development, a print resulted which accurately reproduced the original superposition of transparency halves, but in addition the

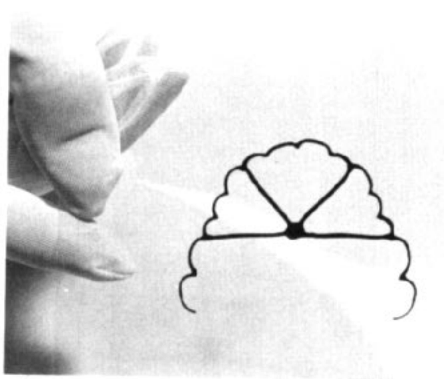

Fig. 2. Transparency produced from the radiograph of a continuous buccal clasp fabricated as shown in Fig. 1. In order to reinforce the otherwise fragile casting, the sprues were not cut off, but their silhouette was etched out of the transparency before proceeding.

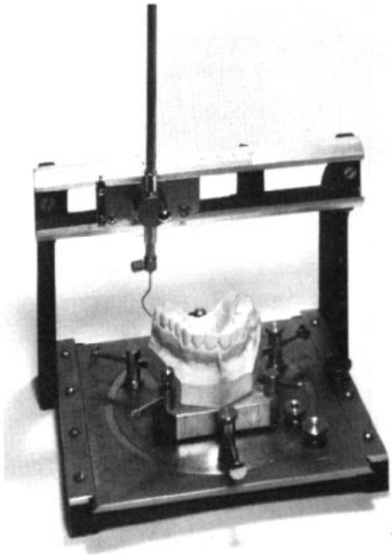

Fig. 3. Korkhaus symmetrograph with dental cast oriented so that the raphe midplane was perpendicular to the instrument's base. The end point of the upright sliding rod was positioned so that it just touched the maximal buccal convexity of the left second molar when the base platform was moved back and forth. The distance from this point to the midline was read off from the scale on the top of the instrument. Readings were also taken from the left first premolar to the midline, in addition to similar measurements for corresponding teeth on the right side. (The symmetrograph's parallelogram linkage is not required in this technique).

right segment now appeared gray, and the left, black.

Symmetry of the segments in terms of their relationships in the horizontal plane to the raphe midline was assessed by placing the cast on the platform of a Korkhaus[12] symmetrograph, and orienting it so that the vertical plane containing the median raphe was perpendicular to the base of the instrument, as detailed by Lebret.[13] Using the upright sliding rod of the symmetrograph, horizontal distances were measured between the midpalatal plane and the following points (Fig. 3):

a. The maximum buccal convexity of (i) the left second molar and (ii) the left first premolar, at the level of the casting of the arch contour.

b. The corresponding points on: (i) the right second molar, and (ii) right first premolar.

In order to mark the midpalatal line in its correct position on the transparency, a fine straight pencil line was first drawn on a sheet of paper which served as the "datum" or "mid" line. To the left, a second line was drawn parallel to the first one, so that the distance between these lines equalled *a(i)* above. Similarly, a third line was drawn whose distance from the initial line equalled *a(ii)*. To the right of the datum line, fourth and fifth lines were drawn at distances equivalent to *b(i)* and *b(ii)*.

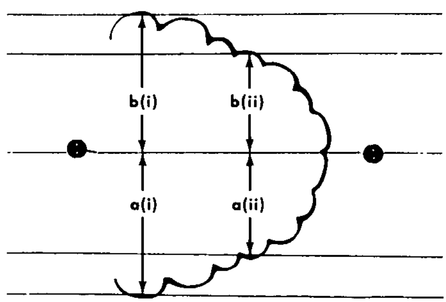

Fig. 4. Grid based on distances from midpalatal plane to maximal buccal convexity of the following teeth: maxillary left second molar, dimension *a(i)*; left first premolar, *a(ii)*; right second molar, *b(i)*; right first premolar, *b(ii)*; (see text and Fig. 3). The transparency of the buccal tooth contours was superposed on the grid so that the lines were tangent to the maximum buccal convexity of the appropriate teeth; hence, the grid center line bore the same relation to the silhouette as the median raphe bore to the teeth on the cast. The relationship of the segments to the midpalatal plane was revealed by folding the transparency along this median line, that is between the pinholes. For clarity in reproduction the grid has been thickened; in practice, fine lines were used to enhance accuracy.

A second, unfolded transparency of the arch contour was positioned over these lines so that the maximum buccal convexity of the left second molar was tangent to the second line, and the maximum buccal convexity of the left first premolar was tangent to its reference line (Fig. 4). Corresponding tangent relationships were established for the right side. Only one orientation of the transparency was possible which would fulfill the above conditions and, when so oriented, the datum line had the same relationship to the silhouette of the dental arch as the palatal midplane bore to the buccal contours of the teeth themselves. Accordingly, when the datum line was transcribed onto the transparency, and a fold made along this line, any discrepancy in the relationship of the left and right dental arch segments to the midplane was revealed, the differences being more easily visualized when a print with differential contrasts was made by the technique already described.

Assessment of palatal vault symmetry:

Silhouettes of the transverse palatal contour were made by sealing half-round wax strips to the dental cast along lines which ran at right angles to the midplane between left and right premolar contact regions $(Pm_1\text{-}Pm_2)$ and from the right and left intermolar $(M_1\text{-}M_2)$ regions. Where necessary, mesiodistal discrepancies at the termini of the lines (the contact points) were averaged. The dental cast was slightly indented at the intersection of the transverse and midpalatal lines to leave a small projection at the palatal midline, when the wax pattern was cast in technique metal. Two transparencies were made from radiographs of each casting in the manner already described. One such transparency was folded to produce the "best fit" of the two sides of the palatal contour with the midpalatal point registered, thus showing the degree of homogeneity in shape between left and right sides of the palate.

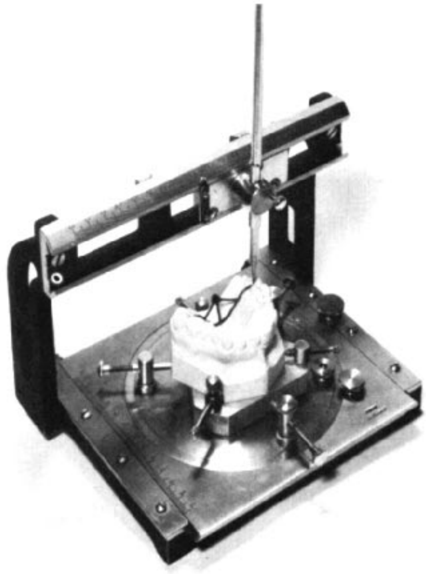

Fig. 5. Dental cast oriented in symmetrograph to determine distance from the extremities of the transpalatal casting to the median raphe.

To compare the relationship of each half of the palate to the raphe midplane, the metal castings were placed on the dental cast in the symmetrograph, and the horizontal distance measured between the extremities of the castings and the midline (Fig. 5). Using these measurements, an orientation grid was constructed similar to that detailed above. The relation of the left and right sides of the palate to the raphe median plane was revealed by folding the transparencies along the datum line, dividing them, and printing in sequence as described previously.

To demonstrate the potential of the technique, comparisons of bilateral contours of arch and palate are shown for two individuals.

Both subjects were young adult males, with neutroclusion of molars and canines, and a regular alignment of teeth which was esthetically acceptable and

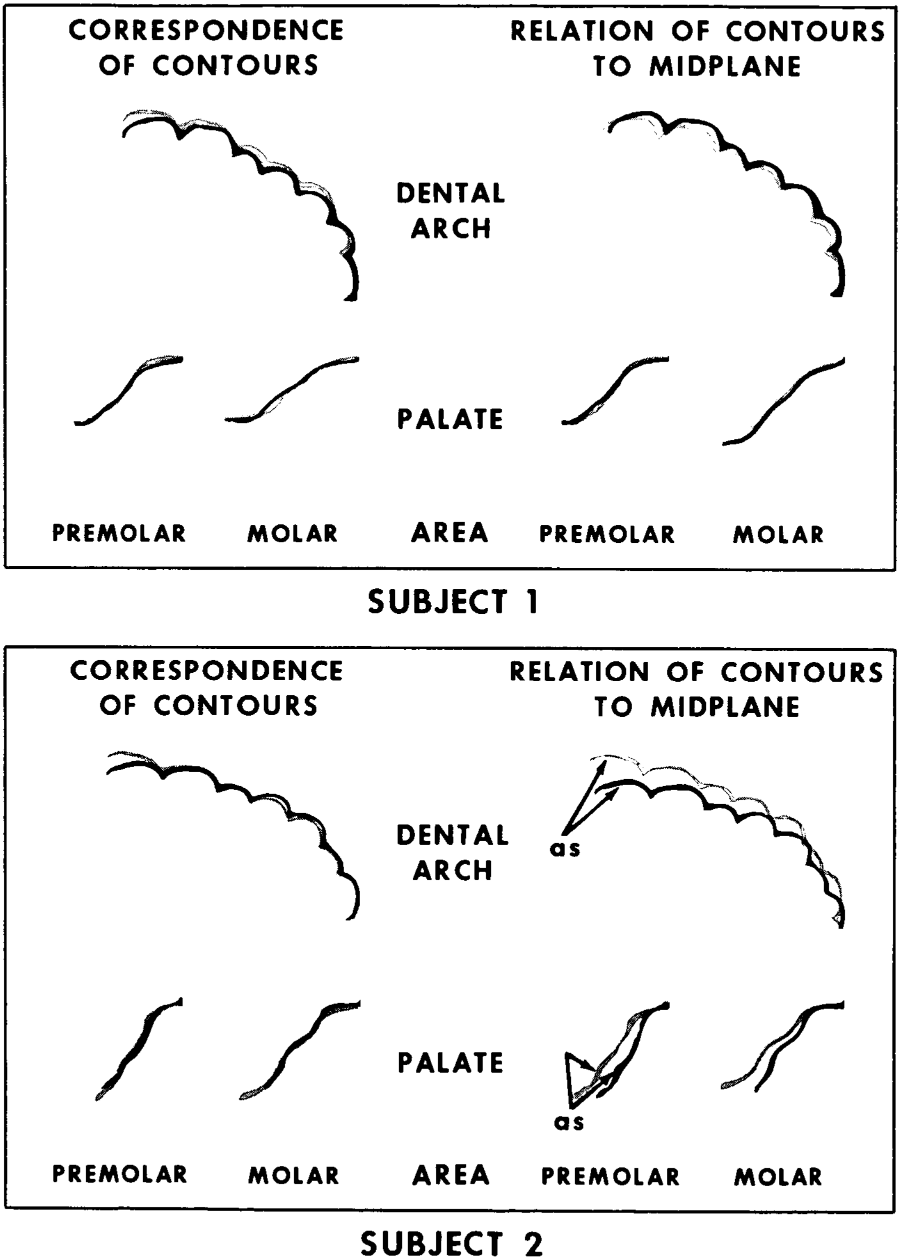

Fig. 6 Superpositions of palate and dental arch contours for two subjects showing the extent of correspondence in shape of left and right sides, and the relationship of the contours to the raphe midplane. Thickness of the silhouettes should be ignored since only the relationships of the anatomical surfaces *(as)* are of significance. In every case the left side is black and the right side gray.

apparently functionally correct. Neither case showed clinically conspicuous facial or intraoral asymmetry.

Results

When contours of the arch segments were compared (central incisors and first molars registered to give "best fit"), it was found that in each individual left and right sides were closely similar, except that in both cases the right second molar was displaced buccally (Fig. 6). Using the raphe midline registration, superposition of the palatal contours in premolar and molar regions also showed a close left-right correspondence in shape, although the right side of the palate was broader in the second subject.

Notwithstanding the general similarity in shape of arch and palate segments, the relationships of each side to the raphe midplane revealed slight asymmetry in the first subject and marked asymmetry in the second subject. The latter exhibited a maximal discrepancy of 5.7 mm in the relationship of arch segments to midplane. The left-right transpalatal contours were separated by as much as 4.4 mm and 6.2 mm, respectively, in premolar and molar regions.

The superposition also revealed that the dental midline (contact point of the central incisors) did not coincide with the raphe midline (based on landmarks in the posterior two thirds of the palate). This finding indicated that the maxillary dentition was displaced to the right of the raphe line. It is noteworthy that the subject did not show clinically conspicuous asymmetry of the midface.

Discussion and Summary

Asymmetry may be studied on dental casts by modifications of map-making techniques,[14] although high precision, complex and expensive equipment is required. Moreover, orientation of the cast is critical and calls for preliminary computer analyses. Other graphic methods employ contact points[15] or cusp tips[16] as references for studying arch symmetry but interproximal or occlusal wear may pose serious problems in determining the datum points. Symmetrograph tracings[13] of arch and palate contour are readily made, but tolerances in the parallelogram linkages may give rise to appreciable errors.

The technique described here overcomes the above limitations and furnishes visible evidence of the location and extent of arch and palate asymmetries. Metric data may also be derived. Additionally the system is readily adaptable for longitudinal studies of changes in tooth position or palatal contour caused by growth, function, or treatment.

The usefulness of the method has already been established in two studies on the relationship of muscle action and dental arch form.

In a preliminary reexamination of the hypothesis[7,8] that head posture during sleep is related to shape of the dental arches, it was found that a preference for pressing one side of the cheek into a pillow at night did not result in asymmetrical arches. Conversely, it was observed that a markedly asymmetric arch developed in a subject who spent equal portions of the night with left and right cheeks pillowed. The conclusion was reached that the traditional but unsubstantiated[17,18] hypothesis relating arch form to sleep posture needs reconsideration.

Another study[9] of the total labiolingual forces exerted on the dentition over 24 hour periods has shown that dental arches may remain stable in width for at least a year in the presence of lingual forces which exceeded those from the buccal muscles by a ratio of as much as 3:1. In another case, an asymmetrical arch had developed and remained asymmetrical for an extended period despite being surrounded by lingual forces of identical magnitude on the left and right sides which were exactly counterbalanced by the buccal forces.

Such studies indicate that the form-function interrelationship is more complex than generally acknowledged. Hence there is an obvious need to continue the development of biometric techniques for measurement of morphological characteristics, and for determining the nature of the multiplicity of forces which fall on the dentition, as well as the response of the supporting tissues to those forces.

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