ACTA STEREOL 1982; 297-304
STEREOL 82 SHEFFIELD.

A THREE DIMENSIONAL ASSESSMENT OF DENTAL ASYMMETRY IN HUMAN MAXILLARY FIRST PREMOLAR TEETH

SIVAPRAGASAM SRI-SKANDA, JOHN GERALD CLEMENT and ERIC DYKES
The London Hospital Medical College, Department of Dental Anatomy, Turner Street, London E1 2AD England

ABSTRACT

In previous studies dental asymmetry was assessed from two dimensional measurements made on teeth. To describe dental asymmetry better, this study extends the measurements to three dimensions. Five contralateral pairs of extracted human maxillary first premolar teeth were investigated. The asymmetry is described in terms of difference in volumes of the contralateral pairs of teeth and their major components viz. enamel, dentine and pulp. An asymmetry was observed in enamel, dentine and pulp. However, the asymmetry was greater in enamel than in any of the other components. Some evidence to suggest that the local environmental conditions contribute in bringing about the dental asymmetry is discussed.

INTRODUCTION

Teeth are bilateral structures in the body. They are formed from an interaction involving both ectodermal and mesenchymal tissues. All the hard tissues of the tooth are formed incrementally and, once formed, are subject to little, if any, turnover. The incremental patterns of the enamel, dentine and cementum can give information about severe systemic disturbances affecting the individual and his growth whilst his teeth were forming. Furthermore, the crowns of teeth are unusual, if not unique, in that they are fully formed before coming into function. For this reason in teeth the phenotype may more closely express the characters of the genotype than any other organ system. Assuming the genotype and environment affect both right and left sides to the same extent, a symmetry of the resulting contralateral pairs of teeth should result. For contralateral pairs of teeth to be considered symmetrical they should not only be of similar shape and size, but should also contain within them identical incremental patterns.

Previous studies of the size and shape of contralateral pairs of teeth have detected asymmetry. This asymmetry has no observed predeliction for left or right side, even for all the contralateral pairs of teeth for a single dentition (Garn et al, 1966). The phenomenon has been termed fluctuant dental asymmetry (Van Valen, 1962) which has been found to increase in some genetic (Sofaer, 1979; Barden, 1980) as well as environmental conditions (Perzigian, 1977; Harris and Nweeia, 1980).

All previous workers have assessed tooth size from two dimensional measurements on either teeth or replicas of the teeth made from dental impressions. Dimensions chosen for measurements are usually the intercuspal distances, maximum mesio-distal diameters and maximum bucco-lingual diameters. It has been necessary to study large numbers of teeth because of the lack of well defined landmarks on the teeth (Garn et al, 1979).

The aim of the present study on dental asymmetry was to extend the measurement previously restricted to the external surface of the crown to measurement derived from the whole tooth. This approach also made it possible to accurately calculate the relative contribution of each of the major structural components of the tooth (enamel, dentine and pulp) to the resulting asymmetry.

MATERIALS AND METHODS

Five pairs of contralateral human maxillary first premolar teeth extracted for orthodontic reasons were collected and documented. They were fixed in 10% formalin. Prior to embedding, they were washed in distilled water, taken through a series of solutions of ascending order of concentration of methanol till 100% was reached. The teeth were further rinsed for two weeks in a Soxhlet with 1:1 mixture of methanol and chloroform, and then embedded in methyl methacrylate resin. Polymerization of methacrylate was allowed to progress slowly at room temperature to allow better infiltration over a period of two weeks. These methacrylate blocks were re-embedded in methyl methacrylate resin. The polymerization was allowed to occur at 35°C over three days. The embedded specimen was blocked out to an approximate dimension of 30 x 25 x 20mm. On one face of the block three 'V' shaped fiducial marker grooves, two of them parallel with each other at a known distance apart and the third groove in between the former at a known angle to them were milled in. The grooves were then filled in with pigmented methyl methacrylate.

The specimens were sectioned serially in a transverse plane with a fast rotating diamond impregnated metal disc cooled by water. Around 25-30 sections of 400 ± 100µm thickness were made from each tooth. Each section contains three fiducial markers arising from the three grooves milled into the face of the original block. The two outer parallel fiducial markers allow alignment of each section to its neighbour in the X,Y plane whilst the varying position of the diagonal fiducial marker gives the position of the section (Z value) in the original unsectioned block.

Each section in turn was firmly fixed to the stage of an X,Y co-ordinate plotting microscope (Dykes and Clement, 1980) and the outlines of the sectioned structures were digitised by reference to the fixed cross-wires present in the eyepiece of the microscope. In order to digitise an outline in the section, a point on the outline is made to coincide with the cross-wires visible in the eyepiece of the microscope. Depression of a foot pedal transfers the X,Y co-ordinates displayed on digital voltmeters to punched paper tape. Movement of the section is achieved by rotation of the X and Y micrometers such that another point on the chosen outline is made to coincide with the cross-wires and is output onto paper tape. This is repeated until the whole outline has been converted to X,Y co-ordinates. Also digitised in each section are the three fiducial markers.

Programs for orientating every section to a common origin and magnification have been described by Kimura et al (1977). From all the X,Y co-ordinates stored, areas enclosed by outlines in each section were calculated and using the Z value calculated for each section it is possible from these areas to calculate volumes (Sullivan, 1976).

All computer programs were run at the University of London Computer Centre on a CDC 6600 machine.

RESULTS

Figure 1 gives an example of what was actually traced from one of the sections of one of the teeth used in the series. All the outlines for one tooth superimposed on each other as shown in Figure 2.

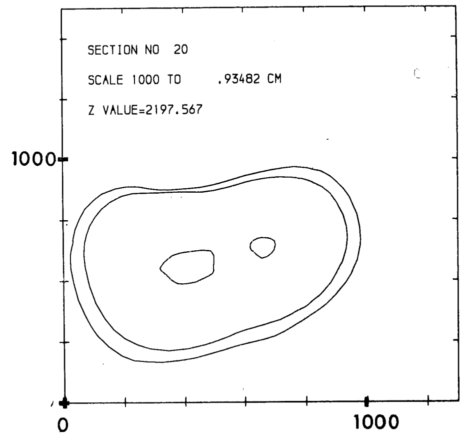

Fig.1 A computer generated drawing of section No.20 of the maxillary right first premolar (Tooth pair No.1 - see Tables 1 and 2). Four traced outlines i.e. enamel, enamel-dentine junction and two dentine-pulp junctions are shown. The Z value quoted is an arbitary value but the difference in Z values between adjacent sections gives the true separation of the sections.

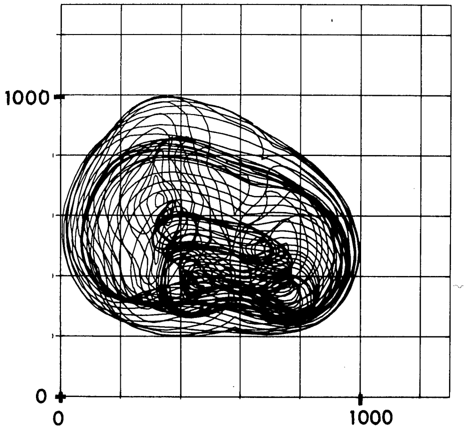

Fig.2 All 29 of the traced sections for the maxillary right first premolar (Tooth pair No.1) superimposed on each other.

Using the program described in the preceding paper, it is possible to reconstruct the sectioned teeth and view them as a stereo pair (Figs.3 and 4).

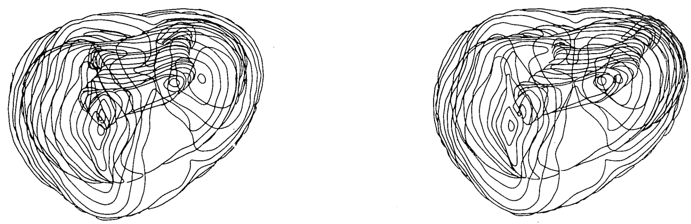

Fig.3 Stereo pair with an interocular angle of 6° showing the occlusal view of the maxillary right premolar tooth (Tooth pair No.1).

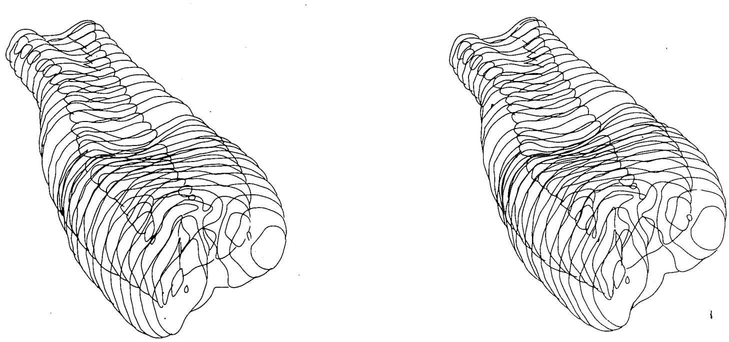

Fig.4 Stereo pair of same tooth shown in Fig.3 after a rotation about the X axis by 30° and the Y axis by 30°.

The volumes of the dentine and pulp for the 10 teeth studied are given in Table 1 and Table 2 shows the volumes for enamel and for each of the 10 whole teeth in the study.

TABLE 1 Volumes (cm^3) of dentine and pulp for the 5 contralateral pairs of human maxillary first premolar teeth

Tooth pair No	DENTINE (L)	DENTINE (R)	DENTINE (L–R)	PULP (L)	PULP (R)	PULP (L–R)
1	•2993	•2937	+•0056	•0269	•0271	–•0002
2	•2827	•2810	+•0017	•0165	•0162	+•0003
3	•3530	•3538	–•0008	•0288	•0268	+•0022
4	•3517	•3666	–•0149	•0258	•0261	–•0003
5	•2507	•2422	+•0085	•0255	•0219	+•0036

VOLUME (cm^3)

(L) = Left (R) = Right (L–R) = Difference

TABLE 2 Volumes (cm^3) of enamel and of each of the 10 whole teeth studied

Tooth pair No.	ENAMEL (L)	ENAMEL (R)	ENAMEL (L–R)	WHOLE TOOTH (L)	WHOLE TOOTH (R)	WHOLE TOOTH (L–R)
1	•1622	•1571	+•0051	•4884	•4779	+•0105
2	•1429	•1492	–•0063	•4421	•4464	–•0043
3	•1254	•1616	–•0362	•5072	•5422	–•0350
4	•1694	•1861	–•0167	•5469	•5788	–•0319
5	•1248	•1237	+•0011	•4010	•3878	–•0132

VOLUME (cm^3)

(L) = Left (R) = Right (L–R) = Difference

A simple linear regression analysis of volumes of enamel, dentine, pulp and whole tooth on right and left sides are given in Table 3.

TABLE 3 Simple linear regression analysis of volumes on left and right sides for the 5 contralateral pairs of human maxillary first premolar teeth

	VOLUME CORRELATION BETWEEN LEFT AND RIGHT SIDES			
	ENAMEL	DENTINE	PULP	TOOTH
r	0·7083	0·9941	0·9362	0·9815
m	0·7763	1·1596	0·9135	1·3107
c	0·0430	-0·0491	0·0011	-0·1387

y = mx + c
r = correlation coefficient
n = 5

x = volume (cm^3) (L) side

y = volume (cm^3) (R) side

m = slope

c = intercept on y axis

DISCUSSION

In previous studies on dental asymmetry, tooth sizes have been characterized by only a few two dimensional measurements on the external crown. In the present study up to 8000 measurements on a single tooth have been recorded and this has enabled volumes of the dental tissues enamel, dentine and pulp to be determined as well as the total volume of the whole tooth.

The present study has not only demonstrated an asymmetry in volumes of the whole tooth but also an asymmetry in the individual components which make up the tooth (Tables 1 and 2). Furthermore, the asymmetry is greatest in the enamel (Table 3).

Tooth pair No.3 (Table 2) shows a large (approximately 25%) difference between the enamel volumes for the left and right teeth. We have been able to examine the patient's clinical records for these teeth and have found that the deciduous maxillary first molar from the left side had a disto-occlusal amalgam restoration. We believe that local pathology may have affected either the number of ameloblasts, their secretion of matrix, or their period of secretion of matrix of the developing premolar tooth. The fact that enamel is more affected than dentine is, we believe, due to this close proximity of the enamel producing cells (ameloblasts) to the roots of the primary teeth, whereas the dentine producing cells (odontoblasts) are relatively protected by a barrier of formed enamel and dentine.

ACKNOWLEDGEMENTS

We are grateful to Mr.D.H.Clark for providing the documented tooth specimens. We acknowledge the financial assistance of the Central Research Fund of the University of London and the Special Trustees of The London Hospital.

REFERENCES

Barden HS. Fluctuating dental asymmetry: A measure of developmental instability in Down's Syndrome. Am J Phys Anthropol 1980; 52: 169-174.

Dykes E, Clement JG. The construction and application of an X-Y co-ordinate plotting microscope. J Dent Res 1980; 1800.

Garn SM, Lewis AB, Kerewsky RS. The meaning of bilateral asymmetry in the permanent dentition. Angle Orthod 1966; 36: 55-62.

Garn SM, Cole PE, Smith BH. The effect of sample size on crown size asymmetry. J. Dent Res 1979; 58: 2012.

Harris EF, Nweeia MT. Dental asymmetry as a measure of environmental stress in the Ticuna Indians of Colombia. Am J Phys Anthropol 1980; 53: 133-142.

Kimura O, Dykes E, Fearnhead RW. The relationship between the surface area of the enamel crowns of human teeth and that of the dentino-enamel junction. Archs Oral Biol 1977; 22: 677-683.

Perzigian AJ. Fluctuating dental asymmetry: Variation among skeletal populations. Am J Phys Anthropol 1977; 47: 81-88.

Sofaer JA. Human tooth-size asymmetry in Cleft lip with or without Cleft palate. Archs Oral Biol 1979; 24: 141-146.

Sullivan PG. Growth of the canine mandible. Ph D Thesis 1976, University of London.

Van Valen L. A study of fluctuating asymmetry. Evolution 1962; 16: 125-142.