A STUDY OF THE VARIABILITY OF THE CUSP TIPS OF THE MANDIBULAR FIRST MOLAR IN TWINS

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INTRODUCTION

The study of the size and morphologic characteristics of the teeth has been of interest for a long time. Comparisons of the size, shape, and number of teeth and of the cusps have been used to help classify primates and human racial groups.[1] These classifications are based on the assumption that genes control these traits in teeth. Wiedenreich[2] described in detail the teeth of Sinanthropus as an anthropologic trait. Others have studied racial differences in shovel-shaped incisors, Carabelli's cusp, and the relationship in the number of cusps and sizes of the teeth. These were, for the most part, subjective classifications.

The change in the number of cusps has been used as an evolutionary trait. Dahlberg[3] stated that the Y-Five or Dryopithecus pattern is the earlier form and that the four + cusp pattern is the evolutionary progression. These traits are inherited.

Equally as important and interesting is the positioning of each cusp tip and the degree of genetic control in the variation in tip placement.

The purpose of this investigation is to establish a reliable method of locating the cusp tips of the lower first permanent molars and to determine the variability in positioning between these cusps.

REVIEW OF LITERATURE

The use of twins in studying possible genetic traits offers certain advantages. It is generally accepted that two types of twins exist; monozygotic (identical) arising from a single ovum, and dizygotic (fraternal) from two ova and two sperms. Theoretically, monozygotic twins have identical genetic endowments and any differences in their characteristics are assumed to be due to environmental differences. Dizygotic twins and siblings have a coefficient of genetic relationship of 0.5; identical twins have a 1.0 coefficient.[4,6] Thus, fraternal twin differences are due both to genetic difference and to environmental differences.

The significance of such studies depends upon the degree of certainty and the methods employed in diagnosing zygosity. Sutton[6] and others[4] describe in detail the methods of diagnosing zygosity using blood group antigen comparison, trait similarities and dermatoglyphics. Price[7] has written the prenatal and postnatal primary biases in twin studies. These methods will not be described in this paper.

Most of the studies concerning dental traits in the past have been subjective in nature.[1,2,3] In describing the protostylid, a paracusp on the buccal surfaces of the lower first permanent molars, Dahlberg,[8] describes in detail variations in the size and form of this cusp subjectively. Others[9,10,11] have made racial comparisons on a subjective basis. Lundstrom[12] described a subjective method of diagnosing zygosity by the variation in tooth morphology. He found a rather high (94.4 percent) agreement between other methods of detecting zygosity and his method.

The genetic control in the variation of the mesio-distal diameters of the teeth has been studied between twins in both permanent and deciduous teeth. Osborne and co-workers[13] studied the mesio-distal diameter of the maxillary and mandibular six anteriors in 33 monozygotic and 21 like-sex dizygotic twin pairs. F ratios of the mean intra-pair variances ($Ed^2/2n$) were used as the statistical test. Their findings agreed with Lundstrom's earlier work in that a strong genetic component of variability exists in the mesio-distal diameter which was greater in dizygotic twin pairs than in monozygotic intra-pair differences. They concluded that genes control the general tooth size.

Earlier, Lundstrom[14] studied 100 monozygotic and 102 dizygotic Swedish twin pairs of like sex. Zygosity was determined by similarity of traits. He found a larger dizygotic intra-pair variability than monozygotic intra-pair variability for mesio-distal crown diameters.

Yap[5] studied 29 monozygotic twin pairs (17 male and 12 female) and 15 like-sex dizygotic twin pairs (7 male and 8 female). She measured the mesio-distal diameters of the primary maxillary and mandibular canines, first and second molars. She concluded that "genetic control of variability of the mesio-distal dimension of primary canines and molars is not discernible except for three teeth, all on the right side."

The literature cited has shown that the number of cusps is used as a morphologic criterion and classification, and that the use of twins can be used satisfactorily in genetic trait studies of dental characteristics. No studies have reported on the genetic control in cusp tip positioning either within or between twin pairs.

METHOD AND MATERIALS

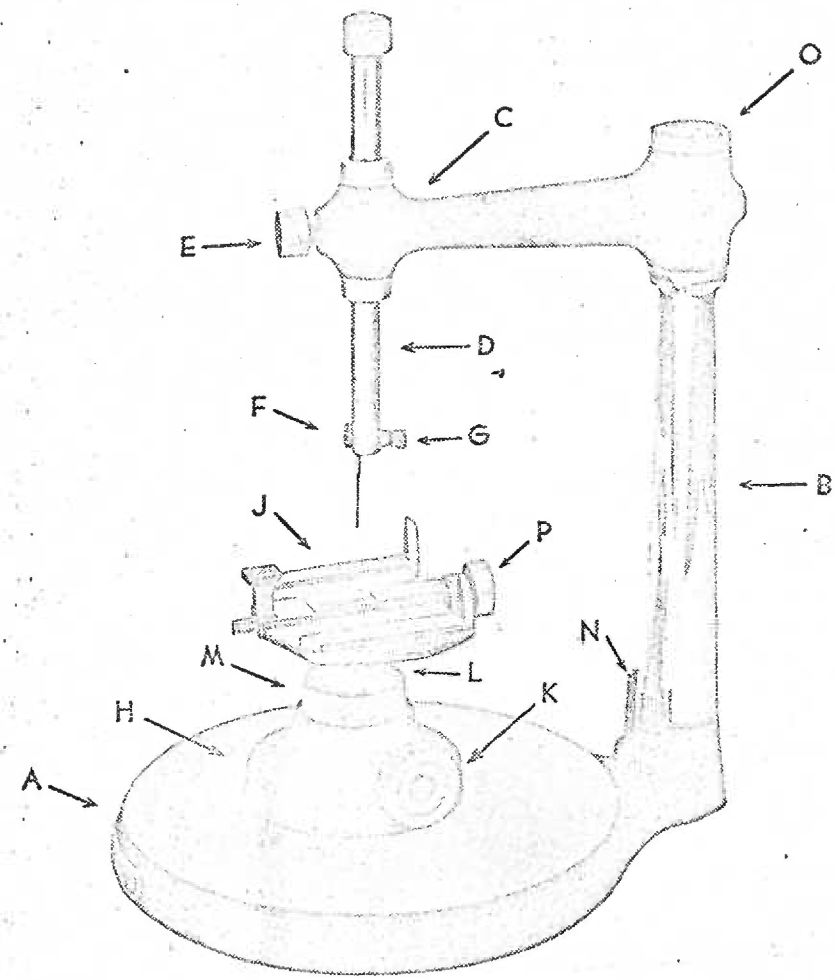
The sample selected for this study consisted of ten sets of monozygotic twins and nine sets of dizygotic twins obtained from the records of the Child Study Clinic of the University of Oregon Dental School. Monozygosity was previously established by the Child Study Clinic and the University of Oregon Medical School Department of Hematology by blood group antigen analysis as described by Yap.[5] In 95 percent of the time, monozygosity is accurate, but in five percent of the cases, dizygotic twins will be accepted as monozygotic.

The group of twins referred to above was selected because they had completely erupted right and left mandibular first permanent molars. The casts were obtained as soon as the clinical cusp tip for all the cusps were completely visible and accessible. No cast of a tooth either left or right was used when an area more than one mm. in diameter was abraded. If such abrasion was present, the cast and that twin pair were discarded from the study.

Since one purpose of this investigation was to establish a reliable method of locating the tips of the cusps and to study the variability in the distance between these cusps, it was necessary to define the cusp tip of a cusp of the mandibular permanent first molar as the highest point on a cusp at a tangent common to a plane established by three or more cusp tips of that tooth.

A common plane was established for each tooth studied by fixing the mandibular cast on the movable table of a Ney Surveyor. A round disc, cut at right angles to the vertical spindle of the surveyor was firmly fixed in the tool holder. See Figure 1 for surveyor parts. The cast on the surveyor table was positioned under the disc which almost contacted the tooth. The tilt-top of the table containing the cast was visually oriented until three cusp tips formed a common plane with a cover glass resting on the cusps and positioned parallel to the disc. This plane was oriented so that the two lingual cusp tips always formed two of the three common points establishing the plane. In some instances, four cusps entered into forming this common plane.

Once the plane was established, a milled stainless steel marking disc, approximately 1/4 inch in diameter,



PARTS DESCRIPTION—THE NEY SURVEYOR

A. Horizontal Surveyor Base
B. Upright Column
C. Cross Arm with Spindle Bearing
D. Vertical Spindle
E. Spindle Tightening Screw
F. Tool Holder
G. Tool Holder Locking Nut
H. Survey Table
J. Tilt-Top and Model Clamp
K. Locking Screw of Tilt-Top
L. Ball Pivot
M. Ball Retaining Ring
N. Rack for accessories when in use
O. Storage compartment for Tools (Undercut Gauges, Analyzing Rod, Carbons, Wax Trimmer)
P. Model Clamp Adjusting Screw

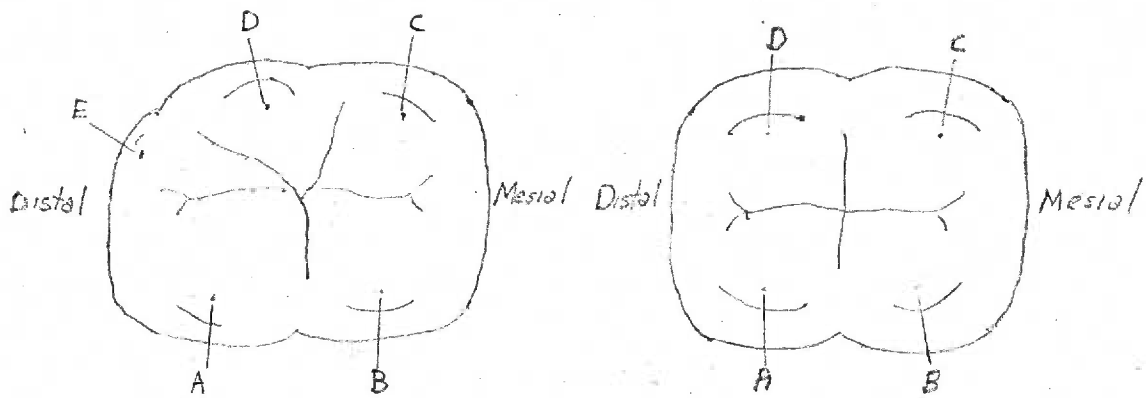
Figure 1. Instrument used to orient and mark casts

was rubbed on carbon paper, and was lowered until it contacted with minimum pressure each of the cusp tips of that particular tooth. All cusp tips were established at a point contact at right angles to the plane and were the highest point on the cusp tangent to the common plane. Some deviation may have been present on the location of the other cusp tip or tips, not forming the common plane; but since the casts were uniformly oriented, all points should be reproduced easily if this plane was reestablished.

Once each tooth was marked, a 10 mm. marker was placed along side the tooth under study and fixed at the same height as the cusp tips. The marker consisted of a 10 mm. strand of stainless steel orthodontic wire with each end bent at right angles to the mainshaft at the distance of 10 mm. The cast was then placed under an opaque projector and projected into a flat sheet of paper fixed on a wall perpendicular to the projector's light source. The projections of the marked cusp tips were enlarged 10 times determined by a 10 cm. marker constructed similarly to the 10 mm. marker. The centers of the cusp tip were punched with a pin and circled. Right and left mandibular permanent first molar projections were made adjacent to each other. The same procedure was followed for each cast used.

Before measurements were made, the cusp tips were assigned letters. Cusp A was the disto-lingual or Entoconid; cusp B the mesio-lingual cusp or Metaconid; cusp C the mesio-buccal or Protoconid; cusp D the distal buccal cusp or Hypoconid; and in the instance of a five-cusp molar, cusp E was the distal cusp or the Hypoconulid. Dual linear measurements, A to B, B to C, C to D, D to E, E to A, and D to A, were made and the average taken between them. (See Figure 2) Student's "t" test was determined to test the right-left differences within the individual, right-right and left-left differences between the twin pairs in each category of twins.

To ascertain the precision of measurement, the entire measuring and cast marking procedure was repeated for 20 molars from the ten original casts at the end of the marking procedure. The standard error of the measure, SEMeas. $= \sqrt{\frac{\Sigma d^2}{2N}}$ was used to report the differences between independent double determinations for each of the dimensions. No significant right-left differences were obtained and the results were pooled. The pooled SEMeas. varied from 0.11 mm. for the dimension between the distal buccal cusp, D, to the disto-lingual cusp, A, to 0.19 mm. for the dimension between the distal buccal cusp, D, to the distal cusp, E. Cusp E was the most difficult cusp to reproduce. This was due to its flattened summit. A surprising right-left cusp dimension difference was found between the A-B measurement. This was of interest and difficult to explain since these should have been the two most reliable measurements, being both between the lingual cusp tips of the right and left molars, which uniformly showed the least degree of abrasion. The three buccal cusps were the most susceptible to abrasion.



A - Entoconid
B - Metaconid
C - Protoconid
D - Hypoconid
E - Hypoconulid

Five-Cusp Mandibular First Molar

Measurements made

1. A-B
2. B-C
3. C-D
4. D-E
5. E-A
6. D-A

Four-Cusp Mandibular First Molar

Measurements made

1. A-B
2. B-C
3. C-D
4. D-A

Figure 2. Landmark to which John Bull calipers were used to measure to the nearest 0.01 mm.

The results of the SEMeas. are reported in Table 1 and are given for each set of measurements for both right and left molar cusp tip dimensions.

FINDINGS

The results of the statistical analysis for right-left molar difference for within individual variation for each twin pair are reported in Table 2. The analyses for the right-right molar difference and left-left molar difference between the twin pairs are found in Table 3.

All of the within right-left molar dimensional differences for the monozygotic twin pairs were not statistically significant. The within right-left molar dimensional differences for dizygotic twin pairs were also not significant except for the cusp dimension E-A. This difference was significant at the five percent level of confidence.

The monozygotic between-twin pair right-right molar differences were not significant except for the A-B cusp dimensional difference which was significantly different from zero at the five percent level of confidence. No right-right molar differences between dizygotic twin pairs were significant at the five percent level of confidence.

No statistically significant difference was found between left-left molars in monozygotic or dizygotic twin pairs.

A comparison of the standard deviation of the differences for each measurement between pairs of monozygotic and

TABLE 1

Standard Error of the Measure
in mm.

	A-B	B-C	C-D	D-E	E-A	D-A
Right Molar N=20 teeth	0.09	0.15	0.14	0.25	0.16	0.14
Left Molar N=20 teeth	0.17	0.09	0.17	0.13	0.13	0.07
Right-Left Pooled N=40 teeth	0.13	0.12	0.16	0.19	0.15	0.11

Grand SEMeas.- $\sqrt{\frac{\Sigma d^2}{2N}}$ = 0.146 mm.

TABLE 2

Mean
Right-Left Differences

	A-B	B-C	C-D	D-E	E-A	D-A
Monozygotic Pairs $\bar{d}$	0.01	0.12	-0.15	0.10	-0.01	-0.03
Number	20	20	20	17	17	20
"t" value	.095	1.86	-1.01	.638	-.045	-.403
Dizygotic Pairs $\bar{d}$	-0.064	-0.02	0.12	-0.32	-0.13	-0.02
Number	17	17	17	10	10	17
"t" value	.783	-.290	.717	-1.45	-2.75*	-1.86

*Significant at 5% level

N = 17 T95df = 2.12

$\bar{d}$ = Mean difference in mm.

TABLE 3

Mean Differences
"t" Test Right-Right
and
Left-Left Between Pairs

	A-B	B-C	C-D	D-E	E-A	D-A
Monozygotic Twin Pairs						
Right-Right $\bar{d}$	-0.12	-0.01	-0.16	-0.22	0.06	-0.12
Number	10	10	10	8	8	10
"t" value	3.74*	.348	1.06	.995	.395	1.80
Left-Left $\bar{d}$	0.12	0.19	-0.12	-0.02	-0.04	-0.01
Number	10	10	10	9	9	10
"t" value	.753	1.72	.620	.215	.430	.069
Dizygotic Twin Pairs						
Right-Right $\bar{d}$	-0.27	0.08	0.01	0.08	0.10	0.10
Number	10	10	10	6	6	10
"t" value	1.39	.341	.056	.292	.725	1.47
Left-Left $\bar{d}$	-0.19	-0.06	-0.29	≠0.19	0.14	0.11
Number	10	10	10	5	5	10
"t" value	1.39	.295	1.04	.930	.738	.672

*Significant at 5% level

N = 10 T95df = 2.26

$\bar{d}$ = Mean difference in mm.

TABLE 4

Standard Variation of the Differences
in MM.

Twin Pairs	A-B	B-C	C-D	D-E	E-A	D-A
Right-Left						
Monozygotic	0.438	0.302	0.657	0.649	0.309	0.348
Dizygotic	0.333	0.319	0.675	0.737	0.185	0.366
Right-Right						
Monozygotic	0.324	0.282	0.506	0.611	0.405	0.241
Dizygotic	0.585	0.670	0.592	0.599	0.294	0.227
Left-Left						
Monozygotic	0.504	0.372	0.589	0.264	0.269	0.351
Dizygotic	0.406	0.613	0.670	0.473	0.389	0.490

$$SD = \sqrt{\frac{\Sigma d^2}{N}}$$

dizygotic twins is found in Table 4. These right-right molar and left-left molar differences appear to be larger in nearly all measurements between the two twin groups. These apparent differences were not evaluated statistically. However, none of the dizygotic twin pair differences were significantly different from zero.

Two unrelated dizygotic male twins and one monozygotic female twin present one four-cusp molar and one five-cusp molar. The sibling of one male dizygotic twin had four-cusp molars and the other twin sibling presented five-cusp molars. The monozygotic female sibling had five-cusp molars.

DISCUSSION

One of the more interesting findings was the occurrence in three individuals of a five-cusp mandibular permanent first molar on one side and a four-cusp molar on the other. This variation in molar cusp pattern was found between the twin pairs in both monozygotic and dizygotic twins and between both male and female twin pairs. This finding tends to indicate that some degree of right-left independence exists in the number of cusps a molar may have and that this independence was unrelated to sex or zygosity.

The within right-left molar differences were not statistically significant for any cusp dimension for the monozygotic twin pairs. This finding is consistent with the hypothesis that monozygotic twins have the same genotype.

From this it is suggested that the cusp tip position variability is primarily under genetic control.

Similar findings were found in dizygotic twin pairs with the exception of the dimension between the distal cusp and the disto-lingual cusp (E-A) which was significantly different from zero at the five percent level. This inter-pair difference may be accounted for by the difficulty in locating the cusp tip of the distal cusp. The rest of these findings are consistent with a theory that the inter-cusp distance between cusp tips in right and left mandibular permanent first molars are determined by a common gene or group of genes (multifactorial inheritance), for both sides within a single individual regardless of zygosity.

The analysis of right-right and left-left molar differences between twin pairs in monozygotic twins did not reveal any significant differences except for the dimension A-B in between the right-right molars of the twin pairs. This finding appears to be consistent with the theory that intra-pair variation is genetically controlled. This finding is in agreement with that of Lundstrom[14] and Osborne[13] that tooth size variation in monozygotic twins is genetically controlled.

The right-right molar and left-left molar differences also were not significant. This finding would not be in agreement with that found by Osborne[13] and co-workers. They[13] found a significantly larger mean dizygotic than monozygotic intra-pair variance for most of their mesio-distal diameters. Although statistical tests were not made, an inspection of Table 4 indicates that neither right nor left variations were consistently larger for one group than for the other.

Because of the limited size of the sample, no definite conclusions can be drawn, and the sample size did not warrant heritability indices to be constructed. This study pointed out the need for further investigation to determine to what extent variations in tooth morphology are under genetic control.

SUMMARY AND CONCLUSIONS

A method for determining the cusp tips of the lower first permanent molar was presented. The variation between the cusp tips was studied in both monozygotic and dizygotic twin pairs for right-left molar differences within each twin. The right-right molar and left-left molar differences between each twin pair were also analyzed. The following conclusions were made:

1. The method employed allowed the location of the cusp tips and inter-cusp measurements to be repeated within $\not\leq$ 0.142 mm.

2. The occurrence of both a five-cusp and a four-cusp permanent first molar may occur in one individual.

3. Genetic control for the intra-cusp variance was suggested for both twin zygosity groups.

4. Additional controlled twin studies are needed to determine the degree of genetic control in variation of cusp positioning.