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Root Surface Area Measurements of North American Negro and Caucasian Extracted Mandibular Teeth

Noel Molini
Loyola University Chicago

ROOT SURFACE AREA MEASUREMENTS OF NORTH AMERICAN NEGRO AND CAUCASIAN EXTRACTED MANDIBULAR TEETH

by

NOEL MOLINI

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LIFE

Noel Molini was born in Yauco, Puerto Rico on September 19, 1937.

He graduated from Holy Rosary High School in May, 1955. In May, 1959, he received the Degree of Bachelor of Arts at the Inter-American University of Puerto Rico.

He entered the University of Puerto Rico School of Dentistry in August, 1959, and received the Degree of Doctor in Medical Dentistry in May, 1963.

He served as a commissioned dental officer in the United States Air Force from 1963 to 1965. He has been enrolled in the Department of Oral Biology at Loyola University working toward a degree of Master of Science since June, 1966.

The author is married and has a son and a daughter.

DEDICATION

To my wife, Idalia, whose encouragement, patience, and untiring devotion were beyond measure, I dedicate this thesis.

ACKNOWLEDGEMENTS

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CHAPTER I

INTRODUCTION AND STATEMENT OF THE PROBLEM

A. Introductory Remarks:

The orthodontist is becoming more conscious of the importance of recognizing tooth movement a result of root pressure rather than a simple function of force. The distribution of forces against the alveolar walls during orthodontic treatment determines the pattern of bone resorption and apposition needed for tooth movement. Due to variation in root surface area the forces applied by the orthodontic appliances to the crowns of the teeth cannot be distributed equally to the walls of the alveoli. Knowledge of root surface area is then a prerequisite in establishing a reliable method for determination of optimum root pressure.

Many procedures have been used in attempts to determine root surface area. The latitude of variation of results approaches that of the procedures used.

Moromisato and Emmanuelli (1967) refined the polyvinyl membrane technique used by Jepsen (1963) for the determination of total root surface area and designed a photographic procedure to determine the projected root surface area. Their procedure appears to be reliable and accurate. A similar technique was employed in this investigation.

The fact that all previous investigations utilized sample of teeth collected at random is of particular interest to this investigator. No attempt has been made to determine variations and interactions of root surface area in different ethnic groups.

B. Statement of the Problem:

The purpose of this project was to measure the total and projected root surface area of mandibular teeth in the North American Negro and Caucasian population and to determine if any correlation exists.

CHAPTER II

REVIEW OF THE LITERATURE

Hanau (1917), a consulting engineer, wrote in the International Journal of Orthodontia:

> "The resultant of the applied force is transmitted to the bone at the surface of the root, in the case of a commonly malposed tooth. For the sake of simplicity it will be assumed that the resisting pressure is uniformly distributed on the projected area of the root, that is, projected in the direction of movement."

Morelli (1920), as cited by Jepsen in 1963, gave a series of area values based on the root being a well defined geometric figure---the central incisor in the upper jaw, for instance, being considered a cone---the surface area of which can be calculated with the aid of a simple mathematical formula.

Schwarz (1932) postulated that to achieve "ideal biological tissue reaction" desired for "optimum"tooth movement, the applied force must not be stronger than the capillary blood pressure which is approximately 23 Gms. per square centimeter of root surface.

Orban (1936) concurred with Schwarz that there is a biological optimum for tooth movement, but added that the "pressure field" exerted by the root surface was dependent upon the shape of the root.

Rhode (1948) stressed the fundamental importance of root surface area as related to the applied force and to tooth movement.

He stated, "....any force transmitted to teeth eventually is transmitted to bone through push and pull" and "....the greater the root surface area which the roots afford, the greater will be the resistance."

Brown (1950), at the Department of Periodontology of the University of Toronto, reported what appears to be one of the first values recorded for total root surface area. He reported values for the maxillary central incisors. Brown coated the surface of the root with a milky liquid latex. After setting, the latex was removed in one membrane-like piece and laid flat on grid paper. The total area was recorded in square millimeters.

Renfroe (1951) divided cross sectional root morphology into three general categories: round, triangular, and oblong. Like Orban, he indicated that variation in design dictates resistance to movement. In his article "The Source of Power," he stated, "Movement of teeth is more than the mere pitting of one tooth against another. It is a matter of which teeth are you pitting against which." The significance of this statement became apparent the following year when a report about "differential forces" was published in "The Australian Journal of Dentistry."

Storey and Smith (1952) investigated the effects that differential forces had on canines and on the anchor units. They mention that it is not the force exerted on the tooth which is significant,

but rather the resulting pressure created at the interfaces between tooth, periodontal ligament and bone.

Mac Ewan (1954) reported that in the treatment of a typical distocclusion case the mandibular anchorage was undisturbed when using intermaxillary traction throughout treatment. He explained that this was possible because "....the amounts of force used are kept below the stability limit, which is about 7 Gms/square cm of root surface if the periodontium is physiologically normal."

Phillips (1955) filed the apices of maxillary and mandibular central and lateral incisors to simulate root resorption. He measured the root surface of each tooth by the use of tin foil adapted to the roots and then removed and measured with a planimeter.

Boyd (1958) measured the "periodontal area" of five teeth of each type in a sample of 80 teeth. A membrane technique was used but the procedure was not discussed.

Tylman and Tylman (1960) gave values for root surface area of the maxillary and mandibular dentition but failed to mention how these values were determined.

Jepsen (1963) described a method in which area determination of root surface was made with the aid of a polyvinyl membrane technique. He also investigated an x-ray photographic method to determine root surface area.

Jarabak and Fizzell (1963) concluded that, "....the first requirement is to accept the idea that root pressure is the important factor in determining tooth movement instead of the force applied to the crown of the teeth." They employed a mathematical model to advance their concept.

Freeman (1965) computed root surface area utilizing a membrane technique. In this study the first premolars, second molars and third molars were excluded.

Emmanuelli and Moromisato (1967), as co-workers, determined the total and projected root surface area of mandibular and maxillary teeth respectively excluding second and third molars. Using a membrane and photographic technique they measured a sample of 20 teeth in each category for both maxilla and mandible.

CHAPTER III

METHODS AND MATERIALS

A. Selection of the Sample

Extracted mandibular teeth from the Caucasian and Negro population were obtained from the Department of Oral Surgery at the Loyola University School of Dental Surgery, from the Fantus Clinic at the Cook County Hospital, and from practicing dentists in the Chicago area. All teeth collected for this study were labeled and stored in a solution of 10% Formalin. A total of 180 mandibular teeth, both left and right excluding second and third molars, were selected. Fifteen teeth were used in each of the following categories: central incisor category, lateral incisor category, canine category, first premolar category, second premolar category, and first molar category.

The criteria for selection were:

1. Each tooth must be readily identified.
2. The root or roots must be completely developed and free from macroscopic damage.
3. The cemento-enamel junction must be easily identified.
4. Each tooth must be free from obvious pathology.

B. Preparing the Sample Teeth

All teeth were cleaned by hand. The first molars were sectioned

at the junction of the roots with a disc mounted on a straight handpiece. Each tooth was numbered in sequence (e.g. central incisor no. 1, central incisor no. 2, etc.). The cemento-enamel junction of each tooth was marked with a sharp lead pencil.

C. Selection of Membrane Material

The membrane technique was used to determine the total root surface area. Formvar (Polysciences, Inc.) was selected as the membrane material because it has the following characteristics: (1) it may be air cured; (2) it is simple to apply; (3) it is readily accepted by the root surface; (4) it may be easily removed after being air cured for twenty minutes; (5) it requires no special storage precautions; (6) it has good dimensional stability; and (7) it accepts the inclusion of a dye.

The Formvar solution was made by mixing five grams of Formvar powder with 25 c.c. of 1,2 ethylene dichloride. The powder was allowed to dissolve for twenty-four hours and then three grams of Calcazoid Black, a strong dye, was added to the solution. The inclusion of a dye was necessary because Formvar in liquid form is colorless and would not photograph well. It would also be extremely difficult to coat and remove such a material from the root of a tooth without the aid of a dye.

The accuracy of this membrane technique was established by Emmanuelli and Moromisato (1967) and will be discussed in Chapter V.

D. Photographing the Teeth

The projected root surface area of all the teeth was obtained by photographing the mesial surface of the roots. Geigel (1965) defined projected root surface area as:

> "The area of the projection of the root of a tooth that is made on a screen that is in a plane parallel to the long axis of the tooth when rays of a light are parallel"

The teeth were fixed in mortite with the mesial surface facing the camera lens. The long axis of the root was positioned parallel to the film plane of the camera. A Nikkormat FS camera body fitted with an intermediate ring and a 55 mm F. 3.5 Micro-Nikkor auto lens was used. Photographs were taken with Panchromatic, Plus X film (Kodak Co.) with an A.S.A. of 125. A ring light with power box (Lester A. Dine, Inc.) was attached to the front of the lens. (Fig. 1)

The teeth were placed on a black surface to increase contrast between the subject and background and eliminate reflections. Identifying numbers for every tooth and a reference metal square (Cameron-Miller Surgical Instruments Co.) were included in each photograph. The metal square was precision made from stainless steel. Each surface on the square had a known area of 25 sq.mm and were accurate to the nearest $\pm$0.00015% of a millimeter. The surface portion on which the square was positioned was white to insure proper identification of its borders. The image was recorded with a lens reproduction ratio

of 1:1 at f/32 and 1/125 sec. A setting of 20 was used for the ring light power box. The exposed film was processed through a commercial laboratory in the Chicago area.

E. Coating the Root Surface and Photographing the Membranes

The crown of each tooth was covered with mortite. This material served as a handle for ease of manipulation while coating the root surface and also as a stand for subsequent drying. After the tinfoil substitute dried a thin coat of Formvar solution was painted with a small brush. The root surface was completely coated from the apex to the cemento-enamel junction. (Fig. 2) After air curing for twenty minutes, the membrane was slit with a scalpel along the cemento-enamel junction and then down the long axis to the apex. The membrane was identified and placed flat on a microscope slide with the metal square. The slide was then placed over the transilluminating box for photographing.

The photographing technique was identical to that used earlier for photographing the teeth; however, the light source and camera settings were different. The light sources were provided by the transilluminating box and by two Tensor high intensity lamps (Tensor Corp.) positioned at a 45^{o} angle to the top of the box and about three inches from the slide. (Fig. 4) The photographs were taken at f/11 and 1/30 sec. on Panchromatic Plus X film.

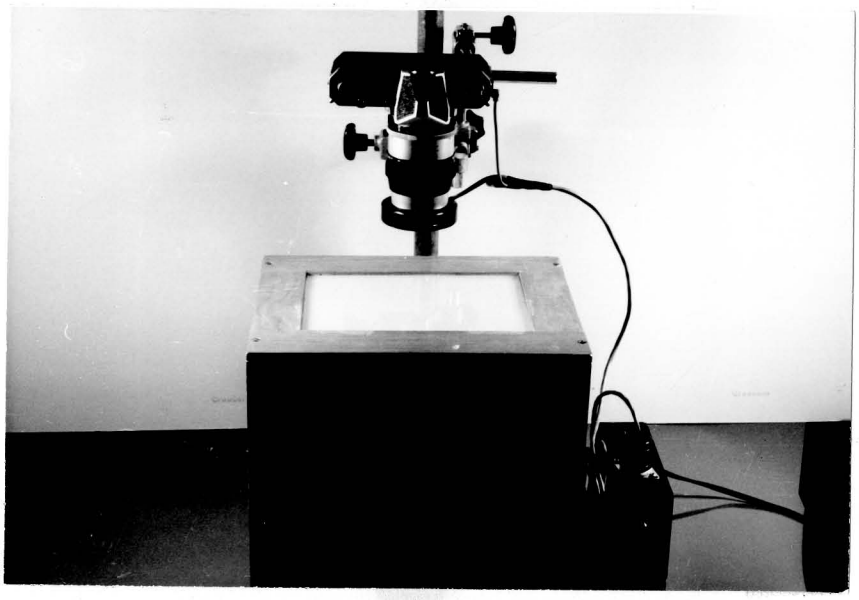

FIGURE 1

PHOTOGRAPHIC SET-UP FOR PROJECTED SURFACE AREA

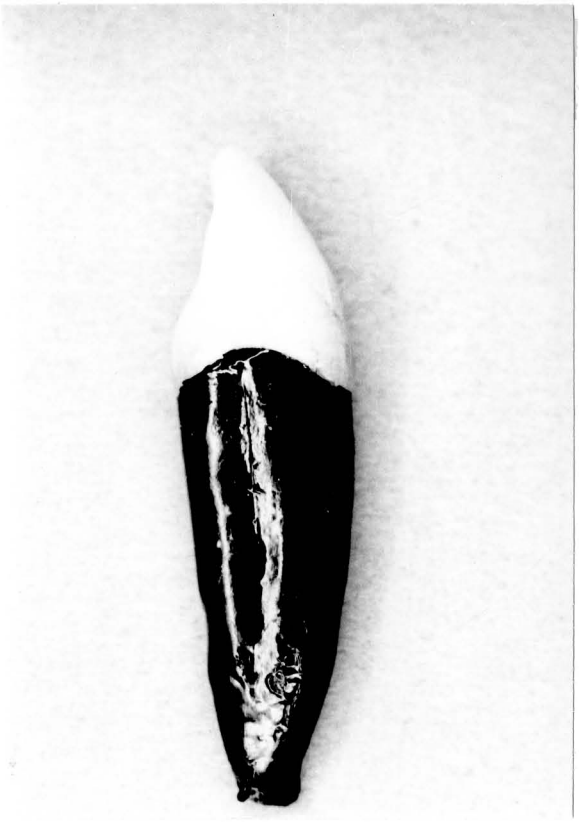

FIGURE 2

FORMVAR MEMBRANE ON TOOTH

FIGURE 3

SLITTING OF MEMBRANE

F. Measurements

The first step in the process of ascertaining the true dimensions of the total and projected root surface areas was the measurement of the recorded images in the photographs. These were positioned on a drawing board beneath a clear non-magnifying glass. This arrangement provided a flat immobile picture beneath a smooth surface.

A Keuffel & Esser Compensating Planimeter 620005 (Serial No. 42741) was used for the measurements (Fig. 5). This is an instrument for accurately measuring plane areas of any form. Measurements are made by running a tracer point around the periphery of the figure and then reading the distance which a measuring wheel has revolved during the process. The outline of the membranes, projected root surface, and metal square were then traced. Each was measured three times and the average of the three readings was used in the calculations for the true area.

The true total and projected root surface areas were calculated by the following ratio:

$$\frac{A}{B} = \frac{C}{D}$$

Whereas: A is the measured area of the membrane

B is the measured area of the square

C is the true area of the membrane

D is the true area of the square

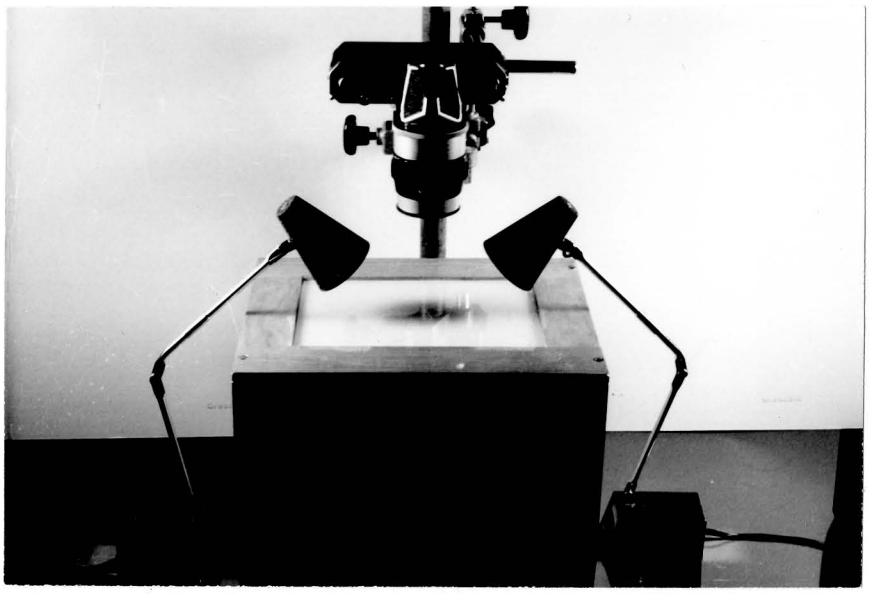

FIGURE 4

PHOTOGRAPHIC SET-UP FOR TOTAL SURFACE AREA

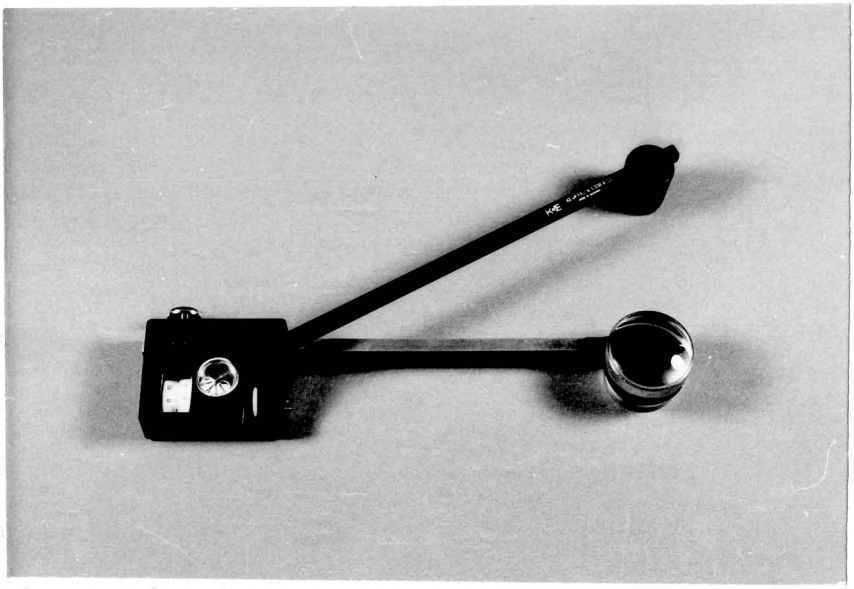

FIGURE 5

COMPENSATING POLAR PLANIMETER

Solving for Total Root Surface Area (C):

$$C = \frac{A}{B} \times D$$

or:

$$\text{Total Root Surface Area} = \frac{\text{Measured area of membrane}}{\text{Measured area of square}} \times \text{True area of square}$$

To solve for the Projected Root Surface Area we substitute the true area of the membrane for the true Projected area:

$$\text{Projected Root Surface Area} = \frac{\text{Measured area of projected}}{\text{Measured area of square}} \times \text{True area of square}$$

G. Computer Assessment of the Data

All data accumulated in this study were organized and recorded on punch cards for assessment using electronic computer. The punch cards were placed into the I.B.M. 1402 card reader and the information contained was printed out on the I.B. M. 1403 line printer. The data was then verified to assure correct punching of the cards. The calculations were done in a programmed I.B.M. 1401 at the University of Loyola.

CHAPTER IV

FINDINGS

The true total and projected root surface areas for all the teeth considered in this study may be found in Tables I through VI. The statistical evaluation may be found in Tables VII through X.

A. Normal Distribution

1. With respect to the Caucasian Population

The mean total root surface area of the central incisor was 140.8 sq.mm with a standard deviation of 13.5 sq.mm. The average projected surface area was 69.2 sq.mm $\pm$10.0 sq.mm. This standard deviation was the lowest of both populations.

The lateral incisor had a total surface area of 171.9 sq.mm, with a standard deviation of 19.1 sq.mm. The projected root surface had the smallest experimental range of the population (39.4 sq.mm). The mean value for this surface was 79.2 sq.mm $\pm$11.6 sq.mm.

The canine had the second largest total and projected root surface area of the Caucasian population. The average for total surface area was 250.0 sq.mm with a standard deviation of 60.0 sq.mm which was also the largest of the population. The experimental range had a high of 366.9 sq.mm and a low of 169.6 sq.mm. The resultant experimental difference of 196.5 sq.mm was the largest of the population. The projected area mean value was 112.0 sq.mm with a standard deviation of 19.0 sq.mm.

The first premolar had an average total root surface area of 229.8 sq.mm ±44.1 sq.mm. The mean value for projected surface area was 65.8 sq.mm which was the lowest for both populations. The standard deviation was 11.7 sq.mm.

The second premolar had a total root surface area mean value of 180.8 sq.mm with a standard deviation of 34.0 sq.mm. The projected surface area average was 84.3 sq.mm ±18.1 sq.mm.

The root surface area of the first molar was determined by adding the true areas of the mesial and distal roots. The total and projected surface areas in this category were the highest of the Caucasian population. The mean value for total root surface area was 411.6 sq.mm with a standard deviation of 45.4 sq.mm. The projected root surface area had an average of 163.5 sq.mm ±27.1 sq.mm.

2. With respect to the Negro Population

The central incisor total root surface area had an average of 214.9 sq.mm with a standard deviation of 36.0 sq.mm. The projected surface mean value was 71.1 sq.mm ±32.3 sq.mm. The experimental range of the total surface area had a high of 278.8 sq.mm and a low of 148.8 sq.mm. This range was the lowest of all the total root surfaces in this category.

The total root surface area average of the lateral incisor was 200.3 sq.mm with a standard deviation of 32.3 sq.mm. The mean projected surface area was 85.8 sq.mm ±14.4 sq.mm. This was the lowest value

for the population. The experimental range varied from a high of 116.3 sq.mm to a low of 55.4 sq.mm. The resultant experimental difference of 60.9 sq.mm was the lowest of the Negro population.

The canine had the second largest total and projected root surface area of the population. The average for total surface area was 297.4 sq.mm $\pm$70.5 sq.mm. The projected surface area mean value was 109.0 sq.mm $\pm$36.9 sq.mm. This standard deviation was the largest for projected surface area in the population. The experimental range of this surface in this category was the largest for projected surface area in the Negro population. (39.2 sq.mm/162.9 sq.mm)

The first premolar total root surface area average was 245.0 sq.mm $\pm$54.0 sq.mm. The projected surface area had a mean value of 84.9 sq.mm $\pm$22.0 sq.mm.

The second premolar total root surface had an average of 257.5 sq.mm with a standard deviation of 47.7 sq.mm. The projected surface area mean value was 101.0 sq.mm $\pm$18.3 sq.mm.

The root surface area of the first molars in the Negro population was determined in the same manner as that of the Caucasian population. The total and projected root surface areas in this category were the largest of the Negro population. The total surface area mean value was 510.7 sq.mm $\pm$54.7 sq.mm. The experimental range of this surface (241.3 sq.mm/606.3 sq.mm) was the largest for the total surface area in the population. The projected surface area mean value was 193.6 sq.mm with a standard deviation of 26.6 sq.mm.

B. Correlations for the Negro and Caucasian Populations

For this study the data were divided into four variables: Variable 1 was the Caucasian projected surface area; Variable 2 was the Caucasian total root surface area; Variable 3 was the Negro projected surface area; Variable 4 was the Negro total surface area.

The correlation coefficient for the four variables was computed by electronic computer. The variables were correlated in the folfowing manner:

Column A (X)		Column B (Y)
Var 1	vs	Var 2
Var 1	vs	Var 3
Var 2	vs	Var 4
Var 3	vs	Var 4

Whereas Column A is the independent variable column (X) and Column B is the dependent Variable column (Y). The correlation coefficients for the variables may be found in Table IX.

Highly significant correlation (95% level) was found between the total and projected surface areas of the Caucasian central and lateral incisors, the canine and the first premolar. The second premolar correlation was not significant. The first molar correlation coefficient of 0.427 approached the 95% level of significance. (0.482)

The total and projected surfaces of the central and lateral

incisors, canine, and first premolar Negro teeth were found to be very highly significant (95% level). The second premolar and first molar correlations were significant at the 95% level.

No significant correlation was found between the projected and total surface areas of the Negro and Caucasian populations.

TABLE I

CENTRAL INCISORS

Root Surface Areas (Sq. MM)

	CAUCASIAN		NEGRO	
Tooth No.	Projected	Total	Projected	Total
1	61.3	124.3	60.0	169.2
2	44.2	120.7	38.3	239.2
3	85.0	151.3	66.3	228.0
4	71.2	121.7	57.9	174.2
5	71.3	153.7	52.5	215.4
6	67.1	142.7	101.2	278.8
7	72.5	169.0	94.6	264.2
8	66.8	139.6	68.3	206.3
9	75.0	143.0	74.6	201.7
10	60.4	142.6	95.0	246.7
11	75.6	145.4	52.9	175.4
12	62.9	129.3	92.9	242.5
13	65.4	140.0	75.4	202.1
14	72.9	130.0	80.8	231.7
15	87.1	159.4	56.3	148.8

TABLE II

LATERAL INCISORS

Root Surface Areas (Sq. MM)

	CAUCASIAN		NEGRO	
Tooth No.	Projected	Total	Projected	Total
1	100.8	182.7	55.4	186.3
2	101.7	184.0	100.0	215.4
3	80.8	160.7	101.2	201.7
4	62.5	163.3	78.8	175.4
5	87.5	193.7	116.3	305.4
6	78.8	198.3	67.5	197.5
7	62.3	140.3	85.4	191.7
8	88.8	159.0	78.8	189.6
9	65.8	139.0	80.0	190.0
10	77.5	190.0	90.0	164.2
11	73.3	198.3	82.1	166.7
12	70.4	155.3	98.8	227.9
13	76.7	161.7	90.0	194.6
14	84.2	167.0	75.4	200.0
15	76.3	185.0	86.3	197.5

TABLE III

CANINES

Root Surface Areas (Sq. MM)

	CAUCASIAN		NEGRO	
Tooth No.	Projected	Total	Projected	Total
1	129.1	286.0	52.9	330.0
2	126.7	232.7	125.4	227.5
3	115.0	211.3	128.8	291.7
4	110.4	169.6	135.4	372.9
5	107.1	249.2	130.8	393.7
6	136.3	293.7	160.8	387.5
7	87.5	191.0	146.7	341.3
8	86.7	175.0	87.9	209.2
9	85.0	170.0	127.5	290.8
10	111.3	287.1	162.9	367.8
11	114.2	273.8	82.9	241.6
12	147.1	366.1	39.2	229.6
13	104.2	273.9	100.4	367.9
14	87.5	220.0	75.0	226.7
15	132.1	351.3	78.8	183.3

TABLE IV

FIRST PREMOLARS

Root Surface Areas (Sq. MM)

	CAUCASIAN		NEGRO	
Tooth No.	Projected	Total	Projected	Total
1.	80.7	205.4	87.1	224.1
2	61.3	230.8	117.8	313.3
3	76.7	211.3	77.5	212.9
4	66.3	219.6	94.3	215.0
5	42.0	207.5	67.9	211.6
6	56.6	214.2	130.0	351.6
7	54.3	195.2	110.0	273.8
8	70.0	177.5	73.7	219.5
9	65.0	188.3	96.3	294.5
10	63.7	266.3	95.0	307.0
11	79.0	279.2	75.0	190.4
12	67.7	212.9	61.3	150.0
13	59.3	228.8	50.4	186.3
14	89.3	361.3	56.3	250.0
15	55.0	249.2	80.0	275.4

TABLE V

SECOND PREMOLARS

Root Surface Areas (Sq. MM)

	CAUCASIAN		NEGRO	
Tooth No.	Projected	Total	Projected	Total
1	77.1	197.0	122.9	185.8
2	58.8	105.3	121.3	328.3
3	109.2	172.0	100.4	296.7
4	84.6	174.4	96.3	225.8
5	107.9	172.3	105.8	284.6
6	103.8	186.7	112.5	273.6
7	100.4	167.0	105.4	297.1
8	102.9	196.0	113.3	281.3
9	76.7	145.3	137.5	317.9
10	86.3	150.6	89.2	253.3
11	87.5	159.2	80.4	248.3
12	84.6	247.5	81.7	221.7
13	78.2	232.9	78.3	247.8
14	53.8	198.8	100.0	257.5
15	52.1	206.3	69.6	142.5

TABLE VI

FIRST MOLARS

Root Surface Areas (Sq. MM)

	CAUCASIAN		NEGRO	
Tooth No.	Projected	Total	Projected	Total
1	150.1	460.4	241.3	509.5
2	160.0	455.0	213.8	241.3
3	165.8	398.3	221.3	590.4
4	185.0	340.0	167.0	440.8
5	160.4	353.8	159.5	428.3
6	130.8	354.3	155.4	460.4
7	127.9	371.5	180.0	525.8
8	158.3	407.3	239.5	606.3
9	145.8	430.8	168.3	527.9
10	195.0	493.3	181.3	455.4
11	199.2	477.9	201.6	498.3
12	125.4	378.8	199.1	512.5
13	162.9	426.6	172.0	600.8
14	159.6	401.3	207.9	462.5
15	226.3	425.4	195.8	500.8

TABLE VII

STATISTICAL EVALUATION OF DATA

Total Root Surface Area of N. American Negro

Cat.	Exp. Range	Mean	S.D.*	95% Confidence	
				High	Low
1	148.8/278.8	214.9	36.0	233.2	196.7
L	164.2/305.4	200.3	32.3	216.6	183.9
C	183.3/393.7	297.4	70.5	333.1	261.8
1P	150.0/351.6	245.0	54.0	272.3	217.7
2P	142.5/328.3	257.5	47.7	281.7	233.3
M	241.3/606.3	510.7	54.7	538.4	483.0
Projected Root Surface Area of N. American Negro					
I	38.3/101.2	71.1	18.2	80.3	61.9
L	55.4/116.3	85.8	14.4	93.0	78.5
C	39.2/162.9	109.0	36.9	127.7	90.3
1P	50.4/130.0	84.9	22.0	96.0	73.7
2P	69.6/137.5	101.0	18.3	110.2	91.7
M	155.4/241.3	193.6	26.6	207.1	180.1

* S.D. - Standard Deviation

TABLE VIII

STATISTICAL EVALUATION OF DATA

Total Root Surface Area of N. American Caucasian

Cat.	Exp. Range	Mean	S.D.*	95% Confidence	
				High	Low
I	120.7/169.0	140.8	13.5	147.7	134.0
L	139.0/198.3	171.9	19.1	181.6	162.2
C	169.6/366.9	250.0	60.0	280.5	219.6
1P	177.5/361.3	229.8	44.1	252.1	207.5
2P	105.3/247.5	180.8	34.0	198.0	163.5
M	340.0/493.3	411.6	45.4	434.6	388.7

Projected Root Surface Area of N. American Caucasian

I	44.2/87.1	69.2	10.0	74.3	64.2
L	62.3/101.7	79.2	11.6	85.1	73.3
C	85.0/147.1	112.0	19.0	121.6	102.4
1P	42.0/89.3	65.8	11.7	71.7	59.9
2P	52.1/109.2	84.3	18.1	93.5	75.1
M	125.4/226.3	163.5	27.1	177.2	149.8

* S.D. - Standard Deviation

TABLE IX

CORRELATION COEFFICIENT

Root Surface Areas of N. American Caucasian

Cat.	CORRELATION VARIABLES X Y Var 1 vs Var 2	Regression Coefficient	Intercept Value
I	0.626	0.843	82.442
L	0.472	0.774	110.624
C	0.797	2.521	-32.328
1P	0.483	1.820	110.055
2P	0.004	0.007	180.160
M	0.427	0.714	294.845

Cat.	CORRELATION VARIABLES X Y Var 3 vs Var 4	Regression Coefficient	Intercept Value
I	0.653	1.294	122.960
L	0.652	1.464	74.711
C	0.622	1.187	168.062
1P	0.802	1.971	77.766
2P	0.592	1.545	101.463
M	0.505	1.038	309.738

	Critical Value
95% Significance Level	.6055
99% Significance Level	.4821

TABLE X

COEFFICIENT OF VARIATION

	Total Surface Area		Projected Surface Area	
Cat.	Negro	Caucasian	Negro	Caucasian
I	16.7%	9.5%	25.5%	14.4%
L	16.1%	11.1%	16.0%	14.4%
C	23.7%	14.0%	33.8%	16.9%
1P	22.0%	19.0%	25.9%	17.7%
2P	18.5%	18.8%	18.1%	21.4%
M	10.7%	11.0%	13.7%	16.5%

CHAPTER V

DISCUSSION

Evaluation of the data obtained in this study revealed broad standards that are descriptive of the root surface areas of the Negro and Caucasian mandibular teeth with exception of the second and third molars. Our discussion will be centered to the variations and interactions between the surface areas as observed in this investigation.

Todd (1915) stated that the crowns of all the teeth are large in the Negro when compared to other ethnic groups. Altemus (1960) concluded that the amount of tooth material is larger in the Negro when compared with the Caucasian. This present study indicates that generally this is also true for the root surface areas. A comparison of Tables VII and VIII for the Negro and Caucasian populations respectively shows that the mean values for projected and total root surface areas were larger for the Negro teeth with the exception of the projected surface area of the canine tooth. (109.0 sq.mm for the Negro and 112.0 sq.mm for the Caucasian).

Even though it is not the purpose or scope of this work to relate these findings to the biophysics of tooth movement, the following observation should be considered. Orthodontic forces when applied to the crowns of the teeth are transmitted to alveolar bone

by the root surface through the periodontal ligament. The resistance offered by the alveolar bone is directly proportional to the root surface area. We must assume then from the data previously presented that significant differences in force magnitudes are needed to achieve optimum tooth movement in different ethnic groups and categories of teeth.

A review of the literature showed that numerous pieces of research have been done to establish values for total root surface areas, but only two investigators, Emmanuelli and Moromisato (1967), gave values for projected root surface area (bucco-lingual projection). A comparison of the values for root surface area obtained in this study and some previous investigations can be found in Table XII.

In order to compare the variability of root surface areas in the Negro and Caucasian populations, the coefficient of variation (100 X Standard Deviation/Mean) was computed. This coefficient of variation is specially useful for comparing variability in different populations whose means differ widely. Table X shows that the variability as related to the mean (Coefficient of Variation) for total and projected root surface areas is larger in the mandibular central incisor, lateral incisor, canine, and first premolar of the Negro population and larger in the mandibular second premolar and first molar of the Caucasian population.

Some of the values found in Table X appear large, and we must

accept that these biological measurements may have an unmeasurable degree of error. But it is the innate complexity of biological systems that usually causes a degree of variability much larger than can be accounted for by measurements alone.

Since projected and total root surface area may be quantitatively related within or between populations, an attempt was made to correlate these surfaces by means of the I.B.M. electronic computer. The correlation of the root surface areas is described in Chapter III, and the correlation coefficients obtained can be found in Table IX. The correlation of the projected surface area vs. total surface area in the Caucasian population disclosed the following. A highly significant correlation exists between the two surfaces in the central incisor (C.C. 0.626) and the canine (C.C. 0.483). The lateral incisor (C.C. 0.472) and the first molar (C. C. 0.427) were close to the 0.5% level of significance. No significant correlation was found for the second premolar.

The correlation of the projected surface of the Caucasian population vs. the projected surface of the Negro population (Var 1 vs. Var 3) and of the total surface of the Caucasian population vs. the total surface of the Negro population (Var 2 vs. Var 4) was not significant.

Correlation of the projected surface vs. total surface area (Var 3 vs. Var 4) of the Negro population was significant at the .01%

level for the central incisor, lateral incisor, canine, and first premolar. The second premolar and first molar correlations were highly significant at the .05% level. The correlation coefficient in this study measured the strength of relationship between two independent variable traits, the projected and total root surface areas. Of particular interest to the clinician could be the use of this data in relation to prediction of root surface areas.

The technique employed in this investigation was similar to the one described by Emmanuelli and Moromisato (1967). They proved the accuracy of the method by using a cylinder with measurements accurate to 0.002 mm. The surface area of the cylinder was calculated mathematically to be 157.0 sq.mm and the projected area 50.0 sq.mm. By using the membrane technique, the total surface areas were found to be 153.8 sq.mm. This was 3.2 sq.mm less than the known value or a 2% error from the true value. The projected area was measured to be 50.7 sq.mm or an error of 1.4%. This proved the technique to be accurate and was one of the most important factors in adopting this method with some modifications for this investigation.

The foregoing discussion of the data obtained in this study reveals evidence of the importance of this information to the orthodontist and emphasizes the need for additional studies to search further for relationships that might assist the clinician.

TABLE XI

A COMPARISON OF ROOT SURFACE AREA DETERMINATIONS

Tooth Cat.	PRESENT STUDY 1968				EMMANUELLI 1967		JEPSEN 1963	TYLMAN & TYLMAN 1960	BOYD 1958
	Caucasian		Negro						
	Total	Projected	Total	Projected	Total	Projected*	Total	Total	Total
I	140.8	69.2	214.9	71.1	150.440	63.327	154.0	103.0	162.2
L	171.9	79.2	200.0	85.8	161.094	66.211	168.0	124.0	174.8
C	250.0	112.0	297.4	109.0	234.419	98.956	268.0	159.0	272.2
1P	229.8	65.8	245.0	84.9	187.363	79.721	180.0	130.0	196.9
2P	180.8	84.3	257.5	101.0	199.424	79.392	207.0	135.0	204.3
M	411.6	163.5	510.7	193.6	402.420	146.194	431.0	352.0	450.3

* - Bucco-lingual projection

CHAPTER VI

SUMMARY AND CONCLUSIONS

This study was undertaken to measure the total and projected root surface area of mandibular teeth in the North American Negro and Caucasian populations and to determine if any correlation exists.

A sample of fifteen teeth in each category (e.g., central incisor, lateral incisor, etc.) excluding second and third molars were selected for the Negro and Caucasian populations. The Formvar membrane technique was used to measure the total root surface areas. The projected root surface areas were measured by photographing the mesial surface of the roots.

The values obtained from the statistical evaluation were considered to represent standards for root surface areas of the mandibular teeth in both populations.

From the statistical analysis of the data, the following conclusions were made:

1. Broad standards were determined for total and projected root surface areas in the Negro and Caucasian populations.

2. Generally, the total and projected surface areas were found to be larger in the Negro population than in the Caucasian population.

3. When comparing both populations, the variability of the total and projected root surface areas was larger for the central

incisor, lateral incisor, canine, and first premolar in the Negro population; and the variability of the second premolar and first molar was larger in the Caucasian population.

4. The total surface area of any tooth excluding second and third molars in the Negro population can be predicted with a high degree of accuracy if the projected surface is known.

5. The total surface of the central incisor, canine, and first premolar in the Caucasian population can be predicted with reasonable accuracy if the projected surface is known. The total root surface area of the lateral incisor and first molar can be predicted to a lesser degree of accuracy.

6. A significant coefficient of correlation could not be found between the Negro and Caucasian population root surface areas.

7. The data provided in this study could be useful in the study and clinical application of the biophysical concepts of tooth movement.

CHAPTER VII

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APPROVAL SHEET

The thesis submitted by Dr. Noel Molini has been read and approved by members of the Departments of Anatomy and Oral Biology.

The final copies have been examined by the director of the thesis and the signature which appears below verifies the fact that any necessary changes have been incorporated, and that the thesis is now given final approval with reference to content, form, and mechanical accuracy.

The thesis is, therefore, accepted in partial fulfillment of the requirements for the Degree of Master of Science.

Nov 23, 1968
DATE

James A Evans D.D.S. M.S.
Signature of Advisor