Comparative Study of the Pressure of Brushing with Three Types of Toothbrushes

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Toothbrushing is a factor in the etiology of gingival recession and dental abrasion. Patients with good oral hygiene have been found to have more gingival recession [3, 8] and more dental abrasion [5] than those with poor oral hygiene. Several factors are related to toothbrushing abrasion including the composition of the dentifrice, method of brushing, and the force of brushing.[6] The forces involved in brushing are examined in this study.

Data from investigations of toothbrushing forces indicate significant variations in the magnitude. Some of the variations appear to be related to research methods. Studies have reported the "mean maximum force" used in toothbrushing to be 203 grams for sweep versus 406 grams for scrub method,[4] 183.9 grams for soft powered to 1,153.3 grams for soft multitufted handbrushing,[2] 775 ponds for vertical and 457 ponds for horizontal reciprocal brushing,[1] and 539 grams for men versus 478 grams for women.[7] The "average brushing force" has been reported to be 106 grams for powered versus 318 grams for hand brushing [9] or to range from 92.7 grams for a soft powered to 471.4 grams for a soft multitufted hand brush.[2]

While these studies have examined the total force applied to the toothbrush handle in brushing, the potential detrimental effects of brushing are related to the force applied at a particular point in the mouth. Thus, the arrangement, length, number and character of the bristles and the stiffness of the brush handle are important determinants in how the forces applied at the brush handle are transmitted to the tissues.

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Materials and Methods

A miniature FM radio transmitter was designed specifically to determine the pressure exerted at the tooth surface by various toothbrushes. It was constructed within a nylon occlusal plate suitable for placement between the subject's teeth. A circuit diagram for the transmitter is shown (Figure 1). Power was provided by a 1.5 volt mercury battery.

The range of pressure likely to be encountered was determined from a pilot study. In order to provide the appropriate range of response a strain gauge sensor was rigidly fixed to a 0.020 gauge stainless steel wire which was attached to the occlusal plate at one end. The other end of the wire was formed to have a flat surface area of 2 sq. mm. This end was suspended in an elastic material within a channel in the occlusal plate and terminated flush with the lateral edge of the plate. Any force exerted on the free end of the 2 sq. mm. wire produced a change in the resistance of the sensor. The response curve produced by this device was linear for the range of use (Figure 2). The transmitting device is shown in Figure 3.

Thirty-two subjects, 16 women and 16 men who were clinical patients at The University of Michigan School of Dentistry and who had had experience in the use of a power brush were requested to take part in this study. Their ages ranged from 19 to 49 years, the mean age being 25.1 years.

All the tests were carried out with the subjects standing before a mirror at a sink. Care was taken to avoid any mention or make any inference that measurements of force was involved in the test. With the radio transmitter held between their teeth, the subjects brushed in their normal manner on the side of the mouth being tested. The bite plate was inverted to measure the same area of each side of the mouth, the side brushed first being randomly selected. The test period was 1.5 minutes When the bite plate was placed between the subject's teeth, it was placed as close as possible to the plane determined by the buccal surface of the maxillary teeth. The sensing area was usually subjacent to the maxillary first bicuspid with slight variation.

Three brushes were tested: (1) the manual hard—a Dr. Butler nylon brush with 12 tufts of 30, 0.012 inch diameter bristles, 7/16 inches long, arranged in two rows; (2) the manual soft—a Dr. Butler Sub-G with 18 tufts of approximately 45, 0.008 inches diameter bristles, 13/16 inches long, arranged in three rows; and (3) the powered soft—Dr. Butler electric with a brush head of 15 tufts of approximately 45, 0.008 inches diameter bristles, 3/8 inches long, arranged in three rows. New brushes were used in the testing.

FIGURE 1. CIRCUIT DIAGRAM FOR RADIO TRANSMITTER

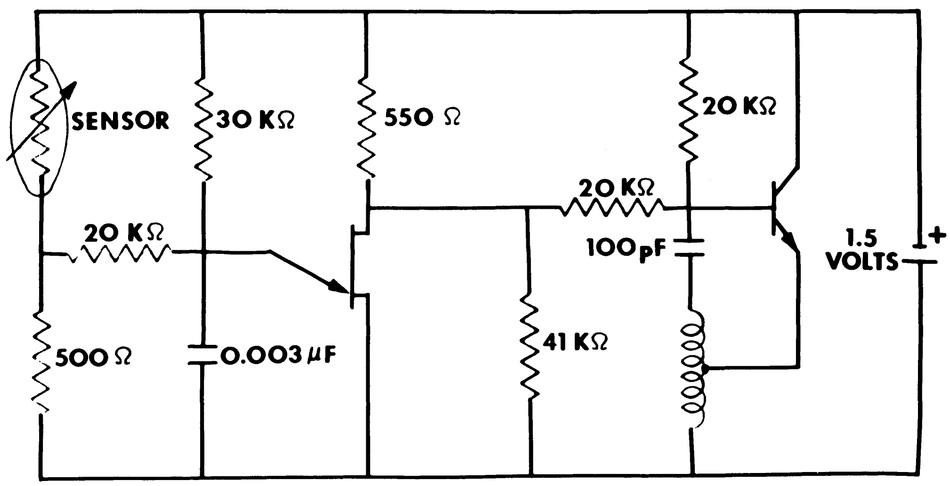

FIGURE 2. RESPONSE CURVE

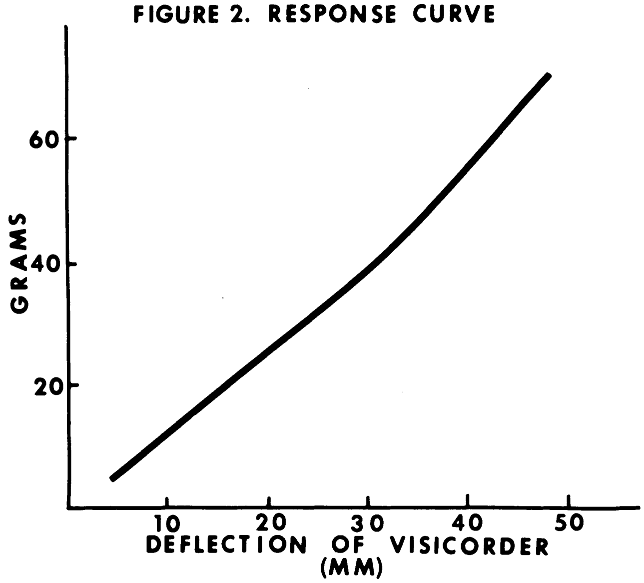

FIGURE 3. MINIATURE RADIO TRANSMITTER

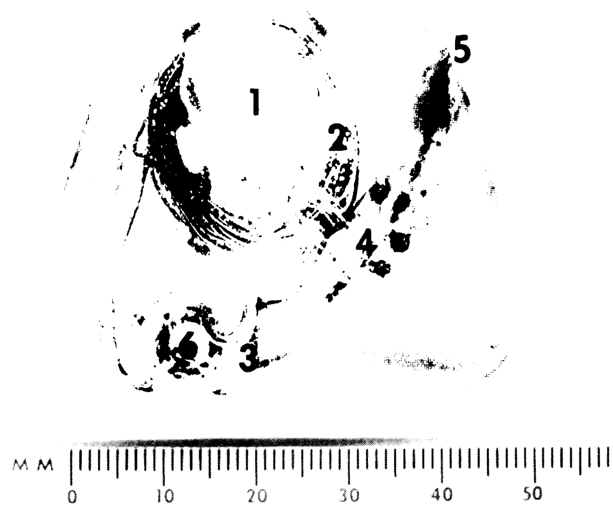

FIGURE 3. *1. Miniaturized radio components (Figure 1). 2. Transmitting antenna. 3. Point of fixation of 0.020 wire at the end of the cavity which extends from 3 to 5 in the acrylic occlusal plate. 4. The 0.020 wire within the cavity in the occlusal plate to allow movement of wire caused by brush pressure at (5). Strain gauge sensor is fixed to wire at (4). 5. 2 mm² terminal block attached to 0.020 wire and flush with lateral edge of occlusal plate. 6. Mercury battery power source (1.5 volts).*

All tests were recorded on a Model 1706 Visicorder. The recorder was out of view of the subjects. The Visicorder was run at one centimeter per second with one second markings across and two millimeter markings the length of the recording paper. The peaks in the recordings represented sweeps of the bristles across the sensitive area of the plate.

Analysis of Data

The ten greatest peaks in any 30 seconds of the recording period were averaged, transposed to grams/mm ^{2} via the calibration graph, and used as the pressure for that particular test. The single 30 second interval was selected on the basis of having the greatest number of maximum pressure values for any 30 second period out of the 1.5 minutes of recording time. Pressures were determined for the right and the left side of the mouth of the subject for each brush. In comparing brushes, the higher value of the two sides was used in the analysis of the data.

The student t test was used in the statistical analysis. The differences in mean maximum pressure examined were those between the manual hard and the manual soft brush, the manual hard and the powered soft brush, the manual soft and the powered soft brush. The side of the mouth of hand dexterity was compared to the other side. The differences between men and women were examined for each of the three brushes.

Results

The in vivo mean maximum brushing pressures were greatest for the manual hard brush, 19.53 ± 6.48 gm/mm,[2] while the manual soft and the powered soft brushes were very similar, 11.32 ± 5.32 gm/mm[2] and 11.29 ± 5.02 gm/mm[2] respectively. The mean maximum brushing pressures for all the tests, for men and women, and for the two sides of the mouth are shown in Table 1.

Table 2—The differences in pressure between the manual hard and the manual soft brush were significant at the 1 per cent level of confidence, as were the differences between the manual hard brush and the powered soft brush. The differences between the manual soft and the powered soft brushes were not statistically significant ($p > .05$).

Table 3—With all three brushes there was significantly greater pressure used on the side of the mouth of hand dexterity as compared to the side opposite. The difference was significant at the 5 per cent level of confidence for the manual soft brush, the manual hard brush and the powered soft brush.

Table 4—There was no significant difference in pressure values between men and women for any of the three brushes tested.

Discussion

It is generally accepted that oral cleanliness is essential to oral health but soft and hard tissue abrasion can occur with oral hygiene procedures. An ideal oral hygiene procedure would be one that would be effective in cleaning but would not produce oral damage.

The results of this study might indicate that soft powered or soft manual brushes have less wear potential than hard manual brushes. However, it has been shown that more abrasion occurs on the side of the mouth away from the hand used in brushing,[6] while in this study significantly less pressure was used on the side of the mouth away as compared to the side toward the hand used in brushing.

The values that were examined were for mean maximum pressure. The method of brushing has an influence on the duration of the pressure a toothbrush exerts on the teeth as explained by Björn and Lindhe.[1]

Table 1.
Mean Maximum Toothbrushing Pressures
(Gms./mm.²)

	*Hard**	*Soft***	*Power****
All tests	19.53 ± 6.48	11.32 ± 5.32	11.29 ± 5.02
Men	19.70 ± 8.66	12.44 ± 6.20	10.46 ± 4.38
Women	18.01 ± 4.25	10.34 ± 4.34	12.06 ± 5.57
Dexterity side	18.02 ± 7.09	10.75 ± 4.87	10.66 ± 5.07
Other side	14.80 ± 6.08	9.03 ± 5.43	8.73 ± 3.62

*Dr. Butler Hard, 0.012″ diameter nylon filaments.
**Dr. Butler Soft, 0.008″ diameter nylon filaments.
***Dr. Butler Electric, 0.008″ diameter nylon filaments.

Table 2.
Comparison of Toothbrushing Forces:
Differences Between Brushes

	Hard vs. Soft	*Hard vs. Power*	*Power vs. Soft*
Direct Mean Diff. (Gms./mm.²)	7.08*	6.92*	1.09
S.E.	1.46	1.26	0.95
t Value	4.84	5.48	1.15
p	<0.01	<0.01	>0.05

*Difference favoring the hard brush.

Table 3.
Comparison of Toothbrushing Forces:
Side of Hand Dexterity vs. Opposite Side

	Hard	*Soft*	*Power*
Direct Mean Diff. (Gms./mm.²)	3.17*	1.17*	2.00*
S.E.	1.35	0.80	0.76
t Value	2.33	2.13	2.61
p	<0.05	<0.05	<0.05

*Difference favoring side of hand dexterity.

Table 4.
Comparison of Toothbrushing Forces:
Men vs. Women

	Hard	*Soft*	*Power*
Mean Diff. (Gms./mm.²)	1.69	2.10	−1.60
S.E.	1.47	1.16	0.91
t Value	0.57	0.95	0.90
p	>0.05	>0.05	>0.05

In the sweep or roll method with the brush against the gingiva, the pressure will be zero on the teeth and build up to the maximum value as the brush crosses the teeth, only to quickly return to zero, the duration of the pressure depending on the speed of the stroke. With a scrub or powered brushing method, the pressure may remain near the maximum value while brushing a particular area. These patterns were reflected in the recordings.

Wide variations occur in the pressure of brushing with each of the three brushes tested. There was a correlation within each patient as to the pressure exerted between the different brushes, i.e., individuals applying heavy pressure with one type of brush also used heavy pressure with other brushes.

Conclusions

Under the conditions of this study, it is concluded that:

1. A manual soft toothbrush and a powered toothbrush with a soft brushing head exert similar pressure on the teeth during brushing.
2. A manual hard toothbrush produces more pressure at the tooth surface than either a manual soft brush or a powered soft brush.
3. More pressure is exerted during brushing on the side of the mouth of hand dexterity than on the opposite side.
4. A wide range of pressure was found for each type of brush.

Summary

A miniature radio transmitter was specifically designed to measure the pressure of toothbrushing at the tooth surface.

Tests were carried out on 32 subjects, 16 men and 16 women, using three different toothbrushes. The brushes tested were the hard nylon manual brush, the soft nylon manual brush, and a powered brush with a soft nylon brush head. Readings were obtained from similar areas on the right and left side of the mouth of each subject.

Similar mean maximum pressures were found for the soft manual brush and the soft powered brush while significantly greater pressures were found with the hard manual brush. Significantly greater mean maximum pressures occurred on the side of the mouth of hand dexterity as compared to the other side. No significant differences in mean maximum brushing pressures existed between men and women. A wide range of pressures was found with each brush type.

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Abstract

Demineralization of Bone Transplants In Vivo

Narang, R., Wells, H., and Lloyd, W. S.
Oral Surg., 36:291, 1973.

Midfibular fracture gaps were made in rats to sample the bone induction capabilities of decalcified allogeneic bone matrix (DABM), fresh autologous bone, fresh allogeneic bone, and decalcified xenogeneic bone matrix (DXBM). The DABM implants were accepted by the host animal. Rejection was observed in 55 percent of the DXBM grafts. Calcium levels showed an initial decline with normal levels by the eighth week using autologous or allogeneic grafts. All of the autologous grafts were accepted but 45 percent of the allogeneic grafts were rejected. It was suggested that calcified bone grafts can become partially or completely decalcified in tissues. It was concluded that since decalcification of bone could be accomplished *in vitro*, DABM grafts may be used in human osseous defects. *Boston University School of Graduate Dentistry, 100 East Newton Street, Boston, Massachusetts 02118.*