Experimental Findings on Tooth Movements Under Two Conditions of Applied Force

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This paper reports findings from a study of distal movement of the first permanent molars in a selected sample of sixteen young orthodontic subjects. For each subject, during a twelve week period, a force of 400 grams was applied to the molar on one side of the maxillary arch, while a force of 200 grams was applied to the molar on the opposite side of the arch.

Objectives

The two major aims of the experiment were:

1. To obtain central tendency and variability statistics for the amount of tooth movement elicited in both force groups and to test the significances of any differences found.

2. To test the hypothesis that a force of 400 grams applied for twelve successive weeks will yield a greater molar movement than 200 grams applied for the same length of time.

Relevant Previous Studies

Storey and Smith,[1] working with a sample of five patients between the ages of twelve and fifteen years, described distal movement of mandibular canines under the influence of differential forces. Using mandibular second premolars and first molars as anchorage units, they fitted heavy springs (400-600 grams) to one side of each arch and light springs (175-300 grams) to the opposite side. The forces were continuous, and tooth movement measurements were made weekly. The authors concluded that, up to a limit (approxi-mately 300 grams), there is a relationship between magnitude of applied force and rate of tooth movement. The 200 and 400 gram force values used in the present study were derived from Storey and Smith's work.

Haack and Weinstein have demonstrated that well-controlled differential forces can be maintained by the use of eccentric headgear.[2] This is accomplished by varying the length of the external arms of the headgear. In the present study differential forces of 200 and 400 grams were obtained by constructing a headgear of the Haack and Weinstein design.

Material and Method

Subjects: Sixteen healthy females, ages eight to ten years, were drawn from the clinic population of the University of Iowa Orthodontic Department. All were of northwestern European ancestry and from families of average or above average socioeconomic status. Criteria for selection were: (a) no previous orthodontic treatment, (b) tendency toward distal occlusion, and (c) crowns of unerupted maxillary second permanent molars lying above the cervix of the adjacent first molars.

Orthodontic Appliances: Preformed maxillary first molar and central incisor bands were fitted for each subject. Molar bands carried .045 buccal tubes; in-

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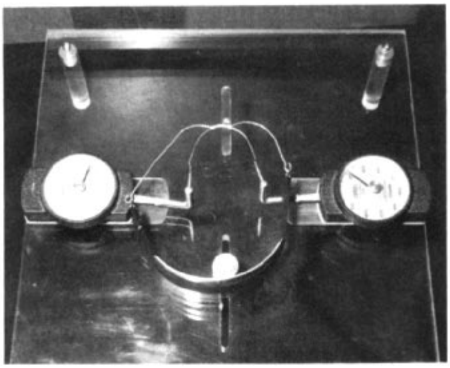

Fig. 1 Force board used to measure eccentric forces on the headgear.

cisor bands carried .022 x .028 siamese brackets. Kloehn-type headgears with cervical strap elastics were fitted for each subject.[3] Following the Haack and Weinstein design, the outer bows were left long on the 400 gram side and were made short on the 200 gram side. A sliding attachment was placed on one outer arm of the headgear and repositioned until correct 200 and 400 gram force values were recorded on the Correx force gauges. After this position was marked, a permanent hook for attaching the cervical strap was made on the outer bow arm. Individual headgear adjustments were made each week to maintain the 200 and 400 grams of force. Each headgear was worn ten hours per day.

Force Measurement: A force board was designed to establish and measure unilateral forces of eccentric headgear (Figure 1). The force board base consisted of clear lucite on which two Correx force gauges (0-1000 gram range) were placed containing .045 tube fittings. The gauges were so designed that they would permit lateral adjustment to compensate for variations in the width of the inner bow of the headgear. A cervical strap-holder was made to simulate the neck; the force board was adjustable for variations in the anteroposterior dimensions of the neck. In order to reproduce the force, as distributed on the patient, the cervical strap-holder was made to move freely about a center bearing and thus it equalized the forces on the outer bow arms. The use of a dental vibrator beneath the force board facilitated the removal of friction between the neck strap holder and the bearings.

Measurement of Tooth Movement

Tooth movement values were obtained independently by each of the authors at exact weekly intervals over the twelve week period of study. Measurements were made using a four step procedure:

1. One point of the spring bow divider was placed in a point where a lingual groove crossed the band on the first permanent molar. 2. The divider was adjusted so that the outer point rested in a point indentation in a metal bar carried by a stone jig fitting over the anterior teeth (Fig. 2). 3. The adjusted divider was removed from the subject's mouth and the interpoint interval transferred to a sheet of paper by perforating it with the divider points. 4. The distance between the two perforations was measured with a helois sliding caliper having sharp point arms and a dial readout to 1/20 mm. The jig for each subject was constructed at the beginning of the study period and used at each subsequent weekly interval dur-

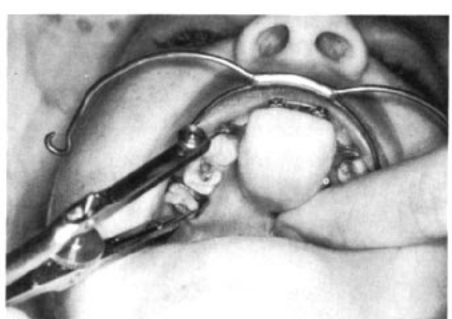

Fig. 2 Measurement of tooth movement.

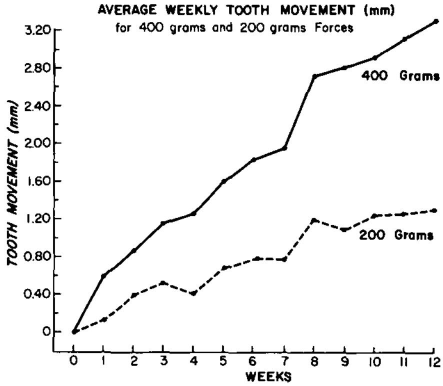

Fig. 3 Two unsmoothed curves of mean weekly posterior maxillary first molar movements for 400 gram and 200 gram force values during the twelve weekly intervals.

ing the study period. Its purpose was to provide a stable anterior point from which to measure molar movement.

The two series of independent measurements totaled three hundred seventy for each investigator. The series for one investigator on a given subject was to derive values for weekly tooth movement. The same procedure was followed to obtain values for weekly tooth movement for the other investigator. Analysis of the differences between paired values (i.e., values obtained by the two investigators for a specific week and force condition) gave a standard error of measurement of .27 mm.

Findings: On the average, teeth in the 400 gram force group moved farther than those in the 200 gram force group at each of the twelve weekly intervals. The weekly means for movement of teeth in both force groups are depicted graphically in Figure 3. Examination of the curve suggests the following generalizations: On the average, during the twelve week treatment period, the teeth in the 400 gram force group moved approximately two and one-half times as far as did the teeth in the 200 gram force group. This finding enables us to confirm the hypothesis

GROUPING OF TOTAL TOOTH MOVEMENT DIFFERENCES (mm) INDICATING CENTRAL TENDENCY AND VARIABILITY

PATIENTS	1st week of 1st 4wks	4 WEEKS 1st	4 WEEKS 2nd	4 WEEKS 3rd
1	0.25	0.62	0.24	-0.19
2	0.75	1.02	1.33	-0.61
3	0.28	0.82	1.03	0.23
4	1.65	1.47	0.70	-0.11
5	0.40	0.71	1.43	0.67
6	0.35	0.80	1.10	-0.37
7	-0.05	2.06	1.00	0.41
8	0.22	0.36	0.42	0.32
9	0.40	0.98	1.56	0.47
10	-0.07	0.31	-0.06	0.97
11	0.66	1.41	0.94	1.10
12	1.56	1.15	0.27	0.40
13	-0.08	0.29	-0.48	1.53
14	0.57	0.42	0.15	0.71
15	-0.60	-0.04	2.07	0.05
16	1.13	0.81	-0.38	1.54
$\bar{D}$	0.46	0.82	0.71	0.45
S.D.*	0.57	0.51	0.71	0.61
S.E.*	0.15	0.13	0.18	0.16
t*	3.07	6.31	3.94	2.81

*S.D. = Standard Deviation
*S.E. = Standard Error of the Mean
*t = Statistic is Significant at 0.01 level of Confidence (df=15) (t at .01 level is 2.60)

Table 1 Grouping of total tooth movement differences (mm) indicating central tendency and variability.

that a force of 400 grams applied for twelve successive weeks will yield a greater molar movement than 200 grams applied for the same length of time.

Findings for the relative intergroup differences in tooth movement are summarized in Table 1.

Here, for each subject, the *difference* in distance moved by the 200 gram tooth and the 400 gram tooth is reported. In column 1, the differences are for the first week of treatment. Columns 3, 4, and 5 contain aggregate differences for the first, second, and third four week subdivisions of the twelve week treatment period. The bottom rows in the table record the appropriate central tendency and variability statistics. Some of the findings which may be abstracted from the table are:

1. There was much intraforce group variability in the distance moved dur-

ing each period; i.e., standard deviations are of the same order of magnitude as the distance difference means.

2. There was more treatment difference between the two force groups during the first month of treatment than in either of the two succeeding months, and in the third month the relative intergroup differences approximated that of the first treatment week.

3. All four of the tabulated mean differences in tooth movement were positive; that is to say, there was no relapse or mesial movement of the molars during eccentric headgear treatment.

4. All the statistics for the .01 level of confidence were significant.

Discussion

Findings of the present study suggest that eccentric tooth movement can be attained by using an eccentric headgear.

Increased forces and increased rates of tooth movement do have an effect upon correction of malocclusions since asymmetries often exist in a malocclusion. If a malocclusion shows an asymmetry, the orthodontist must move certain teeth at a faster rate than others to correct the malocclusion to a symmetrical form. For example, a malocclusion showing an end-to-end molar relationship on one side of the mouth and a Class II molar relationship on the other side of the mouth is an asymmetrical malocclusion. The orthodontist has to move the molar that is in Class II position at a faster rate distally than the molar that is in an end-to-end position in order to secure Class I molar relationships on each side of the mouth. It is, therefore, necessary to know whether a tooth will move faster through the bone, within physiologic limits, if the orthodontist places a heavier force on the tooth. For the maxillary first molars, the findings of this investigation indicate that a faster rate of molar movement is produced by placing an increased force upon it.

Summary and Conclusions

Findings from a study of effects of differential force application have been presented. Using cervical traction with eccentric headgear, forces of 400 and 200 grams were applied to first permanent molars on opposite sides of the same maxillary arch. Teeth receiving the 400 gram forces moved over greater distances at higher rates of speed than did the teeth receiving the 200 gram forces.

Findings from this and similar studies should enable orthodontists to treat asymmetric malocclusions in a much more efficient manner than they can without using differential forces.

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