Comparison of Two Methods of Applying Lingual Root Torque to Maxillary Incisors

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Introduction

Attainment of a satisfactory labiolingual inclination of the maxillary central incisor teeth is an important requirement of successful orthodontic treatment. Frequently however, especially in Class II, Division 2 cases and in extraction cases where closing loops have been used to retract the incisors, the crowns of these teeth have been tipped lingually to such an extent that the teeth appear "rabbited." In such cases lingual root torquing usually is required to achieve satisfactory labiolingual inclinations and to prevent relapse in the overbite and overjet relationships. This paper centers on two methods of applying lingual root torque to the maxillary central incisor teeth, and findings from a comparison of the two methods are presented.

Objectives

The purpose of this investigation is to evaluate two different methods of applying lingual root torque to the maxillary central incisors. Specific aims are:

1. To determine the amount of change, in degrees, in the labiolingual inclination of the maxillary central incisors that may be obtained by application of lingual root torque for a period of ten weeks with: (a) an .021 x .025 inch stainless steel rectangular wire, and (b) an .016 inch round stainless steel auxiliary torquing wire.

2. To test the hypothesis that the round auxiliary torquing wire is more effective than the rectangular wire in torquing these teeth.

3. To relate the quantitative findings to practical suggestions that may be useful to the clinical practice of orthodontics.

Literature

Torque force is that force obtained from a twisted spring wire in its effort to untwist itself, and the term "torque" is used to describe the effect on a tooth when a twisted archwire delivers the resultant force.[13,15]

To create torque there must be two-point contact between the bracket, which is the holding device, and an active force member, which is the wire. In the edgewise appliance the precise fit of the rectangular archwire in the bracket slot makes it impossible for the wire to turn upon itself without exerting a torquing force upon the tooth. For this reason the edgewise bracket is ideal for the production and use of torque force, and the mechanical ease with which rectangular wires can be used to apply torque to teeth has been one of the principal advantages of this bracket.[3,13]

Other force systems employing the two-point contact principle of force distribution have been developed. With the introduction of the Begg technique, the use of vertical loops bent into round

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auxiliary torquing wires has become rather widespread. This method of torquing is claimed to be superior to the edgewise method because the force exerted is of lower magnitude and is capable of acting continuously and through a wider range than is the force which is produced by the twisted rectangular wire in the edgewise bracket.[3]

No investigations were located in which different methods of torquing teeth have been directly compared. However, Boman[1] reported an average angular change of 7.78 degrees after six months of force application on fifty patients in which maxillary central incisors were torqued lingually with an appliance of his own design.

Wolf,[17] using an extraoral appliance which acted upon a torqued archwire to increase the force of the archwire when it was engaged in the brackets of the maxillary central incisors, reported that in two patients the angulation of these teeth to the sella nasion plane was changed "2 or 3" degrees over a period of eight weeks. The extraoral force was supplied by a headcap and traction bar, but the exact method by which this force was applied was not specified.

Willian[16] studied the lingual root movement of the maxillary central incisors of five *Macaque rhesus* monkeys which were subjected to continuous torquing moments of varying forces for from nine to twenty weeks and concluded: "The greater the magnitude of the moment the greater the amount of tooth movement that occurred." Neither the method of force application nor values for the forces applied were specified.

Differences of opinion continue to be expressed in the literature as to the appliance of choice, the magnitude of force, and the manner in which the force should be applied in order to accomplish desired tooth movements in the least time and with the least amount of tissue damage.

The periodontal response to force application, therefore the tooth movement attained, varies with the magnitude of the force, the duration of time the force is active, the direction and the distance through which the force is active.[2,11] The forces used in current practice vary from no force at all to force values which cause pain and looseness of teeth; there is no generally accepted reference listing force values that should be used for particular orthodontic purposes. Further, although much discussion is given to "light" and "heavy" forces, no explicit definitions of "light" and "heavy" forces have been agreed upon.[12]

Halderson, Johns, and Moyers[2] have noted that the forces inherent within the edgewise appliance are high. In many instances the strain gauges used, with upper limits of two pounds, were unable to record the magnitude of the force applied. However, the edgewise mechanism can be used successfully because the distance through which the force is active is relatively small, and the movement is precisely controlled. Stuteville[14] gives support to the use of heavy forces through short distances by stating, "One could use a ton of force if it were possible, and as long as the force was not active for a great enough distance to obliterate the blood vessels in the periodontal membrane in any area, the tooth would probably move without root resorption."

Forces employed in the light round wire techniques are considerably less than those produced by the edgewise appliance.[5]

Reitan[9] believes that light forces are better than heavy, at least initially, because formation of hyalinized cell-free areas in the periodontal membrane occurs less when light forces are employed, i.e., with light forces, initial tooth movement will occur more quickly because of a more favorable periodontal response. After the tooth has started to move, the forces may be increased to counter the retarding effect of stretched fiber bundles on the tension side.

Regarding the significance of the direction of applied force, Moyers and Bauer[4] have pointed out that tipping and extrusive movements are more easily carried out than bodily and intrusive movements, because less blood supply in the periodontal membrane is cut off. From this it follows that a tipping movement can be accomplished with less force than is required for a bodily movement.

Differences of opinion exist as tc whether continuous or intermittent forces are more advantageous. Schwarz[10] believes that the most optimum tooth movement is produced by forces (1) not greater than the pressure in the blood capillaries, i.e., approximately twenty-five grams per square centimeter of root surface, and (2) acting through a distance of less than one millimeter.

In 1935, Oppenheim[6] stated that, ". . . only the weakest elastic forces, intermittently applied, and interrupted by longer or shorter intervals of rest, are now permissible in practice." However, by 1944 Oppenheim[7] came to favor the use of light continuous forces.

Orban[8] noted that when intermittent forces are used, a period of movement is followed by a period of rest. During the rest period osteoid tissue is formed, and this must be resorbed before further tooth movement can occur. Although resorption of this osteoid tissue does occur eventually, Orban[8] claims it is resorbed more slowly than bone. Therefore, a gentle continuous force applied over a longer period of time will produce faster tooth movement than will an intermittent force, because there will be no formation of osteoid to hamper tooth movement.

Not only is it very difficult to measure precisely the value of the force being exerted, and its direction, range, and duration of action in a clinical situation, but also reactions to forces vary with sex, age, root anatomy, individual tissue response, and other factors. Stoner[11] summarizes the situation as follows: "Very little scientific data are available concerning the amount of force required to move teeth. As little as 20 grams per square centimeter, and as much as several pounds have been tested on certain appliances in common use today. Much investigation is needed to establish force standards to serve as a useful guide."

Sample

The subjects were six Caucasian girls and four Caucasian boys ranging in age from twelve to seventeen years. All were under treatment at the University of Iowa orthodontic clinic, and none had been subjected to torquing of the maxillary central incisors.

Materials and Methods

A stone core was constructed from dental casts to fit the labial surface and incisal edge of each central incisor. A straight piece of .025 inch stainless steel orthodontic wire approximately one and one-half inches long was incorporated within each core (Figure 1).

The wire in the left core was placed approximately two or three millimeters closer to the labial surface of the tooth than was the wire in the right core to facilitate identification of the left and right central incisors on subsequent lateral cephalographs.

At the beginning of the experimen-

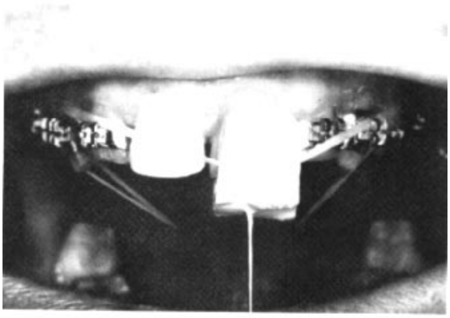

Fig. 1 The stone core held in place by the molar-to-molar elastic. The stabilizing matrix may be seen in the background.

tal period the bands were removed from the maxillary central incisors and, with the left stone core held in place with a molar-to-molar elastic, a lateral cephalograph was taken. Without removing the patient from the cephalostat, the left core was removed, the right one was placed on the right central incisor, and a second cephalograph was taken.

The bracket from one of the maxillary central incisor bands was removed and a bracket with a 25° angulated slot was spot-welded in its place. The slot of the bracket attached to the other central incisor band was enlarged by grinding so that the rectangular archwire would not exert any torquing force upon this bracket and tooth (Fig. 2). The central incisor which received the 25° torqued bracket was determined in each case by the flip of a coin. Both bands were cemented to place.

An .021 x .025 inch stainless steel rectangular archwire was conformed to the arch, and an .016 inch round stainless steel auxiliary torquing wire was bent to a standardized size with the Nance loopforming pliers. Both wires were then heat-treated simultaneously in the electric oven at 750°F. for three minutes and then polished briefly in the anodyzer.

The rectangular wire was tied into each bracket and tied back to the first molars on each side of the arch by means of brass wire "tie-backs" soldered to the archwire just anterior to the molar tubes.

The round auxiliary torquing wire was tied into its bracket, and the ends of this wire were hooked over the continuous rectangular archwire distal to the second bicuspid on each side of the arch (Figure 3).

Cervical traction, employing one pound of tension on each side (as measured with the Dontrix gauge), was used 20 hours per day to counter the forward pull exerted by the torquing

Fig. 2 Front view of the bands cemented on the central incisors. The 25° torqued bracket is attached to the left band. The slot of the right bracket has been enlarged.

Fig. 3 The rectangular and round archwires in place in the mouth. Prior to activation by tying to place, the "U-shaped" gingival extension of the round wire lay in the same plane as the posterior ends of the wire.

action of the two archwires. With patient No. 9 Class II elastics were used instead of cervical traction, because anterior movement of the mandibular teeth was desired in her case.

At approximately two and one-half and seven and one-half weeks the teeth of all subjects were checked for loose bands, ligature ties, and constancy of cervical traction pull. At the middle of the experimental period (five weeks) both archwires were removed, reshaped, heat-treated, and retied.

At the end of ten weeks the central incisors were stabilized prior to removing the archwires by adapting Kerr's brown denture compound to the palate and lingual surfaces of the maxillary incisors and hardening it by spraying with ice water. When the final cephalographs were taken, this matrix was held in place with elastics stretched from the first molar and cuspid on one side of the arch to the corresponding teeth on the opposite side (Figure 1).

Collection of Data

For each subject a tracing of one of four lateral cephalographs was made. On this tracing a straight-edge was placed parallel to the anterior border of the wire which protruded from the stone core, and a line was drawn along the straight-edge with a fine-line ball point pen. This tracing was subsequently superimposed upon the other three cephalographs of the subject, and the same procedure was followed in drawing the lines parallel to the anterior border of the wire. In superimposing the tracing over the cephalographs, the entire outline of the skull, the sella turcica, the clivus, and the base of the occipital bone were utilized in positioning.

By measuring the angle formed by the two intersecting lines, one from the pretreatment film and one from the posttreatment film, the angular change in the labiolingual inclination of each of the central incisors was determined. This angle was measured to the nearest 0.1 degree.

The two investigators, working independently, traced and measured the cephalographs of each subject three times; the tracings and measurements were done in sequential order to make it as difficult as possible for the results to be biased by remembering readings from previous determinations. The measurements of the angles were initially recorded under columns labeled "right central" and "left central," and separation of the angles into "round wire torque" and "rectangular wire torque" groups was not done until all measurements were completed.

The means of the three measurements by each investigator and the differences between the mean angular change produced by the round torquing wire and the rectangular wire are given in Table 1.

Mean Number of Degrees of Lingual Root Torque Obtained with Each of the Two Methods

The mean number of degrees of lingual root torque obtained with each of the two methods employed was determined (a) with three deviant subjects excluded, and (b) for the total sample. In subject No. 8 there was a negative change in the angulation of both maxillary central incisors, i.e., at the conclusion of treatment the roots of these teeth were more anteriorly positioned relative to the crowns than they were at the beginning of treatment. Apparently the posterior pull of the cervical traction was sufficient to cause distal or lingual movement of all the teeth in the arch including the central incisors. The lingual movement of the crowns of the central incisors was rela-

TABLE I

Mean measurements of the angular change in the labiolingual inclinations of the maxillary central incisors as determined from three independent measurements by investigators A and B.

	Round Wire Torque		Rectangular Wire Torque			
Patient No.	Mean A	Mean B	Mean A	Mean B	Diff. A	Diff. B
1	3.13	2.83	2.83	2.60	+0.30	+0.23
2	4.37	4.03	2.23	2.33	+2.14	+1.70
3	7.78	7.83	11.63	11.67	—3.85	—3.84
4	4.67	4.47	3.90	3.33	+0.77	+1.14
5	1.83	1.47	1.13	0.87	+0.70	+0.60
6	4.67	4.93	3.73	3.63	+0.94	+1.30
7	2.43	2.70	3.07	3.23	—0.64	—0.53
8	—4.80	—4.93	—3.37	—3.67	—1.43	—1.26
9	1.23	1.33	—0.93	—1.20	+2.16	+2.53
10	4.63	4.60	1.40	1.87	+3.23	+2.73

tively greater than the lingual movement of the roots; the change in the labiolingual inclination was thus in the opposite direction from that which was expected. Much the same thing happened with subject No. 9. With this subject, however, only the right central incisor showed a negative change. In both of the above subjects the upper and lower incisors were in an end-to-end bite relationship at the conclusion of the experimental period further attesting to the lingual movement of the crowns of the maxillary central incisors.

In subject No. 3 the amount of tooth movement that occurred was considerably greater than in any of the other subjects. In addition, she had a history of rather rapid and unusual tissue response to orthodontic forces.

The results of this part of the investigation are more meaningful if the extreme data (due to assignable causes) from these three subjects are excluded.

The mean number of degrees of lingual root torque obtained over the ten week period was 3.63° with the round wire; the standard deviation was 1.23. With the rectangular wire the mean was 2.58°, and the standard deviation was 1.01. However, if the data from the three deviant subjects are included, the results for the total sample of the investigation are as follows: the mean number of degrees of lingual root torque obtained over the ten week period was 2.96° with the round wire, the standard deviation being 3.16. With the rectangular wire the mean was 2.51°, and the standard deviation was 3.73.

Testing the Hypothesis that Round Wire is more Effective than Rectangular Wire in Producing Lingual Root Torque

For the total sample the mean difference between the number of degrees of lingual root torquing accomplished with the round wire and the rectangular wire was +0.446°. The standard error of the mean difference was 0.63°. The hypothesis to be tested was that there was no difference in the torquing capabilities of the two methods. The alternative hypothesis considered was that the mean difference in torquing capability was positive in favor of the round wire. Therefore, a one-sided Student's "t" test was performed at the 5% level of significance. For nine degrees of freedom, the critical value that would lead to rejection of the null hypothesis is 1.83. The experiment yielded a "t" value of 0.709. It follows that the hypothesis of no difference cannot be rejected.

Evaluation of Chance Error Involved in Measurement

As an evaluation of how closely the angular measurements of investigator "A" coincided with those of investigator "B", the standard error of the mean for the grouped means was determined for each investigator. The standard error of the mean of the angles as measured by investigator "A" was 0.1086°; for investigator "B" it was 0.1076°. This indicates, as far as the chance error involved in measuring is concerned, that ninety-five per cent of the time the mean value of an angle as determined from three independent measurements would not be expected to deviate from the true value of the angle more than 0.467° for investigator "A" or 0.463° for investigator "B".

Discussion

The conclusion that round wire torque is *at least as* effective as rectangular wire torque seems to be justified. In addition, torquing with round wire has certain other advantages: (1) The area of attachment of the round auxiliary torquing wire is remote from the teeth which are being torqued; the adjacent teeth are therefore not subjected to adverse reactive forces. An equal and opposite torquing action is created in the teeth adjacent to those which one is attempting to torque when a rectangular wire is used. (2) Because of the relative ease with which a round auxiliary torquing wire may be utilized, this method may be especially useful in situations where lingual root torquing of single teeth is indicated. (3) When an auxiliary round wire is used, torquing may be started earlier in treatment or in other situations where it might not be possible to use a rectangular wire. This would be beneficial during treatment of Class II, Division 2 cases and in situations where it would be desirable to torque the incisors at the same time that they are being retracted. (4) Pain does not appear to be a disadvantageous factor when a round wire is used for lingual root torquing, while with rectangular wire most patients complained of at least some pain when the wire was seated in the bracket slot. This was probably due to the heavier force generated by the rectangular wire as compared with the round wire.

Failure to sufficiently torque the roots of the maxillary central incisors is one of the major shortcomings in orthodontic practice. All orthodontists recognize the detraction from esthetics and the possible instability of the overbite and overjet relationships in cases where the upper incisors are left in a lingually inclined position. Frequently, the maxillary incisors may be "rabbited" several degrees during the course of treatment, especially in cases where they have been retracted several millimeters. The results of this study indicate that torquing of the roots of these teeth is a rather slow process; in ten weeks only an average of 3.63° was accomplished with the round auxiliary torquing wire and only 2.58° was obtained with the rectangular wire. Thus, in a patient where several degrees of torquing remain to be accomplished after most of the other goals of treatment have been realized, treatment time may be considerably prolonged. One way of alleviating this situation is to begin torquing procedures earlier in treatment, as previously mentioned. Also, in those cases where "rabbiting" of incisors is initially present or likely to occur during the course of treatment, torquing action should be applied while the incisors are being retracted. This may be accomplished by one of the two methods used in this study or, if desired, both methods may be used simultaneously.

The amount of force exerted by the round auxiliary torquing wire and the rectangular wire in the 25° slot was not determined in this study; however, on the basis of clinical impression and subject response, it is the authors' opinion that considerably more force was generated by the rectangular wire than by the round wire.

Conclusions

This study was designed to compare the effectiveness of two different methods of applying lingual root torque to the maxillary central incisor teeth. Specific objectives were: (1) to determine the amount of change, in degrees, in the labiolingual inclination of the maxillary central incisors which may be obtained by application of lingual root torque for a period of 10 weeks with: (a) an .021 x .025 inch stainless steel rectangular wire, and (b) an .016 inch round stainless steel auxiliary torquing wire; (2) to determine if the round auxiliary torquing wire is more effective than the rectangular wire in torquing these teeth; (3) to relate the quantitative findings to practical clinical suggestions that may be useful to the clinical practice of orthodontics.

In ten subjects torque force was applied to one maxillary central incisor with the rectangular wire and to the adjacent central incisor with the round wire. Total treatment time was ten weeks. The change in the labiolingual inclination of these teeth was determined from measurements of tracings of the lateral cephalographs taken before and after treatment.

Summary

(1) Excluding the data from the three deviant subjects, the mean number of degrees of lingual root movement accomplished with the round wire was 3.63°, with a standard deviation of 1.23°; for the rectangular wire the figures were 2.58° and 1.01°, respectively.

(2) For the total sample the mean difference between the number of degrees of lingual root torque accomplished with the round wire and the rectangular wire was +0.446°; the standard error of the mean difference was 0.63°. This experiment yielded a "t" value of 0.709, which is not significant at the 5% level of significance.

(3) Torquing of the roots of the maxillary central incisors appears to occur relatively slowly. For this reason it might be well to begin applying torquing forces early in treatment in order to reduce total treatment time.

(4) Torquing with round auxiliary wire appears to be *at least as* effective as torquing with rectangular wire. In addition, the use of round wire has certain other advantages over rectangular wire. These are discussed.

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