Maxillary Central Incisor Root Length in Orthodontically Treated and Untreated Patients

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The enigma of root resorption has puzzled dental researchers and clinicians for many years. Root resorption has been reported in nonorthodontically treated patients at incidences ranging from 1 to 86.4 percent.[6,9,10,17,19]

Orthodontic tooth movement has been alleged to be a primary cause of root resorption although no cause and effect relationship has been clearly demonstrated. Various studies of orthodontically treated patients have reported an incidence of root resorption ranging from 19[6] to 93.3 per cent.[9,10] These same studies suggested that if root resorption is present before orthodontic treatment, it will be exacerbated by orthodontic tooth movement.[6,9,10]

Many etiologic factors have been suggested for root resorption including systemic disease,[1] metabolic factors,[1,3,5] diet,[8] direction of tooth movement,[7] orthodontic forces[2,12,14] and duration of orthodontic treatment.[4] At least one investigator reported no correlation between the amount of root loss and sex, age at inception of treatment, length of treatment, and the amount of tooth movement.[13]

Baselines for normal root length have not been clearly established. It is possible that some people may have relatively shorter roots than others according to studies by Riesenfeld, Siegel and Tratman.[15,16,19]

This study was undertaken to provide appropriate baseline data for evaluating the range of root length in the orthodontic and nonorthodontic population and changes in root length following orthodontic treatment.

METHODS AND MATERIALS

One group of 50 patients was randomly selected from a list of 500 patients between the ages of 12 and 20 years under current dental care in the operative clinic of the University of Minnesota, School of Dentistry. This nonorthodontic group had 26 females and 24 males with a mean age of 16 years and 8 months. All patients had periapical radiographs and intact and undamaged maxillary central incisors.

A second group of 45 preorthodontic patient records was randomly selected from 550 postorthodontic treatment retention patients in the orthodontic clinic of the University of Minnesota, School of Dentistry. The preorthodontic group was composed of 27 females and 18 males, whose records were obtained at a mean age of 12 years and 8 months. The only requirements for acceptance was a pretreatment cephalometric radiograph showing good definition of maxillary central incisors. Cephalometric radiographs were utilized for dental measurements since periapical radiographs were not always available.

A third group of 45 postorthodontic records was formed by using the postorthodontic records for the same 45

patients used in the preorthodontic group. The mean age at the time of obtaining the postorthodontic records was 15 years and 10 months. This group received full-banded comprehensive orthodontic care that involved the maxillary central incisors for a mean duration of 24.3 months. Each record in this group also had postorthodontic cephalometric radiographs showing good definition of the maxillary central incisors.

Both right and left central incisors were measured on the periapical radiographs of the nonorthodontic group. In the cephalometric radiograms of the pre- and postorthodontic groups the clearest and most definite radiographic image of a central incisor (right or left) was evaluated and measured. If one incisor was shorter, it was measured in preference to the longer incisor.

The anatomical crown was measured from the most superior point on the cemento-enamel junction on the facial surface to the incisal edge. The root was measured from the most superior point of the cemento-enamel junction on the facial surface of the tooth to the apex of the root. The total length of the central incisor was the sum of the crown and root lengths. No magnification factors were corrected. To minimize problems of magnification, foreshortening, elongation or inconsistent radiographic technique, a root length ratio was calculated. The ratio was determined by dividing the root length by the total tooth length.

The apical anatomy of the maxillary central incisor was also evaluated and graded according to the most common apical configuration observed. The classes were as follows: (Fig. 1)

1. Normal, regular and definite apical outline,

2. Irregular, break in continuity or irregular outline,

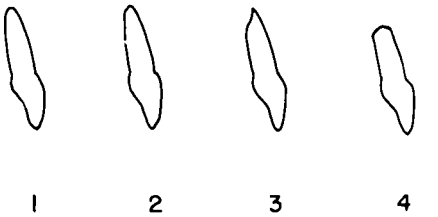

Fig. 1 Arbitrary classification of root resorption by severity. Class 1 is normal and Classes 2 through 4 show progressively greater amounts of root loss. This system is supplemental to the use of root length to total tooth length ratios.

3. Angular, definite angular discrepancy to apex,

4. Rounded or flat, either round or flat appearing with either angular or rounded borders.

If the apex had characteristics of two classes, the more severe class was recorded.

Results

The total tooth length, root length and the ratio between these parameters are shown in Table 1. Smaller ratios indicate relatively shorter roots. The mean ratio between root length and total tooth length was 0.520 for the nonorthodontic group and 0.521 for the preorthodontic group. The mean ratio for the postorthodontic group was 0.495. Note that in the range of ratios for all three groups the high ratios or relatively long-rooted teeth were identical (0.59). The low extreme of the range was almost identical for the nonorthodontic and preorthodontic groups at 0.42 and 0.41, respectively. The low extreme of the postorthodontic group was lower at 0.33.

The per cent frequency distribution of the root length to total tooth length ratios is shown in Figure 2. No notable differences are apparent in the distribution of the data for the nonorthodontic and preorthodontic populations. The postorthodontic ratios, however, are apparently skewed to the left. Approximately 10 per cent of these

TABLE I

Root length, total tooth length and the ratio between these two parameters. The lengths are shown in millimeters.

Group	Total Tooth Length			Root Length			Ratio = Root Length / Total Tooth Length	
	Mean	S.D.	Range	Mean	S.D.	Range	Mean	Range
Nonorthodontic N = 100	26.76	3.23	19.0-34.0	13.97	2.37	8.0-19.0	0.520	0.42-0.59
Preorthodontic N = 45	27.70	2.56	21.5-33.5	14.48	2.11	9.5-18.5	0.521	0.41-0.59
Postorthodontic N = 45	25.92	2.85	17.5-32.0	12.96	2.60	6.0-19.0	0.495	0.33-0.59

patients were in the 0.30 to 0.40 range of root length ratios.

The apical anatomy of the nonorthodontic group showed 36 (72%) of 50 incisors in Classes 1 and 2 for both the right and left incisors (Table 2). This left 14 (28%) of 50 incisors in Classes 3 and 4. The preorthodontic group similarly showed 33 (73%) of 45 central incisors in Classes 1 and 2 and 12 (27%) in Classes 3 and 4. The postorthodontic group, however, had 23 (54%) of 45 central incisors in Classes 1 and 2 and 22 (46%) in Classes 3 and 4.

Discussion

An examination of Table I shows many similarities between the root lengths of the three groups. When variation in the radiographic technique is obviated by the use of ratios, the non-

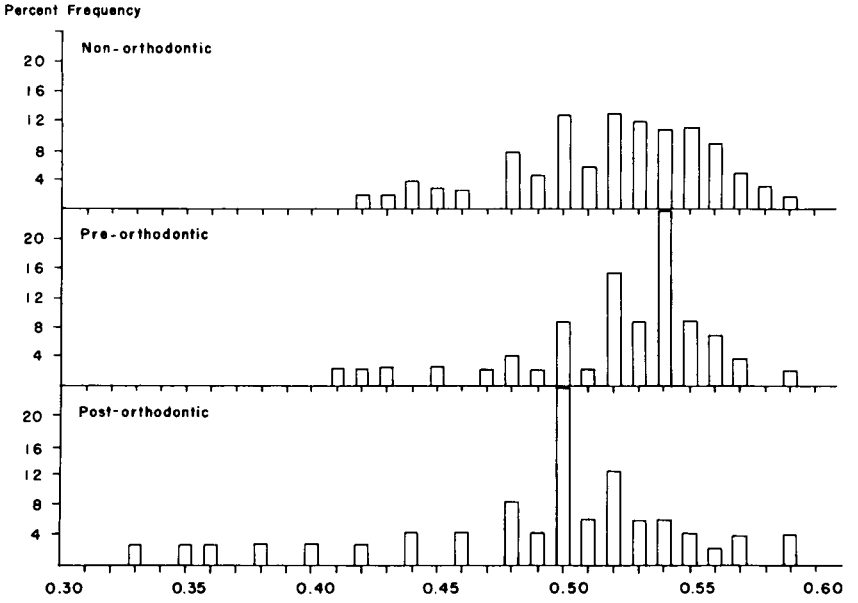

Fig. 2. Per cent frequency distribution of root length to total tooth length-ratios in the nonorthodontic, preorthodontic and postorthodontic samples. The use of ratios compensates for variation in normal root lengths and variation in radiographic techniques.

TABLE II

Maxillary central incisor apical anatomy classification. The frequency reported is for the right and left incisors of the nonorthodontic group and the most radiographically visible incisor for the pre- and postorthodontic groups.

Group	N	Class 1	2	3	4
Nonorthodontic					
Right incisor	50	14	22	7	7
Left incisor	50	8	28	7	7
Preorthodontic	45	13	20	4	8
Postorthodontic	45	9	14	7	15

orthodontic and preorthodontic groups appear remarkably similar. The mean ratio and the range of ratios show no apparent differences. The postorthodontic group does not seem to be any different when the long rooted or high ratios are compared. Only the short rooted or low ratio (and therefore, the mean) appear to be affected.

Figure 2 also suggests that the distribution of the maxillary central incisor root-length ratios of the postorthodontic group was skewed to the shorter root length end of the scale. Approximately 10 per cent of the postorthodontic patients were in the 0.30 to 0.40 root length ratio range. These ratio values had the substantial effect of reducing the mean root-length values of this group. Except for this skewed portion of the postorthodontic group, the distribution of the three groups does not show any marked differences.

These findings are consistent with an interpretation that most patients' root lengths are not significantly shortened by routine orthodontic care. However, about 10 per cent of this postorthodontic sample did show an effective reduction in root length ratios. These patients did not demonstrate any specific common parameter of treatment mechanics or specific biological variable. Thus for the present, no conclusive data exist enabling the clinician to predict the occurrence of root shortening prior to orthodontic treatment.

The techniques used in this study do possess error. The magnitude of the study plus the use of ratios appear to randomly distribute the error so that the nonorthodontic and preorthodontic groups appeared very similar. The mean root-length ratio of 0.52 reported for these two groups is very similar to the ratio determined using G. V. Black's mean dental measurements for central incisors (0.53).

What is the significance of the root shortening seen in orthodontic patients? The ultimate effect on the dentition is difficult to evaluate. The loss of 1 to 2 mm of apical root structure with approximately 5-10 per cent reduction in retentive surface may be insignificant.[11,13] On the other hand, root shortening could be an additive factor when coupled with loss of alveolar bone due to age or periodontal disease. The combination of these two factors could be potentially destructive to the stability of the dentition. A long range study to evaluate patients over a lifetime would probably answer this question.

Others have reported that preorthodontic patients demonstrating short roots may have a tendency toward shortening of roots during orthodontic procedures.[6,9,10] This was reported many years ago and should be reexamined with respect to contemporary clinical procedures. The effects of specific procedures on root length are not clearly established today. If this predilection can be established, it would be possible to predict root foreshortening prior to orthodontic care. This would permit modification of treatment plans to reduce or eliminate the likelihood of treatment affecting root length. If this is not the case, it would permit all necessary treatment for people with shorter roots with no more risk for

root shortening than the general population. It is interesting that the high values of the ranges for root length and root to total tooth length ratios were all very similar.

Another important aspect of this study is the use of root length to total tooth length ratios. This technique permits identification of relatively short rooted teeth using more than root morphology. It also minimizes radiographic distortion. Shorter roots could result from early normal closure of an apical foramen. If the root length is relatively short, it will probably have the same effect on the dentitional life expectancy regardless of whether the root resorbed after formation or completed formation prematurely. Most importantly, the application of reproducible quantitative methods to the problem will allow more precise comparisons of data from different studies.

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