The Effects of Tooth Movement Upon Endodontically Treated Teeth

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There is a paucity of documented information concerning the prognosis of the endodontically treated tooth undergoing orthodontic movement. Although teeth can be moved after root-canal therapy, many orthodontists consider them more likely to experience root resorption, ankylosis, or fracture under appliance fabrication and removal. In general, these teeth are viewed with little enthusiasm. These opinions are not always derived from personal clinical experiences but are based more on table-clinic rumors than on fact. Such rumors may have come from Steadman's[1] 1942 review of root resorption in which he suggested that the roots of the root-canal tooth may act as a foreign body and "melt away as the years pass." He also noted that following the root-canal filling, the peridental membrane (sic) often becomes indistinct due to alternate resorption and repair on the root surface, possibly resulting in ankylosis.

Other orthodontists feel that endodontically treated teeth can be directed through a vast range of orthodontic movements and should not experience greater root resorption or difficulty than their vital antimeres. This clinical observation was studied by Huettner and Young[2] who found no histologic difference between bone, periodontal membrane or cementum in orthodontically moved nonvital and vital teeth in the Macacus rhesus monkey. Unfortunately, animal studies of tooth response to stress may not be directly related to the human situation. Basic differences between species antigenicity must be considered when comparing cellular responses to the altered chemical environment found in endodontic treatment.

Integrity of the periodontium in its entirety is a prerequisite in orthodontic tooth movement. The supporting tissue is responsive to the forces placed upon the teeth and in turn influences the osteoclastic and/or osteogenic activities of the alveolar bone which results in tooth migration.[3] The tooth that has required an endodontic procedure has experienced pulpal inflammation due to insult of the pulpal tissue. The continuity of the pulpal elements with the periodontium via the vascular supply, accessory canals, lymphatics and tissue fluids may well involve this apical area of supporting tissue in a comparable pathologic response. Pulpal extirpation and subsequent endodontic therapy in experimental animals can also produce an acute inflammation in the interradicular periodontium. This inflammation is usually accompanied by resorption of cementum as well as crestal resorption. The repair of the lesions will in time occur but occasionally the inflammatory lesions persist.[4]

Endodontically treated teeth have been observed to have resorption areas of cementum and/or dentin at their

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apices which were frequently related to the presence of granulomatous tissue in those areas. In healed lesions, the repair tissue was cementum.[5] Similar areas of resorption occur in vital teeth undergoing orthodontic movement. McLaughlin[6] reported 92.6 per cent incidence of some degree of root resorption of orthodontically treated maxillary central incisors. Therefore, delineation of resorption etiology in the pulpless tooth undergoing orthodontic movement would be improbable. Only by comparison with its vital antimere could an index of pressure-related resorption be established.

Ankylosis is a clinical problem which precludes orthodontic tooth movement. When ankylosis occurs in the dentition, either primary or permanent, of a growing child it may often lead to faulty occlusal relationships.[7] Histologically, there is a calcified union of part of the root cementum to the supporting alveolus and localized dissolution of the periodontal membrane.[8] The etiological factors for ankylosis range from trauma to metabolic, from endodontics to genetics.[9] Ankylosis is a frequent sequela in replanted teeth treated endodontically.[10] However, pulpless teeth with successful endodontic treatment are infrequently ankylosed.[5]

Orthodontic movement of treated pulpless teeth has been successfully accomplished in the rhesus monkey[2] but Baranowskyj[11] reported delayed bone healing in a dog when intrusive forces were applied to endodontically treated teeth. These limited studies may not relate to the human clinical response.

This report is the result of a field study to examine the effect of orthodontic movements upon endodontically treated teeth. The study includes long-term clinical data from orthodontic specialty offices as well as selected general practices where adjunctive tooth movement procedures are routine. Every direction of tooth movement was represented in the orthodontic history of the endodontically treated pulpless teeth.

Methods and Materials

Case histories of forty-five orthodontic patients with endodontically treated teeth were reviewed from six practices which included edgewise, Begg and partial banding mechanotherapy. The following items were collected: 1) review forms for collection of historical data, 2) lateral cephalograms, 3) pre- and posttreatment dental casts, and 4) panorex and/or periapical radiographs.

These data were examined as follows:

1) A special dental history form was completed by the participating clinicians. Questions contained in this form concerning the pulpless teeth included: time of endodontic treatment as related to tooth movement, caries experience, type of pulpal therapy and restorations, tooth color change and the need for retreatment, if any.

The history of orthodontic therapy included questions concerning appliance design, treatment objectives and treatment response. Specific inquiries were made of the dentist's subjective evaluation of ease of movement, patient comfort, excessive mobility, and relapse tendencies.

2) The second area of the investigation utilized pre- and posttreatment periapical radiographs. An endodontist examined these films for evidence of root resorption, crestal height change and integrity of the lamina dura of the pulpless teeth as compared with control antimeres.

3) Serial cephalograms were traced and superimposed to observe the nature of tooth movement accomplished in the vertical and anterior-posterior directions. The basal configurations of the

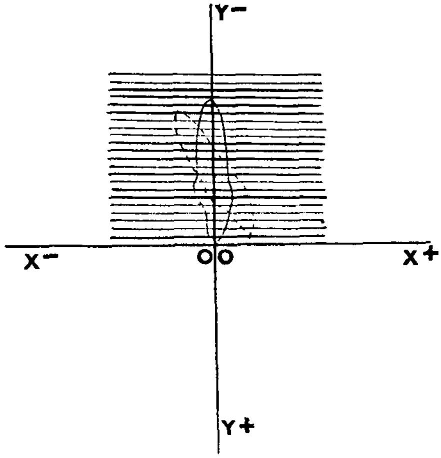

Fig. 1 Superimposition of pretreatment (solid) and posttreatment (dotted) tracings from cephalograms. Grid permits measurements of anterior-posterior and intrusive-extrusive movements.

maxilla or mandible were used for serial superimpositions. The opaque endodontic filling material greatly facilitated the reproduction of the treated teeth.

To standardize measurement procedures, a grid of millimeter squares was placed on the serial tracing. The long axis of the pulpless tooth (object tooth) prior to orthodontic movement served as the y-axis. The most occlusal or incisal point of this tooth served as the 0.0 point on the grid. Serial points of the moved teeth were plotted and used to define the vector X-Y (Fig. 1). If the value of X was negative the tooth had been retracted; conversely, a positive X value indicated tooth advancement. Changes in positive or negative Y values indicated extrusive or intrusive movements, respectively.

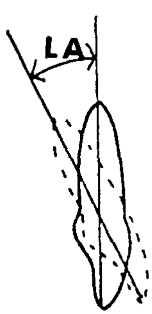

Fig. 2 Angle LA represents the rotational change accomplished during orthodontic treatment.

The degree of root torque for incisors was determined by lines drawn through the long axis of the object tooth, before and after movement, and measuring the angle LA formed by their intersections (Fig. 2).

4) Standardized photographs of the orthodontic casts were also used to confirm tooth movement. Tape markers were used to identify selected palatal rugae as reproducible physical landmarks.[12,13,14] A small millimeter scale was placed in the palatal or tongue space to permit consistent measurements. Two exposures of each cast were taken at 6-8 inches with Kodak Panatomic-X black and white film using a side flash on a Minolta SR-7, 100 mm bellows type intraoral camera. Four inch by five inch prints were made from each exposure (Fig. 3).

Maxillary Object Teeth

The median palatal raphe and the selected palatal rugae were used to orient tracing paper on each before and after photograph (Fig. 4). The midpoint of the incisal or occlusal surface (B) was marked by a point on the tracing paper as was the point denoting the rugae landmark (R). These points were reproducible on both the before and after treatment casts. Perpendiculars (C,D) to the median palatal raphe line were dropped from points B and R.

First the distance between the points R-D were measured with the millimeter scales on the pre- and posttreatment photographs. Minor linear distance differences due to the influence of photo-

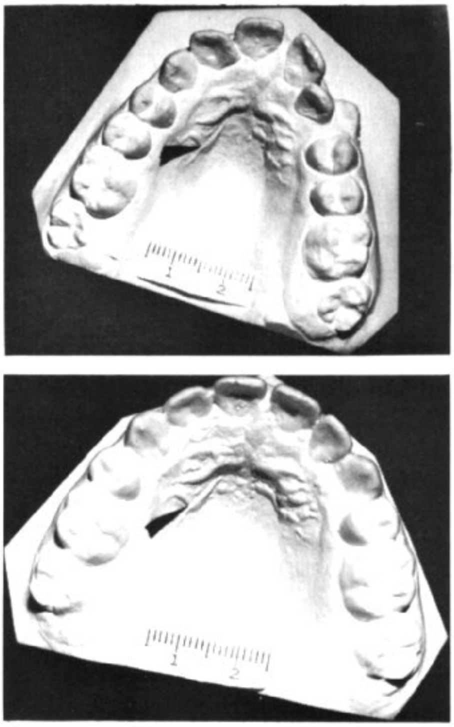

Fig. 3 Pre- and posttreatment photographs showing rugae marker and millimeter rule.

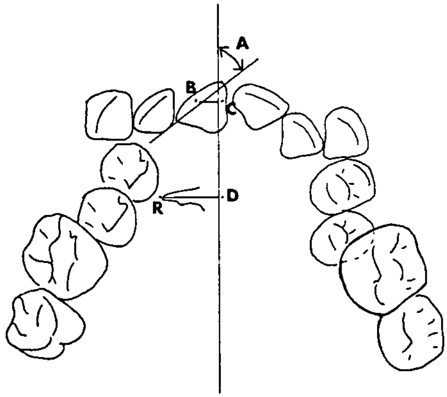

Fig. 4 Technique for measuring linear and angular tooth movements on pretreatment photograph of maxillary dental casts.

graphic magnification were mathematically interpolated.

The following measurements were made on photographs and compared for change:

1. B-C, perpendicular distance of object tooth (anterior or posterior) to median palatal raphe to determine mesial-distal, buccal-lingual movement.
2. Angle CAB to determine the degree of rotational change.
3. C-D, linear distance along the median palatal raphe to denote labial-lingual movement of anterior teeth or mesial-distal movement of posterior teeth.

These measurements from the cast photographs plus the cephalometric tracings permitted the determination of 1) buccal-labial-lingual movement, 2) rotations, 3) mesial-distal movement, and 4) intrusive-extrusive movement.

Mandibular Object Teeth

The mandibular dental arch unlike the maxillary arch affords no stable reproducible landmarks on dental casts. It is possible to transfer points from maxillary casts to mandibular casts to establish reproducible points of reference.[15] However, due to the additional armamentarium required this technique was not considered feasible for this field study. Therefore, the measured tooth movement seen in the posttreatment mandibular casts substantiates the cephalometric evidence that movement did in fact occur but the degrees of change and accuracy of linear movements lack control.

Figure 5 outlines the method used to determine movement in the (1) buccal-labial-lingual, (2) rotations, and (3) mesial-distal. A line was drawn to intersect the mesial surface of each first molar (S-T). A perpendicular from the midpoint (P) of the object incisor was dropped to the transmolar line (V). The incisal edge position was paralleled by the line (QR). A construction line (BL) bisecting ST was drawn. A perpendicular from P was

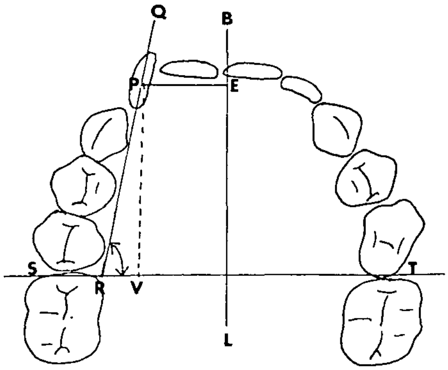

Fig. 5 Technique for measuring linear and angular tooth movements on pretreatment photograph of mandibular dental casts.

dropped to BL at (E). The following pre- and posttreatment comparisons were made:

1) The change in distance PV reflected labial-lingual repositioning for anterior teeth or mesial-distal for posterior object teeth.
2) Angle PRV represented angular change.
3) The linear distance PE reflected changes in the mesial-distal direction for anterior teeth or buccal-lingual for posterior teeth.

It is readily apparent that the comparison technique was based upon stability of molar position as a pretreatment and posttreatment landmark. In nonextraction treatment this kind of stability may occur; however, in extraction procedures movement of the molar segments is well-documented.[16] Because of this built-in error component, we elected not to place credulousness on the derived numbers and degrees but to view the results in terms of clinically-acceptable orthodontic tooth movement that occurred in the endodontically treated mandibular object teeth.

Results

Table I is a summary of the history of the types of endodontically treated teeth (n=53) examined in this study. The majority of the patients were children who had received a traumatic injury prior to orthodontic treatment. Approximately one half of the traumatized teeth were also fractured. All of the teeth were treated by a pulpectomy and four had root resections in addition.

Two patients were partially banded and the others wore multibanded appliances and received a typical full-term orthodontic treatment. Length of treatment varied, one to eight months (n=

Table I

Etiology of Pulpal Pathology	*N*	*Therapy*	*N*	*Untoward Sequela*	*N*
Trauma				*Color Change*	
Pretooth movement	28	Pretooth movement	41	Frank	6
During tooth movement	10	During tooth movement	12	Slight	5
				None	42
		Endodontics			
Intrusion	4	Pulp cap	0		
Extrusion	1	Pulpotomy	0	*Retreatment*	
Luxation	5	Pulpectomy	53	During tooth movement	4
Replantation	6	(root resection)	4	Ellis Class II	2
Unknown	6			Intrusion	1
Fracture		*Restoration*		Replantation	1
Ellis Class I	3	Simple	43		
Ellis Class II	12	Temporary Crown	8		
Ellis Class III	1	Inlay	0		
		Permanent Crown	1		
Caries		Post and Core	1		
Pretooth movement	15				
Silicate	1				
Alloy	14				

Table II
Average Orthodontic Movement of Maxillary Endodontically Treated Teeth

Dental Casts	*Anterior*	*N*	*Posterior*	*N*
Rotation (°)	9.2	40	4.3	3
Mesial (mm)	1.6	14	4	1
Distal (mm)	1.5	24	1	1
Buccal-Labial (mm)	1.8	9	3.5	1
Lingual (mm)	4.3	29	1.2	2
Cephalometrics				
Torque (°)	12.7	34	2	1
Intrusion (mm)	2.4	19	0	0
Extrusion (mm)	1.7	10	2	2
Retraction (mm)	6.2	22	1	1
Advance (mm)	2.6	9	2	1

4), nine to eighteen months (n=23), nineteen to twenty-seven (n=15), and twenty-eight to thirty-six months (n=11). It was difficult to determine whether this extended therapy time reflected the degree of treatment difficulty, patient response, or the nebulous quality-cooperation. The participating clinicians were well-qualified in orthodontic therapy. The subjective evaluation of the clinicians indicated that the treatment response of the treated teeth was equal to that of the vital teeth and their tendency to relapse (n=4) was not remarkable.

Table II is a quantitative summary of the vast range and variability of the maxillary tooth movement included in this study. Intrusion, extrusion, tipping, and bodily movements were determined from the cephalometric films. Rotations, mesial, distal, buccal-labial and lingual movements were measured from the dental cast photographs. The average values may be of less interest than the number of teeth in each category of tooth movement.

The number of patients studied was reduced to thirty-four for radiographic evaluations due to switching to panoramic surveys from periapical radiograms during treatment. A comparison of the treated pulpless teeth with their antimeres was made from pre- and post-treatment periapical radiograms. In seven teeth there was evidence of greater root resorption than observed in the vital control. Five treated teeth showed a decrease in crestal height following orthodontic treatment. No evidence of ankylosis was observed radiographically or clinically.

Discussion

Our data support the clinical observation that endodontically treated teeth can be effectively moved by orthodontic forces without excessive untoward responses. All teeth in this series had been similarly treated with pulpectomy. Inadequate numbers of pulpotomy or pulp-capped teeth precluded their inclusion in this study.

The various types of dental trauma recorded included crown fracture, intrusion, extrusion, and replantation. These injuries influenced some specific problems during treatment. Four teeth which required endodontic retreatment had traumatic histories which included two Ellis Class II fractures, one traumatic intrusion and one had been replanted. This may give some indication that the more severe the traumatic history, the poorer the prognosis for the endodontically treated tooth in orthodontic therapy.

The clinicians reported color changes in eleven of the fifty-three teeth in the study. All of these teeth had been involved in a traumatic accident prior to endodontic therapy. While color changes of the enamel may occur due to pulpal hemorrhage following trauma, it may also occur as a sequela to endodontic instrumentation. Therefore, it may be coincidental that a tooth color change may occur during the time of orthodontic movement. The possibility of this occurrence should be anticipated and discussed with the parents and patient prior to initiating orthodontic treatment.

The type of mechanotherapy selected by the orthodontists had no effect on producing untoward results of treatment. The total range of orthodontic tooth movements was well-documented with the cross section of anterior and posterior teeth represented in this study. All movements appeared to have been done with equivalent ease as compared with the antimeres.

The actual treatment time of the orthodontic procedures appeared longer than usual. However, such variables as complexity of malocclusion, individual patient response and no doubt the conscious effort of the orthodontist to avoid undue stress on "questionable" teeth may have influenced treatment time. The response of the individual teeth to treatment was excellent. Three teeth were reported as being sensitive to tooth moving forces. This, however, did not preclude successful orthodontic treatment.

The radiographic survey found the incidence of root resorption to be greater in the endodontically treated teeth when compared with an adjacent vital control. These findings cannot be based upon differential force applications, for the investigated teeth and their controls were subjected to a similar force system. Regardless of the exact etiology, this propensity for root resorption should be noted by the orthodontist.

Andreasen[10] reported that certain trauma which results in displacement such as intrusion or extrusion followed by endodontic treatment can result in a decrease in crestal bone height. The radiographic survey in this study substantiates Andreasen's report. Seventeen per cent of the teeth examined showed decreased crestal bone height. No other radiographic changes were observed.

The more adult orthodontic treatment that is demanded and the more preservation through endodontic therapy that is practiced, the incidence of endodontically treated teeth will increase in the orthodontic patient population. This study has shown that past clinical intuition about the ease of movement and low risk of retreatment in these teeth is true. Except for cases of replantation or severe trauma, the orthodontist should be able to include endodontically treated teeth in his mechanotherapeutic treatment plans with confidence.

Summary

A group of forty-five orthodontic patients who had fifty-three endodontically treated teeth was examined to study the effects of pulpectomy on tooth movement. It was found that teeth with root canal therapy move as readily as vital teeth. This apparent ease of movement was not related to any particular system of mechanotherapy. There appeared to be a greater frequency of root resorption in the endodontically treated teeth as compared with the control group. Discoloration and endodontic retreatment were related to the occurrence of trauma in the history of the pulpless tooth.

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