A Laminagraphic Study of Cuspid Retraction versus Molar Anchorage Loss

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Introduction

When the extraction of bicuspid teeth is indicated as a prerequisite to the correction of a malocclusion, the total treatment plan includes closure of these extraction spaces. Depending on the characteristics of the original malocclusion, these extraction spaces may be closed through anterior tooth retraction, mesial movement of the posterior tooth units or some combination of these actions. Commonly it is preferable to control or prevent the mesial movement of posterior tooth units until the anterior teeth are aligned in positions of stability over a foundation of basal bone. The stability of the patient's dentition following orthodontic treatment will be closely related to the ability to achieve the tooth positions that the original treatment plan dictated.

In this study, spaces produced by the extraction of maxillary first bicuspids were closed using reciprocal "light" magnitude forces between the molar units and the independent cuspids on a continuous archwire. Laminagraphic techniques were utilized to measure the amount of anterior molar movement and posterior cuspid movement that occurred. The study was undertaken to describe the actual tooth movements that occur while using one method of cuspid retraction characterized clinically by simplicity and efficiency.

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Literature

The use of forces on posterior "anchor teeth" as a reciprocal for forces applied to teeth in the same arch or opposite arch is one of the most basic principles of orthodontic mechanics. Various studies have shown that it is difficult to prevent the forward movement of posterior teeth during the retraction of anterior teeth.

Taylor[15] analyzed the cephalometric records of 101 extraction and nonextraction patients and found that all except one had mesial movement of the maxillary molars with the least amount seen in the nonextraction cases.

Storey and Smith[12] and Streed[14] have shown that as much as five per cent to fifty-five per cent of the total extraction space can be taken up by an anchor unit made up of the first molar and second bicuspid when used for the retraction of a cuspid tooth.

Begg[1] has maintained that a differential force application made it possible to control tooth movement as desired. He stated that reciprocal light forces move anterior teeth while the posterior teeth remain stationary. With heavy forces, he observed the opposite effect.

Salzman[10] stated, "regardless of the skill one may possess in the mechanics of space closure following the extraction of the teeth, the teeth in the posterior buccal segment will be displaced mesially to some extent. If the mechanics of treatment are incorrect, teeth will be displaced mesially about one-half or more of the space, and if one is careless in treatment, it is possible to utilize the entire space by mesial displacement of the teeth in the buccal segments."

Guay and Baker[5] cephalometrically evaluated forty maximum anchorage extraction cases in which six anterior teeth were retracted at once. Their results indicated, when auxiliary appliances such as a headgear were used, less anchorage loss was experienced than when differential forces alone were used to maintain control.

One reason that studies on tooth displacement have not been reported quantitatively or more conclusively in the literature is that it is difficult to find stable landmarks or points from which to measure tooth movement. Newhouse[7] demonstrated anteroposterior tooth movements using superimposed cephalometric laminagraphs. Fine bony outlines in the maxilla and cranial base were used as landmarks for registration. The stability of the landmarks for the time period involved was verified in four patients who also had maxillary implants. The laminagraphs were shown to be highly reproducible which made accurate determination of tooth changes possible.

Efficient tooth movement has been reported in the literature using a variety of force magnitudes. Burstone and Groves[3] reported that the optimal force for incisor movement is about 50-75 grams. Reitan[8] suggested a very light force of 25-40 grams for the initial stages of orthodontic treatment. Burstone[4] advocated 150 grams for cuspid tipping with the cuspid retraction assembly.

Storey and Smith[13] used five young patients in arriving at their conclusion that the cuspid tooth would move considerably using 175-300 grams, but the anchor teeth would be displaced very little.

Reitan[9] found a fairly thick layer of osteoid tissue formed on the tension side after 8 days of movement of a maxillary first bicuspid with a continuous force of 70 grams in a 12 year old patient. Similarly, he noted bone resorption on the pressure side during the first eight days.

Jarabak[6] considered the establishment of equal cellular activity on the pressure and tension side as the optimal condition for tooth movement. He contended that light forces in the range of 28 to 110 grams best created these conditions.

Forces actually capable of causing bone resorption and subsequent tooth movement are considerably less than the force values proposed as necessary for optimal tooth movement. Weinstein[16] used gold onlays extended two millimeters buccally on the premolars to cause an increase in buccal musculature force of 1.68 grams. Significant tooth movement was observed as a result of such light forces.

The preceding review underlines the variability of force magnitudes capable of producing tooth movement. Although the magnitudes of force do vary, Storey and Smith,[12] Burstone,[2] and Jarabak[6] are four investigators among many who contend that a continuous light force is most effective for optimum tooth movement.

Materials and Methods

Six patients ranging in age from twelve to twenty years were used in this study. All of the patients presented Class I malocclusions with varying degrees of arch-length shortage. In each patient four first bicuspid teeth were extracted prior to placement of orthodontic appliances. In this study only changes in tooth position of the maxillary cuspids and maxillary molars were investigated. The exclusion of mandibular tooth changes from this investigation will be explained in the section on laminagraphic techniques.

The appliance used consisted of the

widest possible Siamese brackets with .018 slots on each tooth except for standard .018 × .025 × .045 double buccal tubes on the first molars. The second molars were not banded. An .016 round archwire was used during cuspid retraction. Cuspid retraction was accomplished with a latex elastic attached from the maxillary molar to a sliding hook mesial to the maxillary cuspid. Maxillary molar anchorage was reinforced with an .036 transpalatal arch[4] and a cervical headgear that was worn only while the patient was sleeping.

The latex elastic size selected for each patient delivered an initial force of 75 to 100 grams. This initial force, however, was reduced in the mouth fluids by approximately 25 grams within thirty minutes. Therefore, the effective force delivery was considered to be 50 to 75 grams. The patients were given strict instructions to wear the elastic at all times and to change the elastics every morning. The elastic force measurements were made in the mouth using a Correx guage.

Two laminagraph exposures were made of each patient. The first exposure was taken on the day that cuspid retraction was started. The second exposure was taken at the time that cuspid retraction was considered completed in accordance with the treatment plan for that individual. In five of the six patients, cuspid retraction was completed within a period of ten weeks to four months. In only the sixth patient, a twenty year-old female, was it considered necessary to retract the cuspid the full width of the first bicuspid extraction space.

The equipment used to obtain the cephalometric laminagraphs consisted of component parts, specially designed and assembled for the Division of Orthodontics at the University of Minnesota, and described by Speidel.[11] While in a sitting position, the patient's head was held in a Wehmer cephalometer capable of rotating 360° in a horizontal plane and adjustable to obtain a laminagraph of any preselected vertical plane. The target and object film distances remained constant. The radiation source was a Dynamax "50-40" rotating anode x-ray tube manufactured by Machlett and suspended by a ceiling tube conveyor manufactured by Profexray. A Potter-Bucky diaphragm with a reciprocating 8:1 grid having a 60-72 inch focal distance was utilized. Kodak Blue Brand x-ray film was used.

All laminagraphics were exposed at 100 milliamps at 1.5 seconds taken at ten degree amplitude producing the radiographic image of a plane approximately one centimeter thick. The kilovoltage varied from 78 KV to 85 KV depending on the patient head size. Newhouse[7] used a Victoreen r-Meter to assess the amount of radiation emitted to a patient for a laminagraph exposed at 80 KV, 100 MA and 1.5 seconds and found it to be from 110 to 120 milliroentgens per exposure.

The maxillary model and the conventional lateral cephalogram were used to determine the section through the buccal quadrants after the method described by Newhouse.[7] It is important to emphasize that the thickness of the plane of section that provided clearly definable maxillary outlines would not consistently provide the same clarity of mandibular teeth or other mandibular structures. A reliable investigation of mandibular tooth changes, therefore, would have required an additional series of laminagraph exposures using a slightly different plane of section. In order not to subject the patients to any additional radiation, this investigation was necessarily limited to maxillary tooth changes only.

Only landmarks or areas that were

clearly definable on both the beginning and progress films were traced. The primary landmarks were borders of the maxillary sinus and maxillary tuberosity, the ethmoidal air cell trabeculations and other maxillary fine bony outlines. In tracing the teeth, outlines of the root and crown, pulp canals and chambers, radiopaque dental restorations, and the inner enamel border were noted. Secondary outlines that were traced included the sphenoid cross sections, anterior cranial base and the orbital roof. Superimposition of the two tracings was accomplished by registering primarily on the maxillary tuberosity and sinus borders and the developing crowns of the third molars. The secondary outlines were used in verifying this method of registration.

The amount of retraction of the crown of the cuspid was measured on the superimposed laminagraph tracings using a millimeter rule. The distance between the distal contour of the cuspid crown on each film was measured at the level of the archwire, as determined by the outline of the brackets. Measurements were recorded to the nearest 0.5 millimeter and reported without correction for magnification.

No attempt was made to document angular changes of teeth in the maxillary section. Superimposed tracings of each case are presented, however, to permit visual assessment of the degree of parallelism of roots at the completion of cuspid retraction.

Results and Discussion

The most striking finding drawn from the laminagraphic superimpositions was the complete absence of mesial movement of the maxillary first molars during cuspid retraction. In one of the cases, patient D. H., the molars actually moved distally during cuspid retraction, probably due to the individual response to the cervical headgear. In the other

TABLE I

Patient	Amount of cuspid retraction	Time of cuspid retraction
A.C.	2.5 mm	2 months 3 weeks
D.H.	3.0 mm	4 months 1 week
C.D.	3.5 mm	3 months 1 week
W.L.	3.5 mm	3 months 3 weeks
D.D.	5.0 mm	8 months 1 week
L.L.	6.0 mm	2 months 2 weeks
Mean amount of cuspid retraction	3.9 mm	

five cases the first molars superimposed exactly demonstrating a remarkable stability. The amount of cuspid retraction and time required for retraction is summarized in Table 1 and the superimposed tracings are presented in Figures 1 through 6.

The stability of maxillary molars during cuspid retraction may be related to one, or more, stabilizing influences. The Class I molar relationship that each patient possessed may have been the dominant factor in holding the molars, merely through function. The use of a cervical headgear while the patient was sleeping may have been all that was needed to prevent mesial movement of the molars. The transpalatal arch may have been the only stabilizing influence necessary to secure the molar positions. This is not to imply that all of these molar stabilizing factors must be present if mesial movement of the molars is to be prevented. It should be recognized that, regardless of the factors that are most responsible for preventing mesial movement of maxillary molars, the demands made on the patient in preserving molar anchorage are minimal. By the same token there is no intention of implying that the "secret" to retraction of maxillary cuspids is the use of .018 brackets or an .016 round archwire or force magnitudes of 50 to 75 grams.

The intent of this paper is to quanti-

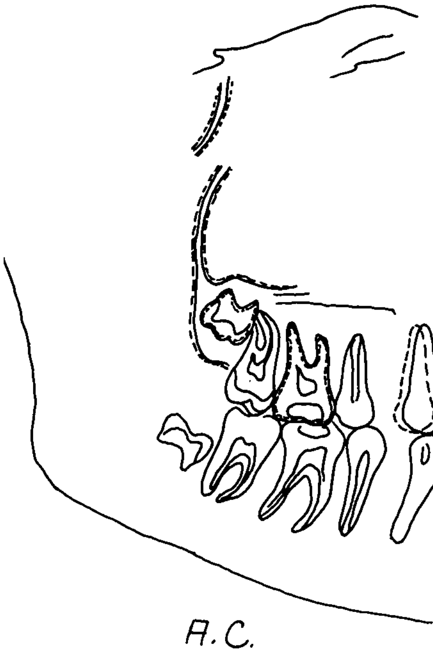

Fig. 1

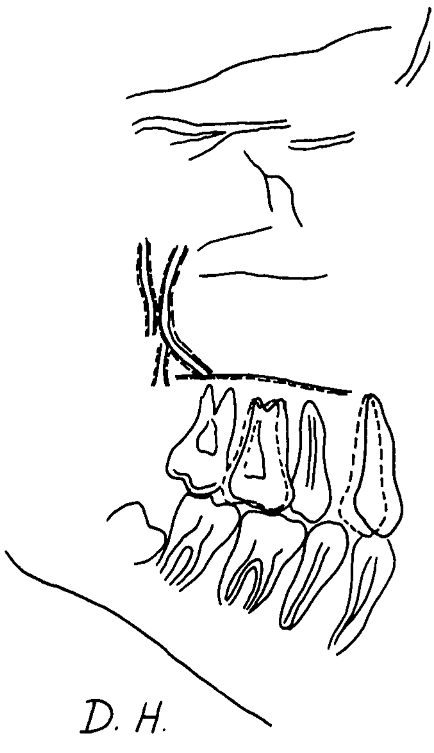

Fig. 2

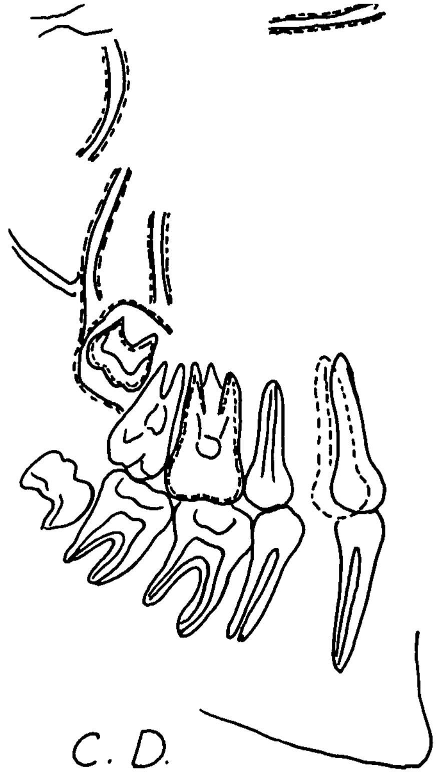

Fig. 3

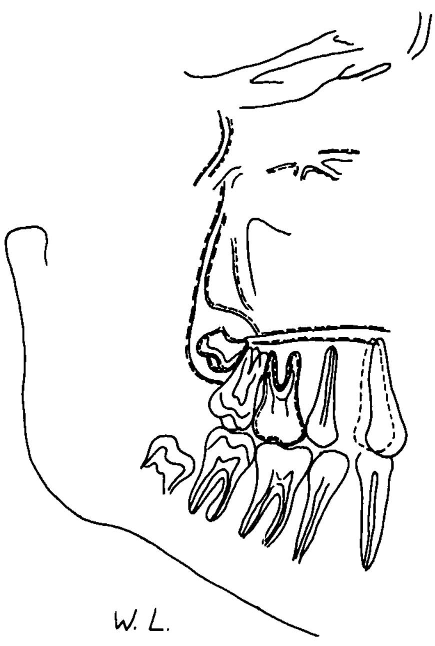

Fig. 4

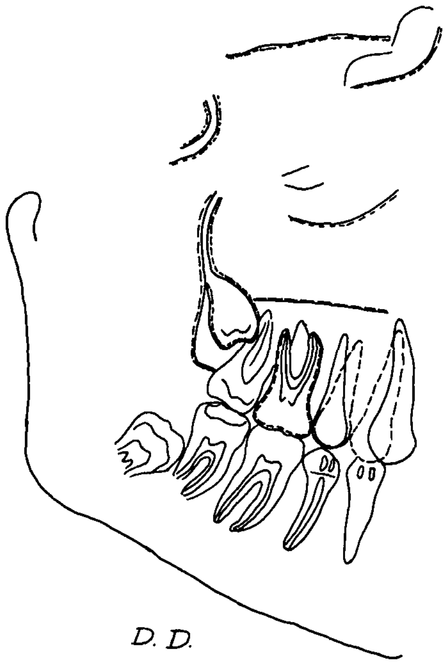

Fig. 5

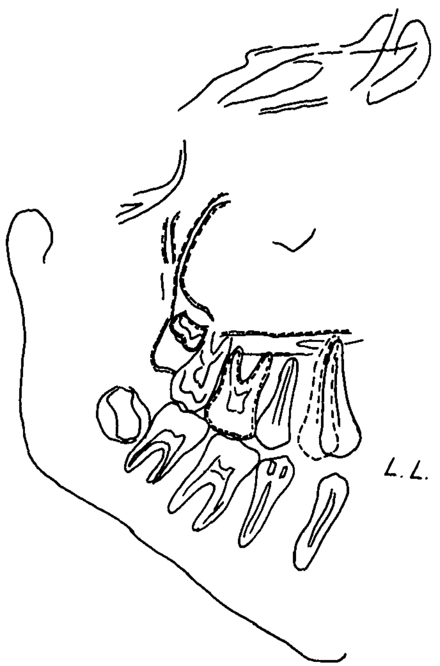

Fig. 6

tate the actual tooth movements that occur in a group of patients under these circumstances. The results of the study certainly suggest that the inevitability of molar anchorage loss during cuspid retraction need not be accepted. There are unquestionably many combinations of appliances and force magnitudes that would accomplish similar results.

The amount and time of cuspid retraction in this study underlines the individual variation that is encountered in orthodontics. The greatest amount of cuspid retraction, 6.0 mm, was accomplished in the shortest amount of time, ten weeks, for patient L. L. Patient D. D., a twenty year-old female, required over eight months to retract the cuspid into contact with the second bicuspid, a distance of 5.0 mm. However, the maintenance of anchorage in this adult patient was considered of greater importance than the time required to retract the cuspid, and this goal was achieved. Except for this one patient, cuspid retraction was completed for each patient in accordance with his treatment plan in four months or less.

Inherent in the use of serial laminagraphs for determining anteroposterior tooth changes is the assumption that changes due to growth are negligible over the short period of time studied. Based on previous clinical experience with cuspid retraction, this study was initially projected to cover a three to four month period and would, therefore, not be influenced by growth changes. Patient D. D. was included, despite the long time required for cuspid retraction, only because she was beyond the period of active facial growth.

Two important variables enter into the system of cuspid retraction used in this study. One of these, the friction introduced by the tightness of the ligature engaging the .016 archwire in the cuspid bracket, is critical. The other variable, patient cooperation in placement of the latex elastics, can be of equal concern in treatment progress. A measurable force delivery of 50-75 grams to the cuspid for retraction purposes is actually delivering less force to the periodontal membrane and surrounding bone due to the friction of the appliance. If the cuspid teeth are retracting satisfactorily, it can be concluded that the force delivery is adequate to initiate the necessary bony responses and that the patient is reliable in maintaining the continuous force delivery. If the teeth are not moving at a satisfactory rate of progress, these two variables need to be examined carefully, especially restrictions on cuspid movement caused by friction. If frictional forces have been reduced to a minimum, unsatisfactory cuspid retraction with this system should most often be remedied by reducing the magnitude of force delivered to the cuspid and increasing the patient cooperation.

Retraction of a cuspid on an archwire as small as .016 round might suggest the hazard of merely tipping the crown distally while the root moves mesially. A visual appraisal of the laminagraphs demonstrates a satisfactory final root position. The difference in size between the .016 archwire and the .018 Siamese bracket slot is probably less significant than the width of the Siamese brackets. The wider the Siamese bracket, the greater the control exerted over the position of the root. However, if an .018 archwire were used to gain more control of the root, the friction developed between archwire and bracket might inhibit the sliding of the cuspid along the wire. Using the minimal forces that were delivered to the cuspid in this study, this frictional factor has evidently been reduced to a minimum, based on the cuspid movement achieved.

One of the main reasons for this study was to validate the actual tooth movements that occurred while using the method of cuspid retraction described. This method evolved from a desire to complete an important stage of treatment, one that is necessary in many orthodontic cases, in a minimum amount of chairtime with relatively few emergencies or undesirable tooth changes being introduced. With the increasing demands made on the orthodontist to treat more cases in a shorter time without reducing the quality of his final result, attention to simplicity in appliance design is essential. If the patient is properly motivated prior to the stage of treatment described in this study, appointments during cuspid retraction should require little more than a replenishment of the elastic supply.

Summary and Conclusions

(1) Serial laminagraphic superimpositions were used in this investigation to study the amount of molar anchorage loss that occurs while retracting maxillary cuspids independently on a continuous archwire using controlled "light" force magnitudes.

(2) Six patients ranging in age from twelve to twenty years were used. All patients presented Class I malocclusions requiring the extraction of four first bicuspids prior to placement of orthodontic appliances.

(3) The appliance consisted of the widest possible .018 Siamese brackets and an .016 round archwire. Cuspid retraction was accomplished with a latex elastic attached from the maxillary molar to a sliding hook mesial to the maxillary cuspid. The effective force delivery of the elastics was 50 to 75 grams.

(4) Maxillary molar anchorage was reinforced with an .036 transpalatal arch and a cervical headgear that was worn only while the patient was sleeping.

(5) The most striking conclusion

that could be drawn from the superimpositions was the complete absence of mesial movement of the maxillary first molars during cuspid retraction.

(6) The average amount of cuspid retraction was 3.9 millimeters. Five of the six patients completed the stage of cuspid retraction in four months or less. The sixth patient, a twenty year-old female, required eight months to effect complete closure of the first bicuspid space through cuspid retraction.

(7) Superimposed tracings of each case are presented to permit a visual assessment of the degree of parallelism of roots at the completion of cuspid retraction.

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