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Response of Human Pulpal Tissue to Orthodontic Extrusive Applications

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The aim of this study was to investigate histologically the human pulp response to orthodontic extrusive force applications. In group 1,20 teeth were extruded with the use of a fixed sectional orthodontic appliance. In group 2, 20 teeth were extruded by means of 1/4-inch 4.5-oz elastics. The test periods were 10 and 40 days. None of the teeth in the groups showed any inflammatory reactions or reparative dentin formation at the test periods. Five teeth from the elastics group and two teeth from the sectional appliance group showed large and numerous pulp stones in the serial sections (17.5% of all cases). Seven teeth from the sectional appliance group and two teeth from the elastics group showed odontoblast aspiration into the dentin tubules (22.5%). The results of the study showed that the extrusive forces applied in this study did not cause significant pathological changes in human pulp tissue.

Profitt (1) explained that the orthodontic force applications may produce periodontal inflammatory reactions but should not show effects beyond mild inflammation of human dental pulp. Results of published histological data demonstrate that the dental pulp is affected by the orthodontic movement, showing pulp reactions from circulatory vascular stasis to necrosis (2—6).

Butcher and Taylor (2) demonstrated that the application of retraction forces caused pulp necrosis in monkey teeth. Stenvik and Mjör (3) and Mostafa et al. (4) showed that intrusive and extrusive forces caused odontoblastic layer degeneration due to circulatory disturbances in human pulp tissue. Anstendig and Kronman (5) observed the disruption of the odontoblastic layer after bodily movement and torque force on dogs' teeth. In an experimental study Turley et al. (6) traumatically intruded dog teeth, then applied orthodontic extrusion and observed that half of the teeth became totally necrotic and the rest showed calcification and degeneration of the pulp tissue.

Using the radiorespirometric method, Unsterseher et al. (7) and Hamersky et al. (8) observed that pulp tissue respiration was depressed between 27 to 33% after orthodontic force application. Recently McDonald and Pitt Ford (9) demonstrated using the laser Doppler flowmetry that human pulpal blood flow decreased significantly after continous light-tipping force activation. However Barwick and Ramsay (10) found no pulpal blood flow reduction with laser Doppler flowmetry during and after brief intrusive force application.

The purpose of this histological study was to investigate the response of the human dental pulp tissue to two different extrusive force applications for 10 and 40 days. In the first test group teeth were extruded by means of a fixed sectional orthodontic appliance. In the second group the extrusive force was applied using !/4-inch 4.5-oz elastics.

MATERIALS AND METHODS

Forty maxillary and mandibulary first premolars from 15 patients between the ages of 15 to 18 scheduled for the extraction before the begining of orthodontic therapy were used in the study. The selected teeth were clinically and radiographically fully developed with mature apices, noncarious, nonrestored, showing no peridontal involvement and no more than superficial attrition. Patient consent was given after they were informed about the study.

Teeth were divided into two groups. In group 1, 20 teeth of 10 patients were extruded with the use of a fixed sectional orthodontic appliance. The brackets were bonded to the mandibular or maxillary first premolars and first molars. A molar band with a buccal tube cemented to the first molar and an 0.016-inch arch wire circled from the molar side was placed between the teeth to extrude the premolars. Bite plates were used to avoid traumatic occlusion and provide space for movement. The recorded extrusive force, by means of a Correx measure, was 75 g at the begining of the study. No other force arrangement and recordings were made during the test periods. Ten teeth were extracted at 10 days and the rest of the teeth at 40 days.

In group 2, 20 teeth from five patients were extruded by means of !/4-inch 4.5-oz elastics. Maxillary and mandibular first premolars were bracketed and the elastics were hooked from the buccal side. The force was approximately 75 g when the patients were speaking. The patients were told to change the elastics every 24 h and immediately in case of breakage and not to use them during the meals. Bite plates were used to avoid traumatic occlusion and

TABLE 1. Histological findings of the study

			Inflammatory Cell Response			Soft Tissue Response				Hard Tissue Response			
Group	No. of Teeth	Time (days)	1	2	3	1	2	3	4	1	2	3	4
1	10	10	10	0	0	6	4	0	0	10	0	10	0
	10	40	0	0	0	7	3	0	0	10	0	8	2
Q	10	10	10	0	0	8	2	0	0	10	0	8	2
	10	40	10	0	0	10	0	0	0	10	0	7	3

provide space for the movement. Extractions were made after test periods of 10 and 40 days.

After extraction the tip of each root was cut with a bur to facilitate fixation. Teeth were fixed in 10% formalin, demineralized in 0.5 mol/L EDTA, washed in distilled water, and processed in a Hypercenter-2 (Shandon-Lipshaw, Inc., Pittsburg, PA), dehydrated in ascending grades of A-butyl alcohol and embedded in Paraplast Plus (Sherwood Medical Co., St. Louis, MO). Uninterrupted 83 p,m serial sections were cut in a buccal-lingual plane, placed on gelatin-coated slides, and stained with either hematoxylin & eosin and Preece's trichrome. Each tooth was examined in serial sections for inflammatory response, soft tissue response, and hard tissue response using a modification of criteria used for the pulp tissue test of biomaterials (11). Serial sections of each tooth were independently examined by two investigators.

Inflammatory Response

1. None or a few inflammatory cells in the pulp below the remaining dentin.
2. Mild to moderate infiltration of acute and/or chronic inflammatory cells.
3. Severe infiltration of inflammatory cells.

Soft Tissue Response

1. No detectable change of the pulp tissue structure.
2. Odontoblast aspiration into the dentin tubules and/or loss of the odontoblast layer at some region.
3. Change of the pulp tissue to fibrotic tissue.
4. Necrosis at the crown pulp tissue or reaching to the root canal pulp tissue at least to some level or total pulp necrosis.

Hard Tissue Response

1. No additional rim of reparative dentin.
2. Additional reparative dentin formation.
3. None or a few small pulp stones in the pulp tissue.
4. Several and large pulp stones in the pulp tissue

RESULTS

Histological findings of the study are summarized in Table 1.

Group 1: Pulp Reactions to Fixed Sectional Orthodontic Appliances

At 10 days all 10 pulps showed no inflammatory response (Fig. 1) . There were only a few mononuclear cell infiltrations into the zone where odontoblast aspiration was seen in 4 of 10 cases (Fig. 2) . Four cases associated with odontoblast aspiration in narrow regions showed grade 2 soft tissue organization. None of the cases showed a hard tissue response at this period.

At 40 days all 10 cases demonstrated a grade 1 inflammatory response. Three cases showed odontoblast aspiration inside a small zone. None of the teeth showed an additional rim of reparative dentin deposition. Two pulps showed several large pulp stones (Fig. 3).

FIG 1. Tooth extruded with a fixed orthodontic appliance for 10 days. Pulp has a no normal appearance with no signs of inflammation. (Original magnification X10, hematoxylin & eosin.)

Group 2: Pulp Reactions to the Elastics-Activated Group

At 10 days there was no tooth showing inflammatory response (Fig. 4). Two pulps demonstrated odontoblast aspiration inside a small area. None of the cases showed a hard tissue response at this period. There were two teeth showing several pulp stones formations in the pulp tissue.

FIG 2. Tooth extruded with a fixed orthodontic appliance for 10 days. Numerous odontoblast aspirations into the dentin tubules and a few mononuclear cell infiltrations are seen. (Original magnification X40, hematoxylin & eosin.)

FIG 3. Tooth extruded with a fixed orthodontic appliance for 40 days. Pulp is normal and pulp stones are present. (Original magnification X10, hematoxylin & eosin.)

FIG 4. Tooth extruded with elastics for 10 days. Pulp has a normal appearance with no signs of inflammation. (Original magnification X10, hematoxylin & eosin.)

At 40 days there was no infiltration of inflammatory cells, no soft tissue changes, and no reparative dentin deposition in any of the cases (Fig. 5). Three teeth exhibited pulp stone formations.

FIG 5. Tooth extruded with elastics for 40 days. Pulp is normal and no sign of inflammation is seen. (Original magnification x10, hematoxylin and eosin.)

DISCUSSION

According to the results of the present study none of the teeth in the groups showed any inflammatory reactions at the test periods. Seven of 20 teeth from the sectional appliance group and 2 of 20 teeth from the elastics group exhibited odontoblast aspiration into the dentin tubules in the serial sections (22.5% of all teeth). No other soft tissue changes were observed in this study. Five teeth from the elastics group and two teeth from the fixed sectional appliance group showed several large pulp stones in the serial sections (17.5 of all teeth). Histological data of the study revealed first that the extrusive force application for 10 and 40 days using a fixed sectional apparatus with a initial force of 75 g caused histologically no major pathological changes to the pulp tissue. Second, an extrusive force by means of a 4.5-oz elastisc for 10 and 40 days was also well tolerated by the human pulp tissue.

The orthodontic force applications may cause different pulpal reactions according to the maturation of the root formation (2, 4, 8). The teeth selected in this study were clinically and radiographically fully developed with mature apices.

Reitan and Vanarsdall (12) recommended that the extrusive force for adults must be between 25 to 30 g to prevent pulpal damage. On the other hand, Profitt and Fields (1) considered that a range of 50 to 75 g force is the optimum force magnitude for extrusion. In group 1 the spring of the sectional apparatus was activated at 75 g initially and no more force application was done during the experiment. The initial force decreased possibly in time but the final force was not recorded in this group.

In this experiment 75 g force by way of elastics was applied to the teeth in group 2. By changing the elastics every day teeth were extruded with approximately the same force during the test intervals, and no pulp tissue changes were observed. These results indicated that the extrusive applications used in this study did not cause significantly different pulp tissue reactions.

Studies have shown that one of the first visible pulp reactions to a deleterious effect through dentin tissue is the aspiration of odontoblasts (13, 14). In this study, nine teeth from both groups exhibited odontoblast aspiration into the dentin tubules in narrow regions. No other degenarative changes of odontoblasts were seen. These results indicated that the extrusive forces applied in this study did not cause significant deleterious effects on the odontoblasts.

Mostafa et al. (4) observed that after 4 wk of extrusive 50 g mean force application through a fixed apparatus caused fibrotic changes to the human pulp tissue. However they did not mention the number of the teeth showing fibrotic pulpal changes. No pulp exhibited fibrotic changes in this study.

Seven of 40 cases exhibited several large pulp stone formations. There seems to be no correlation between the presence of the pulp stones and the orthodontic force application in this study. It has been stated that there is no certain cause of pulp stone formation (15-17).

Similar histological studies have found the pulp tissue impaired due to orthodontic movements (4, 5). One of the histological findings of these studies is the vacuolization of the odontoblast layer (4, 5). Vacuolization of a cell, cellular swelling as described by Kumar et al. (18) is the first histological sign of cell death due to improper aerobic respiration and can hardly be determined with light microscopy. On the other hand, Seltzer and Bender (16) pointed out that vacuolization of the odontoblasts is a histological artifact due to poor fixation or mistakes during tissue processing. Odontoblastic vacuolization was not seen as a histopathological pulpal change in this study.

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