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The Histopathological Investigation of Pulpal Tissue following Heavy Orthopaedic Forces Produced by Rapid Maxillary Expansion

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This study aimed to investigate the effects of heavy orthopaedic forces, produced by rapid maxillary expansion, on pulpal tissue of pre-molar teeth. Teeth extracted as part of an orthodontic treatment plan, an average of 3 months, 6 months and 18 months after rapid maxillary expansion, were analysed using histopathological techniques. Control teeth were extracted, for orthodontic reasons, before any force treatment. Non-parametric tests were used to compare the results from the three treatment groups and one control group. Vessel diameter, haemorrhage, congestion and inflammatory cell infiltration varied between groups, and the differences between the control and 3-month groups, and the 3-month and 18-month groups were most significant. In conclusion, orthopaedic forces exerted by rapid maxillary expansion caused reversible vascular changes in pulpal tissue of upper pre-molar teeth.

KEY WORDS: RAPID MAXILLARY EXPANSION; HISTOPATHOLOGICAL PULPAL CHANGES; TEENAGE PATIENTS; PRE-MOLAR TEETH; ORTHODONTIC FORCES

Introduction

Rapid maxillary expansion (RME) is an orthodontic technique used to correct maxillary constriction and posterior cross-bite.[1] RME exerts a powerful force (7.54 – 15.8 kg)[2] on the crown of the tooth that is transmitted, via the root, to the bones. This causes distraction along certain suture lines.[3] The dental pulp is a specialized tissue located in a rigid dentinal layer of tooth. The architecture of the pulp is unique; blood vessels and nerves enter the tissue through the apical foramen. Various dental materials and procedures, including those of tooth movement, have been reported to adversely affect the dental pulp.[4] There are several reports stating that orthodontic force causes permanent injury and loss of pulp vitality,[5,6] but these claims have been rejected by other groups.[7 – 9] The pulpal responses to orthodontic forces, particularly intrusive forces, have been studied,[4,6] but few have investigated the reaction of dental pulp to the orthopaedic forces produced by RME.[10,11]

This study aimed to compare the histopathology of pulpal tissue, in teeth from patients treated with RME, 3 months, 6 months and 18 months after treatment, with teeth from control, untreated patients.

Materials and methods

TEETH AND TREATMENT

Intact upper pre-molar teeth extracted as part of orthodontic treatment, from male and female patients, aged 13 – 17 years, were used for the study. Teeth were extracted at an average of 3 months, 6 months and 18 months after RME completion, and assigned to these groups, respectively. The control group comprised upper pre-molars extracted as part of orthodontic treatment before any kind of force was applied.

A Hyrax-type RME appliance was used. This was cemented onto the upper dental arch and the screw activated three times a day, until mid-palatal suture opening was obtained, then twice daily until satisfactory widening of the maxilla was achieved (Fig. 1).

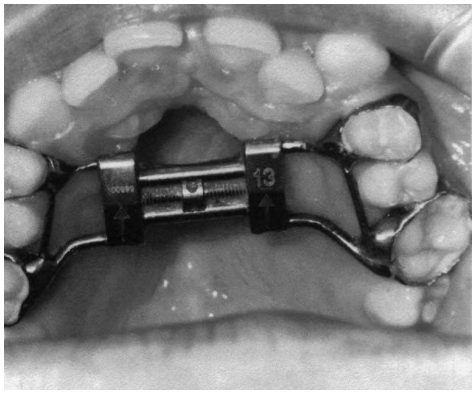


FIGURE 1: The Hyrax-type rapid maxillary expansion appliance. This is cemented onto the teeth and used to widen the maxilla by opening the mid-palatal suture. This technique is used to treat maxillary constriction and posterior cross-bite

HISTOPATHOLOGICAL ANALYSIS

Immediately after extraction, teeth were fixed in 10% neutral buffered formalin solution for 10 days, decalcified in 5% nitric acid solution, and embedded in paraffin. Paraffin sections, 4-µm thick, were cut buccolingually and stained with haematoxylin and eosin. Sections from four experimental and four control teeth were cut from the paraffin blocks, stained with Masson's trichrome, and analysed by light microscopy.

To determine vascular proliferation, five separate high power fields were viewed from the crown, middle and root of each tooth. The number of vessels in each field was counted and a mean obtained. Pulpal tissue was examined objectively for vessel diameter, haemorrhage, vascular congestion, inflammatory cell infiltration and vacuoles by semi-quantifying the parameters. The following scale was used: 0, no change; 1, mild change; 2, moderate change; and 3, severe change.[6] All evaluations were carried out by the same investigator.

STATISTICAL ANALYSIS

Reproducibility of the rating scale was assessed by re-evaluation 15 days after the first evaluation. The paired *t*-test was applied to these two sets of evaluations.

Non-parametric statistical methods were applied to data because of the limited sample size. A Kruskal–Wallis test was performed to identify significant differences in each parameter between the groups, and the Mann–Whitney *U*-test was used to determine which groups were responsible.

Results

A total of 28 teeth were used in the study, eight in the control, 3-month and 6-month groups, and four in the 18-month group. The average time for RME treatment was 22 days. The rating scale was found to be reproducible

TABLE 1:
Kruskal–Wallis test results showing the significant differences in each parameter between groups

	Control		3 months		6 months		18 months		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P*-value
No. of vessels	10.33	1.37	13.5	6.38	8.33	1.97	8.17	1.37	NS
Vessel diameter	1.00	0.00	2.00	0.00	1.50	0.55	1.00	0.55	$P < 0.01$
Haemorrhage	0.00	0.00	2.00	0.00	1.00	0.00	0.00	0.00	$P < 0.001$
Congestion	0.00	0.00	1.67	0.52	1.50	0.55	0.23	0.52	$P < 0.001$
Inflammatory cell infiltration	0.00	0.00	1.00	0.00	0.50	0.55	0.00	0.00	$P < 0.001$

NS, not significant.

as there were no significant differences between the two sets of evaluation data.

No evidence of damage was observed in the control group (Table 1). Vacuoles were not found in any of the teeth studied, so this parameter was omitted from the statistical analyses. The results of the statistical analyses are shown in Tables 1 and 2.

In summary, tissue damage and fibrosis were evident at 3 months, but gradually improved with time. Most parameters were equivalent to the control group by 18 months.

Discussion

Rapid maxillary expansion is frequently used to correct maxillary constriction and posterior cross-bite. High forces are produced during active expansion of the mid-palatal suture by RME, so clinicians must be aware of all the consequences. This study aimed to evaluate, histopathologically, the effect of RME treatment on pulpal tissue of anchor pre-molars, up to 18 months after treatment.

After expansion, a 3 – 6-month retention period is required to allow reorganization of

TABLE 2:
Mann–Whitney *U*-test results showing which groups were responsible for the differences seen in each parameter between groups

	Control and 3 months	Control and 6 months	Control and 18 months	3 months and 6 months	3 months and 18 months	6 months and 18 months
Vessel diameter	0.002[b]	–	–	–	–	–
Haemorrhage	0.002[b]	0.003[b]	–	–	0.002[b]	0.002[b]
Congestion	0.003[b]	0.002[b]	–	–	0.009[b]	0.02[a]
Inflammatory cell infiltration	0.002[b]	–	–	–	0.002[b]	–

[a]$P < 0.05$.
[b]$P < 0.01$.

the mid-palatal suture, stabilization of the surrounding hard- and soft-tissue architecture, and dissolving of residual forces.[12 – 16] The retention period can extend to 18 months, depending on the clinical situation.[15] We examined teeth extracted 3 months, 6 months and 18 months into the retention period, to determine whether any observed vascular changes were reversible.

We found no difference in the number of vessels between the groups, which verifies the results from Kayhan *et al.*,[11] but contradicts those of Nixon *et al.*[16] and Derringer *et al.*[17]

Fibrotic changes were greatest in the 3-month group, less in the 6-month group, and very slight in the 18-month group. A study dealing with extrusive-type tooth movement also observed fibrotic changes,[18] and Kayhan *et al.*[11] observed fibrotic changes in their 3-month group. These fibrotic changes may represent the increasing duration of excessive force application, or may occur as a result of the start of tooth movement.[11]

Vessel diameter was significantly increased in the 3-month group in our study. This agrees with other studies, which also found increased vessel diameter soon after force application.[11,18] Stenvik and Mjor[6] found stasis in vessels after the application of forces exceeding 150 – 200 ***g***, but a study in dogs[5] found vessel constriction and a decrease in the number of vessels. Vacuoles were not seen in any of our groups, but were observed in two other studies.[6,10]

An increase in all parameters was observed between the control and 3-month groups in our study. These changes then decreased between 3 months and 6 months, and again between 6 months and 18 months. We believe this is due to an inflammatory process occurring in the periodontium as a result of excessive load application. Forces exerted by RME therefore cause vascular injury in pulpal tissue, highlighting the importance of force duration and intensity. Significant vascular changes had disappeared 18 months after the RME treatment, indicating that the vascular changes are reversible. These findings are very important from a clinical perspective, as all orthodontic treatments should maintain tooth viability. Our results show that pulpal health was maintained 18 months after force application, and indicates that orthodontic treatments using large forces are safe.

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