Histomorphometric analysis of orthodontically induced root resorption

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Abstract:

This clinical and histological investigation was designed to study the association between orthodontically applied force and related root resorption in fortyeight adult patients where their treatment involved bilateral maxillary first premolar extraction which was postponed to use the 96 teeth as a test and control for the experiment.

The patients were assigned to one of six groups; the right premolars were moved buccaly using continuous, well controlled, different forces range (30-80 grams) for ten weeks while the left premolars served as a control. By the end of the experimental period, the teeth were extracted and underwent routine histological preparations. Sections were tested using the image analysis computer system.

Statistical analysis of the result revealed a non significant difference in the mean value of resorbed area between the control group and those in which forces of 30, 40, 50 and 60 grams were used but a significant difference in the mean value of groups in which 70 and 80 grams were used.

Regarding the depth of resorption a non significant difference was found in the mean value between the control groups in which forces of 30, 40 gram were used but a significant difference was found in groups in which forces of 50, 60, 70 and 80 gram used. Finally, the mean value of the resorbed area and its depth were always more in the palatal root than the buccal root and in the apical third than the cervical third for all groups.

Key words:

Root resorption, forces, orthodontic treatment, histomorphometric.

Introduction:

The magnitude of the orthodontic force is believed to be an important factor, not only for the amount of the tooth movement but also for any tissue damage. It is believed that too strong forces will

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cause increased damage to the engaged tissues, e.g., root resorption. Therefore, the magnitude of the applied force has been recommended to be related to the root area [1].

External root resorption is a serious iatrogenic and multifactorial problem associated with orthodontic treatment when forces exceed the resistance and reparative ability of the root and supporting tissue [2]. It is considered as a physiologic or pathologic process resulting in the loss of cementum and dentin and it is associated with orthodontic treatment adjacent to an area of hyalinization [3].

Root resorption was believed to result from a complex combination of individual biology, local factors and factors related to orthodontic mechanotherapy e.g. force magnitude, type and duration of the force, others like: systemic factor, genetic, age, sex, nutrition, previous trauma, habits, root structure morphology, impacted teeth, and pathological lesions [4 & 5].

Most orthodontic investigations concerning tissue reactions have been performed in animals, and different species have been used [6, 7] however, there are essential morphological and functional differences in teeth and supporting tissues between animals and man [8].

For more and better understanding of the development of early tissue reactions (root resorption) a study on a representative human material was needed.

The aim of this investigation was therefore to study root resorption in adults after application of a well controlled, continuous orthodontic force of a clinically relevant magnitude and to find the effect of increasing or decreasing the force on the occurrence, surface extension area and depth of root resorption using morphometric parameters of the image analysis computer system.

Materials & Methods:

For analysis of root resorption during orthodontic tooth movement 96 maxillary first premolars with two roots (buccal and palatal from 48 patients, 21 males and 27 females, 17 to 23 years of age (mean age 20 years) were studied and selected from patients attending the Baghdad Dental College / Orthodontic Department.

Orthodontic treatment involved bilateral maxillary first premolar extraction. The scheduled extractions were postponed for ten weeks for all groups to use the teeth as a test and control for the experiment. The upper left first premolars were used as a control group (group I).

The patients were numbered and assigned to one of six groups; each group consisted of eight individuals. Different orthodontic force was used for each group.

Group II: 30 grams.
Group III: 40 grams.
Group IV: 50 grams.
Group V: 60 grams.
Group VI: 70 grams.
Group VII: 80 grams.

Periapical radiographic films were taken within a week before the starting tooth movement and immediately before extraction of the teeth. The' apical radiograph was examined with a magnifying viewer over a bright – lamp which is framed to avoid stray light.

A fixed edgewise orthodontic appliance according to Lundgren et al[9] was inserted the day the experimental period started, consisted of molar anchor bands on the maxillary first molars supplied with buccal attachment having three tubes and united with half round transpalatal bar for reinforcement of the anchorage(Fig.1).

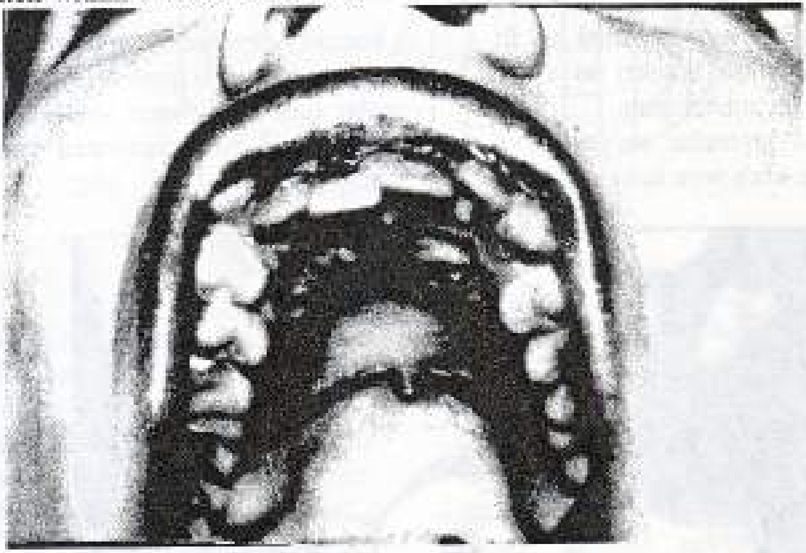


Fig.1: Transpalatal bar for reinforcement of the anchorage.

The first right premolar (experimental) was moved buccaly with a sectional arch wire (0.018 inch, heavy round, stainless steel wire) ligated to a bonded 0.018 × 0.022 inch bracket attached to the buccal surface of the tested tooth at 4mm from the tip of the cusp (Fig.2).

Slight grinding of the occluding cusps was done provided a free movement and reduce the occlusal forces on the tested teeth.

Fig. 2: The first right premolar (experimental).

The arch wire was adjusted to fit passively into the bracket to avoid unwanted movements. The contralateral premolar served as a control. The arch wire activated with a buccally directed force by means of bending the wire just mesial to the molar tube .The force was checked once a week and reactivated using a strain gauge (fig. 3).

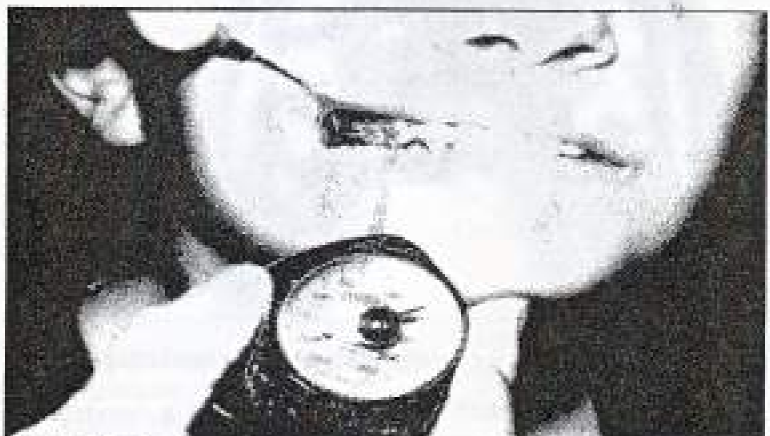


Fig 3: A clinical photograph illustrating the strain gauge used to measure the force magnitude in vivo.

All the extracted teeth were immediately fixed in 10% neutral buffered formalin solution for 48 hours, demineralized in 10% formic acid. Dehydrated, cleared and embedded in paraffin wax and stepserially sectioned parallel to the long axis starting from the mesial surface with the microtome set to 4mm. The teeth were sectioned in a buccolingual direction to the middle of the root (Fig.4).

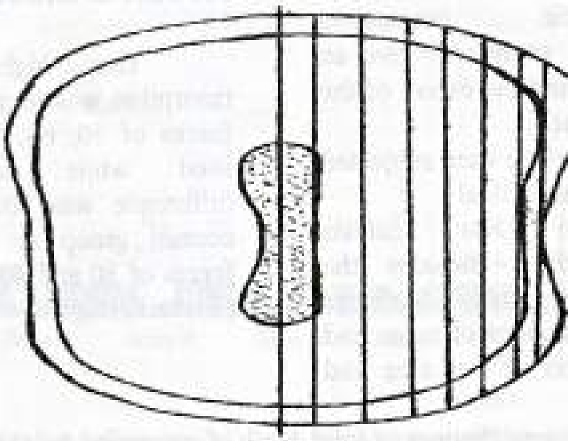


Fig.4: Direction of teeth sectioning.

For histological examination, sections were selected from five levels in the bucco-lingual direction, 22 sections at each level. 110 sections in all and the sections were stained with hematoxylin and eosin.

To describe the locations of the findings, the root was divided into three parts. Cervical, middle and apical and a general survey of the tissue, as well as occurrence of root resorption and repair were made in all sections.

Root resorptions were registered on one randomly chosen histological section at each of five levels, i.e. five sections on each tooth using the image analysis computer system. There was no uniform definition of root resorption, but it can be defined as resorption lacunae in the cementum or extending into the dentin [1].

The Histomorphometric Parameters which were used are:

Area: This is defined as the area under the curve, used to describe the area of resorption.

Maximum Diameter:(DMAX)

This refers to the maximal diameter of the measured area; it will give a clear idea about the depth of the resorption lacunae. Therefore the histomorphometric parameters included in this study will give an idea of the size and the extent of the resorption lacunae.

All data of the sample were subjected to computerized statistical analysis using: Data analysis program and these includes the following:-①Descriptive Statistics Include the conclusions of mean and standard deviation of the area and depth of resorption in the seven groups, Statistical tables, Bar charts. ②Inferential Statistics:- they include: student t-test, analysis of variance (ANOVA)test, and Tukey's HSD test was carried out which is usually referred to as the(honestly difference)test.

Result & Discussion:

The highest depth of resorption was found in groups were forces of 50, 60, 70 and 80 grams used while anon significant difference was found between the control group & group in which forces of 30 and 40 grams were used (Table:1),(fig.5).

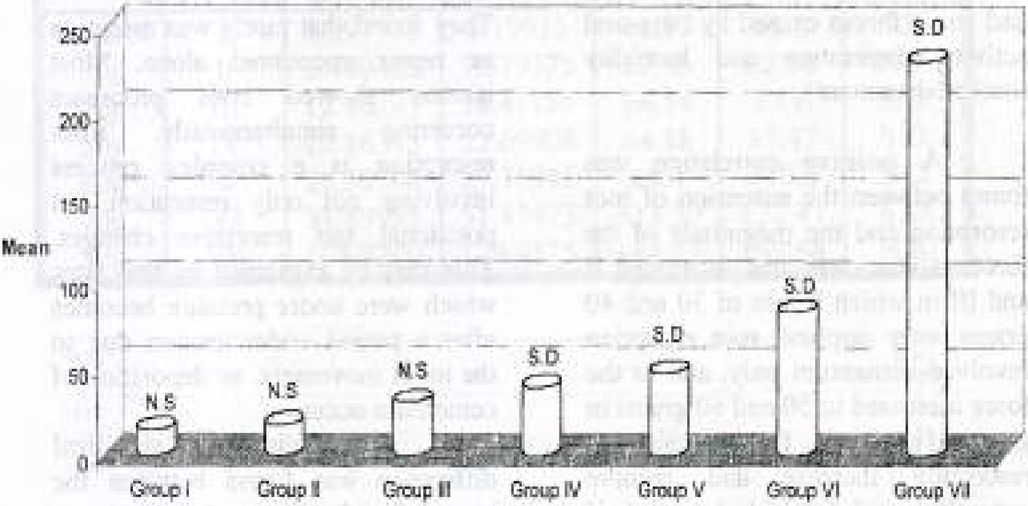
Table 1: The mean changes of total depth of resorption for the seven groups.

Groups	Control	Sum	Mean (planimetric unit)	Standard deviation	HDS test
I	40	595.885	14.89713	±2.08	N.S.
II	40	722.752	18.0688	±4.2	N.S.
III	40	1250.979	31.27448	±7.2	N.S.
IV	40	1582.489	39.56223	±9.4	S.D.
V	40	1926.181	48.15453	±16.2	S.D.
VI	40	3333.383	83.33458	±24.8	S.D.
VII	40	9247.136	231.1784	±72.8	S.D.

In the bioprogressive technique, a force of 100 grams per cm^2 of exposed root surface in the direction of tooth movement is considered to be the optimum. This means 70 grams for buccal tipping of a maxillary canine and 50 grams for premolars [15].

That's why a significant difference was found in the depth of resorption starting from group in which force of 50 grams was used.

Fig.5: :The mean changes of total depth of resorption for the seven groups.



The periapical radiographs in both the test and control teeth failed to reveal any root resorption especially in the early stage and because most of the resorption were located in the buccal and palatal root surfaces.

Most of clinical studies have relied on conventional radiography. This method has certain limitations since only resorption on apical and proximal surface can be assessed without any confidence whereas buccal and lingual lesions are less readily perceived. Also the ability to detect root resorption radiographically not only related to the location of the defect, but also to its size.

Each force system shows a certain amount of force reduction which important to analyze when comparisions are to be made.

The orthodontic force magnitude was found to decrease during the first 7 days in all of six groups, and this force reduction was found in all experimental weeks.

There are at least three possible explanations for the observed force reduction:

1-The deviation of the tooth (Tooth movement).

2- Plastic deformation of the arch wire due to the bending for activation just mesial to the molar tube.

3- Plastic deformation due to stress and strain forces caused by intra-oral activity, temperature and humidity (oral environment).

A positive correlation was found between the extension of root resorption and the magnitude of the force, it was clear that in groups II and III in which forces of 30 and 40 grams were applied, root resoption involved cementum only, and as the force increased to 50 and 60 grams in groups Iv and V, the extension of resorption increase and involve cementum and dentin and reach half away to the pulp or sometimes to the pulp itself especially in the apical region, when the forces increase to 70 and 80 grams in groups VI and VII.

So the amount of cemental cratering activity stimulated during orthodontic treatment was shown to be a direct function of the magnitude of force applied and it is an indication to the degree of tissue damage at sites of greatest pressure.

Three types of resorptive lacunae were found and these were active, arrested and repaired surface resorption. This finding is in agreement with other studies [10-13]. They found that rarely was resrption or repair encounted alone. Most lesions showed both processes occurring simultaneously. Root resorption is a complex process involving not only resorption but positional and resorptive changes. This may be explained by that sites which were under pressure becomes after a period under tension due to the tooth movement, so deposition of cementum occur.

A statistical significal difference was found between the buccal & palatal roots for all groups and the mean value of resorbed area for the platal root was always more than that of the buccal root, this was the same regarding the depth of the resorption except in group II and VII in which a non significant difference was found in the buccal and palatal roots (Table 2), (fig.6).

All the premolars used in this study were with two roots buccal and palatal from the anatomical point of view for the first premolar, the buccal root always is thicker than the palatal one.

Table 2: Results of application a student t-test between the mean values of the depth of resorption between the buccal and palatal roots for the seven groups.

Forces	Groups	Mean (planimetric unit)		Standard deviation		Student T-test
		Buccal	Palatal	Buccal	Palatal	
Control	I	6.697775	8.19935	±1.17	±1.8	S.D.
30g	II	8.489425	9.579375	±2.66	±2.68	N.S.
40g	III	12.86293	18.41155	±4.14	±5.6	S.D.
50g	IV	16.86315	22.69908	±4.18	±7.47	S.D.
60g	V	20.38508	27.76945	±6.4	±10.8	S.D.
70g	VI	31.89985	51.43473	±13.30	±22.47	S.D.
80g	VII	101.7209	129.4575	±44.07	±57.68	N.S.

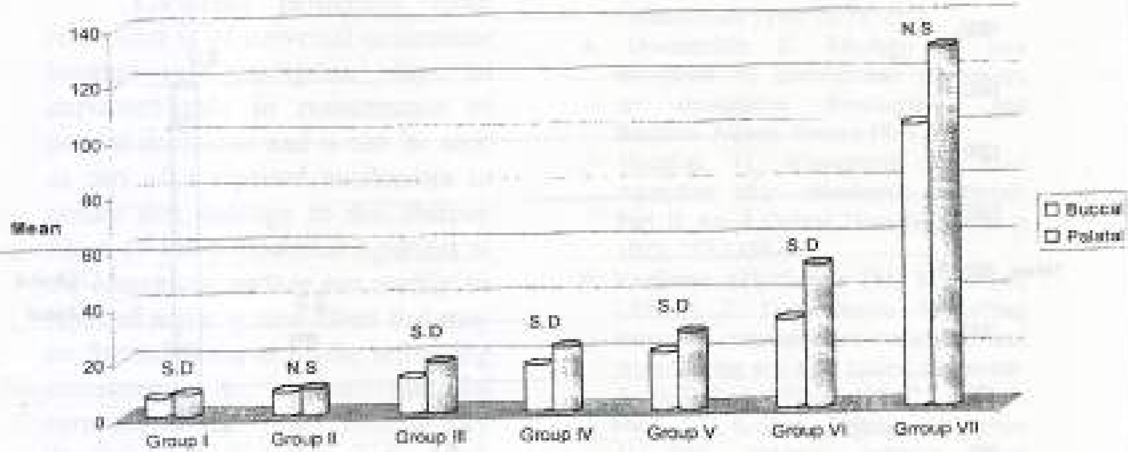


Fig.6: Bar chart shows the differences in the mean values of depth of resorption between buccal and palatal roots for the seven groups.

The great majority of resorption areas in all the test teeth were confined to the apical third of the roots and less in the gingival third with no resorption in the middle third (Table 3),(fig.7).

Table 3: results of application a student t-test between the mean values of resorbed area between the apical and cervical third for the seven groups.

Groups	Mean (planimetric unit)		Standard deviation		Student t-test
	Cervical	Apical	Cervical	Apical	
I	4.256125	28.40348	±1.48	3.68895	S.D.
II	7.296	45.71	±1.6	2.67	S.D.
III	9.08475	50.391	±1.4	4.58	S.D.
IV	15.66525	86.98575	±1.95	7.44	S.D.
V	20.9185	135.923	±2.48	7.87	S.D.
VI	87.7235	586.6785	±12.9	142.3	S.D.
VII	292.889	1431.933	±111.68	322.5	S.D.

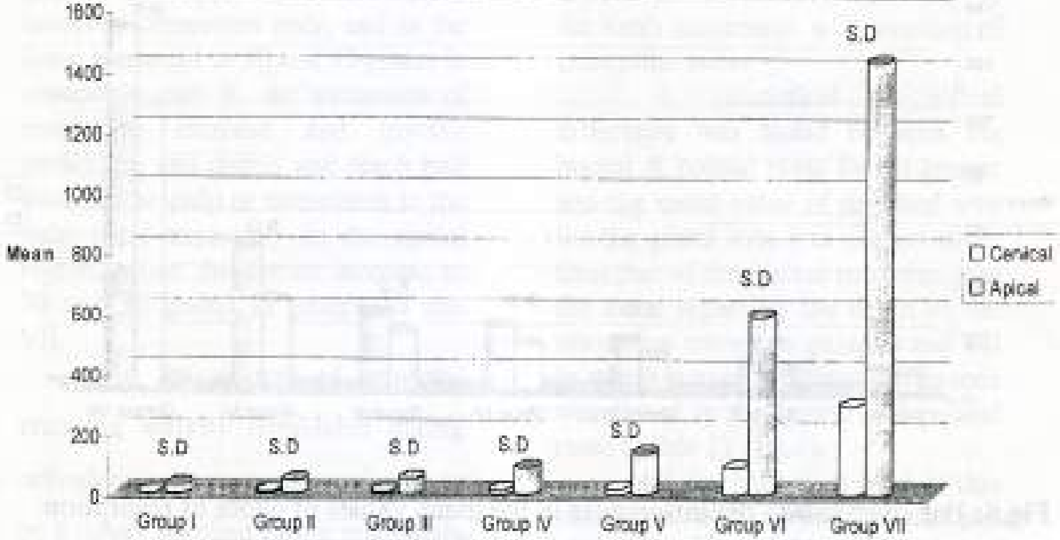


Fig.7: Bar chart shows the differences in the mean changes in the groups was done to find the difference between the seven groups in the resorbed root area for the apical and cervical third.

Because the type of tooth movement in this study was a tipping movement in which the tooth will act as a two-armed lever. The active force is always greater than the force applied and concentrated in small area near the alveolar crest and in the apical region, leading to resorption and loss of root substance.

Root resorption was also found in some of the control teeth but to a much lesser extent than in the test groups and was mostly located in the apical third (mean value 28.40348), less in cervical (mean value 4.256125) and to lesser extent in the middle third of the roots(mean value 2.12475).

Localized permanent tooth resorption is of universal occurrence because root resorption plays an important role in maintenance of normal occlusion and it can be seen as part of a repaired mechanism to ensure that damage to the sharpey fibers of the periodontal ligament at the cementum surface can readily be repaired and any new fibers that may be formed secured in the reforming cementum. It is an essential component of the evolutionary development of a gomphotic tooth attachment.

Investigations on the occurrence of resorption in the roots of permanent teeth have shown that even untreated teeth reveal sites of physiologic movement.

Root resorption occurs in all experimental teeth and in some control teeth and this result in agreement with other studies [1, 14].

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