The effect of glucocorticosteroid medication on orthodontically induced root resorption (An experimental study on rats)

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ABSTRACT

Background: Many patients use drugs on a daily basis, and all these drugs have therapeutic effects, as well as side effects that may influence the cells targeted by orthodontic forces. The aim of this study was to investigate the effect of different courses of glucocorticosteroid treatment on orthodontically induaced root resorption.

Materials and method: A 'Split- mouth design performing orthodontic tooth movement in 30 male Wistar albino rats divided into three groups: control (n = 10), acute (n = 10) and chronic (n = 10). Acute and chronic groups received corticosteroid treatment (5 mg/kg/day of methylprednisolone) for 3 and 7 weeks, respectively, while no pharmacological treatment was performed in the control group. The upper right 1st molar was moved mesially for 21 days in all three groups with a closing-coil spring delivering 20 g of force to cause orthodontic tooth movement by means of fixed orthodontic appliance. A histopathological based assessment method for the percentage of root resorption was performed at the coronal and apical level on both compression and tension sites of the non-appliance and appliance sides.

Results: The results revealed that the acute group showed significantly more root resorption at the compession-coronal level compared with the control and the chronic course group.

Conclusion: The percentage of root resorption is increased significantly in steroid treated groups compared to control group, therefore; steroid administration will influence the occurrence of root resorption.

Key words: Glucocoricosteroid; orthodontics; rats; root resorption. J Bagh Coll Dentistry 2010; 22(1):79-82.

INTRODUCTION

Root resorption is a physiologic or a pathologic process resulting in the loss of cementum and dentin. Root resorption is a common, but unavoidable, adverse reaction to orthodontic tooth movement [1]. The exact etiology of root resorption is unknown, but most likely it is a multifactorial problem involving genetic predisposition, environmental factors related to the morphology of the roots, and orthodontic treatment-related issues [2]. Numerous potential factors, related to both the individual patient and to treatment, have been suggested as risk factors for root resorption, but direct causal factors have not been identified[3]. This lack of consistent findings has led to the recent suggestion of a different approach to the analysis of the problem, where the primary effect is studied among patient factors rather than among treatment variables. Among the patient-related factors, recent investigations have examined the role of genetics, the immune system and the patient's medical history [4]. It has been shown that orthodontic tooth movement can be influenced by general and local pharmacological modulation, patients requiring orthodontic treatment can be anticipated to present variations from normal bone turnover due to metabolic disease or medication, e.g. steroid treatment of allergies[5].

Orthodontic patients may be affected by systemic diseases that need medical treatment with drugs that could possibly affect bone metabolism [6]. Corticosteroids are a class of steroid hormones, produced in the adrenal cortex. They are involved in many physiologic systems, such as stress response, inflammatory and immune responses, carbohydrate metabolism, protein catabolism, and blood electrolyte levels. Corticosteroids are commonly used to treat many different diseases because of their anti-inflammatory effect. Allergy, asthma, dermatitis and eczema are all diseases with high incidence and rapidly increasing prevalence commonly treated with corticosteroids [7].

This high prevalence and the increasing evidence of systemic effects of most forms of steroid treatment, stress the need for a better understanding of the consequences in relation to orthodontic treatment. In the present study the effect of short-term and long-term administration of therapeutic dosages of corticosteroid on orthodontically induced root resorption was investigated experimentally on rat model.

MATERIALS AND METHOD

Laboratory animals. Thirty adult male Wistar albino rats, weighing (220-320g) aged 12 weeks were used for this experiment. The rats were kept in the animal department of (National Center for Drug Control and Research/Baghdad-IRAQ) in separate cages in a 12:12 hour light/dark environment at a constant humidity and temperature of 23°C according to the National Research Council's guide for the care and use of laboratory animals and accessed to drinking water *ad libitum* and standard laboratory rat

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pellets. According to the pharmacological treatment [8], the rats were randomly divided into three groups:

Group I: a control group (n = 10) without any pharmacological treatment but received orthodontic treatment for 3 weeks (week 1–3).

Group II: an acute group (n = 10) received Methylprednisolone and orthodontic treatment simultaneously for 3 weeks (week 1–3).

Group III: a chronic group (n = 10) received Methylprednisolone For 7 weeks (week 1–7) and orthodontic treatment for the last 3 weeks (week 5–7), as shown in Figure 1.

The experimental groups received 5 mg/kg/day of methylprednisolone (Solu-medrol; Pharmacia NV/SA, Puurs-Belgium) intramuscularly every 24 hrs for the prescribed number of days [9].

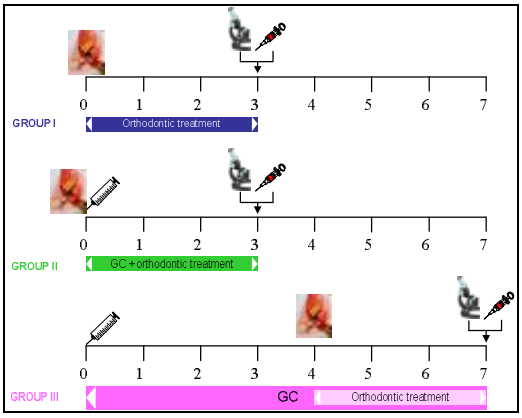

Figure 1: Flow diagram illustration the treatment of the rats in the experimental groups.

Placement of orthodontic appliance. The appliance was inserted under general anaesthesia, induced by an intramuscular injection of a mixture of ketamine (90 mg/kg body weight) and xylazine (10mg/kg body weight). Orthodontic tooth movement was generated by the insertion of a stainless steel ligature-wire with a diameter of 0.009" and 4mm in length interdentally between the 1st and 2nd maxillary molars, which looped around the cervical part of the 1st molar. It was ligated tightly to ensure maximum stabilization of the wire to which a closing-coil spring (9 mm in length, Dentaurum, Germany) was attached, and the end of the wire was bent carefully toward the buccal surface of the tooth by double ended-ligature tucker to avoid any mechanical trauma to the surrounding oral tissues and the slippage of the coil. To compensate the conical shape of the rats' incisors and subsequently prevent the slippage of the wire as well as the appliance, a TEC-TORQUE, angled hand piece (W&H-Austria) with an inverted-cone bur was used to make grooves cervically on the disto-labial surfaces of both maxillary incisors to which another preformed stainless steel ligature wire, with a diameter of 0.009" and 5 mm length, was looped. The ligature wire ligated tightly to which the other end of the closing-coil spring was attached, so that the closing-coil spring of fixed orthodontic appliance was delivering a total orthodontic force of 20 g for mesial traction of maxillary 1st molar was measured by pressure-gauge (CORBLX, Dentarum, Germany). As the closing-coil spring was being attached to the ligature wire, the end of the ligature wire had been carefully adapted toward the distal grooves by using Adam's plier. In order to avoid any mechanical trauma from the appliance to the surrounding oral tissues and to ensure maximum stability of the appliance, a light-cured filling composite material was added to the maxillary incisors. The appliance was checked weekly to ensure any loose or damage to the appliance. Consequently a mesially directed orthodontic force to the maxillary 1st molar with the incisors were used as anchorage teeth resulted in mesial traction of the 1st molar and space creation between the 1st and 2nd molar teeth.

According to Ren et al [10] to limit the influence of inter-animal variation in response to metabolic stimuli, a split-mouth design was used as the right side served as the appliance side and the left side served as the non-appliance side, as shown in Figure 2. At the end of treatment for each group the rats were sacrificed and the maxillae were excised.

Figure 2: Orthodontic fixed appliance in situ.

Evaluating the percentage of root resorption. On the eight H&E stained sections of each group, percentage of root resorption were determined. On the magnified (x120), areas for measurement in the non-appliance side were the mesial and distal aspects of the mesial root of maxillary 1st molars, corresponding to compression and tension sites, respectively, in the appliance side at both coronal and apical levels. A transparent sheet with 10 x 10-mm grids was superimposed and the numbers of grids with or without resorption lacunae were counted separately. Root resorption (percentage of resorption grids) was determined by dividing the number of grids with resorption lacunae by the total number of grids along the root surface. Percentage of Root resorption = (number of girds containing resorbed lacunae/total number of grids) x100[11].

RESULTS

The percentage of root resorption was in general larger on the appliance side than on the non-appliance side in all three groups, as shown in Table 1&2. Steroid administration influenced the

occurrence of root resorption. The acute group showed significantly more root resorption at the compression-coronal level than that in the chronic and the control groups (Figure 3).

Table 1: The difference in mean of percentage of root resorption on the non-appliance side at different sites and levels between 3 studied groups.

Site	Level	Variables	Studied Groups			ANOVA	Sig.
			Control	Acute	Chronic		
Compression	Coronal	Range	1.3-2.1	2.7-3.6	1.6-2.9	< 0.001	HS
		Mean	1.67	3.1	2.41		
		SD	0.29	0.32	0.44		
		SE	0.1	0.11	0.16		
		N	8	8	8		
	Apical	Range	0.7-1.4	1.9-2.7	1.5-2.4	< 0.001	HS
		Mean	1.06	2.28	1.81		
		SD	0.3	0.3	0.3		
		SE	0.09	0.11	0.11		
		N	8	8	8		
Tension	Coronal	Range	0.4-1.4	1-2.2	0.8-1.7	= 0.009	HS
		Mean	0.98	1.57	1.43		
		SD	0.4	0.3	0.4		
		SE	0.14	0.1	0.14		
		N	8	8	8		
	Apical	Range	0-0.3	0.9-1.7	0.9-1.2	< 0.001	HS
		Mean	0.14	1.35	1.12		
		SD	0.1	0.1	0.2		
		SE	0.03	0.04	0.09		
		N	8	8	8		

Table 2: The difference in mean of percentage of root resorption on the appliance side at different sites and levels between 3 studied groups.

Site	Level	Variables	Studied Groups			ANOVA	Sig.
			Control	Acute	Chronic		
Compression	Coronal	Range	6-7.6	16.6-20.5	7.1-9.6	< 0.001	HS
		Mean	6.96	18.48	8.55		
		SD	0.5	1.2	0.8		
		SE	0.19	0.44	0.28		
		N	8	8	8		
	Apical	Range	2.2-3.2	12-15.6	4.7-6.3	< 0.001	HS
		Mean	2.71	13.8	5.57		
		SD	0.3	1.2	0.5		
		SE	0.12	0.43	0.18		
		N	8	8	8		
Tension	Coronal	Range	2.2-3.4	5.8-7.2	2.3-3.8	< 0.001	HS
		Mean	2.55	6.49	3.11		
		SD	0.5	0.5	0.6		
		SE	0.16	0.19	0.22		
		N	8	8	8		
	Apical	Range	1-1.9	3.8-5	1-2	< 0.001	HS
		Mean	1.46	4.42	1.54		
		SD	0.3	0.4	0.4		
		SE	0.11	0.15	0.12		
		N	8	8	8		

Figure 3: Microphotograph view for cross section to 1st molar rat tooth in the acute group (appliance side) showing highly obvious root resorption in the Mesial root (MR) at Compression site (C) compared to Tension site (T), H & E ×100.

DISCUSSION

The percentage of root resorption on the non-appliance side is in general greater in the steroid treated groups compared to the control group. This increase is due to the fact that steroid treatments affect on the mineralized tissues of the body in many ways, they adversely affect on the bone remodeling cycle (lack balance between bone formation and bone resorption) that results in different bone turnover rates between steroid treated groups.

Root resorption is a common, undesirable and the least predictable sequelae of orthodontic treatment, in this experimental study the results indicate that orthodontic treatment cause an increase in the percentage of root resorption in all three groups, and the appliance side has significantly more root resorption compared to non-appliance side in all groups.

As in the non-appliance side, the higher percentage of root resorption on the appliance side is greater in the steroid treated groups compared to control group. This increase indicates that the pharmacological treatment adversely affecting the occurrence of orthodontically induced root resorption. This may be attributed to the fact that in addition to the effect of steroid treatment on bone metabolism as shown on the non-appliance side with the presence of mechanical loading on the appliance side that produce an adjunctive effect on the percentage of root resorption in steroid treated groups compared to control group.

The acute group showed significantly more root resorption at the appliance side compared with the chronic and the control group. While the chronic group showed slight increase in the percentage of root resorption compared to the control group. This increase in the acute group is due to the effect of steroid treatment on changing the effect of orthodontic appliance on the percentage of root resorption resulting from imbalance in bone metabolism occurring in the initial phase of drug administration (as shown in non-appliance side) with higher hyalinization, which could aggravate the

occurrence of orthodontically induced root resorption compared to control group. This is consistent with the finding of Verna et al [12] where a positive association between imbalance in bone metabolism and root resorption induced by orthodontic treatment was found. It can thus be suggested that in clinical situations where turnover of alveolar bone is enhanced or unchanged due to drug administration, root surfaces could already be affected by root resorption as a baseline condition.

In the chronic group which showed less root resorption compared to the acute group is due to faster remodeling of bone (high bone turnover rate) that have been reached during the first 4 weeks of drug administration preceding the appliance insertion with less hyalinization, the result is thus leading to less remodeling of root tissues. Therefore, such a state could slightly increase or unchanged the occurrence of orthodontically induced root resorption compared to control group. This is in accordance with previous investigations of Midgett et al [13]; Goldie and King [14] that did not find increased amounts of root resorption in animals with increased bone turnover. The protective effect against root resorption observed by Poumpros et al [15] was not confirmed by the results of the present study, as the rats with high bone turnover did not display less root resorption than those with low bone turnover.

The percentage of root resorption at the coronal level is higher than that in the apical level in the three studied groups. The localization of root resorption at the coronal level is consistent with studies performed by King et al [16]; Ballard et al [17] showing that the coronal level is the area that undergoes the largest changes after the application of a tipping force. However, these findings are in controversy to a study performed by Verna et al [6] showed no difference in changes between compression-coronal and compression-apical sites after the application of controlled-tipping force. The lack of a higher results at the apex compared to coronal level could be ascribed to a larger concentration of stress at the coronal than at the apical level due to the type of tooth movement achieved[18]. Another possible explanation could be the difference in root anatomy at the apical and coronal level. At the apical level, the root was smaller, more irregular and decreased in size very rapidly close to the apex. In this situation, a slight deviation of the cutting plane will have a larger effect at the coronal level.

Clinical Consideration

Increased amount of root resorption can be expected in patients using short-term corticosteroid. As asthma and other allergic symptoms are in fact often treated in an acute manner and for shorter periods of time, therefore; the orthodontist need to be particularly aware of the increased risk of root resorption in this group of patients. The clinical consequences could be to induce a passive treatment phase during the periods where steroids are administered. Increased frequency of radiographs to control for root resorption may also be indicated, especially in patients who for other reasons are prone to root resorption.

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