External Apical Root Resorption Following Cervical Traction Headgear

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Abstract: Objectives: This study was aimed to evaluate external apical root resorption of the maxillary first permanent molars following cervical traction headgear during orthodontic treatment of Class II division 1 patients**. Methods:** Thirty-eight patients with Angle's class II division 1 malocclusion with a mean age of 13.4 (±1.5) years were selected and divided into two groups. Headgear group comprised 18 subjects treated with extra-oral cervical traction headgear and a control group consisting of 20 subjects (age and gender matched) treated using fixed orthodontic appliances (Roth 0.018" inch slot system). External apical root resorption (EARR) of the mesiobuccal and distobuccal roots was assessed by directly measuring pre- and post-treatment root lengths for both maxillary right and left first permanent molars using orthopantomographs (OPG). **Results:** The duration of treatment for the headgear group (14 ±1.8 months) was significantly shorter than the controls (22 ±4.7 months), $p < 0.001$. There was significant decrease in the means of the mesiobuccal and distobuccal tooth lengths in the headgear group and the controls, $p < 0.001$. However, the decrease in the mesiobuccal tooth length in the headgear group was significantly more than the controls, $p < 0.001$. The distobuccal tooth lengths changes were not different, $p = 0.14$. **Conclusions:** The use of cervical traction headgear resulted in EARR especially in the mesiobuccal root of the maxillary first molars. Continuous radiographic monitoring is encouraged.
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1. Introduction

Extra-oral headgear traction is a widely used anchorage and orthopedic method for control of maxillary growth. Continuous use of headgear may cause rotation, wiggling, extrusion, intrusion and distalizing forces.[1] External apical root resorption (EARR) is a relatively common negative effect of orthodontic treatment noted first by Ketcham [2] in the beginning of the last century. From then on, this phenomenon has taken the attention of many clinicians and researchers. It is usually symptomless and if not diagnosed early may result in tooth mobility and even loss.[3]

The incidents of EARR differ between persons and also within the same person.[4] The diagnosis of EARR could be done using different kinds of radiographs. Although the new technologies, such as Cone Beam Computed Tomography has been proved to be more reliable and accurate,[5, 6] other conventional views are still used due to their wide availability and lesser cost and more importantly, less radiation exposure.[7, 8]

Hendrix *et al.,*[9] used the orthopantomograms (OPG) in verifying EARR. They found that, after orthodontic treatment, there was root shortening in the posterior teeth during active orthodontic treatment. This finding was independent of age, sex, non-extraction versus extraction and the duration of orthodontic treatment. Also, incompletely formed roots at beginning of orthodontic treatment exhibited root lengthening during active treatment, nonetheless normal tooth length did not occur. Relatively few researchers investigated the association between the use of extra oral forces and the EARR. Alwali *et al.,*[1] found that extra-oral forces caused minimal resorption of maxillary molar roots. On the other hand Langford *et al.,*[10] demonstrated in their case report significant distobuccal root resorption during distalization movement.

Hickham [11] showed that high pull headgear does not contribute to EARR and resorption is related to force quality and not the quantity. He also believed that the iatrogenic portion of root resorption is caused by the jiggling effect of teeth resulting from long time use of light wires, indecisive treatment that causes teeth to change direction frequently and also the proximity of the cortical plate. Siqueira *et al.,*[12] evaluated the effect of occipital headgear upon the intensity of EARR of maxillary first permanent molars using pre- and post treatment periapical radiographs of 19 young female patients, age ranging from 8 to 10 years, and having dental Class II division 1 malocclusion. They found that the headgear use did not negatively influence root formation and did not provoke EARR of the molars subjected to extraoral traction. Alwali *et al.,*[1] found that the use of cervical traction headgear as a mean for anchorage augmentation has no difference as regards EARR

when compared to Goshgarian bar or Class II elastics. In a meta analysis, Segal *et al.,*[13] found that there was a strong correlation between apical root resorption and total apical displacement as well as treatment duration in the anterior teeth. However, little attention has been paid to the possibility of apical root resorption EARR of posterior teeth.

Therefore, due to the shortage of studies on maxillary molar apical root resorption in general and the conflicting reports in the literature, this study was aimed to evaluate external apical root resorption of the maxillary first permanent molars following cervical traction headgear during orthodontic treatment of Class II division 1 patients.

2. Materials and Methods

Sample:

Records were obtained from patients treated at the Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia. Selection criteria were: patients with no known medical condition; complete orthodontic records of the malocclusion, treatment plan, and treatment history; good quality pre- progress and post-treatment orthopantomogram (OPG) using the same machine (Kodak 8000C, France); full cusp Angle's Class II Division 1 malocclusion bilaterally; cervical traction headgear use for a minimum of 12 months and minimal daily use of 12 hours supported by a daily note; and full complement of permanent teeth, except for the maxillary wisdom teeth. Patients with dental anomalies and/or agenesis and who had a history of previous orthodontic treatment were excluded. Cases who established class I molar relation before 12 months were omitted from this study. The study was reviewed and approved by the Research Ethics Committee at the Faculty of Dentistry, King Abdulaziz University.

Two hundred and forty-five patient files were examined. Eighteen patients satisfied the selection criteria. The mean age of the patients at the start of treatment was 13.7 (±2.2) years.

All subjects used the headgear with the inner bow placed in the headgear tube that was attached to the maxillary first molar bands and the outer bow was maintained parallel to the inner bow and to the occlusal plane and force magnitude used was 350-500gm per side. The headgear use was checked every 6 weeks and the force was adjusted until Class I molars was achieved.

A total of 20 age and gender matched controls were also selected based on the above selection criteria except that their treatment did not involve the use of headgear. All were treated using fixed orthodontic appliance therapy (Roth 0.018" slot system).

Root resorption:

Pre and post headgear treatment OPG radiographs were used and measurements were taken directly on the OPG radiograph for the overall tooth and root lengths for both the right and left first permanent molars to assess the amounts of EARR. The measurements were taken to the nearest 0.01mm from the mesiobuccal cusp tip to the mesiobuccal root apex and from the distobuccal cusp tip to the distobuccal root apex. The amount of root resorption was then calculated by subtracting the post-treatment tooth length from the pre-treatment tooth length. One trained investigator performed all measurements on the OPG and was blinded to the treatment. Investigator reliability assessment was confirmed by performing the measurements on 10 OPG at two weeks interval. Student's t-test showed that there was no statistical significant different between the two readings, $p = 0.57$.

In this study, the following method was used to access the actual first molar length and consequently the actual magnification error. The length of extracted upper first premolars from 5 patients, not related to this study, who required extraction for orthodontic reasons was calculated and compared to their lengths on the OPG. The mean magnification error was taken and applied for all the radiographic measurements done. The following formula was used:

$$\frac{\textit{Actual molar length (unknown)}}{\textit{Length of molar in radiograph (known)}} = \frac{\textit{Actual premolar length (known)}}{\textit{Length of premolar in radiograph (known)}}$$

Hence, the actual molar length after adjusting for magnification will be:

$$\textit{Actual molar length} = \frac{\textit{Actual premolar length X Length of molar in radiograph}}{\textit{Length of premolar in radiograph}}$$

Statistical Analysis:

Descriptive statistics including mean, standard deviation and minimum and maximum amount of root resorption were calculated. Student's t-tests were used to identify significant differences. Statistical significance was considered when $p < 0.05$.

3.Results

There was no significant difference in the age between the headgear group and controls at the start of the treatment, 13.7 (±1.3) and 13.1 (±1.7) years, respectively, p = 0.086. There was a significant difference in the duration of treatment between both groups, 14 (±1.8) months for the headgear group and 22 (±4.7) months for the controls, $p < 0.001$.

Paired sample t-tests showed that there were significant changes in the means of the mesiobuccal tooth lengths for both the Headgear group and the controls between pre and post treatment, p <0.001. These changes were also significant in the means of the distobuccal tooth lengths in the headgear group and controls, p <0.001 (Table 1).

The mean changes in the mesiobuccal tooth lengths in the headgear group was significantly more than the controls, mean = 1.43 and 1.04, respectively, p <0.001. The mean changes in the distobuccal tooth lengths was not statistically different between the headgear group and the controls, mean = 1.03 and 0.88, p =0.14 (Table 2).

Table 1: Summary and analyses of the lengths of the upper right and left first permanent molars in the two studied groups.

Group	**Mesiobuccal Tooth Length**		**Distobuccal Tooth Length**	
Headgear (n=36)	**Initial**	**Post Headgear**	**Initial**	**Post Headgear**
Minimum	22.50	22.30	22.20	20.80
Maximum	27.00	25.80	25.90	24.60
Mean	25.14	23.71	23.90	22.87
±S.D.	01.21	01.10	01.10	01.07
p-value	**<0.0001**		**<0.001**	
Non- Headgear (n=40)	**Initial**	**Post-treatment**	**Initial**	**Post-treatment**
Minimum	23.30	22.00	22.90	21.80
Maximum	27.30	26.10	26.90	26.10
Mean	24.78	23.74	24.49	23.61
±S.D.	00.92	01.07	00.97	01.06
p-value	**<0.001**		**<0.001**	

Table 2: Summary and analyses of pre- and post treatment changes of mesial and distal molar lengths of the upper right and left first permanent molars.

	Mesiobuccal Tooth Length Change		**Distobuccal Tooth Length Change**	
Group	**Headgear (n=36)**	**Non- Headgear (n=40)**	**Headgear (n=36)**	**Non- Headgear (n=40)**
Minimum	0.30	0.10	0.40	0.00
Maximum	2.10	1.90	2.20	2.00
Mean	1.43	1.04	1.03	0.88
±S.D.	0.50	0.41	0.42	0.46
p-value	**<0.001**		**0.142**	

4.Discussion

External apical root resorption is a complex biological process that is still not fully understood.[14] It is a relatively common problem as a sequence of orthodontic treatment. Not only it varies between persons but also within the same person. This phenomenon is not a physiologic one. Bishara *et al.,*[15] studied the normal changes in root length from early to mid adulthood. They found no significant changes in root length for all tooth types evaluated between 25 to 45 years of age, in both genders. In this study, statistically significant differences were found in the amount of EARR in the upper first permanent molars roots with and without the use of the extra oral cervical traction headgear. The findings obtained in this study are in agreement with the conclusion of Hixon *et al.,*[16] who reported minor molar root resorption with the use of extra oral cervical traction forces. However, the findings are not in concert with Siqueira *et al.,*[12] who concluded that the headgear use did not negatively affect root development and did not provoke EARR of molars and also with and Alwali *et al.,*[1] who demonstrated that the use of cervical traction headgear has no difference as regards EARR when compared to Goshgarian bar.

Several researchers tried to shed light upon the factors contributing to the initiation and progression of EARR during orthodontic treatment. These factors could be categorized into biological, mechanical, and a combination of both and other factors.[14, 17-19]

Various controversial views have been reported about the relation between the force magnitude and duration of orthodontic force and EARR. Heavy force is found to cause more EARR,[20-22] although other studies showed that the mean amount of EARR is the same even when the stress is doubled.[23, 24] A matter of controversy also exists regarding the use of continuous versus intermittent forces.[25] Jiang *et al.,*[26] found that the treatment duration and patient age positively correlates with the amount of EARR. Brezniak and Wasserstein,[14, 17, 18] in their analytical reviews, argued that EARR is a multifactorial problem associated with patient characteristics such as gender, age, systemic conditions, type of malocclusion, and tooth structure, as well as with treatment factor such as type of appliance, duration of treatment, orthodontic force magnitude and type of tooth movement.

Gender and its linkage to EARR is also a matter of dispute. Some investigators [27, 28] reported higher prevalence of root resorption in females; while others reported higher prevalence in males. [29, 30] However, several other investigators concluded that males and females are equally subjected to EARR without any gender difference.[9, 19, 26, 28, 31-34] Genetic background was proposed by some authors to be of great importance in initiating EARR during orthodontic treatment.[19, 35, 36] Cortical bone proximity to the root is another factor. Horuichi *et al.,*[37] tried to find a correlation between cortical plate proximity and EARR. They found that EARR of maxillary central incisors was induced by approximation of the roots to the palatal cortical plate during orthodontic treatment.

The root length is usually measured from the root apex to the midpoint of cementoenamel junction. This method could cause some variations and inaccuracy during measurements. For this reason, the pre- and post-treatment total tooth length was taken for detecting the amount of root resorption. A limitation to the current study is that the sample size is relatively small. However, this was due to the strict inclusion criteria in patient selection and also the quality of the initial, progress and final records including the OPG's.

Conclusion:

The use of cervical traction headgear resulted in EARR particularly in the mesiobuccal root of maxillary first molars and careful radiographic monitoring is encouraged.

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