Comparing Root Resorption in Modified Corticotomy And Peridontally Accelerate Osteogenic Orthodontics

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**ABSTRACT**

Objective:eam of this study was to compare the susceptibility of external apical root resorption (EARR) between two different methods for accelerated orthodontic tooth movement (Modified Corticotomy and Peridontally Accelerate Osteogenic Orthodontics PAOO) Material: the sample included thirty-six Egyptian male and female subjects ages between 20 to 25 years (22.5 years average), which were equally and randomly divided into three groups (twelve each). In-group A (Control) no periodontal surgery's just orthodontic treatment. In-group B (Corticotomy) involved interradicular vertical corticotomies and orthodontics. In-group C (PAOO) involved interradicular vertical corticotomies, bone grafting material and orthodontics. CBCT where taken before and six months after alignment. Paired t-test and ANOVA were used to compare the incidence of EARR. Results: EARR incidence in the lower anteriors was highest in the corticotomy group (1.9), followed by the control group (1.09), and the lowest value was in the PAOO group (0.73). Occurrence of EARR in PAOO group was statistically nonsignificant P-value >0.05 whereas in the corticotomy group it was statistically highly significant P-value < 0.001. Conclusion: PAOO is an effective treatment approach in adults to decrease treatment time and reduce the risk of root resorption.

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**INTRODUCTION**

Presently, many adult patients are pursuing orthodontic treatment. Vig et al. (1990) and Wilcko et al. (2001) stated that the average orthodontic treatment duration for adults is noticeably lengthier than for adolescent patients, ranging from 18.7 to 31 months. Therefore the need to accelerate the rate of tooth movement in adults to decrease treatment duration became an imperative goal for orthodontists. Among the various attempts to accelerate tooth movements are; surgical assistance, chemical mediators, electromagnetic pulses, and laser.

Köle (1959) published the surgically assisted decorticatio-facilitated orthodontics. Köle believed that the resistance to tooth movement was via the continuity and thickness of the dense cortical bone. Therefore disrupting the continuity of this cortical layer of bone byfacial and lingual vertical interradicular corticotomy cuts in addition to ahorizontal supra-apical osteotomy would generate independent bony blocks that would move more rapidly. From Köle’s work arose the term “bony block” to describe the accelerated tooth movement following corticotomy surgery. Subsequent publications by Genersonet al. (1978), Anholmlet al. (1986), Gantes et al. (1990), and Suya (1991) replaced Köle’s horizontal supra-apical osteotomy with a horizontal corticotomy.

However, Köle’s theory of the accelerated tooth movement by “bony block” prevailed until Wilcko et al’s (2001) publication that attributed accelerated tooth movement not to bony block but rather a transient localized demineralization/remineralization process and the regional acceleratory phenomenon (RAP) described by Frost (1983). RAP comprises a state of transient osteopenia, in which there is acceleration in bone turnover coupled by a decrease in the regional bone density, which assists rapid tooth movement. Wilcko et al. (2001) additionally modified the corticotomy-assisted orthodontic procedure by addition of alveolar augmentation and patented the technique as periodontal accelerated osteogenic orthodontics (PAOO). Hajji (2000) stated that PAOO resulted in an increase in alveolar bone width, post-treatment stability, decrease in treatment duration, and decrease in apical root resorption. Nonetheless, successful orthodontic treatment in adults could be
difficult since dentoalveolar development ceases after adolescence.

At present, it is unknown how orthodontic treatment stimulates root resorption (RR). The etiologic factors are multifactorial and complex; Killiany (1999) presented an evidence-based review of literature indicating that patients undergoing orthodontic treatment are more liable to apical root resorption. Orthodontic treatment-related risk factors include treatment duration, force magnitude, tooth movement direction, extent of apical displacement, and technique of force application as described by Owman et al. (1995) Parker and Harris (1998), Acare et al. (1999), Janson et al. (1999), Sameshima and Sinclair (2001), and Brezniak and Wasserstein (2002). Reitan (1960) stated that adults are more prone to RR due to the aplastic, narrow, and less vascular periodontal membrane, in addition to denser, avascular, and aplastic bone.

Sameshima and Asgarifar (2001) avowed that periapical radiographs, via the paralleling technique, arreregaderes the clinical gold standard for determining tooth lengths and estimating root resorption. Nonetheless, periapical radiographs are liable to procedural, orientation, and projection errors conveyed by Brezniak et al. (2004). The orientation errors and overlapping problems inherent with periapical radiographs could be overcome with cone-beam computed tomography (CBCT). Hatcher and Aboudara (2004) stated that CBCT produces more accurate diagnostic information.

Thus the purpose of this study was to use the accuracy of CBCT to compare apical root resorption between two different accelerated orthodontic tooth movements (Modified Corticotomy and PAOO).

MATERIALS AND METHODS

The sample in this study included thirty-six Egyptian male and female subjects. Their ages ranged from 20 to 25 years with an average age of 22.5 years. The subjects were selected from the outpatient orthodontic clinic of Faculty of Dentistry, Ain Shams University. Prior to the conduction of the study all the subjects gave their informed consent after receiving a full explanation of the aim and design of this study. The local ethical committee approved the study protocol.

The inclusion criteria included: all subjects were; in the permanent dentition stage with fully developed roots (except the third molars), had mild to moderate crowding in lower anterior teeth region with bilateral molar class I relationship. The exclusion criteria included; systemic condition that can affect craniofacial growth or bone turnover, periodontal disease, previous orthodontic treatment, exposure to radiation or drugs for the past 6 months, smokers, and pregnant females.

The subjects were equally and randomly divided into three groups (twelve each). In-group A (Control-group) subjects were not subjected to any periodontal surgery’s just orthodontic treatment. In-group B (Corticotomy-group) subjects were subjected to a full thickness mucoperiosteal labial flap reflection followed by interradicular vertical corticotomies via piezosurgery. In-group C (PAOO-group) subjects were subjected to a full thickness mucoperiosteal labial flap reflection followed by interradicular vertical corticotomies via piezosurgery, and addition of bone grafting material (Synthetic bone graft) on the labial plate of bone.

Orthodontic procedures involved; acquisition of a full set of orthodontic records (diagnostic sheet, casts, extraoral and intraoral photos, and CBCT). Prior to periodontal surgery bondable tubes were bonded on the first molars followed by bonding of preadjusted stainless steel brackets on the six anterior teeth and premolars (3M Unitek (TM) Gemini Roth Metal brackets slot 0.022).

All periodontal surgical procedures involved; full-thickness flaps were raised with sulcular incisions while preserving interdental papilla on the mandibular labial and buccal sides. The flap extended from the distal surface of the mandibular second premolar on one side to the other side. No flap elevation or corticotomy was performed on the lingual side.

Vertical corticotomy cuts were performed with piezosurgery interradicularly midway between the root prominences in the region of the mandibular anterior teeth. The vertical corticotomy cuts started 2 mm apical to the alveolar crests, extended approximately 2 mm past the apices, and had a depth of 3mm (figure-1). Flap closure and suturing was performed with nonresorbable interrupted sutures, which were left from 1 to 2 weeks.

In-group C the same protocol was utilized in addition to insertion of synthetic bone graft (easy graft classic, pure phase B tricalcium phosphate, Switzerland) forming a uniform layer of bone graft 1 mm thick (figure-2).

The initial archwire placed in all three groups was (0.014 copper nitinol, reactivation was performed every 2 weeks. After 6 months of treatment CBCT were taken to evaluate external apical root resorption (EARR). CBCT scans were acquired via the Scanora® 3D CBCT scanner (Soredex, Tuusula, Finland). The machine specifications were 85 KV, 15 mA, scanning time of 2.6 sec, voxel size of 0.35 mm amorphous silicon flat panel, and 13cm x 15cm FOV. The CBCT scans were saved as Dicom 3D multiformats and imported into a computer software program (Ondemand 3D version 1.0.9 Cybermed, Korea).

The coronal, sagittal, and axial planes were adjusted to intersect in the pulp chamber of the tooth in question. The root length was measured from the most apical point of the root to the mid of the incisal edges for the incisors and the cusp tip for the canines, along the long axis in the sagittal view (figure-3).
**Statistical Analysis:**

All the measurements were introduced into an excel spreadsheet and analyzed using a standard statistical software package (SPSS version 15.0, Chicago, Ill) for Windows. Paired t-test was used to compare the incidence of EARR within each group pretreatment and post-alignment. Analysis of variance (ANOVA) was used to compare EARR incidence between all three groups pretreatment and post-alignment. Bonferroni test was used to compare the incidence of EARR amid each pair of groups pretreatment and post-alignment. P value of ≤0.01 was used to assign statistical significance. To determine the reliability of the methods, two independent sets of measurements were made by the same operator separated by 3 or 4 days to calibrate for intraexaminer error by calculating the Intraclass correlation coefficient (ICC) between the collected measurements.

**Fig. 1:** Mucoperiosteal flap reflection and vertical corticotomy cuts.

**Fig. 2:** PAOO technique with bone grafting material.

**Fig. 3:** Measurement of root length on the sagittal view along the long axis from the incisal edge to the root apex.

**Results:**

Figure 4 rivals the difference in the amount of EARR between the three groups in the lower anteriors. The graph displays that the EARR for the lower anteriors was highest in the corticotomy group (-1.9), followed by the control group (-1.09), and the lowest value was in the PAOO group (-0.73).

Table 1(a) shows the results of the paired t-test for comparison of the incidence of EARR pretreatment and post-alignment within the control
Incidence of EARR in the lower canines, central and lateral incisors is statistically highly significant with a P-value <0.001. Table 1(b) shows the results of the paired t-test for comparison of the incidence of EARR pretreatment and post-alignment within the corticotomy group. Incidence of EARR in the lower canines, central and lateral incisors is statistically highly significant with a P-value <0.001. Table 1(c) shows the results of the paired t-test for comparison of the incidence of EARR pretreatment and post-alignment within the PAOO group. Incidence of EARR in the lower canines is statistically highly significant with a P-value <0.001, whereas the incidence of EARR in the lower central and lateral incisors is statistically nonsignificant with a P-value >0.05.

Table 2. Displays ANOVA analysis of variance for comparison of incidence of EARR within lower anteriors pretreatment & post-alignment between the three groups (A control, B corticotomy, &C PAOO). The results show that the incidence of EARR between the three groups is statistically highly significant for lower canines, lateral incisors, and central incisors with a P-value < 0.001.

Table 3. Shows Bonferroni Method for multiple comparison of the incidence of EARR within lower anteriors pretreatment &post-alignment among each pair of groups. The results display that the comparison of the incidence for EARR between the control group and the PAOO group for the canines, lateral incisors, and central incisors was statistically nonsignificant with a P-value >0.05. Whereas, the comparison of the incidence of EARR between the corticotomy group and the PAOO group and between the control group and the corticotomy group for the canines, lateral incisors, and central incisors was statistically highly significant with a P-value<0.001.

Fig. 4: Mean difference for EARR pretreatment and post-alignment between all three groups

<table>
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<tr>
<th>Table 1(a): shows Paired t-test for comparison of EARR incidence within control group pretreatment &amp; post-alignment.</th>
<th>Mean</th>
<th>SD</th>
<th>Mean Difference</th>
<th>SD Diff</th>
<th>t</th>
<th>P-value</th>
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<th>SD</th>
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Orthodontic tooth movement is initiated by application of a mechanical force that leads to tissue remodeling within the periodontium. Previous studies related accelerated orthodontic tooth movement to a variety of stimuli such as electromagnetic pulse (Stark and Sinclair, 1987), pharmaceuticals (Igarashi et al., 1994) and laser therapy (Leiker, 1995), and more recently Laser (Kawasaki and Shimizu, 2000) in addition to mechanical force. A study by Krishnan and Davidovitch (2006) on cellular, molecular, and tissue-level reactions to orthodontic force concluded that the stimulus for inducing tooth movement is not just the application of a mechanical force.

One of the iatrogenic outcomes of orthodontic tooth movement is orthodontically induced inflammatory root resorption (OIIRR). Orthodontic tooth movement is displayed on a time-displacement curve which divides orthodontic tooth movement into 4 phases: initial, lag, acceleration, and constant linear phases. Proffit (2000) proposed that the lag phase is associated with hyalinization in the PDL, and preventing hyalinization would improve the efficiency of tooth movement. Kurol and Owman (1998) stated that hyalinization in the PDL precedes and is adjacent to root resorption during orthodontic tooth movement.

Frost (1983) recognized that surgical wounding of osseous hard tissue leads to reorganization activity neighboring to the site of injury. He termed this cascade of physiologic healing incidents the regional acceleratory phenomenon (RAP), which involved accelerated bone turnover and decreases in regional bone densities, thuspotentiating tissue reorganization and healing via transient localized hard and soft tissue remodeling. Corticotomy is defined as a surgical procedure where just the cortical bone is cut, perforated, or mechanically altered therefore leading to rapid tooth movement. Wilcko et
al.(2001)suggested a demineralization-remineralization phenomenon and modified the corticotome-assisted orthodontic technique with the addition of alveolar augmentation and termed it periodontally accelerated osteogenic orthodontics (PAOO), which increased post-treatment alveolar bone width and orthodontic stability. Therefore the aim of this study was to compare the incidence of EARR between modified corticotomy and PAOO via CBCT.

The selected age group in this study ranged between 20 and 25 years, for two reasons; first to ensure that all permanent teeth had fully developed roots and periodontal tissues, and second due to the increased demand for adult orthodontics. All subjects included in the study were non-extraction cases in order to avoid any variables in bone structure that might arises due to bone fill-in at the extraction site. All subjects were free from any systemic condition that might affect bone metabolism and periodontal status. Full-thickness flap surgery allowed good visualization when performing the selective partial decorticating of the alveolar bone as well as uniform establishment of bone augmentation during the surgery. The utilization of piezoelectric surgery systemin this study to create micrometric bone cuts resulted in precise and easy control corticotomies, in contrast to rotary burs or reciprocation saws.

However, unlike the procedures described by Köle(1959) and Wilcko et al.(2003) corticotomy was performed only at the labial aspects of the mandible in this study. This was in agreement with Germec et al.(2006) that reported rapid tooth movement when corticotomy was performed at the buccal aspects of alveolar bone. The elimination of lingual corticotomy decreased the duration and the extent of the surgery plus avoiding the risk of disrupting vital lingual anatomy.

The choice of easy graft as the bone grafting material in Group C was due to the fact that it is an alloplastic bone graft substitute manufactured from mineral raw materials. Therefore, its composition is precisely defined with unlimited availability and no possibility of disease transmission or rejection reactions.

CBCT was taken after 6 months of treatment to evaluate for root resorption since it's cited in the literature that any evidence of EARR starts at this time. Levander et al. (1998) and Artun et al. (2005) reported that, after 3 months of treatment, apical root resorption was detected in only a few teeth, but the number of affected teeth increased significantly after 6 months of treatment. They also stated that patients with detectable root resorption during the first 6 months of active treatment are more likely to experience resorption during the following 6-month period.

CBCT where taken as the most reliable method to assess and measure EARR than periapical radiographs, because of magnification and difficulties with landmark identification (eg, identifying a 3D point on a 2D picture with overlapping structures) as conveyed by John et al.(2010).

The lower anteriors were selected to represent EARR because they are considered to be the most prone to this condition during treatmentas specified by Parker and Harris in 1998.

The results in this study suggested that tooth movement after modified corticotomy showed a statistically significant increase in EARR, which is in agreement with Kurol and Owman (1998) and Wilcko et al. (2003). Whereas, in the PAOO technique the results of this study suggested that there was a statistically nonsignificant EARR, which is in concordance with Wilcko et al. (2003) and Germec et al. (2006). This might be attributed to the presence of the combination of bone grafting material and the transient osteopenia resulting from the selected corticotomy. Osteopenia led to increase in bone turnover, rapid removal of the hyalinated areas, and decrease of bone density in the region of tooth movement. This is condition favors tooth movement with reduced root resorption.

The canines displayed the highest incidence of EARR for all three groups this might be accredited to the increase in bone density around the canines. Whereas the lower lateral showed a higher occurrence for EARR than the central incisors this might be attributed to the amount of tooth movement and the force magnitude upon the lateral incisors to be greater than that upon the central incisors this is in concurrence with Krishnan and Davidovitch(2006).

The PAOO technique entails the utilization of various modified diagnostic and treatment parameters, but once mastered the orthodontist has aninfluentialinnovative treatment option to propose for his patients. With the cumulative number of adults cogitating orthodontic treatment and their propensity for periodontal problems, the PAOO technique could be an attractive treatment option and a “win-win” situation for both the orthodontist and the patient.

Conclusion:

- PAOO is an effective treatment approach in adults to decrease treatment duration and reduce the risk of root resorption.
- Modified corticotomy has the highest incidence of EARR.
- Using a modified surgical approach and limiting the corticotomy to the buccal and labial aspects produced the RAP needed to significantly reduce treatment duration.
- The reduction of surgery time and patient discomfort are advantages to modified corticotomy.
- Lower canines are more prone to EARR than lower incisors.
REFERENCES


