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Quantitative assessment of root resorption in TAD-aided anchorage with and without RAP: A CBCT study on en masse retraction cases

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Abstract

INTRODUCTION: The purpose of this study was to evaluate the amount of root resorption with mini implant-aided anchorage, with and without inducing the regional acceleratory phenomenon (RAP) in en masse retraction cases using cone-beam computed tomography (CBCT).

METHODS: Thirty patients requiring therapeutic extraction of all first premolars were included in the study and randomly divided into two groups of fifteen patients each (groups I and II). Patients of both groups underwent retraction using mini implants. In patients of group II, the RAP was initiated before starting retraction. For each patient, CBCT of the maxillary and mandibular anterior region was taken before treatment and after retraction to evaluate root length changes.

RESULTS: The amount of root resorption post-retraction was lesser in group II as compared to group I for the maxillary canine, mandibular canines, and mandibular lateral incisors. When the amount of root resorption was scored according to the Malmgren index, a greater percentage of teeth in group I (17.8%) showed root resorption of score of 3 as compared to group II (6.1%).

CONCLUSION: The results of the study show that the RAP caused reduced root resorption, but its effect was localized to the area where it was induced. When mini implants are used for absolute anchorage during en masse retraction, the RAP can be induced to reduce the root resorption that results from increased treatment time associated with implant-aided retraction.

Keywords:
Mini implants, regional acceleratory phenomenon, root resorption

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Introduction

Anchorage control assumes a central role in the selection of a biomechanical approach when extractions are planned to relieve crowding or reduce incisor protrusion. Several treatment techniques have been used over the past decades such as headgears, transpalatal arches, and Nance buttons to minimize anchorage loss during en masse retraction of anterior teeth. However, these appliances require several laboratory steps and significant patient compliance.[1]

More recently, implants or temporary anchorage devices (TADs) have been suggested as an alternative method for anchorage control. However, the time needed for the greater amount of en masse anterior retraction with miniscrew anchorage is longer than conventional approaches as the roots of maxillary and mandibular anteriors would have to travel farther through the dentoalveolus.[2]

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Longer treatment duration has been related to an increased risk of decalcification, dental caries, gingival inflammation, and, especially, root resorption.[3] Thus, accelerating the rate of tooth movement is desirable to orthodontists and can be achieved by conservative and surgical methods. Conservative methods include pharmacological agents and device-assisted therapy.[4] All surgical approaches exploit the biological mechanism, namely the "regional acceleratory phenomenon" or RAP explained by Frost in 1983.[5] This phenomenon affects the bone healing pattern and turnover, which leads to a temporary phase of accelerated tooth movement.

In 2007, Ren *et al*. conducted a study on beagles evaluating the effects of alveolar surgery undermining the interseptal bone in orthodontic tooth movement. The results of the study showed that the movement speed nearly doubled on the experimental side compared with the control side.[6] A split-mouth design study was conducted by Leethanakul in 2014. He concluded that interseptal bone reduction can enhance the rate of canine movement.[7]

Surgically facilitated orthodontic treatment by means of selective alveolar decortication leads to transient osteopenia and increased tissue turnover,[8] which permits the orthodontist to move teeth in the desired direction and to achieve the treatment objectives with less risk of shortening the length of the dental roots.[9]

The purpose of the study was to evaluate the amount of root resorption with mini implant-aided anchorage with and without RAP in en masse retraction cases using cone-beam computed tomography (CBCT).

Materials and Methods

The study was conducted at the Department of Orthodontics and Dentofacial Orthopaedics, A.J. Institute of Dental Sciences, Mangalore, Karnataka after attaining Ethical clearance was obtained from Institutional ethical committee of A.J. Institute of medical sciences and research centre on 08/11/2016. It included 30 patients (class I malocclusion) requiring treatment with extraction of all four first premolars and en masse retraction of upper and lower anterior teeth between the age groups of 16 to 30 years in the permanent dentition. The sample was randomly divided into two groups of 15 patients each. Group I included patients who underwent en masse retraction using TAD. Patients of group II underwent the same procedure but RAP was induced simultaneously.

Medically fit patients with no systemic diseases, having a full complement of teeth present till the second molars with healthy periodontium, and not under any medication were included in the study. Patients with angle's class III malocclusion, skeletal class III base, prosthesis such as fixed partial denture (FPD), impacted teeth other than third molars, gross facial asymmetry, congenitally missing teeth except for third molars, history of orthodontic treatment, and orthognathic surgery were excluded from the study.

CBCT scans of the anterior maxillary and mandibular region of all subjects were taken before the start of the treatment and at the end of the retraction phase.

All patients of study groups I and II were treated with the pre-adjusted edgewise appliance system (MBT- McLaughlin Bennett Trevisi prescription, slot size 0.022 × 0.028 in).

In group I, after initial leveling and aligning, the retraction was commenced on 0.019 × 0.025 stainless steel wires using TADs within 48 hours of extraction of all first four premolars.

In group II after initial leveling and aligning, extraction of all first four premolars and initiation of RAP were carried out under Local Anaesthesia simultaneously. RAP was induced by placing grooves 0.5–1 mm in depth vertically inside the extraction socket using a round carbide bur, extending toward the base of the interdental bone distal to the canine [Figure 1a, 1b]. TADs were placed, and the retraction was commenced on 0.019 × 0.025 stainless steel wires within 48 hours of this procedure.

In both groups, the implants were immediately loaded with pre-calibrated nickel–titanium closed-coil springs exerting 150 grams of force extending from the implant head to the crimpable hooks for en masse retraction [Figure 1c]. Routine analgesic was prescribed to all the patients after the procedure in both groups.

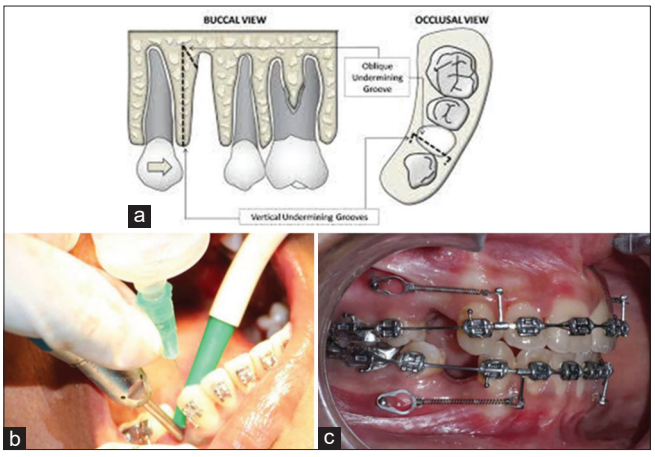

Figure 1: Undermining of interdental bone and retraction: (a) position of grooves, (b) placement of grooves to initiate RAP, and (c) the placement of crimpable hooks and retraction using TADs

Nickel–titanium closed-coil springs were changed every 6 weeks in both groups.

CBCT scans taken before the start of treatment and after completion of the retraction phase in groups I and II were assessed, and changes in root length of maxillary and mandibular anterior teeth were evaluated.

Image analysis and measurement

The Digital Imaging and Communications in Medicine (DICOM) files were transferred to the RadiAnt software for root length estimation. Reconstructions were made such that the axial slices became perpendicular to the long axis of the root [Figure 2a], providing optimal visualization of the root in axial, coronal [Figure 2b], and sagittal planes [Figure 2c]. A reference line was placed connecting the cementoenamel junctions [Figure 2d]. A second reference line was placed at the root apex parallel to the first [Figure 2e]. A corresponding sagittal view was used to ensure the proper positioning of reference lines [Figure 2f]. The perpendicular distance between these reference lines measures the root length [Figure 2g].

Changes in root length from the start of the treatment to the end of retraction, that is, the amount of root resorption, were estimated for the maxillary and mandibular anterior teeth.

Grading scale by Malmgren *et al*.[10] was used to evaluate the degree of root resorption.

- Score 0: Same length as pretreatment with normal apical contour.
- Score 1: Same length as pretreatment with apical irregularity.
- Score 2: Less than 2 mm of apical root resorption.
- Score 3: More than 2 mm of apical root resorption and less than one-third original root length.
- Score 4: Apical root resorption of greater than one-third original root length.

Statistical analysis

All statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS) software package (version 17). The mean and standard deviation for the root length measured at the start of the treatment and post-retraction were calculated for the maxillary and mandibular anteriors using Student's unpaired t-test. The mean difference in root length between pretreatment and post-retraction was assessed for the maxillary and mandibular anteriors using Student's paired t-test.

Results

The mean and standard deviation for the difference in root length between the start of the treatment and post-retraction, that is, the amount of root resorption, were calculated for the maxillary and mandibular anteriors [Tables 1 and 2].

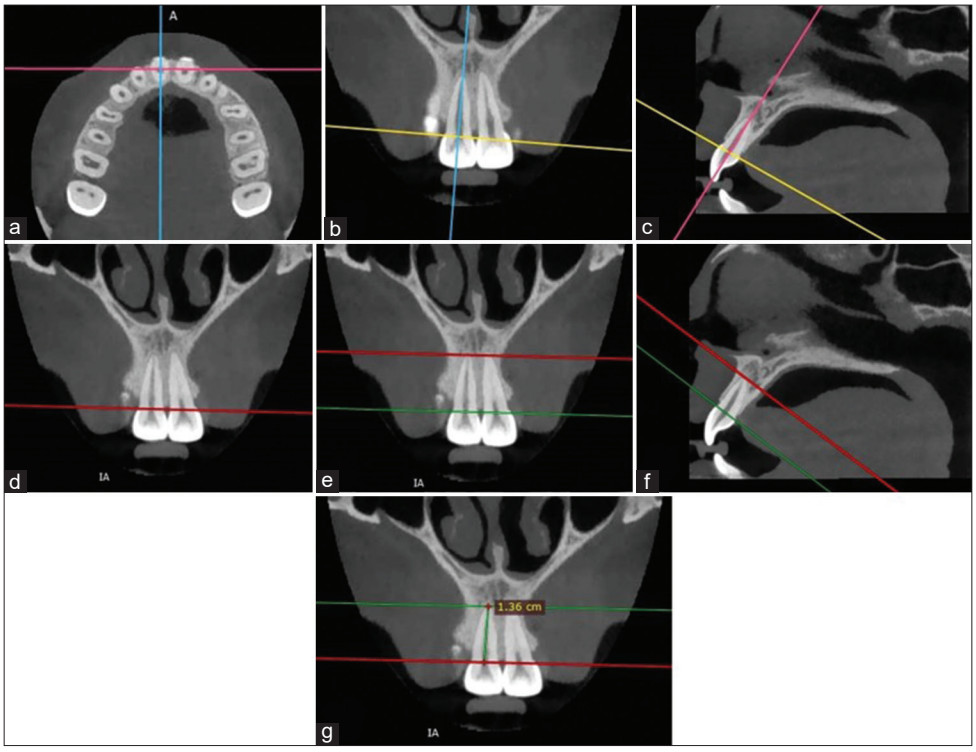

Figure 2: Image analysis for root length measurement: (a) axial view, perpendicular to the long axis of maxillary right central incisor; (b) coronal view; (c) sagittal view; (d) reference line 1; (e) reference line 2; (f) corresponding sagittal view; and (g) perpendicular distance

Table 1: Comparison of the difference in root length from pretreatment to post-retraction of maxillary anteriors

Group	*n*	Mean	Std. deviation	*P*
Maxillary canine				
Group I	30	1.620	0.499	0.001*
Group II	30	0.677	0.287	
Maxillary lateral incisor				
Group I	30	1.330	0.578	0.17
Group II	30	1.523	0.497	
Maxillary central incisor				
Group I	30	1.397	0.512	0.278
Group II	30	1.240	0.595	

*Significant. *P* value <0.001 is significan

Table 2: Comparison of the difference in root length from pretreatment to post-retraction of mandibular anteriors

Group	*n*	Mean	Std. deviation	*P*
Mandibular canine				
Group I	30	1.807	0.483	0.001*
Group II	30	0.507	0.210	
Mandibular lateral incisor				
Group I	30	1.447	0.520	0.001*
Group II	30	0.973	0.256	
Mandibular central incisor				
Group I	30	1.140	0.491	0.444
Group II	30	1.233	0.447	

*Significant. *P* value <0.001 is significant

The difference in root resorption between groups I and II was statistically significant for the maxillary canine, mandibular canine, and mandibular lateral incisor, which showed decreased root resorption in group II as compared to group I.

Although the maxillary central incisor showed decreased root resorption in group II as compared to group I, the difference was not statistically significant.

The maxillary lateral incisor and mandibular central incisor showed greater root resorption in group II as compared to group I, but the difference was not statistically significant.

The Malmgren index was used to describe the degree of root resorption [Figure 3]. A greater percentage of teeth in group I (17.8%) showed severe root resorption with a Malmgren index score of 3 as compared to group II (6.1%). In group II, there was a greater percentage of teeth (92.7%) that showed minor root resorption with a score of 2 as compared to group I (82.2%).

Discussion

Skeletal anchorage utilizes some form of bony anchor in an attempt to provide absolute anchorage. When the anchorage unit in the force system is situated directly within the bone, then theoretically there will be no unwanted tooth movement by reactionary forces.[11]

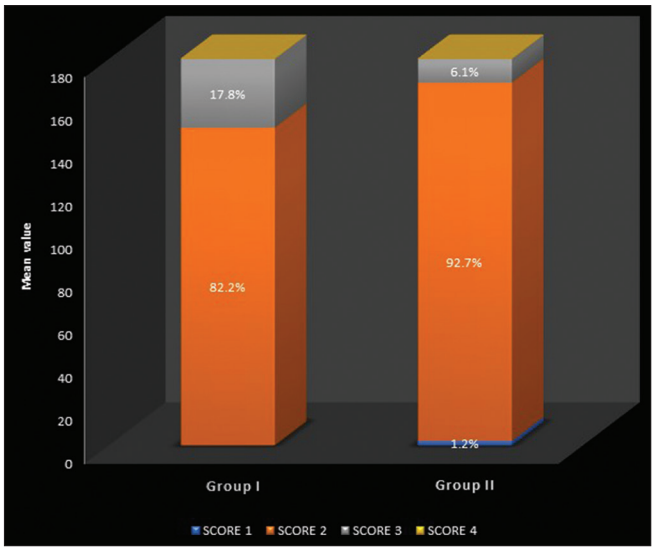

Figure 3: Malmgren index score

As there is no anchorage loss with miniscrew anchorage, more extraction space is available and allows for greater orthodontic tooth movement. The treatment duration needed for the greater amount of en masse anterior retraction is also significantly longer.[2]

Accelerating orthodontic tooth movement has several potential benefits, including shorter treatment duration, reduced side effects (such as oral hygiene-related problems, root resorption, and open gingival embrasure spaces), differential tooth movement, enhanced envelope of tooth movement, and improved posttreatment stability.[12]

Numerous approaches to accelerate tooth movement both surgical and nonsurgical have been studied with the goal of reducing treatment time while also minimizing damage to the dentition and periodontium.

Bone remodeling can be increased to accelerate the repair and achieve functional recovery by surgical procedures that intentionally inflict mechanical damage on the cortical bone. The process takes place by recruiting osteoblasts and osteoclasts activated by the local intercellular mediators. This creates a transitory state of osteoporosis, characterized by a reduction in bone density, which results in less resistance to tooth movement. This phenomenon was described by Harold Frost, and it was named the regional acceleratory phenomenon (RAP).[13]

Alveolar corticotomies have been commonly used in conjunction with orthodontics to initiate RAP.

Corticotomy-assisted orthodontic treatment is an established and efficient orthodontic technique that involves selective alveolar decortication in the form of decortication lines and dots performed around the teeth that are to be moved.[14]

The interseptal bone reduction was combined with the use of a conventional orthodontic appliance with optimum force by Leethanakul *et al*. to effectively accelerate maxillary canine retraction when the bone is sufficiently reduced in both thickness and depth. Vertical grooving and oblique grooving were performed inside the extraction socket at the time of tooth extraction. It reduced the interseptal bone by 1 to 1.5 mm. This method was chosen over other methods to initiate RAP as it shortens the treatment time in extraction case without flap reflection, no separate surgical procedure, or additional armamentarium required.[7]

In this study, both groups I and II underwent retraction with mini implants. In group II immediately following extraction of the premolars, the interseptal bone reduction was carried out to initiate the RAP. The study aimed to assess and compare the quantum of root resorption in TAD-aided anchorage cases with and without RAP.

As root resorption is a three-dimensional (3D) phenomenon, its extent must be quantified with precision. Most studies of orthodontically induced inflammatory root resorption (OIIRR) have used intraoral radiography to assess the extent of root resorption. To become visualized on intraoral radiographs, root shortening had to result from buccal or palatal surface resorption. Root apices, especially of the anterior regions, may become placed outside the narrow focal trough on panoramic radiographs. Super-impositioning of teeth is the major limitation of lateral cephalometric radiography in detecting root resorption.[15]

Computed tomography (CT) as an imaging modality was rarely used in dentistry because of disadvantages such as cost, amount of radiation, and scanner size.[16] CBCT provides highly detailed 3D imaging at any angle, thus offering optimum viewing and eliminating superimpositions Dudic *et al*. found that, compared with CBCT, panoramic radiographs underestimate apical root resorption as a result of orthodontic tooth movement. The ability of CBCT to obtain distortion-free and reproducible images of single roots provides excellent possibilities to study root resorption.[17]

Thus, in this study CBCTs taken before treatment and post-retraction were used to assess the quantum of root resorption.

The difference in root resorption between groups I and II was statistically significant for the maxillary canine, mandibular canine, and mandibular lateral incisor, which showed decreased root resorption in group II as compared to group I indicating that RAP caused reduced root resorption, but its effect was localized to the area where the RAP was induced. The results of the study are in accordance with the findings of Sebaoun and coworkers. Alveolar and periodontal response to selective alveolar decortication was analyzed as a function of time and proximity to the injury, and their study concluded that there was a dramatic increase in the tissue turnover by the third week after decortication surgery, which dissipated to the normal steady state by 11 weeks after surgery. The increased bone turnover was localized to the area immediately adjacent to the injury.[18]

Conclusion

The RAP caused reduced root resorption in group II, but its effects were localized to the area where the RAP was induced. When mini implants are used for absolute anchorage during en masse retraction, RAP can be induced to reduce the root resorption that results from the increased treatment time associated with implant-aided retraction.

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Nil.

Conflicts of interest
There are no conflicts of interest.

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