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Review Article

An Evidence Based Review of Literature-Effect of Orthodontic Treatment on Endodontically Treated Teeth

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***ABSTRACT*:**
There is need of moving teeth for individuals for various reasons, which were endodontically treated or undergoing endodontic treatment procedures. Orthodontic movement of endodontically treated teeth was dealt with confusions for decades by the clinicians. This type of tooth movement over an endodontically treated teeth cause inexorable biological reactions in the periodontal ligament and pulp tissue. On applying a severe orthodontic force for a long period of time can cause necrosis of pulp and irreversible pulpitis by increasing pulp inflammation reactions. Use of moderate and intermittent forces enables sufficient tooth movement, limits the damage in the pulp and allows the healing of damaged pulp. The aim of this review is to ascertain the issues to be considered for orthodontic treatment and its effect on endodontically treated tooth with alterations which may occur in the pulp, hard tissues and periapical region of the teeth before, during and after orthodontic treatment and how these changes affect the treatment outcome.
Keywords: Orthodontic tooth movement, Endodontic treatment, apical root resorption.

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INTRODUCTION:
There is need of moving teeth for individuals for various reasons, which were endodontically treated or undergoing endodontic treatment procedures. The goal of orthodontic treatment is minimizing the biological damage and pain besides enabling an adequate tooth movement[1]. Orthodontic movement of endodontically treated teeth was dealt with confusions for decades by the clinicians. This type of tooth movement over an endodontically treated teeth cause inexorable biological reactions in the periodontal ligament and pulp tissue. However, there are close relations among all the fields of dentistry, the relation between Endodontics-Orthodontics has attracted the attention of researchers less frequently, and there have not been any definitive conclusions on the subject and research studies were very scarce on this topic. This makes planning and follow-up of the treatment difficult for clinicians and causes problems in terms of complications that may occur during the treatment and approaches to the complications.
The aim of this review is to ascertain the issues to be considered for orthodontic treatment effect on endodontically treated teeth with alterations which may be occurred in the pulp, hard tissues, and periapical region of the teeth before, during and after the orthodontic treatment and how these changes affect the treatment outcome in an individual.

THE EFFECT OF ORTHODONTIC FORCE APPLICATION TO PULP:
Orthodontic teeth movement depends on application force to the teeth in a specific timeframe which may vary between months and years. This movement unavoidably causes organic responses in periodontal ligament and pulp tissues. The clinical significance of

pulpal alterations after orthodontic force relies upon whether or not it will imperil the long-term vitality of the teeth.

Orthodontic force, which is called as controlled trauma,[2] can damage the pulp because the lack of collateral circulation in the pulp and makes the pulp one of the most sensitive tissues in the body. The symptoms, which can be diagnosed earlier in the pulp tissues, after orthodontic force is applied are hemodynamic changes with the raise in the volume of blood [3] and circulatory disorders within the 1st hour.[4] When an orthodontic force is applied, pulp tissue reacts with pulp hyperemia at first, and degranulation of mast cells is characterized with cell damage and biochemical reactions. These are the features of classical acute inflammation in which acute inflammatory mediators such as vasodilatation, bradykinin, neuropeptides, prostaglandins and growth factors, vascular permeability, and histamine which causes a rise in blood flow with edema, are released. An increasing neural activity and an increasing response threshold to electrical stimulation of pulp develop after a few days.[5] Then, because of the alteration in the metabolism of pulp, which is stated with increased enzymatic activity, apoptosis, and necrosis of pulp cells increase.[6] The changes in the tissue respiration and possible hypoxia, which develop during orthodontic treatment, results in increase of aspartate aminotransferase (AST) activity levels and affect dental pulp tissue by changing pulpal neural response.[6] The presence of macrophages, the change of odontoblast layer, edema of connective tissue, and increase of progenitor cells and fibroblasts are the reports, which represent an adaptive process and inflammation of pulp tissue to the mechanic aggression caused by orthodontic force.[7] Long-term studies show the decrease of some protein expressions which blockthe regeneration and restoration of pulp structure.[8]Hamersky*et al*.[10] observed a significant correlation between the amount of decrease in pulp tissue respiration rate and the age of the patients. They represented that age is more relative to pulp tissue respiration than orthodontic force. While there is a negative relation between age and respiration rate, a positive correlation between apical opening amount and respiration rate was stated [11] Neural responses and release of specific neural transmitters during orthodontic tooth movement were also examined. Pulpal axon response to orthodontic movement was evaluated by Bunner and Hohnson.[12]However, the number of myelinated axons is more than unmyelinated axons, no significant differences were observed between myelinated axons and unmyelinated between experimental (orthodontic movement) and control (without orthodontic treatment) teeth. The authors concluded that there was not any irreversible problem in the healthy teeth treated conservative orthodontic treatment. According to Grünheid*et al*[13] some pathological symptoms in rats' pulp tissue increase to maximum within 24hrs and 72 hrs and they turn back to initial values after 168 h after force was applied. Researchers draw the conclusion that controlled mechanic forces during orthodontic treatment can cause temporary changes in the pulp unless they are not excessive. Laser Doppler flowmetry was the device of choice in common for human studies[3,14-16] which were carried out to evaluate pulpal blood flow changes associated with orthodontic treatment. There was a decrease in basal blood flow regardless of type of the moved teeth and teeth movement in the most of the studies.[3,14,15] In the other study,[16] no change was stated in the pulpal blood flow in the first 4 minutes after intrusive force was applied. There were conflicting results on the magnitude of the applied force for increase related [3] and not related [15,16] to force. Javed*et al*.[17] stated that applying severe force to the teeth for a long time may affect pulpal blood flow than short-term application of the same forces. They concluded that incidence and severity of these changes can be affected by previous or continuous problems to dental pulp such as trauma or decays while pulps in teeth without complete apical foramen include lower risks for these responses.

RELATIONSHIP BETWEEN ORTHODONTIC TOOTH MOVEMENT AND TRAUMATIZED TEETH:

There are few studies in the literature relating to possible adverse sequelae of traumatized teeth undergoing orthodontic tooth movement. In those that do exist patient numbers are small and involve a heterogeneous collection of traumatic injuries from which definitive conclusions are hard to draw.

Pulp vitality:

A retrospective study[18] has been formulated to examine the influence of orthodontic movement intrinsically, on previously traumatized teeth with respect to risk of loss of pulp vitality and replacement resorption. Although the authors found a higher prevalence of non-responsiveness to sensibility testing in previously traumatized teeth undergoing orthodontic treatment, since the study numbers were too small to be conclusive. In summary, with the evidence currently available it is not possible to say whether orthodontic tooth movement of traumatized teeth increases the risk of pulp necrosis above that of uninjured teeth undergoing tooth movement.

Root resorption:

There are three main types of **root resorption**: 1) Surface resorption, 2) Inflammatory resorption and 3) Replacement resorption.[19]For any type of resorption to occur there must first be damage to the protective cemental layer surrounding the root. Essentially, a race between cementoblasts adjacent to the area of damage and osteoblasts in the surrounding bone, ensues [19]. A critical size defect of 4 mm^2 has been reported above which osteoblastic healing will preferentially occur.[20] A high metallic percussion note is detectable once 20% of the root surface is affected by replacement resorption[21,22] and is usually the earliest clinical

indication of replacement resorption. Ankylosis usually occurs initially on the buccal and palatal surfaces of the root surface and therefore, the process is present at a cellular level and hence it is not visible on conventional radiographs. [23,24]

In traumatized teeth with limited damage to the cementum, adjacent cementoblasts will repopulate the damaged area and surface or cementum healing occurs. This is the same type of healing as seen following resorption secondary to orthodontic tooth movement. Where there is extensive damage to cemental layer, osteoblast sinfiltrate the area and osseous healing or replacement resorption occurs. This results in ankylosis and although it has been reported as transitory in a few cases, [22,24] but it is permanent in vast majority and the tooth is slowly replaced by bone. The speed of replacement resorption is related to the speed of bone turnover and this is slow in an adult wherein young children bone remodelling is rapid. When replacement resorption (ankylosis) occurs in a young child the ensuing lack of vertical growth in the anterior maxilla results in progressive infraocclusion.[25]

If a traumatic injury results in pulpal necrosis and subsequent bacterial infection, toxins within the pulp canal space pass through the dentinal tubules directly to the area of root surface damage and result in external inflammatory resorption of the root surface which will continue until the inflammatory stimulus has been removed. During the post-traumatic healing phase further damage to the protective cemental layer is not advised as this will only increase the inflammatory stimulus and prolong the destructive phase, increasing the risk of osseous healing. A period of observation to allow for periodontal ligament healing, is therefore required prior to orthodontic tooth movement.

Periodontal injuries can be ordered in severity from those producing minor cemental damage to those inflicting more severe trauma: concussion, subluxation, extrusion, lateral luxation, avulsion and finally intrusion.[19]Root resorption receives great attention in the orthodontic literature as there is appreciable evidence that orthodontic treatment results in surface (cemental) root resorption. The length of orthodontic treatment time, root morphology, force applied and previous dental trauma may all have an effect on the prevalence and severity of root resorption seen. It has been shown for teeth which exhibit minor resorption after six to nine months of orthodontic movement, the risk of severe root resorption after further orthodontic tooth movement is significantly increased. When the effect of tooth anatomy is taken into account the degree of root resorption in teeth with bluntor pipette shaped roots is significantly greater than in teeth with a normal root form.[26] It has been recommended that radiographs are taken three months after the commencement of orthodontic treatment in teeth with blunt or pipette shaped apices.[27]Studies investigating the influence of previous dental trauma on root resorption during orthodontic treatment are few in number and results have been conflicting. Malmgren et al [28] found that traumatized teeth did not have a greater tendency to root resorption than uninjured teeth however they suggested previously traumatized teeth which show signs of root resorption prior to orthodontic treatment may be more prone to root resorption during treatment. They suggested an initial observation period of four to five months be allowed prior to the institution of orthodontic forces for any injured teeth.[28]One study has shown the average change in root length for traumatized teeth undergoing orthodontic tooth movement was 1.07 mm compared to 0.64 mm for uninjured teeth.[29]Brin et al.[18] looked carefully at the reaction of previously traumatized teeth to the application of orthodontic forces. Moderate root resorption was noted in 27.8% of previously injured teeth receiving orthodontic treatment compared to 7.8% in the orthodontic treatment only group and 6.7% in the trauma only group. An increased frequency of root resorption was noted in teeth that had experienced multiple episodes of trauma. The authors suggested previous trauma may be predictive of an increased risk of root resorption during orthodontic treatment, although they concede a small sample size and a heterogeneous collection of injuries may render findings inconclusive.

Radiographic monitoring of traumatized teeth:

Current recommendations for radiographic assessment of traumatized teeth or teeth showing signs of pretreatment root resorption, during orthodontic treatment are baseline periapical radiographs or an upper standard occlusal radiograph with repeated views six to nine

months into treatment. If minor root resorption is noted and a decision made to continue with orthodontic treatment, further radiographs should be taken after three months.[30] In the case of severe root resorption arest period of three months is recommended prior to recommencing orthodontic treatment.[31]In a long term follow-up of maxillary incisors with severe apical root resorption a risk of permanent tooth mobility has been shown to occur if the total root length is less than or equal to 9 mm.[32] This risk is reduced if more than 9 mm of tooth root remains in the presence of a healthy periodontium.

RELATIONSHIP BETWEEN ORTHODONTIC TOOTH MOVEMENT AND EXTERAL APICAL ROOT RESORPTION:

Movement of endodontically treated teeth was approached with doubt in practice since 1990s. However, it was not methodologically based; there was almost a consensus that these teeth had more root resorption risk during the orthodontic movement.[33] It is highlighted that root resorption risk did not increase nor decrease in successful endodontic treatments after Spurrier *et al*.study was published in 1990.[34]Several general and specialist dentists believe that external apical root resorption (EARR) is an inescapable result of orthodontics and orthodontist is responsible forit when it develops during orthodontic treatment. The concerns

about EARR as a result of orthodontic treatment are confirmed by high incidence levels.[35]EARR is an irreversible undesirable side effect of orthodontics[36] and can begin at early levelling period of orthodontic treatment.[37] Orthodontic EARR is considered to be a type of surface resorption which is caused by mechanical dental traumas, surgical operations, and orthodontic forces or over pressure of
teeth or tumors.[38] It is characterized by apical rounding morphologically or radiographically but it can present different degrees from slight blunted to round apex to over resorbed apex.[11] Apex or lateral surfaces of roots can be resorbed but only apical root resorption can be observed by radiographic analysis. More than one-third of original root length is lost in severe EARR. [26]
However, EARR is multifactorial, and its reason is not totally understood, several studies sought to identify risk factors including EARR during orthodontic treatment. Certain factors can generally be classified as mechanical or biological. Mechanic factors include the magnitude, direction, and duration of the orthodontic forces.[39]Biological factors include traumatic injury history,[28]
follicle with ectopic tooth eruption,[40] and presence of periapical lesion,[41] root morphology, previous root resorption,[42] individual susceptibility,[43] and genetic predisposition.[44] Adult patients are more prone to resorption because periodontal membrane becomes less vascularized, inflexible, and narrower, and cement becomes thinner and teeth movement becomes more difficult with aging.[42]Animal studies presented contradictory results on teeth with root-filled and vital teeth with similar[45,46] or less[47] EARR levels. In addition, previous clinical studies which compared EARR extents in humans in teeth withroot- filled or vital teeth after orthodontic treatment did not lead to a final decision. **Spurrier *et al***.[34] and Mirabella and Artun[48] found a protective effect to resorption in endodontically treated teeth when compared to vital teeth, Esteves *et al*.,[49] Llamas-Carreras *et al*.,[50,51]and Castro *et al*.[53] could not find significant statistical differences. The latest systematic reviews[53, 54] on the subject stated that there are a small number of studies on the subject in the literature and concluded that EARR risk did not increase in teeth with root-filled. On the other hand, there was not a complete result for proof for less resorption in teeth that are treated endodontically after orthodontic treatment.[55]

RELATIONSHIP BETWEEN ORTHODONTIC TOOTH MOVEMENT AND PERI-APICAL LESION:

When there is a need for orthodontic treatment inpatients having teeth with apical periodontitis, clinicians who have doubt about this topic, experience problems about the treatment plan. The periapical environment of teeth with apical periodontitis can be changed with higher bacterial endotoxic concentration, presence of inflammatory reaction, and bone and root resorption.[56] The existence of these factors can complicate the healing process by increasing inflammatory reaction and root resorption so it can be a concern for orthodontic movement.[57] There are limited histomorphological data in the literature on the orthodontic movement after root canal treatment of teeth with apical periodontitis. De Souza *et al*.[57] concluded that healing process of chronic periapical lesions was faster in the experimental group which does not include orthodontic movement in their study in which they defined dogs' teeth with apical periodontitis submitted or not to orthodontic movement after root canal treatment. After root canal treatment which was received CH dressing, orthodontic movement of teeth with chronic periapical lesion delayed the healing process, but it did not prevent the healing. Paduano*et al*.[58] reported a successful treatment with endodontic and orthodontic combined treatment in a case presentation of a patient who had cyst-like lesion signs radiographically with a severe deep bite and upper central incisors are necrosed by the trauma. After nonsurgical endodontic treatment of an 18-year-old patient, orthodontic treatment was carried out, and it was observed that large periapical lesion was totally healed after 2 years. The authors stated that orthodontic tooth movement can be applied without a need to wait for completely healing after root treatment of periapical cyst-like lesions was completed. In another case report,[59] the treatment of a large periapical lesion, which developed in relation to a previous trauma in the maxillary anterior region of a patient whose orthodontic treatment began 2 months ago was stated. In the treatment, apical openness was obturated by calcium-enriched mixture and the treatment was completed in the first session. Lesion completely healed after 2 years follow-up. Other results such as persistence, partial regression, or increase of the previous lesion as a result of endodontic treatment are independent from orthodontic movement. Endodontic treatment and complete elimination capacity of microbiota must be evaluated in these cases. Another different morphology such as apical deltas, dilacerations, and developmental grooves can complicate elimination of microbiota by endodontic treatment. The reason of failure in teeth which are orthodontically treated is not an orthodontic movement.[33]

RELATIONSHIP BETWEEN ORTHODONTIC TOOTH MOVEMENT IN TEETH WITH APICAL SURGERY:

It was discovered in the literature that there is a limited number of information on the effect of teeth with apical surgery to orthodontic movement. Long-term prognosis of these teeth is a subject which is still unclear in the literature. In Baranowskyj's study,[60] the health rate of hard and soft alveolar tissues was evaluated in dogs' teeth in the early intrusive orthodontic forces to root-filled and previously managed with surgical endodontic procedures teeth. Histological evaluation of examples from 6 weeks showed that healing was late in

the teeth with root-filled and root-end resection. There is a small number of data about the problems which can be caused by movement of teeth which were subject to endodontic surgery. There are evaluations stating that more apical resorption will develop as dentin becomes clear in the root surface which was applied resection, irritation of root-end filling material, permanent inflammation, or insufficient obturation by root end filling material.

RELATIONSHIP BETWEEN ORTHODONTIC TOOTH MOVEMENT WITH ROOT TREATED TEETH:

The results of research involving orthodontic movement of endodontically treated teeth are conflicting. Some authors have reported an increased risk of root resorption [61] whilst others have reported equal[62] or reduced risk.[63,34] More recently a retrospective study has been carried out evaluating the radiographic findings in patients who concurrently had one endodontically treated maxillary incisor, with the adjacent incisor tooth available as a control. No statistically significant difference in the apical root resorption was seen in the root treated teeth compared to vital control teeth.[49] In an animal model it has been shown that vital and non-vital teeth moved similar distances when subjected to the same forces.[48] Histologically, root-filled teeth showed greater loss of cementum after orthodontic tooth movement than vital teeth, but there was no significant difference in radiographic root length.

PROBLEMS CAUSED BY ORTHODONTIC PROCEDURES DURING ENDODONTIC TREATMENT:

Endodontic applications in orthodontic patients can be difficult because of teeth isolation, dental bands, and braces so root canal treatment must be performed in coordination with orthodontist and dentist or endodontist and/or pedodontist. Individual adaption of clamps and other retentive devices must be carried out [64]. Lingual orthodontic braces can cause problems when access cavity is being opened. Removing the braces from the teeth and having them braced again after endodontic treatment can be easier and faster. The applied orthodontic attachments decrease the accuracy of evaluation of radiographic view and pulp vitality tests. Endodontic or periodontal symptoms can be interfered with orthodontic pains. Apical resorption generally breaks natural construction of dentinocemental junction, creating an extremely irregular, rough, notched, and gapped root end three dimensionally [11]

DO THE TEETH WHICH HAD UNDERGONE ENDODONTIC TREATMENT AFFECT ORTHODONTIC MOVEMENT?

It was stated that teeth which had endodontic treatment can be moved as easy as teeth with vital pulp.[45,61] It does not affect orthodontic movement unless ankylosis develops. There are publications which state that root canal must be cleaned, shaped and filled with CH, restored occlusally in order to prevent bacterial leakage, and canal must be filled after orthodontic tooth movement is completed if there is a need for endodontic treatment during orthodontic movement.[11] One of the most important factors affecting success when teeth, which were endodontically treated, are orthodontically treated is the magnitude and duration of the force. Orthodontic forces also cause dental traumas in the teeth in different degrees.

CONCLUSION:

Application of a severe orthodontic force for a long time can cause irreversible pulpitis and necrosis in pulp by increasing pulp inflammation process. Use of moderate and intermittent forces enables sufficient tooth movement, limits the damage in the pulp, and allows the damaged pulp healing. Controlled mechanic forces during orthodontic treatment can cause temporary alterations in the pulp unless they are not severe. Pulp sensitivity test must be interpreted carefully in orthodontically treated patients, and thermal tests are more reliable than Electric pulp test(EPT). The risk of necrosis in pulp increases as a result of orthodontic forces to teeth having a trauma history. It is important to complete the treatment of teeth, which need endodontic treatment with a careful clinical and radiographical evaluation before orthodontic treatment. A successful endodontic treatment is a must for a successful orthodontic tooth movement. The quality of previous root canal treatment, the health of periodontal membrane and careful application of orthodontic forces are the factors that need more attention during the treatment. Microscopic root resorption occurs in all teeth during orthodontic treatment, which is clinically insignificant and cannot be determined radiographically. If the quality of endodontic treatment is good in root-filled teeth, orthodontic forces applied to teeth do not increase external apical root resorption. Teeth which were subjected to trauma are more sensitive to orthodontic movement so clinical and radiographic evaluations must be carried out carefully before force is applied to the particular teeth. The patient must notified about the possible complications and the probability of prolongation of treatment period.

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