

ENDO-ORTHODONTICS- INSIDE AND OUTSIDE THE ROOT - INTERACTIONS: TASKS TO BE TACKLED

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ABSTRACT

Endodontic treatment of teeth is now a common procedure across all age groups, either as a result of caries or trauma. Furthermore, as the number of adults undergoing orthodontic treatment increases, the number of orthodontic patients presenting with restored teeth or having endodontic treatment is on the rise. Diagnosis and treatment planning for these patients require an evidence based approach to achieve a good functional and esthetic results. Orthodontic treatments have profound effect on pulp and periodontal ligament which can lead to root resorption or loss of vitality which remain as orthodontic scars. Literature regarding occurrence of root resorption in vital teeth and teeth having endodontic treatment, the influence of trauma, the provision and outcome of

INTRODUCTION

Interdisciplinary treatments in patients having endodontic and orthodontic problems are of two way approach requiring involvement of both the specialties from diagnosis to the completion of treatment. The roles of endodontist during orthodontic treatment have expanded because of increased awareness. There are two major areas where endodontic and orthodontic interventions share a common ground – One is orthodontic treatment affecting the tooth being moved and some response may be noted in the pulp tissue; and the second is adult and mutilated cases where orthodontic treatment is necessary to gain a desirable result when endodontically involved.

Detailed information of endodontic and orthodontic interaction and their possible remedies are enlightened in this script by answering the following various questions:

1. What is the influence of orthodontic tooth movement on pulpal vitality?
2. Are endodontically treated teeth at greater risk of root resorption?

endodontic treatment when attempted during the course of orthodontic therapy and the adjunctive role of orthodontics in facilitating good endodontic output are inconclusive till now. The integrated endodontic and orthodontic treatment in such situations will give optimum results. This article mainly focuses on orthodontic-endodontic interactive tasks to be tackled that are often encountered in clinical practice which play an important role in treatment planning and its outcome.

KEYWORDS: Endodontic, Orthodontic, Pulp vitality, Resorption, Trauma, Extrusion

3. Will resorption of the apex in RC treated tooth leads to failure of endodontics?
4. Is there any difference between the orthodontical movement of endodontically treated and non-endodontically treated teeth?
5. What is the effect of orthodontic tooth movement on traumatized teeth with vital pulp or endodontically treated?
6. Are there any modifications in routine endodontic procedures during the course of orthodontic therapy?
7. How orthodontic procedures facilitate to optimize final endodontic output?
8. Orthodontic intervention of apicocetomized tooth..... *When?*

The purpose of this review of literature is to provide a meaningful assessment to these questions and to determine how this information can be used in the challenges that are often encountered during the treatment planning of cases in which the integration of endodontic and

orthodontic principles play an important role in treatment outcomes.

1. What is the influence of orthodontic tooth movement on pulp vitality?

Orthodontic tooth movement will usually induce some degree of reversible or transient pulpal inflammation. As early as 1936, Oppenheim demonstrated signs of pulpal degeneration in human teeth undergoing movement with fixed orthodontic appliances. He determined that the lack of a collateral blood supply for the pulp was the main etiologic factor behind this occurrence. Application of light intermittent forces and allow time for repair were advocated to minimize the damage to the pulp¹.

Taintor and Shalla found that under normal conditions the respiratory rate of the pulp cells corresponds to the degree of dentinogenic activity. Hence the authors opined that the greater the activity, the greater the rate of tissue respiration². Hamersky et al using radio respirometric method demonstrated the relationship between the biologic effect of an orthodontic force and the maturity of the tooth, particularly the dentinogenic activity of the pulp. There is significant depression in the pulpal respiratory rate when the tooth is undergoing orthodontic movement. Additionally, as the age of the subject increased, the relative amount of depression in the pulpal respiratory rate also increased³.

Seltzer and Bender stated that the increased risk of pulpal injuries is due to rapid orthodontic tooth movement. This occurs because of alterations in the blood vessels entering the pulp and in the apical periodontium⁴.

McDonald and PittFord using Laser Doppler flowmetry, assessed pulpal blood flow in permanent maxillary canines and found that changes in blood flow were dynamic in response to potentially poor perfusion of the tissues. During the period of tooth movement there was a period of pulpal hyperemia where tissue perfusion improved. The normal activity achieved within 72 hours. This time frame was considered insignificant with regard to long term pulpal damage⁵.

Derringer et al harvested the pulps of orthodontically moved extracted teeth and found that there was significant angiogenesis in the pulp and the presence of the necessary angiogenic growth factors. The factors that have been

implicated and described in this process consist of PDGF (platelet-derived growth factor), EGF (epidermal growth factor) and TGF- β (transforming growth factor beta⁶). These growth factors also present in wound healing of periodontal ligament during orthodontic tooth movement in experimental cats⁷.

According to Seltzer and Bender, orthodontic forces that are beyond the optimum physiological level may result in pulpal necrosis and may not be detected until clinically there is darkening of the tooth crown⁴. Nevertheless, it appear logical that teeth with complete apical formation and teeth with pulps that had previous compromises such as trauma, caries, and restorations or periodontal disease may be more susceptible to irreversible pulpal changes or necrosis⁸. Bunner and Johnson explained the intra pulpal axon response to the orthodontic movement. Neural responses and evidence for the release of specific neural transmitters has also been assessed during orthodontic tooth movement⁹. Bender et al, Neuropeptides (Substance P, calcitonin gene-related peptide (CGRP), neurokinin A, vasoactive intestinal polypeptide, and neuropeptide Y) play an important role in the regulation of pulpal blood flow and influence the resorptive process¹⁰.

During orthodontic tooth movement, the degenerative and/or inflammatory changes in the pulp is induced by specific neurotransmitters (neuro peptides) which influence both blood flow and cellular metabolism, consequently initiation and progression of apical root remodeling/resorption occurs. Poorly controlled forces on teeth with completely formed apical foramen or previous trauma or ongoing insults due to deep caries may result in irreversible changes. On the other view pulps in younger patients with incomplete apices exhibits a reduced risk¹¹.

Rita Veberiene et al explained the pulpal vitality in orthodontic intrusion cases. The intrusive force is applied on one side of premolars and the contra lateral premolars used as control. After 7days EPT (electric pulp test) was done and all premolars were extracted under local anesthesia, later the samples were removed from the pulp and sent for spectrophotometric analysis for evaluation of AST (Aspartate Amino Transferase). Increased neural response and AST activity was observed, these changes may be due to hypoxia of the pulp during orthodontic tooth movement¹².

2. Are endodontically treated teeth at greater risk of root resorption?

Resorption is defined as 'a condition associated with either a physiologic or a pathologic process resulting in a loss of dentine, cementum, and/or bone.' Andreasen and Andreasen defined the process further as being of three types; *surface resorption*, that is a self-limiting process, usually involving small areas followed by spontaneous repair from adjacent parts of the periodontal ligament in the form of new cementum; *inflammatory resorption*, where the initial root resorption has reached the dentinal tubules of an infected necrotic pulp or an infected leukocytic zone; and *replacement resorption*, where bone replaces the resorbed tooth material that leads to ankylosis. Root resorption subsequent to orthodontic treatment is considered as surface resorption or transient inflammatory resorption, because replacement resorption is rarely seen following tooth movement. Morphologically and radiographically it may present as a slightly blunted or round apex to a grossly resorbed apex¹³.

Regarding root resorption in this context various authors came out with dissimilar views based on their studies as follows-

- i. Endodontically treated teeth undergoes more resorption than vital teeth
 - ii. Endodontically treated teeth undergoes less resorption than vital teeth
 - iii. Endodontically treated teeth and vital teeth undergoes similar resorption
- i. *Endodontically treated teeth undergoes more resorption than vital teeth*

Based on histological studies Steadman was criticized the root resorption process stated that roots of the root canal treated teeth acts as a foreign body causing chronic irritation and root resorption subsequently undergoes ankylosis which may impede orthodontic tooth movement¹⁴

Wickwire et al have done radiographical investigation on 45 orthodontic cases contained 53 endodontically treated teeth and concluded that those teeth with root canal treatment moved as readily as teeth with vital pulps, but there appeared to be greater radiographic evidence of root resorption in the endodontically treated teeth when compared to the controls¹⁵.

- ii. *Endodontically treated undergoes lesser resorption than vital teeth*

Huettner and Young challenged Steadman's theory and evaluated the root structure of monkey teeth with both vital and non-vital pulps (root canal treatment) following orthodontic movement and that root resorption was similar in both the vital and devitalized teeth. The authors felt that careful monitoring of the orthodontic forces, endodontic aseptic treatment, and an intact periodontal membrane all contributed significantly to their findings¹⁶.

Bender et al suggested that the loss of the release of neuropeptides from a pulp that has been removed would result in a decrease of the CGRP-IR (calcitonin gene related peptide immune reactive) fibers and a reduction in the amount of resorption seen in endodontically treated teeth^{17,18,19}.

C. *Endodontically treated teeth and vital teeth undergoes similar resorption*

Esteves et al inspected 2,500 treatment records, 16 patients were selected who had a maxillary central incisor treated endodontically prior to orthodontic intervention. The pre and post treatment periapical radiographs shown that there is no significant difference in apical root resorption of endodontically treated teeth and vital teeth^[20].

Tarraf et al investigated the resorptive activity of endodontically treated teeth v/s vital teeth through SEM (scanning electronic microscopic) study and reported that there no difference in resorptive activity in either groups²¹.

3. Will resorption of the apex in RC treated tooth leads to failure of endodontics?

If a root filled tooth has been well cleaned, shaped and three dimensionally obturated the apical seal would be maintained irrespective of the amount of resorption¹¹. However resorption may lead to exposure of dentinal tubules that may harbor bacterial toxins and necrotic material that may provide sufficient irritation to induce an inflammatory response or increased inflammatory root resorption^{22,23}.

Desauza et al evaluated the periapical tissue healing of endodontically treated teeth in dogs. The root canals were prepared biomechanically and given Ca(OH)₂ dressing, then obturated with seal apex [Ca(OH)₂ based sealer] and gutta-percha points. Later all these teeth were subjected to

orthodontic forces. Finally, after sacrificing all animals the histological analysis showed a favorable action on periapical tissue healing and high rate of biological closure of main and accessory canals by newly formed cementum with better organization of periodontal ligament²⁴.

4. Is there any difference between the orthodontical movement of endodontically treated and non-endodontically treated teeth?

Endodontically treated teeth can be moved as readily and for the same distances as teeth with vital pulps^{25,26,27}. Both animal and human studies showed that endodontically treated teeth can be moved orthodontically as readily as vital teeth.^{15, 27} But in case of replacement resorption (ankylosis) or injury to apical periodontium, tooth movement may be prevented¹³

Desouza et al accomplished a study on dog's incisors following pulpectomy, induction of periapical infection, obturation of root canals with gutta-percha and sealapex sealer [Ca(OH)₂], was subjected to orthodontic tooth movement and finally sacrificed for histological study. These results showed that the orthodontic movement is delayed in endodontically treated teeth, but did not hinder the apical healing process²⁸.

There has always been a concern with regard to orthodontic movement of endodontically treated teeth and assumption that these teeth might not respond as readily to orthodontic force or that they might be more susceptible to root resorption. However, since it is the response of the periodontal ligament, not the pulp, that is fundamental to orthodontic tooth movement, moving endodontically treated teeth should be perfectly feasible²¹.

5. What is the effect of orthodontic tooth movement on traumatized teeth with vital pulp or endodontically treated?

The effect of traumatized teeth with vital pulp or teeth with RCT mainly depends upon the type of injuries whether hard tissue injury / periodontal injury [*hard tissue injuries* - fracture of enamel and enamel chipping, fracture of enamel-dentin without pulpal involvement, fracture of enamel-dentin with pulpal involvement, root fracture, crown-root fracture ; *periodontal injuries* - concussion, subluxation , lateral luxation, and avulsion] ,severity/extent of injuries and also type of

orthodontic force application [intrusion, extrusion etc..]

Wickwire et al evaluated endodontically treated teeth, which had received traumatic injuries (crown fractures, intrusions, luxations, and avulsions) prior to orthodontic treatment. Orthodontic treatment times ranged from one to 36 months. Responses to movement of the traumatized teeth were considered equivalent to the teeth with vital pulps but radiographic findings indicated that the incidence of root resorption was greater in the endodontically treated teeth when compared with an adjacent non-traumatized tooth with a vital pulp¹⁵.

One of the most damaging injuries to a mature tooth and its supporting structures is an intrusive luxation. These injuries are often accompanied by fracture of the alveolar socket.^{13,29} A pulpal death usually occurs and the possibility of replacement resorption (ankylosis) and loss of marginal bone support is quite high. These types of cases are suggested for orthodontic extrusion to avoid ankylosis¹³.

A traumatized tooth can be moved orthodontically with minimal risk of resorption, provided the pulp has not been severely compromised (infected or necrotic). If a previously traumatized tooth exhibits resorption, there is a greater chance that orthodontic tooth movement will enhance the resorptive process. If a tooth has been severely traumatized (intrusive luxation/avulsion) there may be a greater incidence of resorption, with or without root canal treatment¹¹.

Bauss O et al explained the effect of orthodontic extrusion on the pulp vitality of orthodontically involved maxillary incisors with history of trauma were compared to non-traumatized teeth of orthodontically involved and traumatized teeth not involved orthodontically. The pulp tests and radiographical parameters revealed that orthodontically involved traumatized teeth especially those periodontally involved have higher susceptibility to pulp necrosis³⁰.

6. Are there any modifications in routine endodontic procedures during the course of orthodontic therapy?

The potential modifications to be accomplished in routine endodontic procedures if at all attempted during the progression of orthodontic therapy. These may be influenced by a number of diagnostic and clinical factors.

Diagnostic factors

Full metallic bands may prevent an accurate response to electrical or thermal pulp testing, in addition to shrouding decay both radiographically and clinically. Patient symptoms may be due to the tooth movement or to an inflamed or degenerating pulp, thus making a differential diagnosis very difficult, especially if there has been a history of trauma. The presence of pulpal calcifications may be due to both an inflamed degenerating pulp following trauma or due to orthodontic tooth movement^{31,32,33}.

Clinical factors

Tooth isolation is compromised by the presence of orthodontic bands and wires. The placement of a rubber dam in these cases needs additional measures to block potential avenues of leakage. Often rubber dam clamps may also be modified by grinding or bending to meet each anatomical challenge.

Endodontic coronal access opening is not a problem in posterior teeth because the approach is from occlusal direction. Lingually or palatally placed brackets require creation of openings down the long axis of the tooth through the incisal edge³⁴.

Working length determination is challenging in the presence of apical resorption or root blunting as root end is wide open from the resorptive destruction, even electronic apex locators are unreliable and are of little clinical value. Therefore many authors have suggested locating the coronal point on the root above the resorbed apex which exhibits sound radio density. This position is used as the new radiographic apex and the working length is established 1.0±2.0 mm coronal to that point^{35,36}.

Obturation of teeth being orthodontically moved may result in fills that are beyond the confines of the tooth³⁷. This is especially true when using thermally softened gutta-percha and vertical compaction techniques. In these cases, techniques of creating an apical matrix or custom fitting of a master cone may be appropriate³⁶.

7. How orthodontic procedures facilitate to optimize final endodontic output?

The role of orthodontic tooth movement to optimize the prognosis of endodontic therapy by improving the access of the tooth for a good restoration. Mainly two types of movement were appraised in the literature in this perspective.

- i. Orthodontic extrusion
- ii. Orthodontic up-righting

i. Orthodontic extrusion

The main intention of orthodontic extrusion is to provide a sound tissue margin and to build a better periodontal surrounding (biologic width) to construct a definitive refined restoration, sometimes adjunctively periodontal surgery may be required in this procedure. Common indications for orthodontic extrusion in this situation include infra alveolar crest/sub gingival fractures, pulpally involved deep root caries, resorptive lateral root perforations, perforations made during post and core preparations.

The orthodontic extrusion of endodontically treated teeth did not present any apparent problems. The alveolar housing moves occlusally as the tooth is extruded followed by bone deposition at the alveolar crest and throughout inter-radicular area. Adjunctively crown lengthening was done to optimize esthetic results and biological width³⁸.

Orthodontic root extrusion or forced eruption is a well-documented clinical method for altering the relation between a non-restorable tooth and its attachment apparatus, elevating sound tooth material from within the alveolar socket. It has some advantages over surgical crown lengthening, which is less conservative considering the sacrifice of supporting bone and the negative change in the length of the clinical crowns of both the tooth and its neighbors³⁹.

Yuzugullu B et al treated a case of cervical line tooth fracture with minimal interdisciplinary approach in which the tooth was endodontically obturated by a glass-fiber post and a composite core, later orthodontically extruded to the desired level to accomplish a final post endodontic coronal restoration⁴⁰.

Addy LD et al presented a case of fractured canine and lateral incisor with sub-crestal cervical root fractures that have been extruded orthodontically for complete restoration and suggested that the treatment option in the management of sub-crestal cervical fractures is orthodontic extrusion, rather than removal of teeth⁴¹.

ii. Orthodontic up-righting

In some instances orthodontic up-righting of posterior teeth is attempted to augment embrasure space to aid in definitive post endodontic restoration

If at all second molars are drifted into a distally decayed first molars can be up-righted orthodontically. Molars that are resected (hemisected or root-amputated) can often benefit from enhanced embrasure spaces through the use of orthodontic movement. Molars that are resected (hemisected or root-amputated) can often

benefit from enhanced embrasure spaces through the use of orthodontic movement⁴².

8. Orthodontic intervention of apicoectomized tooth.....When?'

In this perspective very limited scientific data existed. Bananowsky j studied the periapical healing phenomenon following apicoectomy before commencement of orthodontic movement in dogs. He was chosen two dogs one used as control and other as experimental. RCT and apicoectomy procedures were done in both animals; later experimental animal teeth alone were subjected to orthodontic intrusive force. Histological studies were performed in two phases; first at 6th week and next after 12th week. Specimens of control group at 6th week showed complete healing by periodontal and bone regeneration and experimental specimens showed no signs of healing but at 12th week specimens of control showed complete healing and 2/3rd of experimental specimens also showed healing⁴³.

Geron and Ziskind reported a retrograde root filled incisor was subjected to endodontic surgery [root resection] and extruded orthodontically to accomplish accurate crown restoration⁴⁴. Uematsu presented a case of impacted maxillary central incisor with dilacerated root was aligned into the arch and apicoectomy was performed followed by retrograde filling. After this orthodontic tooth movement was paused for 4 months to allow healing later orthodontic movement was proceeded⁴⁵.

If a tooth is needed orthodontic treatment after endodontic surgery, sufficient time should be provided for periradicular healing before loading orthodontic forces⁴³.

CONCLUSION

Orthodontic treatment is directly dependent on sound periodontal ligament and alveolar bone whereas endodontic treatment is dependent on pulpal tissue. Thus, these two appear independent of each other. Thorough literature review however will demonstrate the following independency and interactions between orthodontic-endodontic procedures:

- Optimal orthodontic forces with appropriate case selection will not affect the pulpal vitality. Closed apices with aged patient selection are at high risk of irreversible pulpal changes when compared to open apices with younger patients.
- When methodically cleaned, shaped, obturated and periapically sealed teeth are subjected to optimal orthodontic forces show similar root resorption as seen in non-endodontically treated teeth. Animal and human studies have shown no difference in orthodontic movement between ideal endodontically treated teeth and vital teeth.
- Severe the trauma to the teeth higher the chance of root resorption during orthodontic movement with or without endodontic treatment.
- If at all endodontic intervention is needed during the course of orthodontic treatment few elements should be taken into consideration by the dentist like accurate clinical tests, radiographic diagnosis and some modifications during working length determination and obturation procedures.

A Methodical and skill-full association is undeniably needed among the endodontic – orthodontic interdisciplinary team approach to tackle the compromised situations which are encountered in routine dental dental practice for a successful outcome, functionally as well as esthetically.

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