A REVIEW OF ROOT RESORPTION IN ORTHODONTICS

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ABSTRACT: Root resorption is unavoidable, unwanted and undesirable consequence of the orthodontic tooth movement. This paper describes the various causes, types and classification of root resorption during orthodontic treatment.

KEYWORDS: Orthodontics, Tooth Movement, Root resorption.

INTRODUCTION

Bone is not necessarily the only hard tissue resorbed during orthodontic tooth movement. Root resorption involving cementum and dentin can be an unfavourable sequel to orthodontic procedures. Apical root resorption is one of the most common iatrogenic problems associated with orthodontic treatment. It is becoming an increasingly more serious problem from a medico legal standpoint.

Root shortening as a result of external resorption is a well-documented possible side effect of orthodontic treatment. It is irreversible, difficult to predict and can be sufficiently extensive to cast doubt on the overall benefit to the patient of an otherwise successful orthodontic treatment. Root resorption is undesirable because it can affect the long-term viability of the dentition, and reports in the literature indicate that patients undergoing orthodontic treatment are more likely to have severe apical root shortening. Bates (1856) was the first person to discuss root resorption of permanent teeth. Ottolengui (1914) related root resorption directly to orthodontic treatment and mentioned that Schwarzkopf (1887) demonstrated resorbed roots in extracted permanent teeth. In 1927 root resorption of permanent teeth was a subject of major concern to the orthodontic field. Ketcham, demonstrated with radiographic evidence, the differences between root shape before and after orthodontic treatment. This observation initiated a research on histological, clinical and physiologic root resorption occurring during orthodontic treatment.

Periodontal and bone response to normal function and orthodontic force

Each tooth is attached to and separated from the adjacent alveolar bone by a heavy collagenous supporting structure and the periodontal ligament (PDL). The principle cellular elements in the PDL are undifferentiated mesenchymal cells and their progeny in the form of fibroblasts and osteoblasts. Remodelling and recontouring of the bony socket and the cementum of the root is also constantly being carried out, though on a smaller scale, as a response to normal function.

Response to Normal Function: During masticatory function, the teeth and periodontal structures are subjected to intermittent heavy forces. When a tooth is subjected to heavy loads of this type, quick displacement of the tooth within the PDL space is prevented by the incompressible tissue fluid. Instead the force is transmitted to the alveolar bone, which bends in response. Bone bending in response to normal function generates piezoelectric currents, which appear to be an important stimulus to skeletal regeneration and repair. This is the mechanism by which bony architecture is adapted to functional demands. When pressure on tooth is applied for a second, very little of the fluid within the PDL space gets squeezed out. However, if pressure against a tooth is maintained, the fluid is rapidly expressed and the tooth displaces within the PDL space, compressing the ligament itself against adjacent bone. Although the PDL is beautifully adapted to resist forces of short duration, it rapidly loses its adaptive capability as the tissue fluids are squeezed out of its confined area. Prolonged force, even of low magnitude, produces a different physiologic response- remodelling of the adjacent bone. Orthodontic tooth movement is made possible by the application of prolonged forces.

Effects Of Force Magnitude: When light but prolonged force is applied to a tooth, blood flow through the partially compressed PDL decreases as soon as fluids are expressed from the PDL space and the tooth moves in its socket (i.e. in a few seconds). Within a few hours,
The process of root resorption is a necessary process that eventually results in the exfoliation of the deciduous tooth in anticipation of the arrival of its permanent successor. However, root resorption that occurs in permanent teeth is an unwanted process and is considered pathologic (Bates 1856). The publications of Wehrbein et al. made substantial contributions to the research concerning OIRR in humans. These authors discussed different grades of root resorption in detail, mainly in terms of the close proximity of the root to the cortical nonmetaplastic bones, as well as other pathologic phenomena such as dehiscence and fenestrations.

The Cellular Process

The studies in mice and rats conducted by Brudvik and Rygh confirmed that Orthodontically Induced Inflammatory Root resorption (OIRR) is a part of the hyaline zone elimination process. The first cells to be involved in this necrotic tissue removal are cells that are negative for tartrate resistance acid phosphatase (TRAP) and that have no ruffled borders. These are Macrophage-like cells, which are most probably activated by signals coming from the sterile necrotic tissue, the result of the orthodontic force application. As described by Brudvik and Rygh, the initial elimination process takes place at the periphery of the hyaline zone, where blood supply to the periodontal ligament exists and is even increased. During removal of the hyaline zone, the nearby outer surface of the root, which consists of the cementoblast layer covering the cementoid, can be damaged, thus exposing the underlying highly dense mineralized cementum. It is possible that the orthodontic pressure itself directly damages the outer root surface layers in such a way that there is a need for their removal as well. The resorption process continues until no hyaline tissue is present and/or the force level decreases. The extent of root resorption was increased only when force reactivation was performed at the peak presence of osteoclast count in the involved region (day 4). Idiopathic root resorption is most frequently found at the apex followed by mesial, buccal, distal and lingual surfaces. Small differences were noted between right and left sides, or between mandibular and maxillary teeth. More resorption areas were seen on molars since their total surface area is greater than that of other teeth.

Factors affecting root resorption

Naphtali Brezniak, Atalia Wasserstein (1993) have described the following factors responsible for root resorption.
I) BIOLOGIC FACTORS:
1) Individual susceptibility
2) Genetics
3) Systemic factors
4) Nutrition
5) Chronologic Age
6) Dental age
7) Gender
8) The presence of root resorption before orthodontic treatment
9) Habits
10) Tooth structure
11) Previously traumatized teeth
12) Endodontically Treated Teeth
13) Alveolar bone density
14) Types of malocclusion
15) Specific tooth vulnerability to root resorption

II) MECHANICAL FACTORS
1) Orthodontic appliances:
   A. Fixed versus removable
   B. Begg versus edgewise
   C. Magnets
   D. Inter maxillary elastics
2) Extraction versus nonextraction
3) Serial extractions
4) Other appliances
5) Types of orthodontic tooth movement
6) Orthodontic force
7) Continuous versus intermittent force
8) Jiggling and occlusal trauma
9) The extent of tooth movement

III) BIOLOGIC AND MECHANICAL FACTORS:
1) Treatment duration
2) Relapse
3) Root resorption after appliance removal

IV) OTHER CONSIDERATIONS:
1) Teeth vitality.
2) Loss of crestal bone and tooth stability

CLASSIFICATION OF ROOT RESORPTION

ACCORDING TO SHAFER, HINE AND LEVY, resorption of root occurs in many circumstances other than the normal process associated with shedding of deciduous teeth. Resorption of root may occur either on the external surface or internal surface of the root. Root resorption is mainly of two types

1. External root resorption: This resorption mainly occurs as a result of a tissue reaction in the periodontal or pericoronal tissues. Following are the few conditions:
   a. Periapical inflammation
   b. Reimplantation of teeth
   c. Tumors or cysts
   d. Excessive mechanical or occlusal forces
   e. Impaction of teeth
   f. Idiopathic

NAPHTALI BREZNIAK ET AL. have published three types of external root resorption originally given by Andreasen:

i) Surface resorption: Surface resorption is a self-limiting process, usually involving small outlined areas followed by spontaneous repair from adjacent intact parts of the periodontal ligament. Root resorption after orthodontic treatment is surface resorption.

ii) Inflammatory resorption: In inflammatory resorption, initially root resorption occurs up to dentinal tubules of an infected necrotic pulp tissue or an infected leukocyte zone. There are two types of inflammatory resorption.

   a) Transient inflammatory resorption
   It occurs when the stimulation to the damage is minimal and for a short period. This defect is usually undetected radiographically and is repaired by a cementum-like tissue.

   b) Progressive inflammatory resorption
   When stimulation for damage is for longer period, ankylosis occurs. Ankylosis is the result of an extensive necrosis of the periodontal ligament with formation of bone into a denuded area of the root surface. Since the tooth becomes a part of the bone, normal remodeling process will gradually lead to a complete destruction of the tooth by the bone.

iii) Replacement resorption: In replacement resorption, bone replaces the resorbed tooth material that leads to ankylosis. Replacement resorption is rarely seen during or after orthodontic treatment.

Fig. 1. Diagrammatic representation of the time course of tooth movement with frontal resorption vs. undermining resorption.
2. Internal resorption: -

According to Shafer, Hine and Levy internal resorption mainly arises from inflammatory hyperplasia of pulp. This begins centrally within the tooth. The cause of the pulpal inflammation and subsequent resorption of the root. David N. Ramigtonet al. in 1989 described the following grading scale for apical root resorption as shown in Fig 2.

![Grading scale for apical root resorption.](image)

**Fig 2:** Grading scale for apical root resorption.

- **Grade-0:** Normal apical contour, same length as pretreatment.
- **Grade-1:** Apical irregularity, same length as pretreatment.
- **Grade-2:** Apical root resorption of less than 2mm.
- **Grade-3:** Apical root resorption more than 2mm, less than one third of original root length.
- **Grade-4:** Apical root resorption more than one third of original root length

**REPAIR PROCESS OF ROOT RESORPTION**

According to the appearance of these incremental lines, histologically the repair process is divided into following phases:

1) **Early lag phase:** - In this phase no cementum apposition was seen which can be explained by the dissipation of residual forces and the replacement of elastic cell population by blastic cell population.

2) **Incipient phase** (First 14 days): - This phase implies a transitional stage from no apposition (lag phase) to active deposition stages of repair cementum. In this phase, first incremental line is seen which is characterized by a slim deposit of cellular cementum with a deficient width in comparison with the sound width of all consecutive incremental lines.

3) **Peak phase** (14 to 28 days): - This phase is seen with successive first and second incremental lines because of spurt in matrix formation as defined by an increase in width. This phase is also characterized by initial incorporation of periodontal fiber bundle into intrinsic cementum matrix.

4) **Steady phase** (42 to 56 days): - This phase included rest of the incremental lines which were of equal width, indicating a steady deposit phase of mix fibrillar cementum.

5) **Retreating phase** (70 days): - This phase was seen during relapse period (after removal of retention appliance). In this phase only first and second incremental lines were seen. This phase may be attributed to the conversion of the former pressure site of active treatment period into the tension side of the relapse period as a consequence of appliance removal. This conversion led to an increase in osteogenesis on the new tension site along with a decrease in cementogenesis.

Naphtali Brezniak and Atalia Wasserstein have mentioned that according to Henry and Weinmann, repair can be classified as,

1) **Anatomic repair**: - In this type of repair the root surface gets restored to its original contour.

2) **Functional repair**: - In this type of repair, a thin layer of repair cementum covers the exposed dentine, resulting in a deficient root outline. In both types, the periodontal ligament (PDL) was restored to its original width.

**DIAGNOSTIC AIDS**

According to Naphtali Brezniak and Atalia Wasserstein (1993) radiographs are commonly used as a diagnostic aid for investigating root resorption. Following are the various radiographic techniques used as diagnostic aids for assessing root resorption:

1) Periapical bisecting angle.
2) Periapical paralleling.
3) Orthopantomogram.
4) Cephalogram.
5) Lamiogram.
6) Computed tomography.

A biochemical assay could potentially offer advantages of 1) sensitivity, 2) non-invasiveness, 3) No radiation exposure, 4) information on the stage of resorptive activity and Sevency, 5) possibly identifying at-risk individuals, 6) reducing the time between clinical onset and Usual clinical diagnosis and prognosis, 7) predicting subsequent
clinical course and diagnosis 8) implementing alterations in therapy, 9) assessment of the actual response to treatment alterations.13 Balducci et al. (2006) explored the presence of dentine sialoprotein (DSP), dentine phosphophosphoprotein (DPP), and dentine matrix protein-1 (DMP-1) in the GCF, concluded that the use of DSP and DPP as biomarkers were suitable alternatives for monitoring root resorption during orthodontic tooth movement16. RANKL and osteoprotegerin (OPG) in periodontal tissues are important determinants for the regulation of bone remodelling as well as root resorption during orthodontic tooth movement.

Zhang et al demonstrated that compressive force stimulates gene expression in the IL-17 and IL-17 (IL-17R) in MC3T3-E1 cells, and also results in the induction of osteoclastogenesis.15 Immunoreactivities for interleukin-6 and interleukin -17 were detected in gingival crevicular fluid of subjects with severe root resorption.16 Hayashi et al demonstrated that heavy orthodontic force induced expression of Th17, IL-17 and IL-17R in rat root resorbed tissue on day7. Therefore, IL-17 and Th17 cells may aggravate the process of OIIRR.

CONCLUSION
In post-orthodontic treatment, all permanent teeth may show microscopic root resorption that is clinically insignificant and radiographically undetected. Root resorption of permanent teeth is a probable consequence of orthodontic force and active tooth movement. The incidence of reported root resorption during orthodontic treatment varies widely among investigators. Most studies agree that the root resorption process ceases once the active treatment is terminated. The question if there is any ideal (optimal) force to move teeth without root resorption and whether root resorption is predictable remains unanswered.

References

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