

A Literature Review on Orthodontically Induced Root Resorption: The Aftermath of the Pursuit of an Attractive Smile

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Abstract: Root resorption is one of the most relevant problems in orthodontics that does not have a clear-cut method of resolution or prevention. We can use lighter forces and create an environment that would minimise the chances of developing root resorption, but nonetheless, there is no fool-proof method or mechanics to completely avoid the development of this malady. Moreover, the multifactorial etiology and other such considerations make it difficult to arrive at a conclusion whether this phenomenon can be effectively controlled at all. What we have now are a set of guidelines that were the result of intense research studies performed by pioneers in the orthodontic field. Utmost care and regular follow up are the only way to reduce the adverse effects and achieve stable and consistent treatment results.

1. INTRODUCTION

Tooth resorption is one of the conspicuous issues that we see on an everyday premise. Albeit a few teeth might be safeguarded, many of them are lost to this process. Although numerous kinds of resorptive processes have been recognized, the etiological variables of this phenomenon are not regularly clear, and there has been a lot of observational clarification and direction on both the source and clinical management hypotheses. Notwithstanding, this was not commonly the circumstance, as the possibility of tooth resorption, as is alluded to today, was not commonly tended to as a noteworthy issue until the mid-1970s. Believe it or not, when initially perceived as an issue during the 19th century, the term resorption didn't exist, and the cycle was not doubtlessly known.

Bates was the first to address the root resorption of permanent teeth in 1856. He alluded to the process as "absorption" which was caused because of injury of periodontal membrane (Bates S, 1856). Dr Broomwell was the principal individual to be given acknowledgment for utilizing the expression "resorption" when referring to roots of permanent dentition, this was in 1898.

Ottolengui, in 1914, connected root resorption legitimately to orthodontic consideration, and called attention to a case report published by Schwarzkopf (1887) demonstrating apical root resorption in extracted teeth. Ketcham utilized radiographic proof to show the contrast between the root structure before and after orthodontic treatment. This was joined by a wide variety of histological, clinical and physiological investigation on root resorption and orthodontic treatment (Brezniak, Wasserstein and Aviv, 1993).

Apical root resorption is an idiopathic condition regularly associated with fixed orthodontic therapy and has as of late started to hold significant consideration because of clinical introduction. Loss of apical root material is not a predictable event and, irreversible when involving dentin (Breznlak, Wasserstein and Aviv, 1993). Increased post-orthodontic root resorption negatively affects the benefits of good orthodontic treatment results.

The etiology of external apical root resorption (EARR) will in general be of multifactorial starting point. It is a permanent shortening of the root apex that can be found in routine dental radiographs. In any case, taking everything into account, the logical proof is varied, and complete ends cannot be draw (Newman, 1975).

2. CLASSIFICATION

Root resorption can be described as "a process in which the tissues created are destroyed and taken up by blood or lymph." Key cells involved in resorption are of a clastic form, including osteoblasts and odontoclasts.

Classification of root resorption:

1. *According to Shafer, Hine and Levy (1999):* root resorption can occur due to various other reasons than the normal process of shedding of deciduous teeth.

Depending on the surface which is affected it can be divided into:

a) *External root resorption:* loss of tooth structure from the external surface of the root. It can be further divided into the following categories (Darcey, J; Qualtrough, 2013):

- *External cervical resorption:* Localized resorptive lesion in the cervical region of the tooth below the epithelial attachment.
- *Eternal replacement resorption:* Ankylosis of the root and the alveolar bone occurs. Thereafter, the tooth tissue is removed and replaced by the bone.
- *Transient inflammatory resorption:* It is caused by localised and minimal damage to the root surface or surrounding tissues and is a self-limiting process.

b) *Internal root resorption:* It refers to the loss of tooth structure inside the root canal /s of the tooth.

2. *Naphthali and Brezniak (1993)* had published three types of external resorption originally given by Andresen:

- i) *Surface resorption*: It is a self-limiting process that typically requires small outlining areas accompanied by spontaneous repair of the adjacent intact sections of the PDL. This is seen after orthodontic therapy.
- ii) *Inflammatory resorption*: Initial root resorption occurs up to the dental tubules of infected necrotic pulp tissue or the infected leukocyte region. Colonization of the denuded surface with multinucleated cells is seen.

According to *Tronstad* there are two types of inflammatory resorption:

- a) *Transient inflammatory resorption*: It happens when the damage is small and typically goes undetected in X-rays. It is healed by a cement-like tissue.
- b) *Progressive inflammatory resorption*: Here, the damage has occurred over a longer period and finally results in ankylosis, is a result of replacement of necrotic PDL by bone.
- iii) *Replacement resorption*: In this type, bone replaces the tooth material that contributes to ankylosis. Replacement resorption is rarely seen during orthodontic treatment.

3. According to *Profitt* (William R. Profitt, Henry W. Fields, 2001), shortening of roots after orthodontic treatment occurs in three distinct forms:

- i) *Moderate generalized root resorption*: An individual who has undergone comprehensive orthodontic treatment show some blunting of the root apex in most teeth.
- ii) *Severe generalized root resorption*: Severe resorption of all teeth is rare. Several studies have indicated that an above-average amount of resorption can be expected if the teeth have a conical root shape with pointed apices, a skewed root shape or a history of trauma.
- iii) *Severe localized root resorption*: In contrast to severe generalized root resorption, this type is more often caused by prolonged duration of orthodontic treatment.

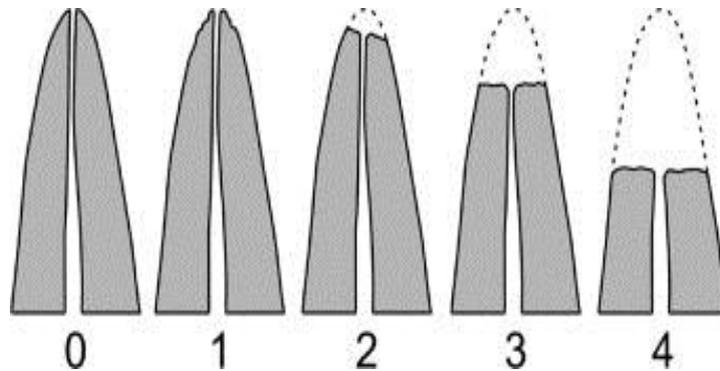
In a study performed by *Kaley and Phillips*(Kaley J, 1991), a twenty-fold increase in the extent of incisor root resorption was seen if their roots were pressed against the palatal cortical plate during treatment.

3. GRADING OF APICAL ROOT RESORPTION:

(A) *Robert W. Shields* (1969) used intraoral periapical radiographs to describe the following grading system for apical root resorption:

Grade 0	No resorption
Grade 1	Possible resorption
Grade 2	Define evidence of resorption. The apical outline was undoubtedly irregular, but the root was not shortened or blunted.
Grade 3	Mild blunting of the apical region. The shortening of root length was less than 3 mm.
Grade 4	Moderate blunting of the apical region. Resorption greater than 3 mm but less than 1/3rd of the root dimension.
Grade 5	Severe blunting of the apical region. More than 1/3 of the initial root length was lost.

B) In 1998 Levander and Malmgren (1988) point by point a climb in severe root resorption from 1% before treatment to 17% after treatment and an extra 1% experienced extreme resorption following 6-9 months of orthodontic treatment and also gave a system to score the severity of root resorption.



Scoring system of Levander and Malmgren

Grade 0	Natural apical contour, same length as seen pretreatment
Grade 1	Apical irregularity, the same length as seen pretreatment
Grade 2	Resorption of apical region of root of less than 2 mm
Grade 3	Resorption of apical region of root more than 2 mm, less than 1/3rd of the initial root length
Grade 4	Apical root resorption more than 1/3rd of original root length

RISK FACTORS

Risk factors for root resorption can be broadly divided into three categories: natural and environmental variables, dental, and mechanical components. Notwithstanding complete examinations, a few of these risk factors stay disputable in the literature.

4. BIOLOGICAL AND ENVIRONMENTAL FACTORS

These variables are straightforwardly identified with the patient and might be influenced by the patient and could be either hereditary or environmental in nature.

Genetics, Ethnicity and Individual susceptibility

(Newman, 1975; Grieve *et al.*, 1994; Basaran G, Ozer T, Kaya FA, Kaplan A, 1997; Harris, Kineret and Tolley, 1997; Iwasaki LR, Gibson CS, Crouch LD, Marx DB, Pandey JP, 2006) Root resorption can happen in certain people without a history of orthodontic treatment as well. This shows the distinction in susceptibility between people to Root Resorption. Singular affectability is regularly known to be one of the main considerations assessing the potential for physiological root resorption.

Rygh (1977) noticed that the root resorption measure will in general change between various individuals and even at various occasions within the same person.

Harris *et al.* (1997) studied the genetic effect of Root Resorption susceptibility and found 70 per cent heritability in Root Resorption. It has also been proposed that siblings are affected with similar levels of root resorption.

Ngan et al. (2004) explored the hereditary commitment of Root Resorption to mono-and dizygotic twins, and the discoveries recommended a hereditary component of Root Resorption.

Abass et al. recommended that hereditary components represent around 64 percent of the distinction in external apical root resorption. (Abass and Hartsfield, 2007).

Asthma and allergy

Davidovitch et al. (1996) and Nishioka et al. (2006) found that the occurrence of asthma, hypersensitivities and indications of mental stress was considerably higher in patients who experienced severe root resorption.

It has been theorized that asthma-induced inflammatory mediators can enter the PDL and work synergistically to improve root resorption and may clarify the incidence of resorption in roots close to the region of an inflamed maxillary sinus.

Gender, chronological and dental age

The connection among sex and the occurrence of root resorption is controversial (Reitan, 1960; Linge BO, 1983; Hendrix I, Carels C, Kuijpers-Jagtman AM, 1994; Mavragani M, Boe OE, Wisth PJ, 2002). The vast majority of the investigations revealed no relationship among sex and the level of orthodontic root resorption (Newman, 1975; Sinclair PM Sameshima GT, 2001; Srirangarnboriboon, Matsumoto and Soma, 2003). Newman (1975) found that females were more susceptible, with a proportion of 3.7:1 for females to males. Kjaer (1995) demonstrated the contrary relationship between sex and orthodontic root resorption among teenagers.

Then again, Baumrind et al. (1996) found that adult male patients (> 20 years old) had a higher predominance of orthodontic root resorption.

Be that as it may, the connection between chronological age and root resorption is yet dubious. A few investigations (Massler M, 1954; Remington *et al.*, 1989; Edward F. Harris, 1990; Harris, Kineret and Tolley, 1997) have demonstrated that age is definitely not a main consideration for orthodontic root resorption. Though different investigations disagree on the absence of significance in the results (Linge BO, 1983; Harris, Kineret and Tolley, 1997; Sinclair PM Sameshima GT, 2001).

Endocrine Imbalance

An irregularity of these hormones, 1, 25-DHCC, PTH and Ca have been found to impact root resorption.

As an outcome, compromised endocrine conditions, for example, hyperparathyroidism (Goldie R.S., 1984), Paget's disease (Smith, 1978), hypophosphataemia (Tangney NJ, 1979), hypothyroidism, hypopituitarism and hyperpituitarism (Becks, 1939) are identified with altered tooth development rates and root resorption levels (Darendeliler *et al.*, 2004).

Nutrition

Root resorption has been found in creatures that were deprived of dietary calcium and vitamin D (Patel, Gupta and Sharma, 2012). Engstrom and coworkers (1988) detailed a connection between the severity of alveolar bone resorption and root resorption.

Nevertheless, some authors have shown that dietary imbalance is certainly not one of the leading considerations in root resorption during orthodontic treatment (Linge BO, 1983; Goldie R.S., 1984)

Habits

Deleterious habits, for example, finger-sucking habit that are carried on past the age of 7 years (Massler M, 1954), nail biting (Odenrick and Brattström, 1985) and lip or tongue dysfunction (Massler M, 1954; Newman, 1975) have been recognized as conceivable perilous factors for development root resorption. An increased duration of altered muscle forces such as that related with a tongue thrust habit can likewise encourage expanded root resorption (Harris and Butler, 1992)

Medications

Verna et al. (2006) described an elevated incidence root resorption in acute corticosteroid administration in rodents when compared with either of chronic corticosteroid administration and control groups.. Diverse dosage levels regularly sway root resorption distinctively in direct proportions. (Ashcraft, Southard and Tolley, 1992).

Studies utilizing NSAIDS has revealed: slowing of tooth movement (Brent Chumbley and Tuncay, 1986; Arias and Marquez-Orozco, 2006), decrease of root resorption (Villa *et al.*, 2005) and both (Gonzales *et al.*, 2009).

Bisphosphonates act as strong inhibitors of bone resorption by initiating osteoclast apoptosis (Reszka *et al.*, 1999). Although, different investigations have discovered that bisphosphonates have caused the arrangement of atypical hyperplastic cementum in such a way that it cannot resist resorptive processes, thereby increasing their susceptibility (Alatli, Hellsing and Hammarström, 1996).

5. DENTAL RISK FACTORS

Previous history of root resorption prior to orthodontic treatment

Patients with pre-existing evidence of root resorption were found to have greater risk in developing further severe orthodontically induced root resorption with treatment (Massler M, 1954; Newman, 1975; Harris and Butler, 1992)

History of trauma

The historical backdrop of trauma has indicated a significant commitment to apical root resorption during orthodontic treatment. Injury itself can prompt root resorption without any application of orthodontic forces, yet the coincidence of injury and orthodontic tooth movement can hasten the resorptive process (Linge BO, 1983)l.

The extent and type of injury are additionally significant with intrusive trauma being the most consequential to prompt outrageous root resorption and ankylosis (Andreasen *et al.*, 2006).

Malmgren et al (1982) postponing any orthodontic treatment for a period of 1 year after a traumatic accident.

History of endodontic treatment

There are conflicting investigations in the writing on the vulnerability of a root canal treated tooth to orthodontically induced root resorption.

It has been indicated that endodontically treated tooth can be moved as effectively as a vital tooth since pulp vitality isn't the principle factor in orthodontic tooth movement (Wickwire NA, Mc Neil MH, Norton LA, 1974).

Others delineated increased occurrence root resorption than teeth that have undergone endodontic therapy in comparison with vital teeth (Wickwire NA, Mc Neil MH, Norton LA, 1974). In contrast to this, a few investigations have gone on the defensive to show less root resorption in endodontically treated teeth. A few authors, for example, Hall et al, Mirabella et al, accept that endodontically treated teeth are more impervious to orthodontic root resorption because of increased hardness and density of dentin(Reitan K, 1985; Remington *et al.*, 1989; Spurrier *et al.*, 1990; Mirabella and Årtun, 1995)

Hypo functional Periodontium

Hypofunctional periodontium has restricted periodontal space because of the disturbance of functional fibres. This lessens the impact resistance of PDL, bringing about increased stress concentration that incites inflammation and resulting orthodontically induced root resorption (Cooper and Sims, 1989; Sringkarnboriboon, Matsumoto and Soma, 2003)

Alveolar bone density and turnover rate

It has been reported that orthodontically induced root resorption is more articulated in the dense alveolar bone (Reitan, 1960; Reitan K, 1985). Furthermore, a heavy continuous force in regions of low alveolar bone density instigated an equivalent measure of orthodontically induced root resorption as a light continuous force at high alveolar bone thickness (Schwarz, 1932).

Verna and partners (2003) found that high bone turnover sped up tooth movement in rodents. In subjects with diminished or delayed bone turnover, there was an increased vulnerability to root resorption.

Abnormal root morphology and dental anomalies

Numerous examinations have demonstrated an increased incidence of orthodontically root resorption in teeth that have abnormally shaped roots. Sameshima and Sinclair (2001) appraised the root shape in decreasing order of susceptibility:

- dilacerated
- pipette shaped
- pointed

In the instance when same level of orthodontic force is applied to the root apex, the pressure conveyance is diverse relying upon the anatomy of the root (Levander E, Malmgren O, 1988), and increased pressure can damage the apical PDL, cause an inflammatory/repair cycle, and progress to apical root resorption (Nishioka *et al.*, 2006).

Utilizing the finite element mode (FEM), Oyama et al. (2007) indicated that considerable pressure was assembled at the apex with a dilacerated or pipette-shaped root.

Along with root morphology, dental imperfections, for example, invagination and taurodontism have been recommended as an inclining factor for orthodontically induced root resorption (Kjaer, 1995; Thongudomporn U., 1998). In any case, other researchers have not revealed singular anomalies as a risk factor for root resorption (R Y Lee, J Artun, 1999; Mavragani *et al.*, 2006).

Specific tooth and site susceptibility

The teeth susceptible to orthodontically induced root resorption are : maxillary lateral incisors, maxillary central incisors, mandibular incisors, distal root of the mandibular first molar, mandibular second premolars, and maxillary second premolars, in decreasing order of severity. (Brezniak and Wasserstein, 1993; Sinclair PM Sameshima GT, 2001; Brin *et al.*, 2003).

Maxillary teeth are more predisposed to root resorption than mandibular teeth (Sinclair PM Sameshima GT, 2001) (Remington 1989).

Kaley and Phillips (Kaley J, 1991; Taner T, Ciger S, 1999) proposed that if no apical root resorption is seen in maxillary and mandibular incisors, noteworthy apical resorption is less inclined to happen in other teeth (Goldson L, 1975).

Types of Malocclusion and proximity to cortical plate

There are contradictory reports in the literature on the connection between OIIRR and malocclusion. A few investigations have recognized an association (Linge L, 1991; Harris and Butler, 1992; Harris, Kineret and Tolley, 1997; Sinclair PM Sameshima GT, 2001), while others have not recorded any association (Mirabella AD, 1995). increased orthodontically induced root resorption has been seen in cases with increased overjet (Linge L, 1991; Sinclair PM Sameshima GT, 2001)

Many reports have been accounted for on the connection between the increased risk of orthodontic root resorption and the type of malocclusion: Class III (Brudvik P, 1994), Class II Div1(Taner T, Ciger S, 1999), Class II Div2 (Janson *et al.*, 2000), Open-bite (Kuperstein, 2005)

(Mirabella AD, 1995). Class III patients requiring surgery exhibited a decrease in maxillary and mandibular incisor lengths of 1.6 percent and 20.8 percent respectively (Kaley J, 1991). This impact may have been because of surgical correction that that has affected the blood and nutrient supply to the periodontium (J. Ghafari, 1995).

In addition, the closeness of the root to the cortical plate has been recognized as another factor in increased orthodontically induced root resorption.

6. MECHANICAL RISK FACTORS

These elements are credited to orthodontic treatment mechanics and are managed by both the clinician and the patient.

Orthodontic Appliances

Studies likewise endeavoured to assess the kind of mechanics and treatment methodology that limits orthodontic root resorption. As a rule, fixed orthodontic appliances cause altogether more orthodontic root resorption than removable appliances (Linge BO, 1983) as removable appliances apply interrupted forces and allow tissue recuperation when not worn. Removable thermoplastic appliances cause a similar measure of root resorption as fixed orthodontic appliances delivering light (25 g) forces (Barbagallo LJ, Jones AS, Petocz P, 2008).

Many researchers have expressed that one system is more favourable than the other, for example Edgewise over Begg (Goldson L, 1975; Hall A.M, 1978), Begg over Edgewise (R.J Parker, 1998), Straight wire over Standard Edgewise (Mavragani M, *et al.*, 2000). Although,

there are others who found no such variation among different bracket types (Malmgren O., Goldson L., Hill C., Orwin A. and Lundberg M., 1982; M Blake, D.G Woodside, 1995; Reukers EA, Sanderink GC, Kuijpers-Jagtman AM, 1998; Mavragani M, Vergari A, Selliseth NJ, Boe OE, 2000)

Alexander (1996) reported no distinction in the level of root resorption between continuous arch and sectional arch mechanics. The utilization of intermaxillary elastics has been set up as a significant danger factor for orthodontic root resorption (Linge BO, 1983; Linge L, 1991; Mirabella AD, 1995) due to shaking powers that have been appeared to expand the danger of root resorption (Mirabella AD, 1995; Baumrind S, Korn EL, 1996) Others, notwithstanding, didn't distinguish such a relationship (Sinclair PM Sameshima GT, 2001).

Treatment duration

Most of studies revealed a connection between the severity of orthodontic root resorption and the length of treatment (Levander E, 1988; B. Goldin, 1989; McFadden WM, Engstrom C, Engstrom H, 1989; Brezniak and Wassersteln, 1993; Vlaskalic V, Boyd RL, 1998; Taner T, Ciger S, 1999; Sinclair PM. Sameshima GT, 2001). A few studies also disagree with these findings (Mirabella and Årtun, 1995). Longer span of treatment duration will hasten the susceptibility to root resorption.

Direction of force application

Various kinds of tooth movements are expressed during orthodontic therapy, depending upon the amount and direction of force delivered.: intrusion, extrusion, tipping, bodily movement, torque and rotation (Dermaut LR, 1986).

Intrusion has been reported to be most likely to cause orthodontic root (Stenvik A, 1970; K Reitan, 1974). The extent of orthodontic root resorption from intrusion is further compounded by the duration and magnitude of the force (K Reitan, 1974; Hary MR, 1982; McFadden WM, Engstrom C, Engstrom H, 1989)

In extrusive movements, Weekes and Wong (1995) demonstrated orthodontically induced root resorption in the interproximal area of the cervical third region of the root.

Bodily movement has been related with lesser root resorption as compared with tipping because of the divergence in stress distribution (K. Reitan, 1964; Follin ME, Ericsson I, 1986). Studies revealed that there is stress concentration at the alveolar crest and the root apex during tipping (Rudolph DJ, Willes PMG, 2001).

Chan and Darendeliler (2005) used micro-CT to demonstrate that buccal cervical and lingual apical areas have considerably more resorption craters during buccal tipping movements. SEM investigations following application of palatal root torque, showed root resorption craters in the palatal root apex and buccal cervical regions.

Furthermore, Sameshima and Sinclair (2001) expressed that the displacement of the incisor root apices altogether corresponded with root resorption.

Magnitude of force application

Numerous animal (EL. Dellinger, 1967; Gonzales C, Hotokezaka H, Yoshimatsu M, Yozgatian JH, Darendeliler MA, 2008) and human (Thongudomporn U., 1998; Casa MA, Faltin RM, Faltin K, Sander FG, 2001; Darendeliler *et al.*, 2004) studies have detailed direct correlation between the magnitude of orthodontic force applied and the root resorption thus

induced. As heavy forces are applied (surpassing 26 g/cm² of narrow blood pressure (Becks, 1939)) ischemia, hyalinisation, resorptive processes set in and reparative processes get affected (Stenvik A, 1970; K Reitan, 1974; P Rygh, 1977; Hary MR, 1982) A series of studies by Darendelliler and associates (2008) found force magnitude to be a main consideration in the level of root resorption; the heavy force group had a 3.31-times greater increment in root resorption and contrasted with the light force group.

Nonetheless, a few examinations have also indicated that there is no relationship between the level of applied force and the severity of root resorption (Owman-Moll P, Kurol J, 1996).

Duration of force application

Various studies have indicated that the measure of orthodontically induced root resorption increased with an increased duration of the power application (Hary MR, 1982). Notwithstanding, application of continuous forces have been found to cause even more amount root resorption than intermittent forces (Ballard DJ, Jones AS, Petocz P, 2009).

Then again, a few investigations reported no relationship between the severity of orthodontic root resorption and duration of force application (Dermaut LR, 1986; Owman-Moll P, Kurol J, 1995) The impact of the interruption of treatment was inspected by Levander et al. (1994). The measure of orthodontically induced root resorption was demonstrated to be generously lower if treatment was halted for 1-2 months after resorptive processes became evident. The interruption of forces empowered the revamping of injured periodontal tissues and the reclamation of blood supply and thereby, diminished root truncation.

Distance of tooth movement

Teeth that are moved significant distances experience an increased exposure to the resorptive cycles and longer duration of treatment. Numerous investigations have upheld this immediate relationship between the extent of orthodontic root resorption and the extent of tooth movement (Dermaut LR, 1986; Sinclair PM, Sameshima GT, 2001). Upper incisors are generally moved through the largest distance and are at the most noteworthy danger of orthodontically induced root resorption (Goldson L, 1975; Sinclair PM, Sameshima GT, 2001)

7. CLINICAL CONSIDERATIONS

According to Naphtali Brezniak and Atalia Wasserstein (1993), the following clinical aspects should be considered before and during orthodontic treatment:

- 1) The patient or his/her parents must be informed about the possible consequence of apical root shortening, since its incidence is highly unpredictable
- 2) Periapical radiographs:
 - a. Pretreatment X-rays are an important component of orthodontic documents and can be used to compare root pretreatment and post-treatment status.
 - b. Periapical radiographs of the incisors should be taken at least on a yearly basis after appliance placement until the end of treatment.
 - c. Posttreatment radiographs are as important as pretreatment radiographs to assess the condition of the roots at the end of treatment.

3) Treatment timing:

Orthodontic treatment should begin as early as possible because, in young patients the chances of root resorption is very less, also, they show better muscular adaptation to occlusal changes.

4) Care should be taken to apply only light and intermittent forces

5) If at any point of treatment, root resorption is detected, the final goals of treatment should be reassessed, and the orthodontist must arrive at a decision to either terminate the treatment or to deliver a compromised treatment. When necessary, applied forces must be stopped and bite plane should be given to dis-occlude the teeth.

6) Habits such as nail biting and tongue thrusting must be taken care of as it has been shown that such patients are susceptible to more severe root resorption.

7) All types of tooth movements can cause root resorption, the most damaging of which is intrusion.

8) Occlusal trauma and jiggling are especially dangerous to the roots and the correct occlusion of treatment is advised.

9) It is important to understand that the application of routine orthodontic force has its own anatomical and physiological limits. If the goals of treatment go beyond these limits, intervention by surgery must be considered.

10) Root resorption can hamper the usefulness of a tooth as abutment for a prosthesis. It can only be used if the root length is more than the crown length.

11) The orthopaedic effect in the early treatment phase has a less adverse effect than the dentoalveolar effect in the later treatment phase.

12) When choosing treatment choices, the likelihood of root resorption should be balanced against the effectiveness of the appliance and the individual treatment goals.

13) Treatment time should be as brief as possible, taking into account other relevant principles.

14) Traumatized teeth should be handled more carefully as they would be more vulnerable to resorption during orthodontic tooth movements.

15) Medical evaluation and familial propensity are particularly important in cases with a history of serious or extensive root resorption.

16) Root canal therapy with calcium hydroxide is recommended if root resorption occurs after treatment, during the retention process. Gutta percha can only be positioned after cessation of resorption.

17) It is advisable to take full-bodied x-rays upon receipt of a transferred case.

8. RADIOGRAPHIC DIAGNOSIS

According to Naphthalia Brezniak and Atalia Wasserstein(1993), radiographs are commonly used as diagnostic aid for investigation of root resorption.

Several radiographic techniques used, which include:

- 1) Periapical bisecting angle
- 2) Periapical paralleling
- 3) Orthopantomogram
- 4) Cephalogram,
- 5) Laminogram
- 6) Cone beam computed tomography

Apical root shortening can only be observed on a radiograph after a certain degree of resorption has occurred. It's hard to come up with a standardized technique to compare the

same teeth at different times. Certain types of tooth motions, including tipping and torquing, make it impossible to measure the exact amount of root loss. Root resorption seen on the X-ray could only determine root shortening. Surface resorption could only be observed if it is located on the mesial or distal surface of the root, facing a direct right angle to the focal beam of the x-rays, or if the resorption has progressed to a serious or advanced level. Commonly used radiographs are unsuccessful in the evaluation of buccal and lingual surface resorption.

9. CONCLUSION

Some amount of root resorption will be present after orthodontic treatment. In most cases, it is microscopic and clinically insignificant and is not observed in radiographs. The occurrence of root resorption reported during orthodontic treatment differs widely among investigators. Most studies conclude that the root resorption process will stop once active treatment is completed.

Root resorption of deciduous teeth, on the other hand, is a natural, necessary, and physiological process. Permanent teeth have the ability to experience substantial external root resorption that can be caused by a number of stimuli. This resorptive ability differs between individuals, as well as between different teeth in the same individual. This leads to a lack of agreement on the role of structural factors as the primary cause of orthodontic root resorption. These differences can be clarified by differences in the shape of the tooth, the alveolar bone structure at different sites, and the form of movements the tooth is exposed to. The length of treatment duration and the mechanical factors have a definite effect on root resorption. The question remains whether there is any ideal or optimal force delivery method for moving teeth without causing root resorption and whether root resorption is truly predictable.

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