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Root resorption in Orthodontics : A review

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ABSTRACT

Root resorption is an unavoidable pathologic consequence of orthodontic tooth movement . Force application initiates a sequential cellular process. The onset and progression of root resorption are associated with risk factors related to the orthodontic treatment such as the duration of treatment, the magnitude of the force applied, the direction of the tooth movement, the method of force application during orthodontic treatment.This review aims to find root resorption in patients who had orthodontic tooth movement based on the currently used advances in orthodontic brackets and aligners and knowledge of the mechanical ,biological aspects and ways to prevent root resorption in orthodontic tooth movement among general practitioners .

Keywords*: Root resorption; orthodontic treatment; fixed appliance; aligners.*

I. INTRODUCTION

Root resorption is a pathological and physiological process that results in the loss of the cementum and dentin (Llamas-Carreras et al., 2010) .Root resorption is of two types namely, external and internal .External apical root resorption (EARR) can be a significant sequela of orthodontic treatment and in the most severe cases may threaten the longevity of the teeth , due to the external forces that caused tooth movement and it is clinically insignificant (Vlaskalic and Boyd, 2001; Walker, 2010).Root resorption associated with orthodontic treatment is more apparent in subjects due to excessive force and of long duration, delivered to the tooth in unfavourable directions, or when the tooth is unable to withstand normal forces due to a weakened support system(Mohandesan et al., 2007). The root resorption may undermine the continued existence and functional capacity of the affected tooth, depending on their magnitude of force since the root structure is changed. However, as the process of root resorption during orthodontic treatment is usually smooth and ends when the force is removed (Bartley et al., 2011).

The most often resorbed teeth is maxillary incisor (Lingeand Linge, 1991). Factors such as age, sex and orthodontic extractions can be considered as risk for root resorption(Sebbar and Bourzgui, 2011). Several biological, mechanical, and clinical factors were considered as causes of root resorption(Remington et al., 1989). The mean degree of resorption varies from 0.2 to 2.93 mm (Copeland and Green, 1986; Costopoulos and Nanda,

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1996). Radiographic examination of orthodontically treated patients shows around 48 per cent loss of radiographic root length (Lupi et al., 1996). Orthodontic rootresorptionhas received much attention in the recent past. This is clearly evident from the significant progress in understanding the actual process and the enormous amount of literature published. Orthodontic treatment is known to induce iatrogenic damage to the tooth (Brezniak and Wasserstein, 2002) .Orthodontists are constantly improving materials and techniques to minimize this undesirable treatment side effect of root resorption in Orthodontic treatment (Janson et al., 2000). This article focuses to review about root resorption in recent orthodontics

II. METHODOLOGY:

Scholarly articles related to root resorption in Orthodontics were explored on the web . An electronic search was initiated in Cochrane , pubmed and google scholar. As per the articles they mostly consistof patient related and clinical causes of root resorption during orthodontic tooth movement . This review is to analyse the causes and root resorption occurring in recently introduced orthodontic appliances.

Inclusion and exclusion criteria

Inclusion criteria :

- studies conducted on humans
- randomized and non-randomized controlled trials
- cohort studies
- descriptive studies
- Case reports
- Animal studies
- Systematic reviews and meta analysis

Exclusion criteria :

- Questionnaire studies

Pathogenesis:

Orthodontic forces represent a physical agent capable of inducing inflammatory reaction in the periodontium(Giannopoulou et al., 2008).When a tooth moves, a necrosis of periodontal ligament on the pressure side with formation of a cell-free hyaline zone occurs. This event is followed by osteoclast resorption of the neighbouring alveolar bone and bone apposition by osteoblasts on the tension side .When there is no balance between resorption and deposition along with loss of some of the protective characteristics of cementum may contribute to the cementoclasts / osteoclasts resorbing areas of the root (Abuabara, 2007).

Tooth commonly affected:

Most of the studies have found that maxillary teeth are more sensitive than mandibular teeth (Harris et al., 2006). The most often resorbed teeth is maxillary incisor (Copeland and Green, 1986). The second commonly affected tooth was maxillary lateral incisors followed by the mandibular incisors (Maués et al., 2015).If there is no apical root resorption seen in the maxillary and mandibular incisors, then significant apical resorption in other teeth is less likely to occur (DeShields, 1969). Vitality of the tooth is usually not affected in root resorption(Ketcham, 1927).

Etiology:

The etiologic factors are complex and multifactorial , but apical root resorption may result from a combination of individual factors . Patient-related factors include genetic predisposition, age, gender, tooth vitality, tooth type, facial and dentoalveolar structure, the experience of pretreatment root resorption, nutrition, habits, root form, previous trauma, and dense alveolarbone.Treatment-related factors that have been associated with apical root resorption include the magnitude of orthodontic force, treatment mechanics, direction of tooth movement, appliance type and treatment duration (Vlaskalic et al., 1998).

Genetic :

Genetic factors account for at least 50% of the variation in external root resorption . Variation in the Interleukin 1 beta gene in ortho patients injury to the periodontal ligament and supporting structures at the site of root compression following the application of orthodontic force as the earliest event leading to resorption . Decreased IL-1β production in the case of IL-1B (+3953) allele 1 may result in relatively less catabolic bone modelling (resorption) at the cortical bone interface with the PDL, which may result in prolonged stress concentrated in the root of the tooth, triggering a cascade of fatigue-related events leading to root resorption(Hartsfield and Everett, 2004).

Immune system:

Nishioka et al , reported that Allergy and asthma may be important risk factors in Japanese patients for the development of excessive root resorption during orthodontic tooth movement (Nishioka et al., 2006).McNab et al, found that subjects with allergy showed an increased risk of root resorption(Owmann-Moll and Kurol, 2000).

Trauma :

Philips found Orthodontically moved traumatised teeth with previous root resorption are more sensitive to further root resorption(Phillips, 1955). Incisors with clinical signs of trauma had essentially the same prevalence of moderate to severe root resorptionduring orthodontic treatment(Brin et al., 2003) .Levander et al , suggested that there are no statistically significant correlations between root resorption and trauma (Levander et al., 1994).

Extraction :

Extraction of tooth due to crowding have a longer treatment duration and more severe root resorption than non-extraction cases(Jiang et al., 2010). In Contrast , McFadden et al found that there is no difference in the extent of root resorption in patients treated with or without extractions (McFadden et al., 1989).

Age:

Adults have significantly more resorption than children (Sameshima and Sinclair, 2001).Patients starting treatment before 11 years of age experienced significantly less root resorption than patients starting later period due to the residual root growth (Linge and Linge, 1983). Brezniak et al, concluded that chronological age may not be a significant factor in the occurrence of orthodontic root resorption(Brezniak and Wasserstein, 2002).

Gender :

Brezniak et al , reviewed that a higher percentage of root resorption is seen in females who underwent orthodontic treatment compared to male (Brezniak and Wasserstein, 1993). In Contrast , Baumrind et al, in a study found a greater prevalence of root resorption in men than in women in adult orthodontic patients (Baumrind et al., 1996). There is no difference between male and female patients for root resorption for any teeth (Sameshima and Sinclair, 2001).

III. Endodontically treated Tooth :

Spurrier et al , compared the root resorption between vital and Endodontically treated incisors, and found that there is no significant difference in root resorption seen among males and females in endodontically treated incisors, while significant resorption was seen in vital Tooth in male (Spurrier et al., 1990). In ContrastThere was no significant difference in the amount or severity of external root resorption during orthodontic movement between root filled teeth and their contralateral teeth with vital pulp (Llamas-Carreras et al., 2010) . Hence,Endodontically treated incisors are less vulnerable to root resorptionwhen compared with normal teeth. Murata et al, stated that filling the root canal with calcium hydroxide might be effective in inhibiting root resorption(Murata et al., 2013).

Habits:

Odenrick et al , found the frequency of apical root resorption to be significantly higher in the severe nail biters before and after orthodontic treatment (Odenrick and Brattström, 1985). Newman concluded that tongue thrust associated with open bite, and increased tongue pressure have been statistically related to increased root resorption(Brezniak and Wasserstein, 1993). Fried et al found that Bruxism has been associated with orthodontically induced root resorption(Fried, 1976).

Root morphology:

Scott et al , quoted that geometrical forms of roots can affect the distribution of the force through the alveolar bone and root, roots with dilaceration are more prone to root resorption(Scott et al., 2008). Some authors have stated that teeth with invaginations , thin or pipette-shaped roots and teeth with short or blunt roots were more likely to be susceptible to root resorption than those without such anomalies (Thongudomporn and Freer, 1998) . It has been concluded by Mavragani et al that , if the root formation was completed at the time of orthodontic treatment root resorption was significantly more , while incase of incomplete root formation the root resorption was slightly less than the completely formed Tooth (Mavragani et al., 2002) . Tooth with longer roots need stronger forces to be moved and that the actual displacement of the root apex is greater during tipping or torquing movements (Hartsfield and Everett, 2004).

Dentition :

Luther found that ,greater the overjet during the orthodontic treatment, the greater the root resorption for maxillary anterior teeth due to increased treatment time and greater force required to decrease the overjet(Luther et al., 2005).

Alveolar bone:

Reitan et al , stated that more denser the alveolar bone the more will be the root resorption occurred during orthodontic treatment ,In a less dense alveolar bone, there are more marrow spaces and presence of more resorptive cells in marrow space which compensates resorption(Reitan, 1985). High bone turnover, found in patients with hyperthyroidism, can increase the amount of tooth movement compared with the normal or low bone turnover state and adult patients (Verna et al., 2003).

Hypofunction of periodontium:

Motokawa et al ,static or dynamic occlusal relationship may result in atrophic changes in Sharpey'sfibers, a decrease in the fibroblastic proliferation activity, and vascular constriction . Further, the periodontal space narrows, and the force becomes concentrated in pressure areas. prevalence of root resorption in hypofunctional teeth is higher than that in normal teeth (Motokawa et al., 2013).

Drugs:

Krishnan et al , reviewed that as the duration of orthodontic treatment is increased for patients under Bisphosphonate therapy it interfered with the osteoclasticresorption activity (Krishnan et al., 2015)**.** It has been found that Local application of Bisphosphonate (riserdronate) used in rats arrests root resorption(Adachi et al., 1994) **.**Administrationof prednisolone and celecoxib have been found to reduce the root resorption and increase in the tooth movement in rats (Jerome et al., 2005). Ong et al .found High dose of corticosteroid administration caused severe root resorption while low doses decreased the root resorption in rats (Ong et al., 2000).

Type of Bracket

Mavragani et al reported significantly more apical root resorption of central incisors in the standard than the straight-wire edgewise group (Mavragani et al., 2002). Some authors have suggested that the Begg technique might cause more harmful effects on the roots (Ten Hoeve and Mulie, 1976). Straight wire patients showed more resorption which could be attributed to more root movement because of built in torque (ZahedZahedani et al., 2013). McNab concluded that the incidence of EARR was 2.30 times higher for Begg appliances compared with edgewise (McNab et al., 2000). Leite et al found that the brackets (passive self-ligating or conventional preadjusted) did not seem to influence the degree of EARR when estimated using CBCT (Leite et al., 2012). Reukers et al compared the prevalence and severity of root resorption after treatment with a fully programmed edgewise appliance (FPA) and a partly programmed edgewise appliance (PPA) and found no significant root resorption(Reukers et al., 1998).

Force:

Intermittent forces result in lesser root resorption than continuous forces(Aras et al., 2012). It has been concluded by Paetyangkul et al , that increasing force root resorption also increases also increase in the application time of light force application increases the root resorption even if a light force was applied, whenever there is an

increase in the application time, root resorption also increases (Paetyangkul et al., 2009). Rapid maxillary expansion might induce root resorption in the premolars and molars (Dindaroğlu and Doğan, 2016). Significantly more root resorption on the side where elastics were used and suggested that jiggling forces the result of function combined with elastics are responsible for the incisors' rootresorption ((McFadden et al., 1989). Rudolph found greater root resorption is seen on the side of the tooth arch where elastics were used Use of Class III elastics increases root resorption of first mandibular molars distal root (Rudolph, 1936).

Types of Tooth movement:

Han et al , studied the root resorption in extrinsic and intrinsic Tooth movements. When compared with intrusive movements, extrusive movements occur easily, but they also cause root resorption in interdental areas in the cervical third of the root. It has been reported that root resorption occurs four times more during intrusion than during extrusion(Han et al., 2005). Philips et al ,reported that there was no direct relationship between root resorption and the sagittal or angular movements of the root apex(Phillips, 1955). Reitan et al , concluded that stress distribution along the other areas of the roots during bodily movement is less than the stress concentration at the apex of the root resulting in tipping. Therefore risk of root resorption that is due to bodily movement should be less than that of tipping (Reitan, 1985). Segal et al , found that apical movement of Tooth increase the severity of root resorption(Segal et al., 2004).

Friction and frictionless mechanics:

Two basic biomechanical strategies can be used to close spaces: frictionless (closing loop mechanics) and frictional (sliding mechanics). Applying force by means of coil springs or power chain elastics in sliding mechanics will produce friction between the bracket and the archwire, and the tooth feels less force than the orthodontist is in fact applying (Ribeiro and Jacob, 2016).

Orthodontists bend closing loops in a continuous archwire or a segmented arch with a view to delivering forces that can perform space closure and promote greater rates of tooth displacement (Ribeiro and Jacob, 2016). Scott et al , concluded that the amount of root resorption in Damon-3 self-ligating braces and brackets (frictional) and conventional brackets are similar (Scott et al., 2008). Maxillary incisor retraction using stainless steel boot loop showed greater root resorption as compared to TMA boot loop in frictionless mechanics (Gupta et al., 2016). Katz et al, demonstrated that metal coating containing fullerene-like WS_2 (*IF*) nanoparticles in orthodontic frictional self-lubricating wires and found the coatings significantly decreased the archwire friction, and alleviate adverse complications (Katz et al., 2006).

Invisible aligners:

Krieger et al, in a radiometric study witnessed that patients with invisible aligners had apical root resorption minimum of two teeth affected with a reduction of the root length after treatment (Krieger et al., 2013). In a retrospective cohort study by Brandon compared the incidence and severity of root resorption after orthodontic treatment using fixed appliances and aligners (Invisalign®) and reported that there is almost similar amount of apical root resorption in patients treated with fixed appliances and removable aligners (Gay et al., 2017; Iglesias-Linares et al., 2017).Incontrast Fowler et al in a comparative study between contemporary and invisible aligner found that root resorption was detected in the group of teeth treated by the Invisalign® technique in maxillary

and mandibular incisors and canine (Fowler, 2010). Barbagallo et al, conducted a randomized controlled trial, in which they compared rate of root resorption in aligners to those of heavy and light force groups and found that group with teeth treated by heavy forces presented the highest incidence of root resorption , while the group treated by light force the resorption incidence was the lowest whereas for the teeth treated by aligners, the resorption incidence was almost similar to that in the light force group (Barbagallo et al., 2008).

Lingual appliance :

Fritz et al , reported that lingual orthodontic therapy resulted in only slight root resorptions and there was no significant relationship between extent of root resorption and other etiologies(Fritz et al., 2003).Nassif et al , reported that the magnitude of apical root resorption in maxillary incisors in patients with anterior crowding was similar regardless of orthodontic technique, lingual or conventional technique (Nassif et al., 2017).

Lasers :

The Orthopulsephotobiomodulation device can be used clinically for acceleration of tooth movement, there is less root resorptionin the lower dose of laser (Nimeri et al., 2014).Ekizer et al , found the light-emitting diode-mediated-photobiomodulation therapy (LPT) method has the potential of accelerating orthodontic tooth movement and inhibitory effects on orthodontically induced resorptive activity (Ekizer et al., 2015)

IV. INVESTIGATIONS:

Scanning electron microscope

SEM enhanced visual and perspective assessment of root surfaces and that when recorded in stereo pairs compared to normal electron microscopy(Kravitz et al., 1992). Chan at el , examined root resorption with SEM and calculated resorption craters with surface signs obtained from micrographs (Chan and Darendeliler, 2004). However Calculation errors remain a limitation with this method .

Radiographic diagnosis

Radiographs are the most popular tool in the diagnosis procedure conventional radiographs (periapical graphs, digital radiography, orthopantomography (OPG) , and lateral cephalometric radiography), light microscopes, and scanning electron microscopes. Recently, computed tomography (CT) ,micro-CT and CBCT are also used . Periapicalradiographs are not routinely taken during orthodontic treatment because of the high quality of the panoramic images. The use of panoramic radiographs for assessing root resorption and root shape has however some drawbacks. It has been suggested that the use of this technique may overestimate the extent of root loss by 20 per cent(Sameshima and Asgarifar, 2001). CBCT is a powerful tool to show apical root resorption during orthodontic treatment compared to conventional radiograph. Conventional radiograph shows 2D Image of a 3D object , while CBCT estimates it from all the three dimensions. Dudic et al has reported that CBCT evaluates patients at risk of developing root resorption , whereas OPG under- estimates it (Dudic et al., 2009). Scarfe et al , has found CBCT to be lesser radiation dosage compared to the conventional Imaging technique (74).Root resorption can be measured or detected only in in vitro conditions, and to obtain high-resolution images in vivo, high radiation levels are required this restricts the use of micro-CT images in vivo (Scarfe et al., 2006).

V. TREATMENT

Several studies have been published in the last decade, it is still impossible to point out a system that will reduce or eliminate the OIIRR (Brezniak and Wasserstein, 2002; Rudolph, 1936)**.** If root resorption is diagnosed on the final radiographs after treatment, follow-up radiographic examinations are recommended until the resorption has stabilized (Brezniak and Wasserstein, 2002). Cheng et al , 2009 found thatresorption continued for 4 weeks after the stop of the orthodontic force. After a four-week light force application which was followed by 4-week retention, there was continuous and regular repair(Cheng et al., 2009). Hence light and intermittent forces application is recommended. Short treatment period is advisable to reduce the risk of root resorption(Fritz et al., 2003). El-bialy et al reported that orthodontically induced Root resorption can be repaired by low intensity pulsed ultrasound as it decreases the osteoclasts activity and increases the RANKL ratio (El-Bialy et al., 2004). Repair of resorbed root after the active force has been removed, as secondary cementum deposits take place and compensates the resorption(Owman-Moll, 1995). Owman et al ,repair process was based on cellular cementumdeposits. Based on the histological level of resorption cavity repair classified it into three repair types , partial repair which was the most frequent type with partial deposition of cementum and functional repair where the total resorption cavity was deposited with varying thickness of cementum(Owman-Moll et al., 1995).

VI. CONCLUSION

Root resorption of permanent teeth is an unavoidable consequence of orthodontic treatment and active tooth movement and patients should be informed about it. The etiology of root resorption in orthodontics is multifactorial in nature . There is no clear treatment suggested to eliminate the root resorption. Orthodontists are constantly improving materials and techniques to minimize this undesirable treatment side effect of root resorption in Orthodontic treatment.

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