ENDO-ORTHO RELATIONSHIP : AN OVER-VIEW

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When teeth are moved orthodontically, the periodontal ligament and the alveolar bone are the tissues which directly respond to the forces. But in addition, the cementum, dentin and pulp also respond to these forces. If the force is within the tolerance limits of the tissues, favourable response in terms of desired tooth movement and healthy teeth and supporting structures would result. However, if the force is in excess, adverse reaction of the tissues would cause pain, excess mobility, resorption of roots etc.

The paper aims to highlight the adverse tissue response to various factors related to orthodontic treatment, their prevention and management. In addition, the paper aims to discuss the timing and effect of endodontic therapy on orthodontic treatment as well as therapeutic use of combined endo-ortho treatment in specific cases to achieve optimal result.

CAUSES AND EFFECT OF ORTHODONTIC FORCES ON PULP

Causes

Heavy continuous force. It causes undermining bone resorption leading to large increments of change and abrupt tooth movement resulting in severance of blood supply to the pulp[1].

Distal tipping of incisors: Tipping movement to an extent that the root-tip is actually moved outside the alveolar process can also cut off the blood supply to the pulp[1].

Thermo-debonding of ceramic orthodontic brackets: Repeated heating cycles for thermo-debonding by electromagnetic induction can cause pulp damage by heat and cracks[2].

Effects

Pulp is very resilient and has great potential for healing. Only when all compensatory mechanisms fail, that the pulp becomes necrotic. The earliest change observed in response to orthodontic pressure is the vacuolization of odontoblast layers[3]. Mild forces causes hyperemia-thus patients experience sensitivity to thermal changes after each adjustment of orthodontic appliances. If pressure is severe, partial or total degeneration is possible. The tooth turns dark as haemorrhage and necrosis occur. During orthodontic treatment decreased sensitivity to electric pulp testing may occur which returns to normal after completion of the therapy.

PATHOPHYSIOLOGIC MECHANISMS IN PULP NECROSIS

Any kind of insult to the pulp triggers off release of inflammatory mediators which cause vasodilatation, and increase in vascular permeability. Extravasation of serum proteins and fluids from the vessels, cause tissue oedema, increase in blood viscosity, hypoxia and fall in tissue pH. These changes in local metabolism leads to vasodilatation in the adjacent areas and gradual spread of inflammation. Circumferential spread of inflammation was demonstrated by Van Hassel[4]. in an elegant experiment in the 1970s.

Evidence of pulp involvement are increased sensitivity after activation of orthodontic appliances, decreased pulp space, periapical radiolucency and internal resorption.

INTERNAL ROOT RESORPTION

The condition is asymtomatic and is generally accidently diagnosed from the x-rays except when it occurs in the coronal aspect to an extent to be visible through the enamel, the condition being described as a "pink spot". The most common aetiological factor in internal root-resorption is trauma including luxation injuries and orthodontic pressures[5]. Other causes described are calcium hydroxide pulpotomy, application of diathermy, bacterial infection, anachoresis and cracked tooth.

PATHOLOGY OF INTERNAL ROOT RESORPTION

Inflammation within the pulp as a cause of internal resorption was recognized[6] as early as in 1830. Root canal provides an atmosphere well-suited for development of hard tissue resorbing cells. Circulation changes influence cell metabolism. Active hypermia with high CO_2 pressure supports and induces odontoclastic activity. Electric activity such as piezoelectricity and streaming potentials (charges arising from blood flow through the vessels) add to resorptive process[7].

Cytologic and histological alterations occur within the pulp when odontoclasts form from the undifferentiated reserve connective tissue cells[8]. Multinucleated giant cells lying in resorptive lacunae in dentin are of similar morphology to the bone resorbing cells and have similar enzymes eg: acid phosphates and glucoronidase.

SEM study has revealed that there are organic materials

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and micro-organisms like structures in resorbed root. Stanley[9] reported that concomitant with resorption, deposition of hard tissues resembling bone or cementum, bearing no relationship to normal form of the tooth takes place.

TREATMENT

Internal resorption can be effectively arrested by conservative endodontic treatment. Removal of chronically inflamed pulp tissue and subsequent hermetic sealing of the root canal and resorption defect is satisfactory in managing internal resorption defect which has not perforated the canal wall.

In cases where the resorption has caused perforation, the management differs depending on whether the defect is apical or coronal to the epithetial attachment (i.e. whether it communicates with oral fluids or not). Perforating defect apical to the epithetial attachment can be managed by recalcification induced by calcium hydroxide dressings of the root canal.

Resorption defect in the cervical area of the root which communicate with the oral fluids need to be treated by endodontic treatment and surgical repair of the defect. After exposing the defect surgically, all pathological granulation tissue is curetted, the necrotic cementum and dentin excavated, defect is cauterized by one minute application of trichloracetic acid. The defect is then sealed with silver amalgam or glass-ionomer cement.

EXTERNAL ROOT RESORPTION

External resorption is almost universal. Microscopic areas of lateral resorption are common in elderly. With light microscopy 80% of healthy teeth and 90% of periodontally-involved teeth showed root resorption[10]. Root resorption was demonstrated on extracted teeth[11] as early as in 1887.

Resorption of root is preceded by hyalinization in the periodontal ligment[12]. Undermining resorption of bone also leads to root surface resorption which starts at the border of the hyalinized zone. If cementiod and predentin layers are thick, resorption does not occur. If the root surface is well calcified tipping movement can cause resorption of the outer side of apical portion as well as along the inside of the root canal. Thick cementum layer and strong apical fibres in adults affects the tooth movement.

Common causes of external root resorption: The most common cause of external root resorption is the peri-apical pathology. Other common causes include excessive mechanical (orthodontic) force, replantation of teeth, tumours and cyst, idiopathic, bleaching of endodontically treated teeth, luxation injuries, periodontal diseases and radiation therapy. Certain metabolic disorders such as hypo and hyperparathyroidism, calcinosis, gauchers disease. Turner's syndrome, paget's disease[13] and herpes zoster[14] can also cause external root resorption.

EXTERNAL ROOT-RESORPTION RELATED TO ORTHODONTIC CAUSES

Mal-occlusion and aberrant oral habits can lead to external root resorption. Open bite with tongue thrusting can cause apical root resorption due to jiggling forces of soft tissue over a period of time[15]. Excessive occlusal load dissipated in the long axis of a premolar in class III cases can cause shortening of tooth apex[16]. An erupting canine can cause resorption of the root of lateral incisor and in some cases can completely resorb its root in a span of just about two months[17]. If detected early, the canine can be moved distally or palatally and resorption of lateral incisor can be arrested. External root resorption secondary to alveolar bone grafting in cleft palate cases is reported by Gerner et al [18].

EFFECT OF ORTHODONTIC FORCE

The net effect of orthodontic force depends on a number of factors like rate, magnitude and direction of force, size and location of teeth, type of tooth movement and orthodontic appliance being used, previous trauma or endodontic treatment in the teeth being moved and finally, the age at which the orthodontic treatment is undertaken.

AMOUNT OF FORCE

Higher the magnitude of force, higher will be the possibility of root resorption. However resorption is less related to the magnitude of force than by the rate of application of the force[19]. Prolonged orthodontic treatment may be associated with increased root resorption[20]. However, others have reported decreased root resorption with increased treatment time[21].

DURATION AND DIRECTION OF TOOTH MOVEMENT

Tooth movement in a mesiodistal direction within the alveolar through is more favourable than in the labio-lingual direction[22]. Tipping leads to increased resorption than bodily movement[23]. Prolonged tipping or intrusion may result in compression of predentin layers and apical root resorption. Tipping force even if it is light but of a continuous nature, can cause extensive apical root resorption[24].

Prolonged tipping of anterior teeth, distal tipping of molars, extensive edgewise torquing of anterior teeth are some of the examples of orthodontic treatment which are related to root resorption.

Resorption ceases at completion of active and retentive phase. If continues, intentional extirpation of pulp and $Ca(OH)_2$ therapy has been found successful in abating the resorption[25].

TYPE OF ORTHODONTIC APPLIANCES USED

Generally, fixed appliance causes more root resorption than the removable appliances[26]. It could be due to the fact

that soft tissues covered in the removable appliances contribute towards anchorage where as in fixed appliances, entire anchorage is borne by the teeth. Thus in rapid maxillary expansion, tooth borne all wire appliance is found to cause more resorption than tissue borne Hans appliance[27]. Similarly, overject correction with fixed appliance using rectangular wires and class II elastics is associated with some amount of root resorption while those treated with functional appliances does not cause any root resorption[28].

SIZE AND LOCATION OF TEETH

Molars and premolars show less tendency for root-resorption, than incisors due to increased resistance offered by the higher surface area of multiple roots of these teeth compared to incisors which have single and slender roots. A resorptive index has been reported for quantitative assessment of occurrence and degree of root resorption during orthodontic treatment. By this index, highest (95%) resorption was found in mandibular central incisors (90%) in maxillary central incisors and (87%) in maxillary lateral incisors. Lowest resorption (53%) was found in mandibular premolars[20].

TRAUMA AND ORTHODONTIC TREATMENT

Age at which trauma was received and age at the start of orthodontic treatment affects the amount of root resorption[29]. Also severity of trauma is positively correlated with increased tendency towards root resorption. Malamgren et al[30] studied the effect of orthodontic treatment on previously traumatized teeth. It was found that orthodontic forces on previously traumatized teeth caused three fold increase in prevalance of root resorption. Recurrent trauma led to resorption in 75% as compared to only in 35% in single trauma cases. Teeth adjacent to traumatized teeth showed more tendency towards root resorption compared to the non-trauma group of patients. Thus, teeth adjacent to traumatized teeth require careful watch during orthodontic treatment to detect early resorptive changes.

ENDODONTIC TREATMENT RELATED TO ORTHODONTICS

There is no contra-indication to endodontic therapy being undertaken simultaneously with orthodontic treatment. Metallic brackets, bands and archwire exclude the use of electric pulp testing devices. Length measurement is critical in these cases as root-resorption could have caused shortening of root length and therefore, over-filling might result.

It has been found that there is no difference in response between a vital and an endodontically treated tooth to orthodontic forces in terms of movement of the tooth since periodontal tissues and not the pulpal tissue is primarily responsible for orthodontic tooth movement[30].

Incidence of external root resorption is found to be greater in vital teeth as compared to endodontically treated teeth[31]. Increased density of dentin in devitalized teeth is believed to be the reason for slower resorption of root filled teeth compared to vital teeth. However, there are conflicting opinions on this aspect, some reporting no difference[32] and yet another reporting higher incidence of external root resorption in endodontically treated teeth[33].

AGE OF THE PATIENT

Age at the start of endodontic treatment affects the amount of root resorption[26]. In older children more root resorption is found than in younger children. In younger children, root is covered with thick cementoid layer which is resistant to resorption[34]. As age advances, the cementum becomes more acellular and heavily mineralized which is more susceptable to resorption[35]. Linge and Linge[36] in a retrospective study on 485 orthodontically treated patients in the age group of 11.5-25 years, found that root-resorption was insignificantly co-related with age. However, below 11.5 years, it was significantly co-related. Thick cementum and strong apical fibers in older age group, affect the amount of tooth movement and root resorption.

COMBINED ENDO-ORTHO THERAPY

Endodontic therapy in conjuction with orthodontic treatment can be gainfully employed in certain cases where one single modality of treatment may not yield optimal results. Two such situations are: forced eruption of teeth and therapeutic ankylosis of deciduous canines. The rationale, technique and advantages of these procedures are discussed.

1. Forced Eruption

The principle of forced eruption of teeth was documented by Angle before 1900[5]. In recent past, the concept was revived by Heithersay[37] and Ingber[38]. Some of the indications for forced eruption or combined endo-ortho treatment include teeth with advanced caries, traumatic destruction of clinical crown, lateral root perforation, external or internal root resorption near the alveolar crest and isolated infra-bony defects. Orthodontic eruption of the tooth along with its attachment apparatus and gingiva eliminates the need for periodontal surgery to expose the sound tooth structure. The multi-disciplinary approach improves the existing periodontal environment by improving the osseous topography and minimizing the need to remove the supporting bone on the adjacent teeth.

Forced eruption is preferred only in anteriors and premolars. The procedure is not indicated in multi-rooted teeth since forced eruption would bring the furcation area closer to the cemento-enamel junction of the adjacent teeth making it susceptible to recurrent infections. Besides, there is no demand on esthetics and adequate bone is available to perform the surgery without compromising the bony support.

Before forced eruption is begun, uprighting and correction of axial tooth position must be done. If endodontic treatment

is indicated or would be required at a later date to restore the tooth, it is preferable to complete it first. In cases, where there is excessive destruction of clinical crown, adequate size post space must be made in the root. A snughly fitting customized or pre-fabricated post is cemented with a semi-temporary cement. A loop bend is provided at the occlusal end of the post for attachment to the rigid arch wire. Direct bonding brackets with horizontal slots are placed on multiple teeth, as far incisally as possible so that the tooth can be extruded a maximum distance. Elastic ligature cord is tied from the loop to the rigid arch wire. Adequate anchorhage atleast two teeth on either side of the tooth to be erupted, is necessary to resist their own displacement.

2. Therapeutic Ankylosis of Primary Teeth

Kokich and collegues[39] first gave the concept of therapeutic ankylosis and reported a case. Sheller and Omnell[40] gave the detailed indications and technique of achieving the therapeutic ankylosis. In young patients, with mild to moderate retrusion, the maxilla can be protracted with a reverse pull headgear. Anchorhage for the protraction of maxilla can be obtained by ankylosing the primary canines. The procedure has several advantages: the autogenous tooth is bicompatible and produces skeletel rather than the dental movement.

Under local anaesthesia and mild sedation, the primary canines are extracted. Endodontic treatment is performed extra-orally and the canals filled with calcium-hydroxide. A hook is bonded to the labial surface of the canine for elastic attachments. Before replantation, all the periodontal ligament tissue is curetted away from the root surface, apical 2 mm of the root-tip is cut off and the blood clot is also removed from the socket to affect ankylosis of the replanted tooth. The tooth is then stabilized from 4-5 weeks with splinting wires bonded to the anterior teeth. Occlusal interference, if any, is removed by giving bilateral occlusal composite additions on mandibular molars. Protraction is started eight weeks after surgery. Retention of ankylosed teeth ranged between 4 to 36 months. However, the time required for protraction of maxilla is only about six months, ranging from 4 to 12 months.

CONCLUSION

Some of the orthodontic factors which may necessitate endodontic treatment are highlighted so that these factors are recognized by the clinicians and guarded against. On the other hand, combined endo-ortho treatment for achieving forced eruptions and for obtaining anchorhage during protraction of retruded maxilla, are highlighted so that advantage could be taken of these therapeutic approaches in appropriate cases.

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