Root resorption in orthodontics

Root resorption has been described as an idiopathic side effect in orthodontics. Although it may seem to be detrimental to the health of the dentition, it has been noted that root resorption could occur naturally and would not undermine the form and longevity of a normal functional occlusion.

Root resorption of the deciduous dentition is a normal, essential and physiologic process. Usually it is a necessary precursor to the eruption of the permanent teeth. Even with agenesis of its corresponding permanent tooth, some deciduous teeth still undergo root resorption. On the other hand, resorption of the permanent teeth, a complex biologic process of which many aspects still remain unclear.

Incidence and susceptibility
The incidence of root resorption varies in different studies. Most investigations, however, agree that idiopathic root resorption does occur in an untreated population. A high percentage (90.5 per cent) of untreated permanent teeth play microscopic lesions of external root resorption (0.75 mm length and 0.10 mm depth).

The numbers of incisors with root resorption increases from 15 per cent before treatment to 75 per cent after treatment. The most frequent site is at the apex, followed by mesial, buccal, distal and lingual surfaces. The most commonly affected teeth (in decreasing frequency) are: maxillary laterals, mandibular incisors, mandibular first molars, mandibular second premolars and maxillary second molars.

The differences between right and left sides or maxillary and mandibular teeth are negligible. When molars do exhibit resorption, they have greater resorption areas than the total root surface area.2 Susceptibility to root resorption varies considerably. Teeth with radiographic signs of resorption prior to treatment have been reported to develop more extensive areas of root destruction than initially intact. However, in most cases, it could still be very unpredictable.

The type of appliances used in the management of the orthodontic malocclusion usually dictates the type of resorption. In palatal expansion, resorption develops mainly in the cervical part of the mesialocclusal surfaces and furcation areas of multi-rooted teeth, and also buccal and apical egests of single-rooted teeth with limited involvement of other areas. However, such cervical resorption generally remains undiagnosed unless it is extensive, whereas apical root resorption is often readily visible on radiographs.

Aetiology and type
The aetiology of root resorption is multifactorial. Whenever extensive areas of resorption occur, various predisposing factors have been proposed: vitality of the pulp, gender of the patient, type and mechanics of force delivery, bone density, magnitude and duration of the force and systemic factors (eg, endocrine disorders, asthma).

In general, clinical orthodontics often presents with three types of external root resorption: surface, inflammatory and replacement resorption. Surface resorption is usually a self-limiting process involving small outlying areas followed by spontaneous repair and adjacent intact parts of the periodontal ligament. Inflammatory resorption occurs when initial root resorption has reached dentinal tubules of an infected necrotic pulp tissue or an infected leucocyte zone. Replacement resorption takes place when bone replaces the resorbed tooth material leading to ankylosis.

Root resorption encountered in orthodontic treatment is often surface resorption or transient inflammatory resorption. Occurrences of replacement resorption as a consequence of orthodontic tooth movement are rare.

Mechanism of root resorption
Orthodontic forces applied to the dental system do not act directly on bone and cementum. This bone-cementum interface is separated by the periodontal ligament (PDL). If there were no differences in the biologic behavior of these two organs, both would undergo resorption equally. However, for tooth movement to occur, bone has to resorb at a greater rate than cementum. Although it has been noted that under applied orthodontic forces, cementum does have a higher resistance to resorption than bone, resorption of the cementum and dentine also occurs.

Clinically, after the application of orthodontic force, it can take between 10 and 35 days for a resorbed crater to appear. This degree of resorption cannot be detected clinically with radiographs, especially when occurring on the buccal and lingual surfaces.

Replacement resorptions appear mainly on the pressure side and rarely on the tension side. With bone, cementum tends to decrease in thickness on the side of compression. If the pressure persists, root resorption progresses even if it was initially protected by uncalcified tissue. Human and animal research demonstrates that periodontal hyalinisation precedes the root resorption process during orthodontic treatment. Loss of root material occurs adjacent and subjacent to this area.

Three stages are described in the hyalinised zone: degeneration, elimination of destroyed products, and re-establishment. During the remodeling process of the hyalinised zone, the necrotic hyalinised tissue and alveolar bone wall are removed by phagocytic cells such as macrophages, foreign body giant cells and osteoclasts.

As a side effect of the cellular activity during the removal of the necrotic PDL tissue, the cementoid layer of the root and the bone are left with raw unprotected surfaces in certain areas that can readily be attacked by resorptive cells. Root resorption then occurs around this cell-free tissue, starting at the border of the hyalinised zone.

Further investigations by Brudvik10-11 and Rygh49-51 have noted that multi-nucleated giant cell-like cells with ruffled borders mainly accounted for the removal of this hyalinised tissue and subsequent resorption.

Force-related factors
The magnitude of force has been considered an important factor with regards to the rate of tooth movement in orthodontics. Brind44-48 has always advocated the use of light orthodontic forces in order to increase cellular activity in the surrounding tissues and reduce the risk of root resorptions. This was later confirmed by King and Fischheiniger28. In an investigation with rats they found that light forces produced insignificant root resorptions whereas intermediate or heavy forces resulted in substantial crater formation. This result was in agreement with earlier findings, both in animals and in humans.

However, contradictory findings were reported by Stevnik and Mjör56 in a study concerning premolar intrusion in humans. They observed that root resorptions increased after application of light forces, 55 g when compared to heavy forces, 250 g.

Storey and Smith42 reported the ‘optimal force’ theory and documented a range of pressure 150–200 g (equivalent to 150–200 cN) on the toothbone interface that would produce the maximum rate of tooth movement for distalization of maxillary canines in humans. For pressures below this range, movement was limited due to the ability of the soft tissue to function as a shock absorber. If the force was increased beyond this optimum, the displacement would be reduced due to tissue necrosis of the PDL, ie, hyalinization.

This theory was critically reviewed by Boester and Johnston51 who found that the amount of space closure after premolar extraction was about the same if the applied force was 5, 8 or 11 ounces (140, 225 and 510 g), but significantly less if only 2 ounces (55 g) was used. A similar opinion has been presented by other researchers who suggested that tooth displacement was the same even if the applied force was increased.

However, other investigations demonstrated a more linear relationship between force magnitude and tooth movement: the heavier the applied force, the greater the rate of tooth movement. In the early 1970s two reports, one on humans43 and one on cats44, presented a large variation in tooth movement in response to applied force magnitudes. This was further confirmed in an investigation in dogs by Matha et al57. They reported that bodily tooth movement...
Recent investigations with beagle dogs revealed that the rate of tooth movement did not depend on the magnitude of forces used, but rather on whether continuous or intermittent forces were applied. They found that there was a greater tooth movement in continuous light force application as compared to intermittent forces applied in premolars of beagle dogs. However, contrary to Pilon’s study, they reported that if forces were sufficiently lighter, the increase in the magnitude of forces can influence the rate of tooth movement.

A more recent study further explored the extent of root resorption using this experimental setup. It was reported that intermittent forces cause less root resorption than continuous forces, and that force duration plays an important role in the extent of resorption. However, they noted that root resorption may still not be sensitive to the magnitude of forces applied.

As a consequence of such diverse findings, it becomes confusing as to whether the direct correlation of the magnitude of force used for hard tissue destruction in orthodontics. Closer examination of the methodologies of these studies explains intricate results and findings.

Quantitative evaluation of resorption using radiographs has proven to be highly inaccurate due to magnification errors and their inability to be readily reproducible. Studies using histology sections of samples have proven to be laborious and technique sensitive. Inherent parallax errors and loss of material in data transfer have diminished the true understanding of this three-dimensional event. The case selection of subject matter is often unclear. Having a multifactorial aetiology, the study of root resorption becomes complicated if underlying systemic and local factors that may predispose to resorption have contributed to other confounding factors cited.

Recent findings in a more controlled clinical evaluation in humans have demonstrated that accurate volumetric quantification of root resorption cannot be obtained. Heavy forces consistently generated more root resorption than lighter forces. There was more root resorption in the areas under high compression as compared to the areas under tension.

These events indicate that a higher level of forces does relate directly to root resorption, and the notion of using light forces in clinical orthodontics should be adhered to as much as possible.

Repair potential

Despite the negative reports on root resorption, most external root resorption could be self-limiting. It should be noted that self-limiting does not equate to a reversal of damage. Approximately 70 per cent of all defects seen in old teeth are anatomically repaired. However, the mechanism behind this self-limiting phenomenon has not been fully explored.

It has been suggested that once the level of force decreases, the healing process is initiated. Repair of resorbed craters is seen after 55 to 70 days after applied force decays. Some cemental resorbed craters are fully anatomically reconstructed. Deep dentinal craters are repaired by a thin cemental layer that results in an irregularly shaped root. However, some authorities would have deemed this effect as irreversible damage. After both types of repair, the periodontal ligament width is usually normal. The root contour is frequently closely followed by bone contour, increasing tooth anchorage without compromising function.

Several studies have been carried out to elucidate the reparative process during reten- tion after rapid maxillary expansion, and they all agreed that repair seemed to increase with retention time. It has been hypothesised that all resorptions will be repaired once the cause of root resorption has ceased. However, Vardimon et al.14 claimed that all resorptions would heal provided that the resorbed surface area does not exceed the unresorbed one.

Case report

The following report demonstrates a case with an underlying condition with a predisposition for root resorption and has shown marked progress of hard tissue destruction during the course of orthodontic treatment.

Case history and treatment plan

Patient RN was 17 years and 8 months old and attended the clinic when she first presented in the clinic for records (Fig. 1). Her chief complaint was her crooked front teeth. She had a history of trauma at region #21 when she fell and hit her front teeth on the side of a swimming pool a few years ago (Fig. 2). The tooth was asymptomatic, and her periapical radiographs did not show any signs of periapical lesion. She was diagnosed as a class II division 1 malocclusion on a skeletal 1 base with normal angle of growth.

The extraction of upper first and lower second premolars was indicated, followed by full fixed orthodontic appliance therapy. Her oral hygiene was fair, and special care was taken to periodontal radiographs of her upper front teeth as treatment progressed.

Upper space closure should be done judiciously in round wires with light forces. Due to her marked upper midsagittal discrepancy, it was noted that her midlines might not be fully corrected at the end of treatment. The decision was made that her upper front teeth would be restored after the completion of orthodontic treatment.

Treatment progress

RN’s treatment progressed well initially, but after a couple of months her oral hygiene deteriorated and she started to miss her appointments. She had repeated constant multiple breakages, but did not report them until the following appointment. On the phone call to her mom revealed that they had some family problems to deal with at home. They were also on government welfare and pension. Most failed appointments were due to her inability to afford a train ticket to travel up for her appointments.

These issues, coupled with her complicated case history, got more complex when she called up one morning reporting that she was expecting a child and was 6 months into pregnancy. As extractions spaces were still present and the progress of her case slow due to her frequent failed appointments, the immediate plan was to complete space closure and get her into a functionally acceptable occlusion as soon as possible.

Her oral hygiene deteriorated further from this point, and after a couple more months, her mobile phone was disconnected and we were not able to contact her. RN did not return to the clinic until after she had her baby son, which was another 4 months later. She still maintained poor attendance at the clinic while we were trying to close up all the spaces and get her out of treatment as soon as possible.

We did not see her for another 6 months. This time she had another fall and hit her already compromised #21 and fractured it further. An emergency appointment was made for her to attend the general dentistry clinic to have that restored, but she failed to attend that clinic as well.

When she turned up again another 9 months later, there were generalised decalcifications, multiple caries detected and ap- palling oral hygiene. At this stage, all the spaces were closed and immediate removal of the fixed orthodontic appliances was performed (Fig. 5).

Radiographs at this stage showed marked root shortening (Fig. 4); however, clinically, the teeth were not any more mobile than usual. Figures 5–a to 5–d document her upper incisor root length through the progress of treatment. She was issued with immediate suck-down type retainers and appointments were made for her with the restorative dentistry department for the management of her caries and oral health conditions. However, she failed to attend any of these appointments.

Her total treatment time was spread over 47 months, and it can be noted from this experience what could go wrong will go wrong in special cases such as this. In hindsight, we might not have started her case in the first place. With a compromised upper anterior dentition complicated by poor compliance and oral hygiene, root resorption or even crooked teeth may not be the issue of utmost importance. Her inability to juggle childbirth and personal commitments with other social difficulties may have taken their toll on RN.

While we attempted to use light forces to achieve our objective of space closure, we wished we could activate these light forces more frequently due to having shorter inter-appointment times. However, this was not possible with RN.

Despite our urgency to get her out of braces, multiple failed appointments and lengthy peri- odics of neglect in supervision of ongoing treatment increased treatment time instead. Her combined endodontic/periodontic/restorative condition did not help the progress of her orthodontic treatment at all. Despite such an outcome, her arch forms and orthodontic treatment objectives were reasonably achieved. With proper management of the restorative condition of RN, the upper incisors may still be reasonably maintained within the short to medium term.

Conclusion

Root resorption is and will remain a complicated subject matter to the orthodontist. The purpose of this article was to provide an overview of the subject and to introduce a more complex case with root resorption.

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A complete list of references for this article is available upon request from the publisher.

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Fig. 5: Periapical radiographs documenting the root length of upper anterior teeth through treatment progress.

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