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Types of root resorptions related to orthodontic treatment

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SUMMARY

Objectives. Root resorption is one of the research topics that may be looked into and that may arise during orthodontic treatment. It is necessary to determine the type of root resorption that was caused by the orthodontic treatment, its factors leading to aforementioned issue, and means to eliminate it.

Material and methods. In this work, articles issued in 2008-2018 and found in biomedical systems such as PubMed and Oxford Journal have been used. The articles were selected with the keywords provided, 25 articles met all criteria. Other articles mentioned have been used for such root tooth resorption analysis, where at least one factor may have affected the issue under discussion.

Results. The mechanism of tooth movement during orthodontic treatment causes external or internal root resorption due to certain biochemical and biological processes. Factors, that cause root resorption during orthodontic treatment, were divided into local and general. Local factors include mechanisms of teeth movement, teeth vitality, length of treatment procedure – these factors may affect the type and level of resorption. General factors include age and other systemic elements.

Conclusions. Root resorption extent and type depends on local and general factors active during the orthodontic treatment. It is not possible to eliminate all active factors, however the root resorption issue can be controlled during orthodontic treatment.

Keywords: root resorption, orthodontics, external root resorption, apical root resorption.

INTRODUCTION

Orthodontic treatment is used to improve the appearance and alignment of teeth, improving your appearance. Many people have crowded or crooked teeth. It is evident that demand for orthodontic treatment is increasing. Each clinical case requires different approach which is based on the choose of the sort of orthodontic appliance, different load of forces, treatment duration which depends on the severity of the problem and the "retention" period. In different countries prevalence of malocclusion varies from 11% up to 93% (1, 3-6). Results of the study done by A. Šidlauskas & K. Lopatiene showed that Lithuania belongs to the countries with high prevalence of malocclusion among 7-15-year-old Lithuanian schoolchildren rate – 84.6%. The most common finding was dental crowding (2).

Numerous studies have showed relationship between external root resorption and orthodontic treatment in vital teeth (7, 8). Existing evidence showed that the resorptive process of apical part of the root during orthodontic treatment is an undesirable side effect which is difficult to predict. Orthodontic treatment is affiliated with two main types of external root resorptions: apical and cervical root resorption. These types have very different characteristics. Nevertheless two main things must occur in order for root resorption to begin. First of all the loss of the protective layer (pre-cementum or pre-dentin) which serves as a guardian to the dental mineralized tissue is required and second – inflammation in the region of the unprotected root surface is obligatory. Therefore follow-up of such patients is very important with the radiographical control mainly of the front teeth of both jaws. Root resorption of apical part is characterized as the loss of cementum and

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dentin due to the odontoclastic action (9). During this process root becomes shorter and is related to the active process of orthodontic treatment while cervical resorption is diagnosed much later after the treatment has finished. Heithersay showed that the latter type of resorption most often diagnosed 18 to 33 months after orthodontic treatment (10).

MATERIAL AND METHODS

In this work, articles issued in 2008-2018 and found in biomedical systems such as PubMed and Oxford Journal have been used. The articles were selected with the keywords provided, 25 articles met all criteria. Other articles mentioned have been used for such root tooth resorption analysis, where at least one factor may have affected the issue under discussion.

The following MeSH terms or/and word combinations were used as principle search terms: "root resorption", "apical root resorption", "orthodontic treatment", "external root resorption". Three researchers independently reviewed the titles and abstracts of potentially relevant studies. Where it was apparent from the abstract that the study subjects were inappropriate for the focus of the review (in terms of the exclusion criteria), full-text articles of these studies were not included.

RESULTS

External root resorption

Four anatomical structures are affected during orthodontic treatment: bone, periodontal ligament, pulp and cementum and are influenced by the forces induced by orthodontic appliances. Surface resorption is a natural process during orthodontic treatment due to the movement of the teeth provoked during the treatment period. It is evident that until cement repair proceeds, dentin is not affected by osteoclasts and resorption process is controlled (11). Such type of resorption is undetectable in radiograms. When dentin loses its protective layers - precementum and cementum - the resorptive process becomes irreversible and becomes visible on radiograms. Levander and Malmgren proposed the classification for the various types of apical external resorption regarding the degree of severity (12). They distinguished four levels:

- Level 1: the resorption is minimal and simply leaves an irregular apical root contour.
- Level 2 (minor resorption): the resorption lesion is no greater than 2 mm on the hard tissues.
- Level 3 (severe resorption): the resorption destroys up to the first third of the root.
- Level 4 (extreme resorption): the resorption extends beyond the first third of the root length.

The speed and extent of resorption are very individual for each patient undergoing orthodontic treatment, but for most of them external root surface resorption is usually not exceeds minor or moderate level (13). Severe resorption is defined when resorption exceeds 4mm. It is rare and is detected in only 1% to 5% of teeth undergoing orthodontic treatment (14). The first radiographical signs of resorption starts to be evident during 6-9 month period after initiation of the treatment. Resorptive process is symptomless therefore radiological screening at this period of time for the patients undergoing orthodontic treatment is indicated (12). In most of the cases even when resorption is evident the pulp remains vital unless blood supply is disrupted.

For radiographical evaluation routinely orthodontists used two types of two-dimensional images: panoramic and periapical x-ray. However due to their nature it is impossible to detect all possible resorptive defects in different localization of the root surface. Also it is related to the difficulties when precise alignment of the x-ray films is required in order to repeat them during follow-up in order to get comparable views. Such discrepancies could lead to the errors in the interpretation of findings. In dentistry three dimensional (3D) visualization is very important. Therefore for the diagnostics and treatment planning 3D examination becomes everyday tool in dental practice. There is no doubt that cone beam computer tomography (CBCT) could compensate the diagnostic inaccuracy of 2D images (15). It was shown by Estrela et al, that when the conventional radiography was used for detection of the root resorption in teeth undergoing orthodontic treatment, it was diagnosed in 68.8% of the cases while examination of the same teeth by CBCT scans resorptive defects revealed in 100%. One more important aspect of this technique is that it allows dentist not only to confirm the resorptive defects, but also to evaluate their extension in apical/coronal, buccal/palatal or mesial/distal directions. A lot of resorptive defects dentists could not diagnosed until they reach the size visible on conventional radiographs. Estrela et al, showed that when CBCT was used extention of resorptive defects varied from 1 to 4 mm and was found in 95.8% teeth while examination when radiograms were used it were detected only in 52.1% (16).

It was shown that during of orthodontic treatment resorption was diagnosed in not all groups of teeth. The most often this process was diagnosed in maxillary lateral incisors followed by maxillary central incisors, mandibular anterior teeth and maxillary canines (15).

Due to the fact that not all patients undergoing orthodontic treatment were affected by external apical root resorption (EARR) it might be associated with the multiple factors such as individual susceptibility, application of strong forces, prolonged treatment, age, the genotype, endocrine disturbances, anatomical factors, morphology of the roots and the alveolar osseous crest, previous traumatic injury or endodontic treatment etc.. (17). Sharab et al, showed that a long duration of the treatment and the presence of specific genotypes were significantly associated with EARR (18). Iglesias-Linares et al, demonstrated that genetic variations involving the interleukine-1ß gene might be involved in the certain apical resorptions (19). Another factor like activation of the osteoclasts also could be genetically linked (20).

Brezniak & Wasserstein stated that some kind of systemic disease could be the reason of the root resorptions. Patients with diagnosed chronic asthma showed more susceptibility to apical resorption of some groups of teeth and mainly in upper molars. It was explained that close proximity of inflammation of the sinuses due to asthma with the apexes of the maxillary molars and premolars could provoke the resorptive process of these teeth (21). Lavander and Malmgren showed the relationship between the anatomical shape. ‘‘Pipette-like’’ or blunt shapes of apices of the roots had higher rate of incidence of the apical resorption (12).

Strong believe among specialists exists that treated teeth are more susceptible to apical root resorption than vital counterparts. This may be due to the lack of scientific evidence related to this subject. Endodontically treated teeth respond similarly to vital teeth to the force application during orthodontic therapy and significant differences was not found (22). During treatment planning orthodontic treatment it is important to remember that it could be initiated on teeth which had gone through endodontic treatment, but delay of the healing of the periapical pathology could be expected (23).

Another risk factor the traumatic dental injury could predispose resorption process due to the damage of the precementum, cementum layers and cells of periodontal ligament during the trauma therefore it is recommended to wait at least 3 months before exerting the orthodontic force on the traumatized tooth (21).

Another risk factors are directly related to the orthodontic treatment and include treatment duration and the magnitude of applied force (24).

Cervical resorption

Cervical resorption is one of the types of external inflammatory resorption which is also related to the orthodontic treatment. The highest rate among patients whom cervical resorption was diagnosed were among the patients who had undergone orthodontic treatment. During the last twenty years orthodontic treatment become dominating risk factor of this type of resorption and increased from 28.4% to 45.7% (10, 25).

The growth of incidence of cervical resorption might be due to more scientific evidence and more accurate diagnostics and the increased uptake of orthodontic treatment as it showed by data from insurance companies of some countries (25, 26). This type of resorption is diagnosed not during active treatment phase, but much more later. Cervical resorption occurs directly below the epithelial attachment of the tooth. It is widely accepted that such specific localization area is a consequence of use of excessive orthodontic forces at the cervical area of the tooth which damages the cementum layer and exposes the dentin (10). This could become a provocative factor to the osteoclasts to start the resorptive process. The hyperplastic lesion extends through the dentin and is filled with a granulomatous tissue, but in most of the cases the pulp in the root canal is not affected due to the protective layer – predentin, referred to as the pericanalar resorption-resistant sheet (27, 28). Scientific evidence showed the correlation between the amount of the tooth movement and the location of the teeth in the jaws. More resorption was diagnosed in mandible teeth (29). Teeth were cervical resorption most commonly diagnosed are maxillary incisors, canines and mandibular first molars. It is tendency that now mandibular molars are less affected by cervical resorption and it might be due to the fact that orthodontic bands are used much less during orthodontic treatment.

It is very important to diagnose this pathology as early as possible due to the fact that then is easy to control the process and prognosis of such teeth are favourable. If it is diagnosed in late phase prognosis becoming worse. In a lot of cases such process is diagnosed when clinical radiographic examination is done due to the fact that it is painless. Main clinical signs of cervical resorption are:

– pink spot in the coronal part of the tooth close to the cervical region, such discoloration is a long term result of the granulomatous tissue in the

resorptive area becomes visible through the resorbed dentin and translucent overlying enamel (9);

– positive reaction to sensitivity tests, unless pulpal involvement occurs;

– profuse bleeding during probing in cervical region of the tooth.

Radiologic signs which are related to external cervical resorption and could be detected during radiologic examination when periapical radiograms are used (9):

– contour of resorptive defect varies from asymmetrically located radiolucency with irregular margins in cervical/proximal region of tooth to uniformly round radiolucency centered over the root;

– early lesions are usually radiolucent in appearance;

– advanced lesions might have mottled appearance which might not always be apparent on radiographs, especially when lesions have relatively small amounts of fibro-osseous tissue;

– root canal should be visible and intact in the resorptive lesion.

For a long period of time Heithersay classification based on 2D imaging was used for external cervical resorption. It distinguishes for different classes of it (10).

- Class 1: a small invasive resorptive lesion near the cervical area with shallow penetration into dentine.
- Class 2: a well-defined invasive resorptive lesion that has penetrated close to the coronal pulp chamber but shows little or no extension into the radicular dentine.
- Class 3: a deeper invasion of dentine by resorbing tissue, not only involving the coronal dentine but also extending into the coronal third of the root.
- Class 4: a large invasive resorptive process that has extended beyond the coronal third of the root.

Due to circumferential nature of cervical resorption and also spread in a coronal-apical direction within the root 2D images gives us inaccurate information about the real situation in each individual case. Knowledge of exact borders of resorption is obligatory in order to perform correct treatment planning in such cases.

Since 2018 new descriptive classification for external cervical resorption was introduced. This classification describes the lesion in three dimensions: height, circumferential spread and proximity to the root canal (30). The coronal-apical extent of the lesion or the height is graded according to its maximum vertical extension within the root surface. The root divided into the coronal, middle and apical third. This dimension could be assessed using periapical radiographs while the coronal and sagittal views of resorptive defect could be assessed only in case where CBCT is used. The height of the resorptive defect has four different classes:

1) localize at cementoenamel junction level or coronal to the bone crest (supracrestal);

2) extends into the coronal third of the root and apical to the bone crest (subcrestal);

3) extends into mid-third of the root;

4) extends into apical third of the root.

The circumference of the lesion and proximity to the root canal could be assessed using axial views of the root and is graded according to the maximum spread within the root. Circumference has four different grades (30):

A. ≤90°

B. >90° to ≤180°

C. >180° to ≤270°

D. >270°

The proximity of the lesion to the root canal include two classes:

A. Lesion confined to dentine.

B. Probable pulpal involvement.

Prior to beginning of the treatment it is important to assess the height, circumferential spread within the root and proximity of the defect to the root canal system and also possibility to restore the tooth.

Earlier several treatment possibilities have been suggested in literature depending on the extent of the lesion and mainly based on case reports. These include: intentional replantation (31), guided tissue regeneration (32) and forced orthodontic eruption (33).

Now three main types of treatment approach are advocated: external, internal access and no access. Some lesions may require combination of external and internal accesses (34).

The main objectives of the diagnosis and treatment are:

– accurate diagnosis;

– suspention and prevention of the further resorptive process;

– restoration of the damaged root surface;

– improved of the esthetics of the tooth.

External access is used when opening of the resorptive defect is wide. In such cases combination of conservative and surgical treatment methods is indicated due to the the fact that in order to access the place of resorptive defect penetration to the dentin in cervical area flap raise is required. After complete rubber dam isolation and cleaning of the defect margins, the lesion is cleaned with 90%

trichloroacetic acid (34). This must be done with care to protect the viability of periodontal ligament cells. After removal of granulation tissue, the cavity must be restored. Endodontic treatment in such cases is required when symptoms are evident, when the lesion overwhelms the pulp chamber or root canal. Mainly root canal performed in cases where detected resorptive process according to Heithersay belongs to class 3 or 4.

Internal access approach is used in cases when resorptive defect has small opening and large internal extension. In such treatment use of external access is contraindicated due to the fact that it would lead to unnecessary removal of tooth substance. When this approach is used, root canal treatment procedure with the elimination of the invasive tissue by using 90% trichloroacetic acid is performed. Afterwards calcium silicate-based materials could be used to seal the opening of the resorptive defect from inside followed by the filling rest of the cavity with restorative material. When decision is made to use the calcium silicate-based materials it is important to remember that they can cause the staining of the tooth and it could have an impact on the esthetics (35-37).

When after the examination is decided that no conventional access leading to the lesion site is possible, prognosis of such treatment is unsatisfactory due to the fact that in such case affected tooth is extracted, the resorption lesion is cleaned mechanically and by the use of 90% trichloroacetic acid, cavity sealed permanently and tooth replanted. In such case is very important to keep safe surface of the root from 90% trichloroacetic acid in order to avoid the damage of periodontal cells. Splint is recommended for 2 weeks and root canal treatment is an obligatory prior removal of splint (34). Such type of treatment is used rarely and another type of treatment planning is proposed for the patient by replacing such with an implant.

Heithersay has reported a 100% success rate in the treatment of class I and II. The success rate in class 3 lesions was 77.8% and only 12.5% of teeth in class 4 cases (10). So early diagnostics of this resorption is very important for successful treatment of this pathology in order to keep the tooth in place and have good prognosis.

CONCLUSIONS

Root resorption is induced during orthodontic treatment. If size does not depend on one or more factors, but from a set of factors that affect everyone in periodontal tissues. It is not possible to remove all the factors. However, it is possible try to control the time of orthodontic treatment used and other factors that are based on research data really promotes the development of resorption. Evaluating the factors that may be the cause external root resorption or apical root resorption can be divided into 3 groups: 1) Factors that cause root absorption; 2) Factors which do not affect resorption; 3) Factors that can affect the resorption. Distribution of factors:

- Local factors: long treatment time, tooth method of treatment, method of treatment using tooth extraction, type of tooth (number), nature of the use of force, size of force, initial resorption, root length and shape, crown shape, tooth vitality, retinal tails, elastic.
- General factors: Patient age, gender, systemic factors.

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