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IP International Journal of Periodontology and Implantology

Journal homepage: https://www.ijpi.in/

Review Article

Changes in periodontal ligament in orthodontic treatment - A review

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ARTICLE INFO

Article history:
Received 07-08-2024
Accepted 19-09-2024
Available online 28-09-2024

Keywords:
Periodontal ligament
Orthodontic treatment
Periodontal health
Tissue degeneration
Periodontal disease
Vascular changes
Root resorption
Interdisciplinary approach

ABSTRACT

This review examines the changes in the periodontal ligament (PDL) that occur during orthodontic treatment and their implications for periodontal health. Orthodontic therapy aims to enhance dental aesthetics and function while preserving the health of supporting structures. The interplay between orthodontics and periodontics is critical, as improper management of periodontal status can undermine treatment outcomes. Various studies highlight the degenerative changes in the PDL during tooth movement, including tissue degeneration, collagen degradation, and vascular alterations. While some periodontal benefits may arise from orthodontic treatment, such as improved gingival attachment and bone induction, potential risks include gingivitis, periodontal damage, and root resorption, particularly in adult patients with pre-existing periodontal conditions. Long-term evaluations shows that orthodontic treatment does not significantly affect periodontal health, though complications such as root proximity may require careful consideration. A multidisciplinary approach involving orthodontic and periodontal care is essential for optimizing outcomes, especially in adult patients.

1. Introduction

The goal of orthodontic treatment is not only to improve facial esthetics and function but also to address to the health of supporting structures and how teeth are placed in them. No matter how talented the orthodontist is, a magnificent orthodontic correction can be destroyed by failure to recognize periodontal susceptibility. Both the short and long term successful outcomes of orthodontic treatment are influenced by the patient's periodontal status before, during and after active orthodontic therapy, which also includes post treatment maintenance by the patient. Periodontal pathogenesis is a multifactorial etiologic process and the orthodontist must recognize the clinical forms of inflammatory periodontal diseases. Co-operation between different specialties in dentistry is extremely important in establishing diagnosis as well as in treatment planning. One such interaction exists between orthodontics and periodontics. The interrelationship between orthodontics and periodontics often resembles symbiosis. In many cases, periodontal health is improved by orthodontic tooth movement, whereas orthodontic tooth movement is often facilitated by periodontal therapy.

2. Changes in PDL During Orthodontic Treatment

Yoshiki Nakamura in AJO 1996[1] studied the degenerating tissue changes in the PDL during tooth movement. There were two types of degenerating tissues found in the compressed periodontal ligaments: One (type A tissue) stained differently from collagen and the other (type B tissue) showed the same color as collagen. The electron

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https://doi.org/10.18231/j.ijpi.2024.027

micrograph showed deposition of fibrin in type A tissue. No collagen fibers with typical bandings were seen in either tissue. The results indicated that collagen degradation, fibrin deposition, and calcification occurred in the degenerating tissues, especially in type A tissue during the experimental tooth movement.

Tanaka[1] described histologically and immunohistochemically the degenerating tissues in the periodontal ligament during the tooth movement. That study showed two types of degenerating tissues in the compressed periodontal ligament; a collagenous type and another that was noncollagenous. Reitan in 1957[2] noted the degenerating tissues in the periodontal ligament on the pressure side during the tooth movement and termed these areas hyalinized tissues because the degenerating tissues usually stained eosinophilically with glass-like structures, with hematoxylin-eosin (H-E) stain.

Schwarz[3] postulated that forces of about 25 gm/cm^{2}equal to blood pressure of PLD terminal capillaries should be optimal for tooth movement, while larger forces would block PDL blood flow, leading to tissue necrosis at compressed areas. Hence necrosis caused is not due to the direct destructive effect of large orthodontic force, but rather to stagnation of blood supply to the area.

An electron microscopic study on attachments between periodontal fibers and bone during alveolar remodeling by Kurihara et al in AJO 1980[4]

revealed three types of periodontal membrane-to-bone attachments for remodeling surfaces of the bony alveolar wall. An adhesive type, which is the most widespread means for tooth anchorage on resorptive bone surfaces during active tooth movements. Such adhesive attachments continuously form and re-form as the resorption front proceeds. A continuous type of attachment also occurs on resorptive bone surfaces in which some bone matrix fibrils survive the resorptive process. These former bone fibrils become incorporated into the periodontal membrane and are continuous between the bone matrix and the stroma of the contiguous periodontal membrane. An intermediate type of attachment also occurs and is primarily an adhesive attachment that also contains a scattering of fibrils which are continuous from the bone matrix across the resorptive bone surface into the fibrous matrix of the periodontal membrane.

Occasional periodontal complications may arise during adult orthodontic therapy although they may also be seen in the adolescent patients. Adult patients with pre existing periodontal disease are considered to be at considerable risk during orthodontic treatment. Prior to orthodontic treatment, it is mandatory that periodontal disease be properly controlled with debridement and reinforcement of oral hygiene. Periodontal problems are generally minimal and in frequent in adolescents.

2.1. Potential benefits of orthodontic treatment:

1. Improved width of attached gingiva especially when moving a labially positioned tooth lingually.
2. Induction of bone formation.
3. Can re-establish biologic width in teeth with subgingival restoration margins by forced eruption.
4. Closure of spaces of extracted teeth may help prevent periodontal disease complications.

2.2. Harmful effects

Gingival and periodontal changes related to orthodontic treatment are, in general, transient with no permanent damage. However, lengthy orthodontic treatment, accompanied with sustained poor oral hygiene leads to gingival and periodontal damage. The deleterious effects include gingivitis, gingival hyperplasia, marginal periodontitis, gingival recession at extraction sites, loss of attachment, interdental clefts, especially at vestibular aspects of extracted mandibular premolars, reduced width of keratinized gingiva, marginal bone loss and apical root resorption.

3. Changes in PDL Following Orthodontics

Periodontal tissues adapt to teeth that are moved orthodontically along the dental arch. Furthermore, experimental studies have shown that orthodontic tooth movements along the arch will not result in loss of periodontal support provided the gingival tissue is kept free of inflammation. Studies have demonstrated that bone dehiscences can be produced in the alveolar bone when mandibular incisors are moved anteriorly. On a short term basis, such tooth movements are not necessarily accompanied by loss of connective tissue attachment. However, if the alveolar bone becomes thinned out during orthodontic intervention due to expansion, the gingival tissue may be more susceptible to long-term recession.

Årtun and Krogstad in AJO 1987[5] studied on the periodontal status of mandibular incisors following excessive proclination. They found that development of bone dehiscence and some gingival retraction during excessive proclination of mandibular incisors seem to be inevitable, especially in patients with thin alveolar housing. However, the long-term prognosis for such teeth with extensive gingival recessions may not be critical. Most of the gingival retraction seemed to take place during or shortly after active appliance therapy.

Dentitions with reduced periodontal support show a marked tendency to return to their pretreatment position following active appliance therapy. Thus, semi-permanent or permanent retention may be required. Thin, flexible spiral wire bonded to the lingual surface of each tooth in a segment may represent a simple and effective way of retaining realigned front teeth.

3.1. Vascular changes in the PDL following force application

After application of orthodontic forces, the blood vessels in the pressure zone of the periodontal ligament demonstrate stasis and ischemia. A gradual decrease in the number of patent capillaries, thrombosis, complete obliteration of blood vessels, and vascular degeneration are then evident. The collapse of blood vessels and reduced blood flow is reported to initiate formation of a hyaline zone and subsequent bone resorption. Degeneration of the vasculature occurs predominately in the capillary and the postcapillary regions of the microcirculation; the arterial components are generally spared. Regeneration and proliferation of the blood vessels within the pressure zone usually occurs 7 days after the initial application of orthodontic forces. In the tension zone, blood vessels become distended in the direction of strain and blood flow increases. The postcapillary venules are primarily affected by tension forces.

Murrel and Yen in AJO sep 1996[6] studied on the vascular changes in the periodontal ligament after removal of orthodontic forces. The pattern of blood vessel distribution in the periodontal ligament was likely affected by changes in the direction of tooth movement produced by the application and removal of the orthodontic force. Changes in blood vessel number and density were associated with the direction of tooth movement.

The periodontal vascular distribution and density was summarized as follows:[1] increased after application of orthodontic force,[2] transient decrease subsequent to removal of force,[3] transient increase during reactivated distal drift, and[4] normalization. Normalization was achieved during an interval equivalent to the duration of orthodontic force, suggesting that the vasculature could be a factor in production of tissue forces resulting in relapse of relocated teeth.

3.2. Long-term effects of orthodontic treatment on periodontal health

Sadowsky and BeGole in AJO 1981[7] evaluated the periodontal health of a large group of patients who had received comprehensive orthodontic treatment during adolescence at least 12 years previously and compared the periodontal health of this group with that of a group of similar adults who had malocclusions that had not been orthodontically treated. The findings were:

1. While no differences were observed in the prevalence of moderate to severe periodontal disease, the orthodontic group manifested a greater prevalence of mild to moderate periodontal disease than the control group in the maxillary posterior and mandibular anterior regions of the mouth.
2. A greater prevalence of mild to moderate periodontal disease was found in the posterior regions of the mouth in those orthodontic patients whose treatment included extractions than in those treated without extractions.

Mucogingival problems were found with similar frequency in the orthodontically treated and control subjects and no differences in this regard were observed between orthodontic patients whose treatment involved extractions and those treated without extractions.

Polson in AJO 1988[8] evaluated the clinical periodontal status of persons who had completed orthodontic therapy at least 10 years previously and compared the findings to those of adults with untreated malocclusions. The comparisons showed no significant differences between the groups for any of the periodontal variables. It was concluded that orthodontic treatment during adolescence had no discernible effect upon later periodontal health.

Zachrisson[9] suggested that a relationship may exist between orthodontic therapy and conversion of gingivitis into periodontitis— for example, orthodontic bands may increase subgingival plaque retention. Furthermore, orthodontic movement resulting in tooth intrusion may shift supragingival plaque into a subgingival location and predispose toward destructive periodontitis. In this respect small but statistically significant loss of connective tissue attachment has been reported shortly after completion of orthodontic therapy.

Long-term effect of root proximity on periodontal health after orthodontic treatment were studied by Årtun and Kokich in AJO 1987.[10]

(1) to evaluate the incidence and distribution of root proximity after orthodontic treatment and (2) to test the hypothesis that interproximal areas with thin interdental bone provide less resistance against marginal periodontal breakdown than areas with normal width of bone between the roots. Only adult patients were examined at least 16 years after active orthodontic treatment. Root proximity was diagnosed between maxillary central and lateral incisors, between mandibular central and lateral incisors, and between maxillary lateral incisor and canine, maxillary first and second molars, mandibular canine and first premolar, mandibular first and second premolars. No statistically significant differences in inflammation, level of attachment, and bone level were observed between root proximity sites and control sites. The results indicate that anterior teeth are not predisposed to more rapid periodontal breakdown when roots are in close proximity.

Excessive orthodontic forces surpassing the blood pressure in capillaries, causing ischemia and the degeneration of the periodontal ligament on the squeezed side. This leads to hyalinization, which prevents the planned movement of teeth. Tooth movement can resume, though, once this hyalinized zone is resolved.[11]

It is now normal practice in orthodontics to forcefully extract teeth that are labially or palatally impacted. A periodontist's intervention is crucial in preventing loss of attachment by carefully exposing the impacted tooth while maintaining keratinized tissue. [12]

Preservation of final orthodontic result is often considered as the third phase of overall orthodontic therapy and its major long-term goal. Post-orthodontic relapse has been mainly attributed to elasticity of gingival tissues that are compressed towards the direction of tooth movement. In order to enhance post-treatment stability attributed to soft periodontal fibres, many authors have suggested adjunctive interventions including circumferential fibrotomy of supracrestal gingival fibres particularly to prevent relapse in the maxillary arch. Again, it demands the expertise of a Periodontist. [12–14]

Crown lengthening procedures can facilitate easy placement of orthodontic attachments on teeth with short clinical crowns. [15]

With the rising number of adult orthodontic patients, orthodontists often encounter individuals with periodontal disease. In these cases, a combined orthodontic-periodontic interdisciplinary approach may prove more effective. Given the higher prevalence of periodontal disease among adults, it is essential for those undergoing orthodontic treatment to receive support for regular oral hygiene practices and periodontal maintenance to preserve their periodontal health during active therapy. [16]

4. Conclusion

Orthodontic tooth movement is brought about by prolonged application of force on the attachment apparatus. One should consider the fact the two disparate processes occur in the gingival alter the transduction of the orthodontic force. First there is an injury to the connective tissue manifested by the torn and ripped collagen fibers, second the genes of both collagen and elastin are activated.

5. Source of Funding

None.

6. Conflict of Interest

None.

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Cite this article: Mutthineni RB, Yachamaneni PR, Paul A, Muralidharan G. Changes in periodontal ligament in orthodontic treatment - A review. *IP Int J Periodontol Implantol* 2024;9(3):132-135.