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Transseptal fibers - crosslinking convolutes: A review

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Abstract

The transseptal fibers come under a group of supra-alveolar fibers, which constitute the principal fibers of the periodontium. They play a very important role in maintaining the position and orientation of the teeth in the arch. These fibers are embedded firmly in the cementum of adjacent teeth which maintain the mesio - distal contacts of the teeth. There are a continuous renewal and self-regeneration of transseptal fibers, even after destruction. They have a role in midline diastema and relapse of orthodontically treated rotated teeth. This review discusses the transseptal fibers and the bridging role of transseptal fibers in periodontic and orthodontic interventions.

Keywords: Frenectomy, fiberotomy, midline diastema, orthodontic extrusion, transseptal fibers

Introduction

Transseptal fibers act as a part of principal fibers of the periodontal ligament system and as they do not have the osseous attachment, they also come under the gingival group of fibers.[1] They form a continuous band of fibers from tooth to tooth, which provide integrity in the arch, and they protect and maintain the contacts between the teeth.[2]

Transseptal fibers play a role in the etiology of midline diastema and in the treatment of relapse of the rotated tooth during orthodontic management.[3] This review discusses the role of transseptal fibers in health and its role in orthodontic treatment procedures and in periodontal interventions.

Principal Fibers of the Periodontium

The main function of the periodontal ligament is anchorage which is provided by the collagen fibers. They are classified into two groups - Principal fibers and the secondary fibers.[2] The principal fibers remain in the space between the tooth root and the alveolar wall.

Holmstrup, in 1996, classified principal fibers based on their location and insertion of periodontal ligament fibers as an alveolar crest, oblique, transseptal, horizontal, inter-radicular, or apical fibers.[4] The transseptal fibers constitute a part of these principal fibers, but they also come under gingival connective tissue fibers.[2]

Gingival Fibers

The gingiva is attached to the tooth surface and the alveolar bone by dense collagenous connective tissue attachment.[2] Schluger *et al.*, in 1990, found that the fibroblasts form the main cell component of the gingival connective tissue which gives rise to connective tissue components.[5]

The major content of the gingival connective tissue is collagen fibers - 60% fibroblasts, 5% vessels, nerves, and 35% matrix.[1] The gingiva is made of various types of dense collagenous network. They are categorized into three groups according to their location, origin, and insertion by Schluger *et al.*, 1990. They are gingivo dental, circular, and transseptal fibers which form a part of dento - gingival unit.[5] The transseptal fibers emerge from the cemental surface just apical to the base of the epithelial attachment, traverse the interdental bone and insert into the opposing tooth.

Transseptal Fibers

Transseptal fibers are situated in the interproximal region forming horizontal bundles just apical to the junctional epithelium, over the alveolar crest that extend between the cementum of adjacent teeth into which they are embedded. They are responsible for the structural integrity of the gingival tissues.[2]

They form a dense ligament between the teeth and form a chain-like structure between all the teeth. If the continuity of

the chain is disrupted, the forces that act on either side of the break are imbalanced, and the displacement of the teeth can occur.

Components of Transseptal Fibers

Transseptal fibers are mainly composed of collagen. The collagen accounts for 60% of the total protein content.[6] Chavrier *et al.*, in 1984, proposed that the gingival fibers contain interstitial collagen Type I (90%), collagen Type III (8%) and collagen Types IV, V, VI, and VIII (2%).[7] Redlich *et al.*, in 1996, studied the response of supra-alveolar gingival collagen to orthodontic rotation movement in an animal model, and the ultra-structural analysis shows two patterns of gingival collagen arrangement: (1) Large thick, mostly parallel collagen-Type-I fibers, which are interconnected by thin fibrils. This arrangement of the collagen fibers provides strength and rigidity to this tissue, which sustains heavy masticatory forces; and (2) short and thin fibers in a fine reticular network situated under the epithelial basement membrane and surrounding the blood vessels.[8] A high turnover rate of the collagen is observed in transseptal fibers, which is comparable to that of collagen in the periodontal ligament. Rönnerman in 1980 studied the transseptal fibers histologically during orthodontic tooth movement and showed that a significant increase in oxytalan fibers as well as increased levels of glycosaminoglycans.[9]

Integrity of Transseptal Fibers

The transseptal fibers maintain the mesiodistal contacts of the teeth in the arch, as they are firmly inserted into the cementum of the adjacent teeth.[10] In an animal study done by Moss and Picton, in 1982, a spacing was created in the middle of molar in the mandible of a monkey. After some weeks, the two halves moved separately because of the absence of transseptal fibers while others were closed by themselves. This shows the ability of transseptal fibers in retaining the teeth in their positions in the arch.[11]

The transseptal fibers do not contain elastic tissue, and they are mainly made of collagen. The force they generate is due to tiny coils into which they contract as they become mature. Stubley, in 1976, stated that transseptal fibers are said to be like an orthodontic chain used for interdental space closure.[12]

Remodeling Mechanism of Transseptal Fibers

The transseptal fibers undergo continuous remodeling, and they are evident even after advanced periodontal destruction. The remodeling of transseptal fibers is due to the continuous activity of fibroblasts in collagen formation and remodeling.

The slow remodeling process of transseptal fibers during and after orthodontic tooth movement tends to pull the teeth into their original positions. On a contrary, according to the study by Reiton *et al.*, in 1959, the transseptal fibers did not show remodeling even after long term retention period.

By using autoradiography, Minkoff and Rippin, in 1976, studied protein turnover rates of subcrestal and supracrestal fibers. They had stated that the fibroblast activity was relatively lower in dento-gingival regions than in dento-alveolar and transseptal regions. The half-life of collagen fibers is:

- 5.7 days in dento-alveolar regions
- 8.4 days in transseptal regions
- 25 days in dento-gingival regions.[13]

Tenshin, in 1981, reported that the collagen synthetic activity increased by 70% in transseptal fibers and 300% in the periodontal membrane during tooth movement.[13]

Transseptal fibers stretch in proportion to the amount of force applied for up to two days. Dynamic remodeling with the proliferation of fibroblasts occurs during tooth movement and slow rearrangement during the retention period. Proliferating fibroblasts remodeled the transseptal fibers through the synthesis and degradation of collagen fibers.

Transseptal Fibers and Maxillary Labial Frenum

Knox and Young, in 1962, studied the frenum histologically and found that it is formed by a fold of mucous membrane and connective tissue, sometimes with muscle fibers.[14] On the contrary, Huang *et al.* found that it contains mostly dense collagenous tissue, loose connective tissue, and elastic fibers but no muscle fibers.[15]

During the developmental stage, the two central incisors erupt widely separated from one another, and the rim of bone surrounding each tooth may not form in the median suture. In such cases, bone is not deposited inferior to the frenum. A "V"- shaped bony cleft forms between two central incisors, and an "abnormal" frenum attachment is created. Transseptal fibers fail to attach across the midline cleft, and space will not close.[16]

Midline Bony Cleft Formation

"V"- shaped midline bony clefts may cause disruption of the formation of transseptal fibers and have been suggested as a cause of diastema. Higley, in 1969, stated that a slight cleft of intercrestal bone can make the teeth apart. Adam, in 1954, proposed that severe midline diastemas pose a mild fusion defect of bilateral embryonic elements and are a micro-type of midline cleft.

Bray, in 1976, concluded with his study that there is a high association between the pre-treatment existence of "notching" and the relapse of orthodontically treated maxillary diastema. Stubley, in 1976, stated that in midline bony clefts, the transseptal fibers from the mesial side of the teeth attach horizontally for a very short distance to the midline suture and then turn upward at 90.[12] This fiber pattern could cause the difficulty in diastema closing spontaneously.

Transseptal Fibers and Midline Diastema

The midline diastema is a gap between the maxillary central incisors.[16] Huang and Creath, in 1995, concluded that space is due to the normal growth characteristics during the primary and mixed dentition and is resolved by the eruption of maxillary permanent canines.[15] Persistent enlarged labial frenum with abnormal transseptal fiber attachment is considered to be the etiology of midline diastema. Edwards, in 1977, stated that the break in the continuity of transseptal fibers in the enlarged labial frenum causes an imbalance of forces with subsequent diastema formation.[17] The midline diastema can be delineated as simple or persistent according to their etiology.

Labial Frenum and Midline Diastema

The abnormal frenal attachment with irregular transseptal fiber formation may cause midline diastema, which poses esthetic problems. There are controversies regarding the association between midline diastema and high frenal attachment.

Angle, in 1907, proposed that the maxillary midline diastema is caused by the superior labial frenum. However, he supported that the stability of the space closure does not depend on frenum excision.[18] Shashua and Artun, in 1999, found that there is a correlation between the width of the diastema and the presence of an abnormal frenum.[19] In 1929, Tait reported that the frenum has no function and that its action, if any in relation to the maxillary incisors is only passive.[20]

Ceremelo, in 1953, expressed his view as that the presence of the frenum is not related to the presence or the width of the midline diastema.[21] Edwards, in 1977, found that there was a high but not absolute correlation of the pre-treatment relationship between clinically hypertrophic superior labial frenum and midline diastema.[22]

Miller, in 1985, recommended that the frenum should be characterized as abnormal when it is unusually large, or there is the absence of an apparent zone of attached gingiva along the midline or the interdental papilla shifts when the frenum is extended. In those cases, the frenum should be removed without disrupting the transseptal fibers which will maintain the contour of the interdental papilla thereby maintaining the esthetics.[23]

Transseptal Fibers in Gingivitis and Periodontitis

In the advanced stage of gingivitis, the gingival connective tissue fibers are destroyed. The inflammatory reaction is confined to the gingiva, and it is separated from the underlying sub-crestal periodontal tissues due to the presence of transseptal fibers.

In periodontitis, there is an apical migration of the junctional epithelium, and the transseptal fibers are destroyed into fiber fragments. In an animal study done by Adams *et al*., in 1979, they proved that the transseptal fibers get reformed and occupies an apical position.[24] They limit the zone of inflammatory front away from the crestal bone.

In supra bony pockets, the reformed transseptal fibers after destruction, are oriented in a horizontal direction in the cementum of adjacent teeth. In infra-bony pockets, the transseptal fibers are in an oblique direction, lying between the base of the pocket and the alveolar crest.[1]

Pathological migration is one of the consequences of the periodontal disease which may cause esthetic problems in the maxillary anterior region. Transseptal fibers play a role in the correction of pathologic migration of teeth.[25] If a newly formed diastema of anterior teeth associated with periodontal disease is ≤1 mm in dimension, closure is predictable after periodontal therapy.

Ross *et al.,* in 1963, stated that the elimination of destructive effects of bacterial infection causes reduction of the inflammatory tissue pressure. This causes reestablishment of the "periodontal force" through the healing of transseptal fibers, and reformation of collagen fibers in gingival fiber apparatus because of elimination of abnormal occlusal forces.[26] Thus, if the transseptal fibers are destroyed, they tend to reform in a more apical level.

Transseptal Fibers in Extraction Socket

The discontinuation of the transseptal fibers is seen after a tooth extraction. Chase and Revesz, in 1944, studied the transseptal fibers during healing of the extraction site and showed that a newly formed collagen fibers create a reestablishment of continuity of the transseptal fibers and creating a fibrous bridge connecting the separated teeth.[27] Parker, in 1972, studied the newly formed transseptal collagen fibers and described them as a coiled and compressed structure and have "football shaped" appearance.[28] According to the study done by Edwards, in 1971, the new transseptal fibers have a normal morphologic appearance after the closure of the extraction site.[29]

Transseptal Fibers in Orthodontic Tooth Movement

Edwards, in 1968, stated that in orthodontic rotational movement, an increase in oxytalan fibers and reorganization of the gingival collagen fibers takes place.[30] The clinical instability of the rotated tooth, which almost always relapses, is because of the stretched collagen fibers.[31] To relieve the rotated tooth from forces created by the assumed stretched fibers and to enable its stability after the release of retention, a procedure of gingival circumferential fiberotomy has been performed.[32] Edwards, in 1970, studied 320 patients with case-control study and with long-term follow-up of 14 years after active treatment, found that the circumferential supra crestal fiberotomy reduced the relapse by 30%.[32] This surgical procedure prevents the rotational relapse and creates no adverse effect on periodontal health.[33]

Transseptal Fibers in Fiberotomy

Supracrestal fiberotomy is the procedure done to prevent relapse of the rotated tooth after the orthodontic procedure. It severes the attachment of supra-alveolar and transseptal fibers around

the tooth.[34] Reitan, in 1969, showed that the relapse of the rotated tooth will occur 5 hours after removal of the appliance.[35] So, the circumferential supracrestal fiberotomy (CSF) procedure should be carried out toward the end of finishing stage of active orthodontic treatment.[36]

The continuous use of CSF in orthodontic forced eruption for crown lengthening prevents the coronal displacement of gingiva and the attachment apparatus. This prevents the additional need for gingival recontouring after orthodontic treatment.

Repositioning of the rotated teeth is often easier during orthodontic procedures but poses a problem in retaining its new position in the arch. The reorganization of the periodontal fiber complexes, transseptal fibers, and the supra-alveolar fibers occur after orthodontic tooth movement.

Transseptal fibers stretch elastically during orthodontic treatment and tend to pull the teeth back toward their original position. Campbell, in 1975, stated that the supra-alveolar fibers are non-elastic by nature and more stable with a slower rate of turnover.

These fibers do not adapt to new tooth positions and are in part responsible for relapse after the active orthodontic treatment procedures. Transseptal fibers, sharpeys fibers of the newly formed bone may rearrange even after a retention period of 4-6 months.[35] Therefore, the retention period should continue for a 12-month period.[36]

Transseptal Fibers in Frenectomy

In cases of thick labial frenum, the abnormal transseptal fiber arrangement may cause difficulty in closing the midline diastema in between the two central incisors with orthodontic procedures. In such situations, the classical frenectomy technique proposed by Archer and Kruger, in 1964, is performed which severes the transseptal fiber attachment. The ideal time for performing this surgery is after orthodontic treatment is complete and at 6 weeks before the orthodontic appliances are removed. Miller, in 1985, stated that if the labial frenum is removed before the orthodontic procedure, the tissue prevents space closure or becomes painful and traumatized.

In the technique recommended by Miller, the transseptal fibers continuity during frenectomy procedure is maintained, the interdental papillary architecture is preserved thereby achieving the good esthetics. However, this can be applied only in Miller's Type III frenal attachments.

Is Transseptal Destruction Necessary?

Edward studied 308 patients who had either a diastema or an abnormal frenum or a combination of both and proposed conservative surgical procedure as the line of treatment which consisted of three procedures:

1. Apically repositioning of the frenum (with denudation of alveolar bone)
2. Destruction of the transseptal fibers between the approximating central incisors
3. Gingivoplasty of any excess labial and/or palatal tissue in the interdental area.[37]

One of the prominent aspects of Edward's technique was the esthetic maintenance of the interdental papilla. But, the healed scar in the midline appeared unesthetic in most cases. He insisted that the transseptal fibers need to be destroyed.

Miller, in 1984, advocated the frenectomy with laterally positioned pedicle graft.[24] In this procedure, the transseptal fibers were not disturbed, surgically as there are simultaneous synthesis and degradation of collagen fibers within the periodontal ligament and in the transseptal area.[18] This will ensure necessary remodeling of the transseptal fibers without surgical intervention.

The above option must be done only when the diastema persists after the eruption of permanent canines, as in most cases, the eruption of the canines cause spontaneous closure of the maxillary midline diastema.[38]

Finally, it must be noted, that sometimes the pressure which is induced to the frenum fibers during the orthodontic approximation of the maxillary central incisors may create avascular necrosis, along with frenum and gingival fibers remodeling, making the surgical intervention useless.

Conclusion

The transseptal fibers protect the integrity of the arch by maintaining the position of the teeth in the arch. They influence the midline diastema through high frenal attachment. Various studies indicate that the transseptal fibers should not be disturbed, as it has the capacity to regenerate by itself and it has influence on the esthetic maintenance of the interdental papilla in the maxillary anterior region. It bridges the orthodontic and periodontic interventions as in the treatment of midline diastema and orthodontic relapse of the rotated teeth.

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