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Factors Associated with Orthodontic Tooth Movement in Periodontally Compromised Patients

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Abstract

There is no consistent relationship between malocclusion and periodontal disease but certain characteristics of malocclusion can promote a pathologic environment conducive to periodontal disease. One of the dramatic means available to improve the local environmental factors is through orthodontic tooth movement. The pretreatment periodontal conditions can include excessive tooth mobility, advanced crestal bone loss, infrabony defects, tipped molars, furcation involvement, and hard and soft tissue dehiscences. Movement of teeth in the presence of periodontal inflammation can result in an increased loss of attachment and irreversible crestal loss. Although absolute reduction in bone and attachment levels does not contraindicate orthodontic correction, it does increase the difficulty of delivering controlled orthodontic mechanics that would potentially minimize further bone loss. The present review article discusses the various factors that are associated with orthodontic tooth movement in periodontally compromised patients namely: 1) tooth movement into infrabony pockets; 2) tooth movement into compromised bone areas; 3) tooth movement through cortical bone; 4) extrusion (eruption); 5) intrusion; 6) tipping.

Keywords

1. Introduction

A malocclusion is a misalignment or incorrect relation between the teeth of the two dental arches when they approach each other as the jaws close. The term was coined by Edward Angle, the "father of modern orthodontics",

[1] as a derivative of *occlusion*, which refers to the manner in which opposing teeth meet (*mal-* + *occlusion* = "incorrect occlusion"). There is no consistent relationship between malocclusion and periodontal disease but certain characteristics of malocclusion can promote a pathologic environment conducive to periodontal disease. One of the dramatic means available to improve the local environmental factors is through orthodontic tooth movement.

Bragger and Lang [2] defined periodontal disease as an inflammatory disease triggered by bacteria that supragingivally affected the gingiva (gingivitis) and subgingivally affected the supporting connective tissue and alveolar bone (periodontitis).

A. Gingivitis: The reversible lesion.

The accumulation of microorganisms around teeth can cause gingival redness, bleeding, and edema, changes in gingival morphology, reduced tissue adaptation to the teeth, an increase in the gingival crevicular fluid, and other clinical signs of inflammation. Chronic gingivitis can be reduced by removal of plaque during orthodontic treatment [3]. Gingivitis has been classified as:

a) The initial lesion develops 1 to 2 days after plaque is allowed to remain on teeth; little or no clinical changes are seen.

b) The early lesion develops after 4 - 7 days; signs of erythema and bleeding on probing may appear.

c) The established lesion develops weeks later; changes in color, size, texture etc. appear. Only this stage lesion can be observed as clinical gingivitis.

The important point is that epithelial attachment is intact and alveolar bone loss has not yet occurred. It is therefore crucial to determine the appropriate plaque control interval for the patient that will prevent destructive alveolar bone loss.

B. Periodontitis: The irreversible or destructive lesion.

Periodontitis is always preceded by gingivitis, but not all gingivitis progresses to periodontitis. All forms of periodontitis are marked by varying patterns of loss of connective tissue attachment and alveolar bone loss, besides gingival inflammation. The "episodic burst" form of the disease usually manifests as short intervals of significant attachment loss followed by periodic remission and an indefinite period of inactivity. Periodontitis may be typified as [3]:

a) Adult periodontitis: The most common form of periodontitis, also called as slowly-progressive periodontitis.

b) Pre-pubertal periodontitis: Rare form that appears soon after eruption of primary teeth, characterized by severe gingival inflammation, rapid bone resorption, and possibly tooth loss.

c) Juvenile (early onset) periodontitis: Localized form has a familial tendency and is marked by severe, rapidly progressive alveolar bone loss that affects primarily the permanent first molars and incisors.

d) Rapidly progressive periodontitis is seen in young adults, associated with rapid bone loss and depressed neutrophil functions.

e) Refractory periodontitis is a disease classification used to define sites present in patients who continue to be infected with periodontal pathogens and who have a high rate of loss of attachment and tooth loss despite intensive periodontal treatment to prevent bone loss. Orthodontic patients who have individual sites with recurrent inflammatory episodes usually are placed in this category.

Periodontitis also can be associated with systemic diseases such as diabetes mellitus, cyclic neutropenia, down syndrome, Papillon-Lefevre syndrome, inflammatory bowel disease, Addison's disease, and immunodeficiency diseases. In general it should be recognized that children can develop severe forms of periodontitis, but the prevalence of destruction is much less than in adults.

The orthodontic patient may be at greater risk of attachment loss after teeth have become mobile because of tooth movement. The clinical signs of inflammation and tooth mobility must be recognized and controlled during treatment to prevent extensive bone loss. Most adults and a part of younger population who seek orthodontic treatment have some form of periodontal breakdown, so the practitioners must treat malocclusions with diverse aggravating periodontal conditions ranging from localized single tooth lesions to advanced generalized periodontal disease. Periodontal attachment loss can result in these patients presenting with varying degrees of over-eruption, tipping, drifting and rotations, predominantly seen in upper labial segment [4].

The pretreatment periodontal conditions can include excessive tooth mobility, advanced crestal bone loss, infrabony defects, tipped molars, furcation involvement, and hard and soft tissue dehiscences. Movement of teeth in the presence of periodontal inflammation can result in an increased loss of attachment and irreversible crestal loss [5] [6]. Although absolute reduction in bone and attachment levels does not contraindicate orthodon-

tic correction, it does increase the difficulty of delivering controlled orthodontic mechanics that would potentially minimize further bone loss.

The present review article discusses the various factors that are associated with orthodontic tooth movement in periodontally compromised patients namely:

1) Tooth movement into infrabony pockets;
2) Tooth movement into compromised bone areas;
3) Tooth movement through cortical bone;
4) Extrusion (Eruption);
5) Intrusion;
6) Tipping.

1.1. Tooth Movement into Infrabony Pockets

Orthodontic forces per se are unlikely to convert gingivitis into destructive periodontitis. However, infra-bony pockets *i.e.* angular bony defects with inflamed connective tissue and epithelium apical to the bone crest, may develop as a result of destructive periodontitis or by orthodontic tipping and/or intruding movements of teeth harboring plaque [7]. Deep infrabony defects were infrequently found before age 40 years. About 20% of patients at least 50 years of age have radiographic evidence of infrabony pockets of 4 mm or more at not more than 5% of sites. Bone loss is more pronounced in the maxilla, especially at molars. In the study of predominantly male population by Muller and Ulbrich [8], periodontal bone loss gradually increased with age but the prevalence of infrabony defects was very low.

The effect of bodily tooth movement into infra-bony defects has been evaluated experimentally in monkeys (Polson *et al.*, 1984) [9] and in dogs (Wennstrom *et al.*, 1993) [6]. Results showed that provided elimination of the sub-gingival infection was performed before the orthodontic tooth movement was started, no detrimental effects on the attachment level were observed. The angular bony defect was eliminated by the orthodontic treatment, but no coronal gain of attachment was found and a thin epithelial lining covered the root surface corresponding to its pretreatment position. It was therefore concluded that orthodontic tooth movement into infrabony periodontal defects had no favorable effects on the level of connective tissue attachment.

However, it was possible to move teeth with reduced healthy periodontium without additional attachment loss. If, on the other hand, the orthodontic treatment involved movement of teeth into and through a site with inflammation and angular bone loss, an enhanced rate of periodontal destruction was noted (**Figure 1** and **Figure 2**).

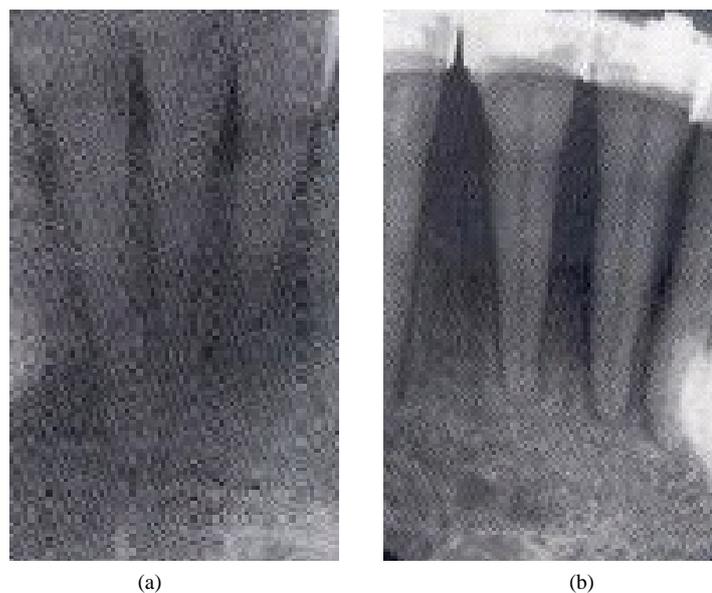(a)   (b)

Figure 1. Increased rate of destruction of the connective tissue attachment seen with movement through inflamed pockets. (a) IOPA radiograph before tooth movement; (b) IOPA radiograph after tooth movement.
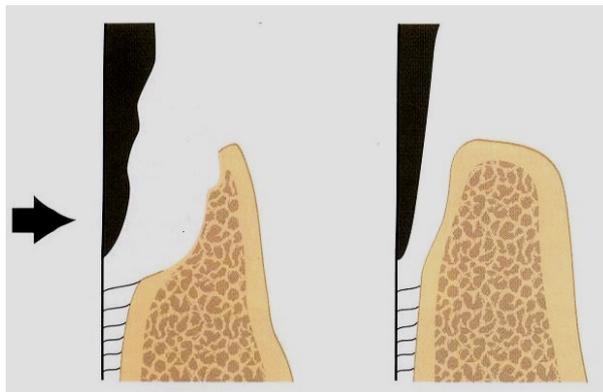
Figure 2. Persisting junctional epithelium subsequent to orthodontic tooth movement (direction of arrow) into an infrabony pocket.

It is clinically essential that periodontal treatment with elimination of the plaque-induced lesion is performed before orthodontic therapy is begun. It is equally important that excellent oral hygiene is maintained throughout the course of the orthodontic treatment (**Figure 3**).

The tooth can move away from a defect and, with sufficient eruption, a bony defect can be reduced or eliminated; this usually is the treatment of choice to improve osseous architecture.

1.2. Tooth Movement into Compromised Bone Areas

Orthodontic tooth movement may sometimes be performed in patients with partially edentulous dentitions having a more or less compromised alveolar process. Intra-oral pattern of tooth and periodontal bone loss between the age of 50 and 60 years was studied by Paulander *et al.* and they found that the incidence of tooth loss was highest among mandibular molars (7.5%) and lowest among canines (1.8%). The relative risk (RR) for tooth loss for endodontically compromised teeth was 4.1 and for furcation-involved molars 2.4 - 6.5, depending on tooth position. Smokers experienced a greater (20% - 131% depending on tooth type) mean bone loss than non-smokers [10].

Experimental reports (Lindskog Stokland *et al.*, 1993) [11] and clinical studies (Stepovich [12], Hom & Turley [9], Thilander [13]) have shown that a reduction in vertical bone height is not a contraindication for orthodontic tooth movement towards, or into, the constricted area. Mandibular second molars can be moved mesially through remodeled edentulous first molar areas in adults, with only a limited reduction in vertical bone height, averaging −1.3 mm (Hom & Turley [9]) (**Figure 4**). Space closure is possible also in edentulous maxillary first molar areas, although vertical bone loss and some space re-opening can be a complication.

Histologic observations in animal experiments have confirmed that when light forces were applied to move teeth bodily into an area with reduced bone height, a thin bone plate was recreated ahead of the moving tooth (Lindskog-Stokland *et al.* [11]), The key to moving teeth with bone is direct resorption in the direction of tooth movement, and avoiding hyalinization. Teeth can be moved with bone into the maxillary sinus also (Melsen, 1991) [14].

Although the results of studies are encouraging, it is probably wise not to stretch the indications for tooth movement into constricted bone areas too far. Even if light forces are used and excellent oral hygiene is maintained, marked gingival invaginations are sometimes seen in such areas, and buccal or lingual bone dehiscences may occur (Diedrich, 1996) [15]. For orthodontic tooth movement into markedly atrophied alveolar ridges, the possibility to acquire new bone by, for example, Guided Bone Regeneration (GBR) procedures should be considered (**Figure 5**).

1.3. Tooth Movement through Cortical Bone

The labial and lingual cortical plates at the level of the apex may represent the anatomic limits of tooth movement. Experimental studies in animals have demonstrated that when a tooth is moved bodily in a labial direction towards and through the cortical plate of the alveolar bone, no bone formation will take place in front of the tooth (Steiner *et al.* [16], Karring *et al.* [17]). After initial thinning of the bone plate, a labial bone dehiscence
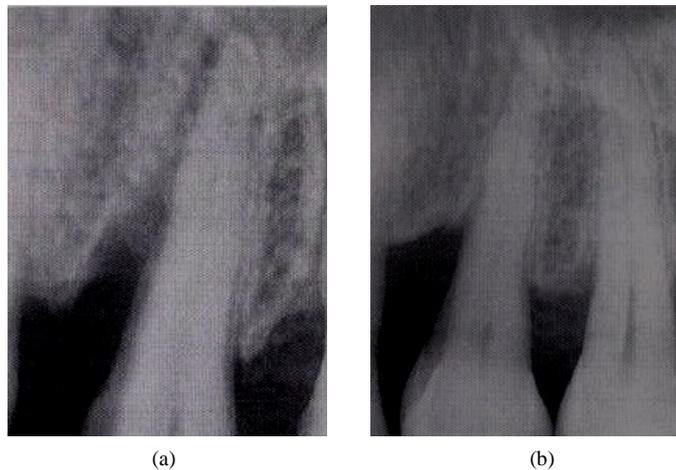
Figure 3. Improvement of infrabony defect using regenerative procedures before orthodontic therapy. (a) IOPA radiograph before regenerative procedures; (b) IOPA radiograph after regenerative procedures.
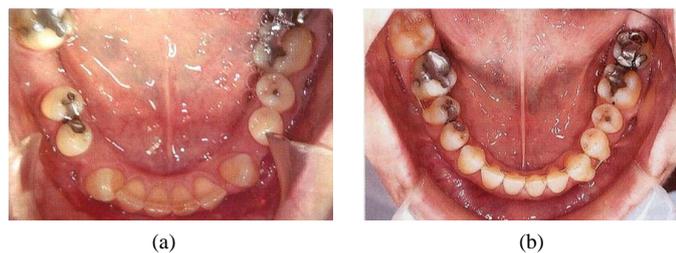

Figure 4. Tooth movement into long standing extaction sites with atrophic ridges. (a) Pre-tooth movement; (b) Post tooth movement.
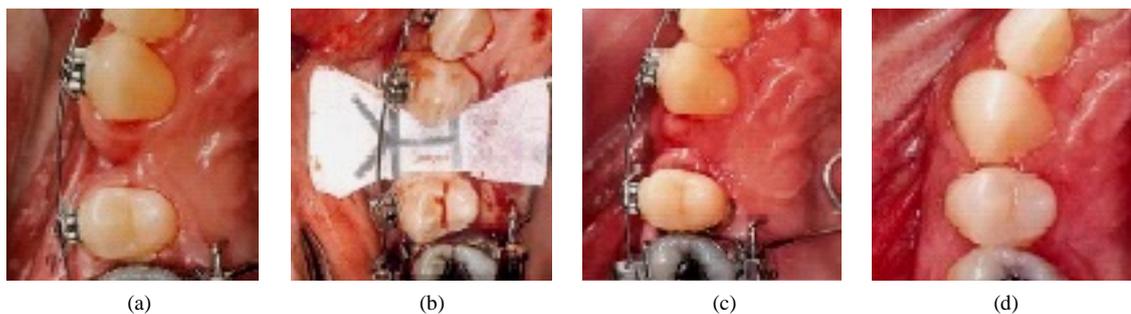

Figure 5. Use of GBR procedure to gain alveolar bone prior to tooth movement into compromised bone areas. (a) Pre-GBR procedure; (b) GBR procedure being carried out; (c) Post GBR procedure—before space closure; (d) Post GBR procedure—after space closure.

is therefore created. Such perforation of the cortical plate can occur during orthodontic treatment either accidentally or because it was considered unavoidable. It may happen for example:

1) In the mandibular anterior region due to frontal expansion of incisors (Wehrbein *et al.*, 1994) [18].

2) In the maxillary posterior region during lateral expansion of cross-bites (Greenbaurn & Zachrisson, 1982) [19].

3) Lingually in the maxilla associated with retraction and lingual root torque of maxillary incisors in patients with large overjets (Ten Hoeve & Mulie, 1976) [20].

4) By pronounced traumatic jiggling of teeth (Nyman *et al.*, 1982) [19].

Interestingly, however, there is potential for repair when malpositioned teeth are moved back toward their original positions, and bone apposition may take place. Evidently, the soft tissue facial to an orthodontically produced bone dehiscence may contain soft tissue components (vital osteogenic cells) with a capacity for forming bone following repositioning of the tooth into the alveolar process (Nyman *et al.*, 1982) [19] (**Figure 6**).

Figure 6. Bodily advancement of incisors through cortical bone leads to dehiscence and perforation.

Bone dehiscences which may occur due to uncontrolled expansion of teeth through the cortical plate may be repaired when the teeth are brought back or relapse, towards a proper position within the alveolar process, even if this occurs several months later (**Figure 7**).

Bimstein *et al.* (1990), [17] reported that during orthodontic treatment that involves lingual positioning of procumbent teeth but no intrusion, an increase in the amount of buccal alveolar bone may take place. Similar repair mechanisms may be expected to occur when marked jiggling of teeth is brought under control and stabilized. In the case of buccal cross-bites, the initial discrepancy can apparently be overcorrected with both slow and rapid expansion treatment approaches without causing permanent periodontal injury to the settled occlusion.

Engelking and Zachrisson (1982) [21] found that in monkeys, reapposition of labial bone can occur in a coronal direction, once teeth in extreme labial position are moved to a more normal environment, that is, a more ideal position in relationship to the underlying bony arch. This would be in agreement with laminographic findings in human beings, reported by Ten Hoeve and Mulie, that a new palatal cortex may reappear with time subsequent to tissue incisor retraction through the lingual cortical plate.

The anatomic limits set by the cortical plates of the alveolus at the level of the incisor apices (esp. palatal wall of the maxilla and the posterior cortex of the synthesis) may be regarded as "orthodontic walls." Other examples of such walls are the maxillary sinus around the premolars, the inferior aspect of the palate (especially in deep bite cases), areas of sclerosed bone, and deeply imbedded fibrous frenula. It is imperative in planning treatment to consider these orthodontic walls as a limit to repositioning teeth, as well as a danger zone for heightened unfavorable sequelae [22].

A simple, visualized treatment objective, performed with overlay acetate papers, will determine if sufficient alveolar bone is available for safe movement of incisors to correct anteroposterior discrepancies. One should keep in mind that the cortical plates of the palate and synthesis that are traced from cephalometric X-rays present a two-dimensional view of a concave surface. The actual limit of the palate and synthesis at the midline may be narrower than the traced image.

Frequently the skeletal discrepancy is large and beyond dental compensation, *i.e.*, outside the "envelope of discrepancy" for orthodontic treatment. At times this discrepancy is small, but the thinness of the alveolar housing will not accommodate even modest movements. Orthognathic surgery is often required to improve skeletal relationships and soft tissue harmony, as well as establish a stable occlusion. There are many borderline patients who may appear to be within the range for orthodontic therapy but who, upon closer examination of their cephalometric X-rays, will require surgery because of limited alveolar width. The mandibular incisors, more frequently than the maxillary incisors, are the cause of limitation in treatment because of the thinness of their alveolar housing. A thin alveolus may be encountered in any skeletal type, but is most frequently encountered in patients with long lower face height and severe bimaxillary protrusion.

1.4. Extrusion (Eruption)

Orthodontic extrusion of teeth, or so-called "forced eruption", of a tooth or several teeth, along with reduction of the clinical crown height, has been reported to reduce infrabony defects and decrease pocket depth. Single tooth eruption should be distinguished from overbite correction and control of the vertical dimension during routine orthodontic correction. Extrusion is used specifically for correction of isolated periodontal osseous lesions and or increasing clinical crown length of single teeth [16] (**Figure 8**).
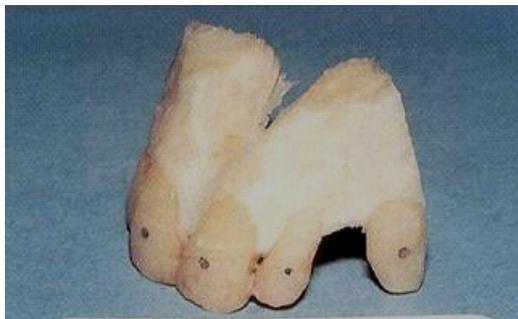
Figure 7. Orthodontic repositioning or relapse leads to bone regeneration.

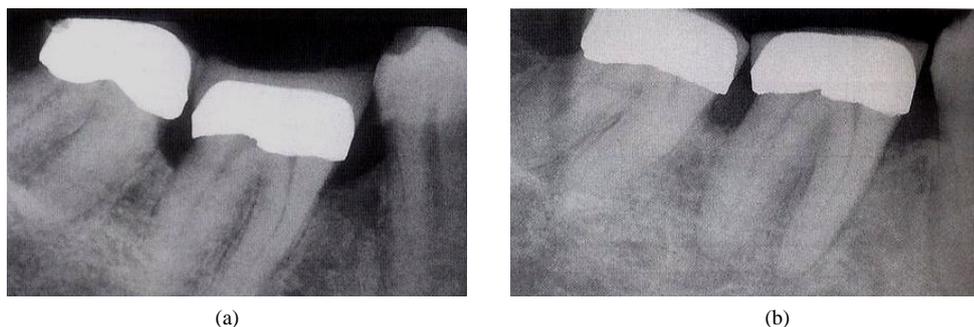(a)   (b)

Figure 8. Improvement of osseous morphology after extrusion. (a) IOPA radiograph pre-extrusion; (b) IOPA radiograph post extrusion.

Studies have shown that eruption in the presence of gingival inflammation reduces bleeding on probing, decreases pocket depth, and even causes the formation of new bone at the alveolar crest as teeth erupt, with no occlusal factor present and while controls remain unchanged. During clinical treatment, however, inflammation always should be controlled to ensure that the supracrestal connective tissue remains healthy and that the crestal alveolar bone height remains at its original level.

The forced eruption technique was originally described by lngber (1974) for treatment of one-wall and two-wall bony pockets that were difficult to handle by conventional therapy alone. The extrusive tooth movement leads to a coronal positioning of intact connective tissue attachment, and the bony defect is shallowed out. During extrusion, the relationship between the CEJ and the bone crest is maintained. This means that the bone follows the tooth during the extrusive movement. This may or may not be beneficial depending on the clinical situation. In other words, it is sometimes desirable to have the periodontium follow the tooth and in other situations, it is desirable to move a tooth out of the periodontal support.

1) Extrusion with Periodontium

Orthodontic extrusion of a single tooth that needs to be extracted is an excellent method for improvement of the marginal bone level before the surgical placement of single implants. Not only the bone, but also the soft tissues will move vertically with the teeth during orthodontic extrusion.

Kajiyama *et al.* (1993), [23] reported that the free gingival moved about 90% and the attached gingival about 80% of the extruded distance. The width of the attached gingival and the clinical crown length increased significantly, whereas the position of the mucogingival junction was unchanged. Orthodontic extrusion of a "hopeless" incisor is therefore a useful method also for esthetic improvement of the marginal gingival level associated with the placement of implants (**Figure 9**).

2) Extrusion out of Periodontium

In teeth with crown-root fracture, or other subgingival fractures, the goal of treatment may be to extrude the root out of periodontium, and then provide it with an artificial crown. When an increased distance between CEJ and the alveolar bone crest is aimed at, the forced eruption should be combined with gingival fiberotomy (**Figure 10**).

Eruption of a tooth is the least hazardous type of movement to solve osseous morphologic defects on individual teeth created by periodontal disease or tooth factures.
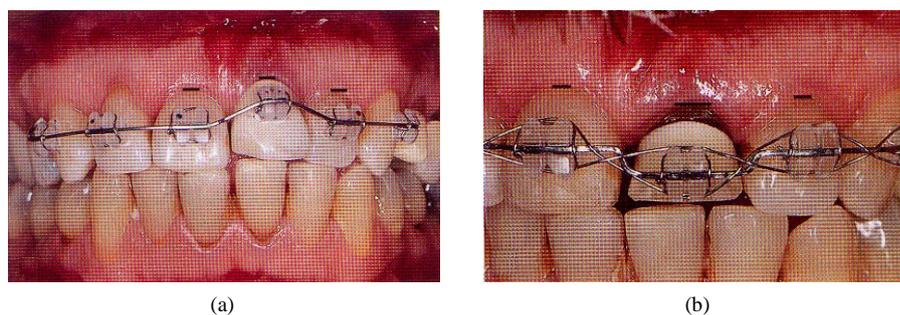
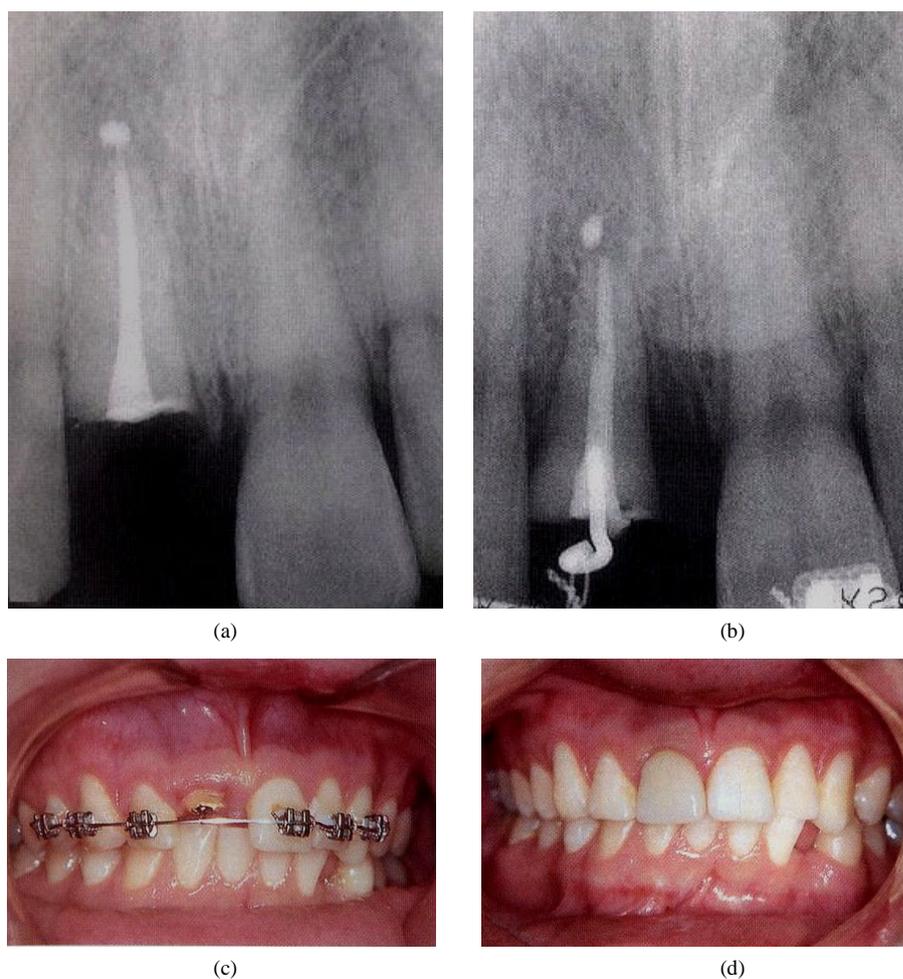**Figure 9.** Movement of gingival margins with tooth extrusion. (a) Pre-extrusion; (b) Post extrusion.

Figure 10. Extrusion and restoration of a root stump (a) IOPA radiograph pre-extrusion (b) IOPA radiograph post extrusion (c) Intraoral frontal view of the extrusion of root stump (d) Intraoral frontal view of the restored root stump crown.

Extrusion is the easiest orthodontic movement to achieve because it closely resembles natural tooth eruption. Only 20 - 30 g of force is required for the forced eruption of a single-rooted tooth. However, extrusion that is too rapid may require a longer stabilization period and can produce marked periodontal inflammation.

Kajiyama *et al.* (1993), [23] examined the reaction of the gingival tissues attached to the extruded teeth and concluded that:

1) The gingiva moved in the same direction in which the teeth were extruded. The free gingiva moved about 90% and the attached gingiva moved about 80% as far as the teeth were extruded.

2) The width of the attached gingiva on the labial surface increased as the teeth were extruded.

3) The sulcus depth decreased about 20% of the distance that the teeth were extruded; the clinical crown height was increased about 20%.

4) The mucogingival junction before the experiment was positioned the same after the experiment.

5) The epithelial attachment originated at the cementoenamel junction of the experimental teeth after the tooth extrusion. There was no gingival migration, gingival pocket formation, or inflammation on the labial surface. No clinical nor histologic problems were encountered in the gingival tissues if the teeth were extruded properly.

Extrusion of anterior segment in skeletal open bite patterns with muscular problems has shown shortening of the roots. If teeth have normal bone support or if bone loss has been horizontal, (the alveolar crests and the cementoenamel junctions are level), then movement should involve intrusion or extrusion as necessary to correct the orthodontic deformity.

1.5. Intrusion

Orthodontic intrusion of teeth has been recommended [16]:

1) For teeth with horizontal bone loss or infrabony pockets;

2) For increasing the clinical crown length of single teeth by leveling of gingival margins by intrusion, followed by restoration.

Conflicting evidence has been reported regarding the benefits of intrusion of individual teeth. Some studies (Melson, 1986 [24], Melson *et al.*, 1988 [25], Melson *et al.*, 1989 [26] have reported that intrusion of individual teeth did not result in the development of pockets and new attachment is possible associated with orthodontic intrusion of teeth provided the gingival inflammation is kept to a minimum. Others have observed that intrusion may result in root resorption, pulpal disturbances, and incomplete root formation in younger individuals. Intrusion of plaque-infected teeth may lead to the formation of angular bony defects and increased loss of attachment [3]. When oral hygiene is inadequate, tipping and intrusion of the teeth may shift supragingivally located plaque into a subgingival position, resulting in periodontal destruction. Therefore subgingival scaling is particularly important with intrusion. Deep pockets should be eliminated before intrusion. Clinicians have cautioned that intrusion of anterior teeth during leveling of the occlusal plane to correct overbite can deepen infrabony defects on individual teeth. These conflicting reports indicate that intrusion can be a more hazardous type of movement; because the force is concentrated at the apex, root resorption has been a well-known sequela, and light forces have been recommended. Even in a healthy periodontal environment the question remains as to whether the orthodontic tooth movement intrudes a long epithelial attachment beneath the margin of the alveolar bone or whether the alveolar crest is constantly resorbed in front of the intruding tooth.

According to Murakami *et al.* (1989) [27], the gingiva moved only about 60% of the distance when the teeth were intruded with a continuous force of 80 gm. However Kokich *et al.* (1984) [28] recommended an interrupted, continuous force for leveling of gingival margins on supra-erupted teeth.

Intrusion is best performed when 1) forces are low *i.e.* 5 to 15 gm per tooth (to keep apical resorption to minimum); 2) the line of action of the force passing through or close to the center of resistance; 3) the gingiva status is healthy, and 4) no interference with perioral function is present (**Figure 11**).

Tooth movement, when properly executed, improves periodontal conditions and is beneficial to periodontal health. Extrusion is much more predictable than intrusion in accomplishing this purpose. Whenever the treatment objective is new connective tissue attachment or periodontal regeneration to restore lost supporting periodontal tissues, guided tissue regeneration (e.g., barrier membranes) is the predictable way to manipulate cells that lead to new attachment. Guided tissue regeneration procedures always should precede orthodontic tooth movement and should be part of the initial therapy before active orthodontic treatment is begun.

1.6. Tipping

When a single force is applied to the crown of the tooth, the tooth can rotate around its center of resistance (for an incisor, approximately the midpoint of the root) and compression (pressure) is increased at the crest and at the root apex. In this case, half of the periodontal ligament has the potential to received high pressure from essentially light force [3]. Experiments have demonstrated that with tipping and intruding movements, forces were capable of causing conversion of a gingival lesion to a lesion associated with attachment loss (**Figure 12**). In tipping movements the force should be light and the area should be kept clean to prevent the formation of angular bony defects.
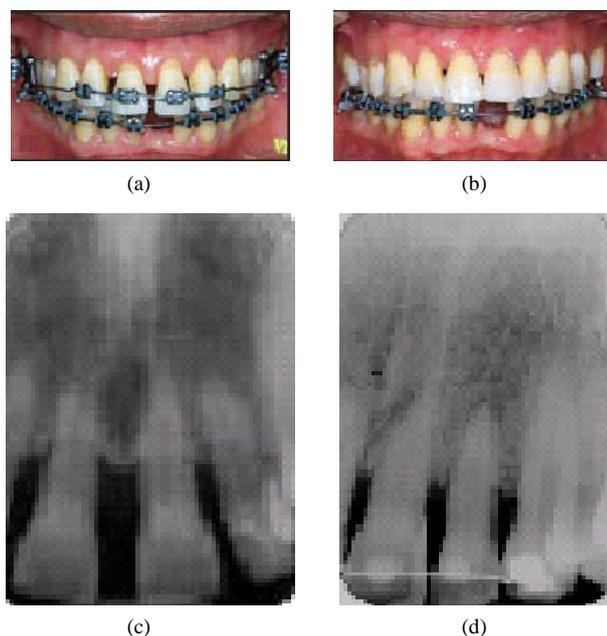
Figure 11. Improvement of bone support after intrusion. (a) Pre-intrusion; (b) Post intrusion; (c) IOPA radiograph pre-intrusion; (d) IOPA radiograph post intrusion.

Figure 12. Tipping of a lower central incisor by using orthodontic force via lower removable appliance leading to attachment loss.

2. Discussion

A malocclusion is a misalignment or incorrect relation between the teeth of the two dental arches when they approach each other as the jaws close. There is no consistent relationship between malocclusion and periodontal disease but certain characteristics of malocclusion can promote a pathologic environment conducive to periodontal disease. One of the dramatic means available to improve the local environmental factors is through orthodontic tooth movement. Bragger and Lang [2] defined periodontal disease as an inflammatory disease triggered by bacteria that supragingivally affect the gingiva (gingivitis) and subgingivally affect the supporting connective tissue and alveolar bone (periodontitis). Gingivitis which is a reversible lesion can be classified into a) The initial lesion; b) The early lesion; and c) The established lesion. Periodontitis which is the irreversible or destructive lesion is always preceded by gingivitis, may be typified as [3]: a) Adult periodontitis Pre-pubertal periodontitis; Juvenile (early onset) periodontitis; rapidly progressive periodontitis; and Refractory periodontitis.

The present review article discusses the various factors that are associated with orthodontic tooth movement in periodontally compromised patients: 1) Tooth movement into infrabony pockets in which the tooth can move away from a defect and, with sufficient eruption, a bony defect can be reduced or eliminated; this usually is the treatment of choice to improve osseous architecture; 2) Tooth movement into compromised bone areas in which although the results of studies are encouraging, it is probably wise not to stretch the indications for tooth move-

ment into constricted bone areas too far. Even if light forces are used and excellent oral hygiene is maintained, marked gingival invaginations are sometimes seen in such areas, and buccal or lingual bone dehiscences may occur (Diedrich, 1996) [15].

For orthodontic tooth movement into markedly atrophied alveolar ridges, the possibility to acquire new bone by, for example, Guided Bone Regeneration (GBR) procedures should be considered; 3) Tooth movement through cortical bone where there are many borderline patients who may appear to be within the range for orthodontic therapy but who, upon closer examination of their cephalometric X-rays, will require surgery because of limited alveolar width. The mandibular incisors, more frequently than the maxillary incisors, are the cause of limitation in treatment because of the thinness of their alveolar housing. A thin alveolus may be encountered in any skeletal type, but is most frequently encountered in patients with long lower face height and severe bimaxillary protrusion; 4) Extrusion (Eruption) which can be with periodontium as well as out of periodontium and is the least hazardous type of movement to solve osseous morphologic defects on individual teeth created by periodontal disease or tooth factures. Extrusion is the easiest orthodontic movement to achieve because it closely resembles natural tooth eruption. Only 20 - 30 g of force is required for the forced eruption of a single-rooted tooth. However, extrusion that is too rapid may require a longer stabilization period and can produce marked periodontal inflammation; 5) Intrusion which has conflicting evidence regarding its benefits in individual teeth. These conflicting reports indicate that intrusion can be a more hazardous type of movement; because the force is concentrated at the apex, root resorption has been a well-known sequela, and light forces have been recommended.

Even in a healthy periodontal environment the question remains as to whether the orthodontic tooth movement intrudes a long epithelial attachment beneath the margin of the alveolar bone or whether the alveolar crest is constantly resorbed in front of the intruding tooth. Intrusion is best performed when 1) forces are low *i.e.* 5 to 15 gm per tooth (to keep apical resorption to minimum); 2) the line of action of the force passing through or close to the center of resistance, 3) the gingiva status is healthy, and 4) no interference with perioral function is present. Tipping in which experiments have demonstrated that with tipping and intruding movements, forces were capable of causing conversion of a gingival lesion to a lesion associated with attachment loss In tipping movements the force should be light and the area should be kept clean to prevent the formation of angular bony defects.

3. Conclusions

Combined orthodontic-periodontal therapy is essential for providing complete rehabilitation in terms of both appearance and function with a satisfactory long-term prognosis in periodontally compromised patients.

Good oral hygiene at home and professional maintenance visits are important during and after active orthodontic treatment. In addition to the need for research in this field, improved communication between orthodontist and periodontist is desirable. Once the basic principles can be determined, elucidated and applied correctly, the movement of teeth in periodontal cases will be limited only by the imagination of the operator.

References

[1] Gruenbaum, T. (2010) Famous Figures in Dentistry Mouth. *JASDA*, **30**, 18.

[2] Brägger, U. and Lang, N.P. (1996) The Significance of Bone in Periodontal Disease. *Seminars in Orthodontics*, **2**, 31-38. http://dx.doi.org/10.1016/S1073-8746(96)80037-5

[3] Graber, T.M. and Vanarsdall, R.L. (2000) Orthodontics—Current Principles and Techniques. 3rd Edition, Mosby, St. Louis.

[4] Johal, A.S. and Lee, R.T. (1998) The Periodontal-Orthodontic Interface. A Simple Solution to a Difficult Problem. *BJO*, **25**, 95-99. http://dx.doi.org/10.1093/ortho/25.2.95

[5] Matthew, K. (1976) Interrelationships between Orthodontics and Periodontics. *American Journal of Orthodontics*, **70**, 154-171. http://dx.doi.org/10.1016/S0002-9416(76)90316-X

[6] Wennström Jan, L., *et al.* (1993) Periodontal Tissue Response to Orthodontic Movement of Teeth with Infrabony Pockets. *American Journal of Orthodontics*, **103**, 313-319. http://dx.doi.org/10.1016/0889-5406(93)70011-c

[7] Baxter, D.H. (1967) The Effect of Orthodontic Treatment on Alveolar Bone Adjacent to the Cementoenamel Junction. *Angle Orthodontist*, **37**, 35-47.

[8] Müller, H.P. and Ulbrich, M. (2005) Alveolar Bone Levels in Adults as Assessed on Panoramic Radiographs. (I) Pre-

valence, Extent, and Severity of Even and Angular Bone Loss. *Clinical Oral Investigations*, **9**, 98-104. http://dx.doi.org/10.1007/s00784-005-0303-x

[9] Hom, B.M. and Turley, P.K. (1984) The Effects of Space Closure on Mandibular First Molar Area in Adults. *American Journal of Orthodontics*, **84**, 457-469. http://dx.doi.org/10.1016/0002-9416(84)90085-X

[10] Paulander, J., Axelsson, P., Lindhe, J. and Wennström, J. (2004) Intra-Oral Pattern of Tooth and Periodontal Bone Loss between the Age of 50 and 60 Years. A Longitudinal Prospective Study. *Acta Odontologica Scandinavica*, **62**, 214-222. http://dx.doi.org/10.1080/00016350410001630

[11] Lindskog-Stokland, B., Wennstrom, J.L., Nyman, S. and Thilander, B. (1993) Orthodontic Tooth Movements into Edentulous Areas with Reduced Bone Height. An Experimental Study in the Dog. *The European Journal of Orthodontics*, **15**, 89-96. http://dx.doi.org/10.1093/ejo/15.2.89

[12] Stepovich, M.L. (1978) A Clinical Study on Closing Edentulous Spaces in the Mandible. *The Angle Orthodontist*, **49**, 227-233.

[13] Thilander, B. (1996) Infrabony Pockets and Reduced Alveolar Bone Height in Relation to Orthodontic Therapy. *Seminars in Orthodontics*, **2**, 55-61. http://dx.doi.org/10.1016/S1073-8746(96)80040-5

[14] Melson, B. (1991) Limitations in Adult Orthodontics. In: Melson, B., Ed., *Current Controversies in Orthodontics*, Quintessence, Chicago, 147-180.

[15] Deidrich, P.R. (1996) Guided Tissue Regeneration Associated with Orthodontic Therapy. *Seminars in Orthodontics*, **2**, 39-45. http://dx.doi.org/10.1016/S1073-8746(96)80038-7

[16] Lindhe, J., Thorkild, K. and Lang, N.P. (1997) Clinical Periodontology & Implant Dentistry. 3rd Edition, Munksgaard, Copenhagen.

[17] Karring, T., Nyman, S., Thilander, B. and Magnusson, I. (1982) Bone Regeneration in Orthodontically Produced Alveolar Bone Dehiscences. *Journal of Periodontal Research*, **17**, 309-315. http://dx.doi.org/10.1111/j.1600-0765.1982.tb01158.x

[18] Wehbrein, H., Fuhrmann, R.A.W. and Deidrich, P.R. (1994) Periodontal Conditions after Facial Root Tipping and Palatal Root Torque of Incisors. *American Journal of Orthodontics and Dentofacial Orthopedics*, **106**, 455-462. http://dx.doi.org/10.1016/S0889-5406(94)70067-2

[19] Greenbaum, K.R. and Zachrisson, B.U. (1982) The Effect of Palatal Expansion Therapt on the Periodontal Supporting Tissues. *American Journal of Orthodontics*, **81**, 12-21. http://dx.doi.org/10.1016/0002-9416(82)90283-4

[20] Ten Hoeve, A. and Mulie, R.M. (1976) The Effect of Anteroposterior Incisor Repositioning on the Palatal Cortex as Studied with Laminography. *Journal of Clinical Orthodontics*, **6**, 804-822.

[21] Engelking, G. and Zachrisson, B.U. (1982) Effects of Incisor Repositioning on Monkey Periodontium after Expansion through the Cortical Plate. *American Journal of Orthodontics*, **83**, 23-32. http://dx.doi.org/10.1016/0002-9416(82)90542-5

[22] Handelman, C.S. (1996) The Anterior Alveolus: Its Importance in Limiting Orthodontic Treatment and Its Influence on the Occurrence of Iatrogenic Sequelae. *The Angle Orthodontist*, **66**, 95-110.

[23] Kajiyama, K., Murakami, T. and Yokota, S. (1993) Gingival Reactions after Experimentally Induced Extrusion of the Upper Incisors in Monkeys. *American Journal of Orthodontics*, **104**, 36-47. http://dx.doi.org/10.1016/0889-5406(93)70025-J

[24] Melsen, B. (1986) Tissue Reaction Following Application of Extrusive and Intrusive Forces to Teeth in Adult Monkeys. *American Journal of Orthodontics*, **89**, 469-475. http://dx.doi.org/10.1016/0002-9416(86)90002-3

[25] Melsen, B., Agerbaek, N., Erikson, J. and Terp, S. (1988) New Attachment through Periodontal Treatment and Orthodontic Intrusion. *American Journal of Orthodontics and Dentofacial Orthopedics*, **94**, 104-116. http://dx.doi.org/10.1016/0889-5406(88)90358-7

[26] Melsen, B., Agerbaek, N. and Markenstam, G. (1989) Intrusion of Incisors in Adult Patients with Marginal Bone Loss. *American Journal of Orthodontics and Dentofacial Orthopedics*, **96**, 232-241. http://dx.doi.org/10.1016/0889-5406(89)90460-5

[27] Murakami, T., Yokota, S. and Takahama, Y. (1989) Periodontal Changes after Experimentally Induced Intrusion of the Upper Incisors in *Macaca fuscata* Monkeys. *American Journal of Orthodontics and Dentofacial Orthopedics*, **95**, 115-126. http://dx.doi.org/10.1016/0889-5406(89)90390-9

[28] Kokich, V., Nappen, D.L. and Shapiro, P.A. (1984) Gingival Contour and Clinical Crown Length: Their Effect on the Esthetic Appearance of Maxillary Anterior Teeth. *American Journal of Orthodontics*, **86**, 89-94. http://dx.doi.org/10.1016/0002-9416(84)90300-2