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Impacts of Orthodontic Treatment on Periodontium: A Review

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Abstract: *With a number of patients opting for orthodontic therapy for esthetic reasons, it becomes necessary to evaluate the resulting effects of orthodontic treatment on the periodontal tissues. In many cases, orthodontic tooth movement improves the periodontal conditions, and also, periodontal therapy often facilitates orthodontic tooth movement. The orthodontic treatment for the patients need to be carefully planned and carried out in order to prevent unwanted effects on the periodontium. So it is of great importance to determine the need and consequences of interdisciplinary periodontal-orthodontic approach in order maintain harmonious periodontal and orthodontic relation and bring out the best results for the patient. Thus, the aim of this review is to discuss in detail the effects of various orthodontic forces on the periodontal tissues.*

Keywords:*Orthodontic forces, periodontal tissues, excessive,infrabony, recession*

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I. Introduction

An increasing number of adult patients are seeking orthodontic treatment, many of whom are likely to have some degree of periodontal disease. A reduction in periodontal support can be associated with labial flaring, extrusion, rotation, spacing and drifting of the teeth [1]. Such changes are believed to occur when the periodontal ligament is no longer able to stabilize the teeth against external forces [2]. Maxillary incisors are particularly susceptible to pathological migration and over-eruption [3]. These acquired occlusal changes, along with any underlying skeletal discrepancy, often result in a complex malocclusion that necessitates an interdisciplinary treatment approach.

Periodontal disease is not necessarily a contraindication to orthodontic treatment provided that the condition has been stabilized; however, loss of alveolar bone and soft-tissue architecture may pose considerable challenges to oral rehabilitation. It has been concluded that adjunct orthodontic treatment may play an important role in developing the optimal base needed for re-establishing an esthetic and functional dentition in these cases [4]. Orthodontic extrusion of unrestorable teeth, for instance, may assist the periodontist and restorative team in harnessing alveolar bone and improving the soft-tissue architecture[1]. This adjunct treatment is particularly useful for patients who require dental implants in esthetic zones.

Orthodontic therapy may also have detrimental effects, including root resorption[5] and bone dehiscence [6]. The introduction of fixed orthodontic appliances into the oral cavity also increases the amount of acidogenic biofilm, thus increasing the risk of gingivitis and caries. A critical issue in the treatment planning of any patient revolves around how much orthodontic movement the periodontium can tolerate before it becomes adversely affected.

TISSUE RESPONSE TO ORTHODONTIC FORCES

When orthodontic forces are applied to teeth, both compressive and tensile stresses develop in the surrounding tissues. Areas under tension have classically been described as sites of bone apposition, while those under compression undergo bone resorption. The net effect of this remodeling process is the movement of teeth along the direction of the applied force and into the space created by the recently resorbed bone. It has recently been demonstrated by Cattaneo PM et al (2005), however, that the distribution of compressive and tensile strains in the periodontal tissues is more complex than initially believed [7].

The magnitude of the applied force is believed to play a role in determining the pattern of stresses and strains in the dento-alveolar tissues. It has also been suggested that different force systems may determine whether a tooth will move 'through' bone or 'with' bone [8]. A tooth is thought to move through bone when undermining resorption, rather than frontal resorption, occurs in response to heavy orthodontic forces [8]. Such forces cause constriction of the microvasculature and localized necrotic areas within the periodontal ligament (hyalinization), which are then removed by tartrate-resistant acid phosphatasepositive macrophages and multinucleate giant cells migrating from adjacent bone marrow sites.Undermining resorption is typically characterized by a delay in tooth movement because no bone apposition can occur on the tension side until the necrotic tissue on the compression side has been removed. Under ideal conditions, it is thought that teeth move with their alveolus when resorption occurs directly at the alveolar–periodontal ligament interface on the compression side, while bone apposition occurs on the tension side and on the external surface of the alveolar process [4]. The net outcome of this near simultaneous process is the movement of a tooth beyond its original alveolar boundary [8].

There has been awareness of the relationship between force magnitude and the type of resorption that occurs on the pressure side ever since Carl Sandstedt's classical experiments (1904-1905) on dogs in the early 1900s [9,10]. In some experiments on Beagle dogs, the use of light forces did not seem to prevent hyalinization of the periodontal ligament in the initial stages [11] or influence the rate of tooth movement [12]. The use of light force systems, however, may still prevent further hyalinization from occurring after the initial period of tooth movement [13].Movement of teeth through bone, for example, may be desirable in cases where the clinician is interested in extruding a root-fractured tooth without the accompanying bone [4]. On the other hand, movement of teeth with bone may help augment bone as teeth are moved into sites with atrophic alveolar ridges [4].

ORTHODONTIC SPACE CLOSURE

One of the most challenging clinical problems in orthodontics is the closure of large edentulous spaces with severely resorbed alveolar ridges. These situations may arise following the loss of a deciduous tooth with no permanent successor or after extraction of an unrestorable tooth. In nongrowing patients, the loss of a permanent molar often leads to progressive tipping, rotation and lingual rolling of the adjacent teeth [14]. Over time, these uncontrolled tooth movements can result in scissor bites, nonworking side interferences, poor gingival contours,deepening of the bite and over-eruption of theopposing teeth [14]. Pseudopockets may alsodevelop because of the bone's tendency to follow theinferiorly displaced cemento–enamel junction ofthe tipped tooth.There are several biomechanical and anatomic challenges in closing long-standing edentulous spaces with narrow ridges. Space closure is particularly problematic in the mandible because of the denser cortical plates and greater susceptibility to ridge resorption. Orthodontic space closure may reduce costs for ridge augmentation and placement of implant-supported restorations [15]. Despite these potential benefits, most orthodontists are often reluctant to close large edentulous spaces because of the risk of localized gingival dehiscence, poor root parallelism, incomplete space closure, increased treatment duration, and relapse [15,16]. Reopening or incomplete closure of these spaces can lead to further periodontal breakdown if they result in open interproximal contacts and food traps.

Two retrospective human studies by Hom BM et al (1984) and Stepovich ML et al (1979) have investigated the effect of space closure and found clinically significant reductions in posterior space and moderate increases in the width of the alveolar ridge [16,17]. Both studies used small convenience samples and did not report on any quantitative measurements of gingival recession or attachment loss. Two notable findings from these studies were the slight loss of crestal bone height mesial to the tooth being protracted [16] and the age-dependent effect on the amount of increase in alveolar bone width [17]. The loss of crestal bone height reported in these two studies may be related to the tipping movements that occur when a tooth is moved along an arch-wire [18]. Tipping movements usually result in an unequal distribution of stresses within the periodontal ligament, with higher active forces and levels of compression found in the marginal tissues.

According to Frost's 'mechanostat' theory, both low and excessive bone strains can cause osteopenia and bone loss. On the other hand, strain levels in the range of 1,500–3,000 microstrains tend to favor a modeling process which is associated with bone deposition [19]. The type of bone deposited during this modeling process is thought to be dependent on the amount of bone strain, with higher levels resulting in the formation of woven bone.Recent advancements in the fields of orthodontics and periodontics have had a large impact on the management of edentulous atrophic ridges. Skeletal anchorage has been useful for uprighting tipped teeth, facilitating bodily tooth movements during space closure and reinforcing anchorage [20]. The risk of anchorage loss is particularly high in patients with reduced periodontal support. The relatively apical position of miniscrews is also useful for applying orthodontic forces closer to a tooth's center of resistance, thus reducing the likelihood of unwanted tipping movements [20]. Despite the potential advantages of skeletal anchorage systems, there is still a lack of high-quality evidence regarding their clinical efficacy. Another important development has been the application of periodontal regeneration therapies during orthodontic treatment. The clinical outcomes of this combined approach are promising as shown by Nemcovsky CE (1996), with increased connective tissue attachment levels reported in selected cases [21].

CONSIDERATIONS FOR TIPPED TEETH WITH INFRABONY DEFECTS

Infrabony pockets are often associated with periodontally compromised teeth or severely tipped teeth adjacent to edentulous spans. Some authors have warned that orthodontic movements can aggravate the periodontal issues and lead to widening of the defect [22]. An important consideration in these treatments is therefore the response of infrabony pockets to orthodontic tooth movement. The response of periodontal tissues to orthodontic tooth movement has been investigated in dogs with poor oral hygiene and experimentally induced infrabony pockets [23]. In contrast to the maxillary control teeth, bodily movement of the mandibular test teeth resulted in a significant increase in pocket depth and loss of connective tissue attachment, especially when the teeth were moved toward the infrabony defects. One probable reason for the continued destruction of the periodontal tissues and the persistence of infrabony pockets in these situations is the apical displacement of the adjacent supragingival plaque into subgingival sites.

Other studies, however, have reported improved healing of infrabony defects when good oral-hygiene measures were implemented. In a study by Weltman B et al (2010)[24], infrabony pockets were experimentally produced around the incisors of four Rhesus monkeys and the effect of tooth movement into these defects was investigated. Histologic findings from that study showed the potential for complete resolution of these defects in the presence of reduced, but healthy, periodontal tissues. Using a rat model, Vardimon et al. [25] performed a histomorphometric analysis on 62 decalcified hemimaxillary blocks following the movement of teeth into surgically created bony defects. Although a 6.5-fold increase in the total area of bone apposition was reported in the experimental group, this increase was not statistically significant. An important clinical implicationfrom both animal and human studies is the need tomaintain healthy periodontal tissues throughout theprocess of uprighting and space closure. Regularmonitoring of oral health should therefore be carried out throughout the course of orthodontic treatment.

CONSIDERATIONS FOR DENTAL IMPLANTS

Space closure can often be challenging in patients with severe Class II or Class III malocclusions unless the underlying skeletal discrepancy is corrected. Single dental implants are useful in these cases provided there is adequate bone at the recipient site. Unfortunately, absence or extraction of teeth can lead to significant reductions in the width and height of the alveolar ridge over time.
Strategic repositioning of teeth in the arch can result in extensive regeneration of the alveolar bone and supporting tissues (Fig. adapted from Periodontology 2000)

Fig. Large osseous defect associated with three missing mandibular incisors. (A) The alveolar bone level was at the apical third of the root of the mandibular right lateral incisor (tooth 42) with gingival recession (B) Tooth 42 was moved mesially along the alveolar ridge using fixed appliances. Both the clinical appearanceand periapical radiograph show significant bone formation distal to tooth 42 (yellow arrows). (C) The final implant-supported restoration.Gingival inflammation around tooth42 has resolved, with no significantchange in connective tissue attachment.

The development of the alveolar bone using this technique may be particularly useful in patients with congenitally missing lateral incisors. In these cases, the alveolar ridge of the lateral incisors can be prepared for receiving future implants by allowing the canines to erupt adjacent to the central incisors and then distalizing them back to their normal positions within the arch [26]. Following treatment, bone deposition would be expected to occur on the mesial aspect of the distalized canine because this represents a site of tension.Use of this particular treatment protocol has been reported by Spear FM (1997) and Kokich V (1994) to result in adequate alveolar bone width, which is relatively stable up to 4 years after treatment [26,27]. Similar findings were recently reported in a larger retrospective study of 80 patients with 128 missing lateral incisors [28]. Over the study's 5-year retention period, the width and height of the alveolar bone were reduced by only 2% and 0.4 mm, respectively. A similar treatment protocol has been recommended for managing congenitally missing second premolars [26]. The late removal of ankylotic primary molars may result in significant ridge resorption and vertical bone defects, prohibiting the placement of dental implants in an optimal position [29]. Instead, a dental implant may be placed at the site of the first premolar tooth after it has been distalized into the second premolar space [26,29]. An important consideration in these situations is the potential effects of moving teeth into areas with reduced alveolar bone.

The management of large edentulous spaces is an important part of oral rehabilitation. Despite the limited evidence available, sagittal movement of teeth into longstanding edentulous sites seems to be a viable method for closing residual spaces and redeveloping variable amounts of alveolar bone. Several treatment factors may also help to reduce the risk of marginal tissue breakdown during space closure, including the use of light forces, bodily tooth movement, absence of inflammatory periodontal disease and the maintenance of good oral hygiene throughout treatment. Nonetheless, the risk of gingival recession and attachment loss should be carefully assessed in individual patients before closing residual spaces.

ORTHODONTIC INTRUSION

Orthodontic intrusion may be a useful treatment adjunct in a wide range of cases, including the management of elongated incisors and traumatic deep-bite, and the restoration of severely worn incisors.

INTRUSION OF FLARED AND ELONGATED TEETH

Flaring and elongation of the incisor teeth is commonly seen in patients with advanced periodontal disease [1]. One consequence of these unwanted occlusal changes is the development of a traumatic deep-bite, which can cause significant soft-tissue and hard-tissue trauma . In adults, severe skeletal deep-bites are often treated using ajoint surgical–orthodontic approach, although intrusion of the anterior teeth is also possible in some cases[30]. Two important advantages of intruding elongated incisor teeth are the improvement in smile esthetics and reduction in soft-tissue trauma.The intrusion of teeth has a number of important effects on the periodontal tissues [31]. Bone deposition occurs along the stretched periodontal ligament fibers in the middle and coronal thirds of the root [32]. The intensity and direction of the intrusive force, however, seem to play an important role in influencing the responses of these tissues. Light forces are likely to reduce stresses in the marginal part of the periodontal ligament, while forces directed through the long axis of a tooth favor bodily intrusion and limit the extent of hyalinization [33]. Force magnitude also affects the reaction of the tissues at an apical level, with heavy intrusive forces associated with a higher degree of root resorption [31,32].

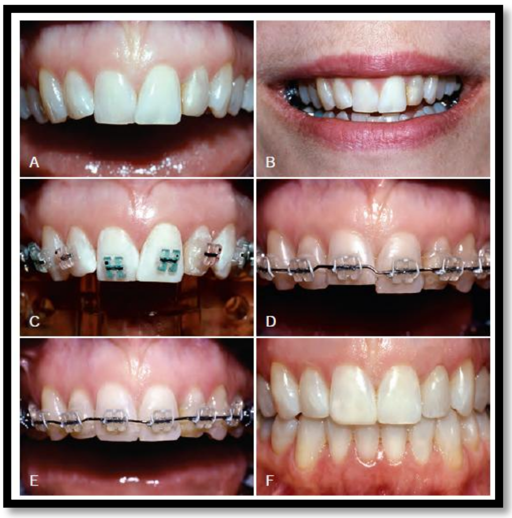

Fig. (adapted from Carranza 12th edition) Patient with a bruxing habit with the objective to level the gingival margins during orthodontic therapy. Intrusion of right central incisor facilitated the both gingival margin correction as well as restoration of abrasion

The clinical effects of intrusion have been extensivelyinvestigated in both animals and humans [31,32,33,34,35]. In one animal studyby Melsen B et al (1989), the useof light and continuous forces resulted in pure intrusionwithout any loss of marginal bone [33]. Followingsurgical debridement, the intruded teeth in thefive Macacafascicularis monkeys had greater attachmentlevels, which were attributed to coronal migrationof the periodontal ligament cells. Meticulous periodontal therapy during intrusion exposes the root surface to the periodontal ligament cells and increases the likelihood for connective tissue regeneration [35].

The effects of intrusion are not limited to the marginal tissues, with bone deposition reported by Bondevik O et al (1980) and Melsen B et al (1986) on the labial and palatal surfaces of the alveolar process and near the root apices [32,34]. The formation of new bone in these areas is reported to result in a small increase in the buccolingual width of the alveolar process. It has been hypothesized that this new bone forms in response to the negative loading created by the intrusive forces on the adjacent structures [32,34]. Similar findings have also been reported in a sample of deep-bite adult patients with horizontal bone loss [35]. In that study, following intrusion, bony support increased and clinical crown length decreased by approximately 7% and 1.1 mm, respectively.

Although orthodontic intrusion has been shown to improve periodontal support under optimal conditions, careful consideration should still be given to some of the adverse side effects that may occur as a result of this tooth movement, especially root resorption and shortening [31]. Findings from both animal models and human samples suggest that force magnitude plays an important role in the extent of tissue loss, with heavier forces associated with a higher degree of root resorption [31,32]. The magnitude of the intrusive force seems to play a more important role in the development of root resorption than does the amount of tooth displacement [31]. It is important to note that other factors, such as genetic susceptibility and history of previous trauma, may also increase the risk of root resorption in some patients. Fortunately, most of the resorption lacunae undergo repair once the intrusive force is terminated and healing is permitted [34].

INTRUSION OF WORN INCISORS

Long-term incisal wear is typically associated with over-eruption, reduction in clinical crown length, uneven gingival margin heights and a 'gummy' smile [36]. The gingival tissues of fractured or severely worn teeth often migrate coronally if these teeth are allowed to continue erupting. In addition to clinical crown-lengthening surgery, orthodontic intrusion may be a viable option for displacing the bone and soft tissues in an apical direction. During intrusion, the gingival tissues typically follow the path of the teeth, although to a lesser extent[37]. Following orthodontic treatment, however, mucogingival surgery may still be needed to increase clinical crown heights and eliminate pockets that develop from the stretching of the gingival fibers[37].Several animal and human studies have investigated the effect of orthodontic intrusion on the periodontal soft tissues and alveolar bone, although direct comparison between studies is generally difficult because of differences in appliance design, force levels, oralhygiene care and treatment durations. Of these different treatment factors, the maintenance of healthy gingival tissues throughout intrusion appears to reduce the risk of marginal bone breakdown. In order to facilitate oral hygiene, surgical periodontal debridement may be needed in some patients to reduce the depth of existing periodontal pockets.

Orthodontic intrusion may be useful for the intrusion of elongated and flared incisors, management of traumatic deep-bites and the intrusion of overerupted worn or fractured incisors. Posterior teeth may also be successfully intruded for receiving prosthetic restorations, managing open-bites and correcting occlusal plane discrepancies. The decision to use intrusive forces in patients with advanced periodontal disease should take into account the risk of root resorption because this may create an unfavourable crown-to-root ratio. In these cases, light forces should be used in order to reduce this risk.

ORTHODONTIC EXTRUSION

The extrusion of teeth has been advocated as an effective method for managing one- and two-wall infra-osseous defects [38]. Numerous case reports have been published to illustrate the potential benefits of tooth extrusion on the adjacent soft and hard tissues [28,39,40]. Some of these reports have found favorable effects on pre-existing periodontal pockets, including a reduction in pocket depth, an increased zone of attached gingiva and crestal bone apposition [39]. Although some of these changes have been attributed to the regular periodontal maintenance often implemented during treatment [38], it seems biologically reasonable that stretching of the periodontal ligament fibers would induce some bone apposition at the alveolar crest [41].

Implant site development

The extrusion of hopeless teeth can help develop theinvesting soft and hard tissues before implant placement[42,43]. The effect of orthodontic extrusionon the alveolar bone has been studied using variousanimal models. In Rhesus monkeys, in a study by Batenhorst KF et al (1974), significantamounts of bone apposition were found on the lingual,interproximal and apical surfaces followingspontaneous extrusion of the mandibular incisors[44]. Although the distance between the cemento–enamel junction and alveolar crest had slightlydecreased at the three sites (by 1 mm or less), thiswas considered to be minimal given that the teethhad undergone nearly 5 mm of extrusion. These findingsare consistent with those of another study by Skerry TM et al (2006) inwhich extrusion of premolars in three Beagle dogsresulted in a similar pattern of bone appositionwithin 2 weeks of starting treatment [45]. After7 weeks, mature bone was found at the crestal surfaceand the periodontal fibers had assumed a similarorientation to controls.

The effect of orthodontic extrusion on the adjacenttissues has been studied by vaVenroov JR et al (1985) in Beagle dogs with a significantlyreduced periodontium and poor oral hygiene[46]. Using light forces, ranging from 20 to 25 g,hemisected premolar teeth were gradually extrudedto the point of extraction and then stabilized for aperiod of 3 weeks. Following retention, new-boneformation was radiographically and histologicallydetected coronal to the marginal bone level, as wellas apical to the root apices.Similar findings have also been reported by Amato F et al (2012) in a small sample of patients in whom the average ratio of bone-to-tooth displacement was 70% and soft tissue-to-tooth displacement was 65%[42]. By extruding teeth approximately 6 mm (to the point of extrusion), the authors were able to achieve nearly 4 mm of bone and soft-tissue augmentation. Interestingly, no soft-tissue migration occurred in any of the patients with established periodontal pockets.

Several characteristic soft-tissue responses have also been described by Mantzikos T et al (1997) when teeth are extruded to the point of extraction [47]. Initially, the gingival margin exhibits a red-collar appearance; pocket depth also tends to decrease during the extrusion process. With continued extrusion, a nonkeratinized red patch may appear coronal to the free gingival margin. This thin tissue, which later becomes keratinized to resemble the surrounding gingival tissues, is formed from eversion of the pocket lining [48].

Extrusion of teeth has a number of desirable effects on the position of the gingival margin, pocket depth and width of attached gingiva. The gingival margin normally follows the direction of tooth displacement, but to a variable extent [42]. In teeth with deep periodontal pockets, for example, the coronal displacement of the soft tissues lags behind that of the hard tissues [47]. In general, however, extrusion of teeth causes the attached fiber bundle to be displaced coronal to the epithelial attachment, thereby inverting the periodontal pocket and reducing its depth [47,48]. The width of the attached gingiva also increases because the free gingival margin is displacedmore coronal than the mucogingival margin [42].

CONSIDERATIONS FOR THE DIRECTION OF TOOTH EXTRUSION

There is some controversy regarding the ideal angle and direction of extrusion when preparing implant sites. In general, teeth may either be extruded along their long axis [42], or with progressive application of labial root torque [43]. In the presence of an angular defect, gradual mesiodistal tipping of the teeth toward the defect may also be considered. Each method has a number of advantages and disadvantages. When extruding teeth with labial root torque, the marginal tissues are believed to follow the root apex as it moves both buccally and coronally [43]. This scenario may be particularly useful in cases with severely resorbed labial bone plates. On the other hand, excessive application of root torque in cases with reduced, but intact, labial plates is likely to compromise the integrity of the remaining buccal bone and create unwanted bony dehiscences/fenestrations. In such cases, it would seem more reasonable and less destructive to extrude teeth along their long axis so that the entire periodontium is displaced coronally.Regardless of the method used, however, extrusion should be carried out using light and controlled forces, and in the absence of deep periodontal pockets [42,43]. Moreover, a short stabilization period following extrusion is recommended to allow the new bone to mineralize and mature [42].

Although most orthodontists are aware of the potential to develop prospective implant sites through tooth extrusion, data on the efficacy of this technique are lacking. Most of the evidence in this area originates from case series and small experimental studies. Based on the evidence available, however, orthodontic extrusion seems to be an effective method for developing the investing soft tissues and alveolar bone. During orthodontic extrusion, the alveolar bone and soft tissues are displaced coronally, along with the cemento–enamel junction. There is some evidence that elimination or reduction of periodontal pockets, before extrusion, increases the likelihood of soft-tissue migration. In general, orthodontic extrusion may offer an effective and less-invasive method for developing prospective implant sites, especially if orthodontic treatment is already indicated.

ORTHODONTIC EXPANSION AND INCISOR PROCLINATION

There is an increasing trend toward nonextraction treatment in orthodontics, whereby crowding is managed by increasing the arch length. Lateral expansion of the buccal segments, and labial advancement of the incisors, can theoretically provide a variable amount of additional space for the alignment of displaced teeth [49]. Proclination and advancement of the mandibular incisors has been suggested as a viable alternative to extractions and orthognathic surgery in adult patients with increased overjets and moderate-to-severe crowding. Nonetheless, there is still some controversy regarding the risks of non-extraction treatment, especially in patients with significant arch-length discrepancies. One important concern is the effect of orthodontic expansion on the gingival tissues and alveolar bone.

TRANSVERSE EXPANSION

Both maxillary and mandibular arches undergo a significant amount of transverse development during normal growth [50,51]. In addition to these growth-related changes, arch expansion can be achieved using a number of orthodontic appliances, including arch-wires, removable plates, fixed expanders and orthognathic surgery. Several animal and human studies have investigated the relationship between arch expansion and gingival recession, attachment loss and bony dehiscence.

Rapid maxillary expansion has been shown to cause significant changes in alveolar bone thickness following treatment [52]. Recently, a comparison between pre- and post-treatment spiral computed tomography images in a small sample of adolescents receiving rapid maxillary expansion identified several areas of bony dehiscence and a 0.6–0.9 mm reduction in buccal bone plate thickness of the banded teeth [52]. Interestingly, the presence of thinner buccal bone plates at the onset of treatment was associated with greater changes in crestal bone levels and the occurrence of a bony dehiscence following expansion.A few studies have investigated the effects of maxillary expansion on the long-term health of the periodontal tissues. In one such study by Graber LW et al (2005), which included young patients, the prevalence of gingival recession on one or more teeth in the rapid maxillary expansion and fixed appliance groups were 20% and 6%, respectively [53].Ballanti et al. (2009)[54] measured bone thickness from computed tomography scans at the level of the root furcation and did not account for the relatively thinner marginal regions in which periodontal breakdown would be expected to occur during tooth movement.

Surgically assisted rapid maxillary expansion is often used to manage transverse skeletal discrepancies in adult patients. The effect of surgically assisted rapid maxillary expansion on the periodontal tissues seems less detrimental, with minimal change in attachment levels reported. One reason for the more pronounced effects of conventional rapid maxillary expansion on the periodontal tissues may be related to the heavy forces delivered by these appliances to the supporting periodontium.

The adverse effects of heavy forces on the supporting periodontium have fueled interest into the use of light-force appliances, which may theoretically favour the movement of teeth 'with bone'. Self-ligation brackets are reported to produce low friction, which permits light forces to be delivered to the teeth [55]. Using a well-designed randomized clinical trial, the changes in buccal bone were assessed following transverse expansion with self-ligating brackets. Transverse expansion was found to occur mainly as a result of buccal tipping, rather than by true translation of the teeth 'with' buccal bone. Unlike the other tooth movementsdiscussed previously, it is plausible that bone apposition does not accompany transverse and sagittal tooth movements to the same extent because the overlying cortical plate in this direction is far too thin for the osteogenic progenitor cells to form new bone [56].

While a small amount of bone may be formed by periosteal apposition, excessive tooth movements are likely to cause the periodontal ligament to fuse with the adjacent periosteum, thus creating a bony dehiscence. This theory seems to be well supported by work of Batenhorstet al.(1974)[57], who found distinctive tissue changes when teeth were both extruded and advanced labially. During these tooth movements, the alveolar bone and epithelial attachment increased at the lingual, interproximal and apical sides of the experimental teeth. On the labial aspect, however, bony dehiscence was noted and the epithelial attachment was located more apically.

The effect of retaining the apices of premolar teeth outside the cortical plate has also been studied by Wainwright WM et al (1973) in a small group of Macaca speciose monkeys [58]. Histologic analysis of the premolar teeth, immediately after expansion, revealed thinning of the buccal cortical plate, lack of bone over the root apex and disorganization of the periodontal ligament. It has been suggested that thinning out of the buccal tissues during expansion may predispose to long-term gingival recession as a result of mechanical trauma and/or periodontitis [58].

SAGITTAL EXPANSION

The ideal position of the mandibular incisors has long been the subject of intense debate. Significant changes in the pretreatment position of the mandibular incisors are associated with a greater risk of relapse, which makes it an important factor to consider when planning orthodontic cases. Still, a more pressing issue is often the effect of incisor proclination on the health of the periodontal soft tissues and alveolar bone. The effect of incisor position on the adjacent alveolar bone has been studied both in dogs [17] and in monkeys [57]. Nearly all of these animal studies have found a consistent reduction in the level of the alveolar bone following incisor tipping or bodily displacement. Interestingly, marginal bone levels increased and experimentally induced fenestrations/dehiscences resolved following the repositioning of previously expanded teeth within the alveolus [60]. However, that eruption of the incisors during this repositioning process may also have influenced the level of the marginal bone in these studies, as the alveolar crest migrates coronallyto maintain its relationship with the cemento–enamel junction [61].

Alveolar bone defects may also occur in theabsence of any deliberate attempt to protrude theteeth outside the cortical plate. In addition to the development of a bony dehiscence or fenestration, labial advancement of the mandibular incisors is reported to cause tension at the free gingival margin, which reduces its apicocoronal height and buccolingual thickness [62]. Several predisposing factors have been reported, including patient age [63], gingival biotype [62] and width of the attached gingiva [64]. The extent of incisor proclination and the presence of visible plaque have also been linked with gingival recession [62]. In particular, a thin gingival biotypes, coupled with excessive proclination of the incisors, can render the gingival tissues less resistant to plaque-induced inflammation and traumatic toothbrushing [62]. A recent systematic review by Joss-Vassalli I et al (2010) in this area described the current level of evidence as low and highlighted a number of methodological weaknesses, including the use of retrospective study designs, inadequate clinical records and lack of follow-up data [65]. The standard of oral hygiene is often not accounted for in these studies. These limitations highlight the need for well-designed prospective studies to investigate the factors that predispose to gingival recession during orthodontic treatment.

Based on the data available, it would seem prudent to maintain the position of the teeth within the alveolar process. Excessive bodily advancement or proclination of the teeth for the purpose of gaining additional arch space may adversely affect the health of the periodontal tissues, especially in the presence of specific triggering factors, such as overzealous toothbrushing [4]. There may be some cases, such as dentoalveolar retrusion, where the incisors can be advanced with less risk of recession [56]. Careful evaluation of the periodontal tissues, oral hygiene, underlying skeletal structures and magnitude of tooth movement is therefore recommended for individual patients.

BENEFITS OF ORTHODONTIC THERAPY

Orthodontic therapy can provide several benefits to the adultperiodontal patient. The following six factors should be
considered:

1. Adult patients will be able to have better access to clean all surfaces of their teeth adequately by aligning crowded or malposed maxillary or mandibularanterior teeth permits. Patients who are susceptible to periodontal bone loss or do not have the dexterity to maintain their oral hygiene could be a benefitted tremenduously by this.
2. Certain types of osseous defects in periodontal patients can be improved by vertical orthodontic tooth repositioning as thetooth movement eliminates the need for resective osseoussurgery.
3. The esthetic relationship of the maxillary gingival margin levels before restorative dentistry can be improved by Orthodontic treatment. Alignment of the margins of the gingiva orthodonticallyprevents gingival recontouring, which could require boneremoval and exposure of the roots of the teeth.
4. The patient with a severe fracture of a maxillary anterior tooth that requires forced eruption to permit adequate restoration of the root is also benefitted by orthodontic therapy.
5. Open gingival embrasures to be corrected by orthodontic treatment to regain lost papilla. These open gingivalembrasures become unesthetic if they are located in the maxillary anterior region. These areas can be mostly correctedwith a combination of orthodontic root movement,tooth reshaping, and restoration.
6. Adjacent tooth position can be improved by Orthodontic treatment before implant placement or tooth replacement. This becomes necessary for the patient who has been missing teeth forlong duration and has drifting and tipping of the adjacentdentition.

II. Conclusions

In general, the controlled movement of teeth seems to have a positive, but highly variable, effect on the supporting tissues. The correction of some orthodontic problems, such as excessively tipped molars, traumatic deep-bites and flared and spaced incisors, may be particularly beneficial in periodontally compromised patients who are motivated to undergo treatment and demonstrate stable periodontal conditions. Specific tooth movements can also help develop alveolar bone sites for placing dental implants. However, several factors may contribute to a harmful periodontal response including the use of heavy forces, inappropriate force systems and poor oral hygiene. Excessive and unrealistic tooth movements are also likely to result in reduced alveolar bone thickness, especially in patients with thin cortical plates. On the other hand, the response of the soft tissues is less predictable and likely to be influenced by multiple factors. Well-designed long-term prospective studies are therefore needed to identify these patient and/or treatment factors.

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