The orthodontic–periodontic interrelationship in integrated treatment challenges: a systematic review

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SUMMARY Orthodontic treatment aims at providing an acceptable functional and aesthetic occlusion with appropriate tooth movements. These movements are strongly related to interactions of teeth with their supportive periodontal tissues. In recent years, because of the increased number of adult patients seeking orthodontic treatment, orthodontists frequently face patients with periodontal problems. Aesthetic considerations, like uneven gingival margins or functional problems resulting from inflammatory periodontal diseases should be considered in orthodontic treatment planning. Furthermore, in cases with severe periodontitis, orthodontics may improve the possibilities of saving and restoring a deteriorated dentition. In modern clinical practice, the contribution of the orthodontist, the periodontist and the general dentist is essential for optimized treatment outcomes. The purpose of this systematic review is to highlight the relationship between orthodontics and periodontics in clinical practice and to improve the level of cooperation between dental practitioners. Potentials and limitations that derive from the interdisciplinary approach of complex orthodontic–periodontal clinical problems are discussed.

KEYWORDS: orthodontics, periodontics, interdisciplinary treatment, aesthetics, function, relapse

Accepted for publication 15 January 2010

Introduction

The most common objectives of an orthodontic treatment are facial and dental aesthetics and the improvement in the masticatory function. There is a continuously increasing number of adult patients who actively seek orthodontic treatment, and it is also an undeniable fact that the incidence of periodontal disease increases with age. Therefore, the number of patients with periodontal problems that attend orthodontic practices is significantly greater than in the past (1).

The most common orthodontic problems found in a periodontally compromised patient include proclination of the maxillary anterior teeth, irregular interdental spacing, rotation, overeruption, migration, loss of teeth (Fig. 1) or traumatic occlusion. Those changes in the dentition are a consequence of the diminished support provided by the compromised periodontium, and they can sometimes hinder periodontal treatment by reducing the conditions for good oral hygiene and impairing function and aesthetics of the stomatognathic system (2). Furthermore, in patients with active periodontal disease, the presence of traumatic occlusion may inhibit bone apposition that can occur following periodontal treatment (3, 4).

In all the aforementioned clinical situations, orthodontic treatment may contribute significantly to the overall rehabilitation (aesthetic and functional) of the stomatognathic system. This is the reason that all these periodontal conditions have to be co-evaluated by the periodontist and the orthodontist to choose the appropriate orthodontic intervention. This may involve adjunct tooth movement that can facilitate other dental procedures or comprehensive orthodontic treatment to correct a malocclusion (5). The final treatment plan must be individualized and tailored to meet the needs, objectives and expectations of the patient (6).
The aim of the present systematic review is to delineate the relationship between orthodontics and periodontology and the mode that each field can contribute to optimize treatment of combined orthodontic–periodontal clinical problems. This attempt includes the description and analysis of (i) the effects of orthodontic treatment on periodontal tissues, (ii) some considerations of orthodontic treatment, (iii) orthodontic tooth movement in compromised periodontium, (iv) periodontal treatment schedule, (v) interdisciplinary management of aesthetic problems, and (vi) prevention of relapse of orthodontic treatment.

Materials and methods

To find the relevant articles, the Medline and Cochrane databases were searched from 1969 to September 1, 2009. The Medline search was based upon the following key words: orthodont* AND periodont* in all fields (limits: Humans, English, French, Italian). A similar search with the same keywords in all fields (limits: Animals, English, French, Italian) was also conducted to identify animal studies. The Cochrane Database was searched using the following keywords: orthodontic and periodontal.

Regarding human studies, observations based on case reports or papers written in another language than English, French or Italian were initially excluded. Articles referring to patients with systemic disorders, congenital malformations or abnormal tooth eruption were also excluded. Irrelevant articles were excluded by title. From the 2076 articles found in Medline, 1385 were excluded by title as irrelevant to the study subject. From the 25 articles found in the Cochrane Database, 21 were also found through the Medline search and four of them were only abstracts. The reference lists of the retrieved articles were hand searched for relevant studies, which may have been missed. Eligibility was determined by reading the reports identified by this search.

In this stage, from the 412 articles selected, 324 of them were excluded because they reported <4 patients. Finally, 88 articles were included in the study. From them, three were systematic reviews, nine were prospective randomised controlled studies, 16 were prospective cohort studies, 18 were prospective case studies, six were cross-sectional studies, nine were retrospective cohort studies, four were retrospective case studies with re-evaluation of treatment outcome, 10 were retrospective case studies, and 13 were review papers including a critical discussion (Table 1).

Table 1. Classification of non-experimental articles cited according to the type of publication

<table>
<thead>
<tr>
<th>Type of publication</th>
<th>Cited reference</th>
<th>Total</th>
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<tr>
<td>Systematic review</td>
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<td>3</td>
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<tr>
<td>Prospective RCT</td>
<td>8, 9, 11, 22, 40, 42, 90, 112, 114</td>
<td>9</td>
</tr>
<tr>
<td>Prospective Cohort Study (comparative and/or controlled)</td>
<td>13, 14, 15, 16, 17, 20, 21, 23, 24, 34, 35, 36, 41, 43, 44, 89</td>
<td>16</td>
</tr>
<tr>
<td>Prospective Case Study (n &gt; 3)</td>
<td>10, 12, 18, 19, 25, 26, 28, 30, 37, 45, 51, 59, 60, 61, 68, 95, 107, 120</td>
<td>18</td>
</tr>
<tr>
<td>Cross-sectional study</td>
<td>2, 101, 102, 105, 117, 118</td>
<td>6</td>
</tr>
<tr>
<td>Retrospective Cohort Study (comparative)</td>
<td>29, 70, 71, 75, 81, 83, 97, 100, 110</td>
<td>9</td>
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<tr>
<td>Retrospective Case Study – re-evaluation of treatment outcome</td>
<td>27, 77, 96, 119</td>
<td>4</td>
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<tr>
<td>Retrospective Case Study (n &gt; 3)</td>
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<tr>
<td>Non-systematic review</td>
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<td>13</td>
</tr>
<tr>
<td>Case report (n ≤ 3)</td>
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<td>8</td>
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<tr>
<td>Clinical article</td>
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<tr>
<td>Book</td>
<td>1, 3, 80, 38</td>
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RCT, randomised controlled.
We further identified 552 animal studies. Thirty-five of them were found relevant to the study subject. However, 17 studies were included, related to fields where controversial, insufficient or no clinical data were available (Table 2). Furthermore, in such topics, selected case reports or opinions expressed in clinical articles and relevant books are cited (Table 1).

Conclusions drawn from animal studies and case reports or opinions expressed in non-systematic reviews, clinical articles or books are not considered strong evidence. However, they could provide useful ideas and possible solutions to complicated clinical situations. Such concepts should be subject to further research before application in everyday clinical practice.

Effects of orthodontic treatment on periodontal tissues

The primary cause for the inception and progression of gingival inflammation and periodontitis is bacterial plaque (7). Orthodontic treatment is sometimes considered a predisposing factor for periodontal disease, as orthodontic appliances may inhibit complete oral hygiene procedures resulting in increased bacterial aggregations (8–13). The problem is not the aggregations *per se*, but there is a possibility of transition of the subgingival plaque to a more aggressive periopathogenic flora (9–18) that favours the conversion of gingivitis into periodontitis. Nevertheless, if a thorough oral hygiene regime is applied before and during orthodontic treatment, minimal or no increase in gingival bleeding index (19–21) or plaque quantity will be evident (19, 21–23). In any case, after appliance removal or even earlier (during treatment), there is significant improvement on plaque index and bleeding index values and a reduction in certain periopathogenic bacteria (8–10, 12, 18, 24–26).

Clinical studies have shown that with adequate plaque control, patients with reduced but healthy periodontium can undergo orthodontic treatment without aggravating their periodontal conditions (24, 25, 27–30). However, clinical and experimental studies have shown that when inflammation is not fully controlled orthodontic treatment may trigger inflammatory processes and accelerate the progression of periodontal destruction leading to further loss of attachment, even in patients with sound oral hygiene (27, 31).

Certain studies report an increase in probing depth measurements during orthodontic treatment (approximately 0.5 mm), but this is attributed to moderate gingival hyperplasia, provided there is no loss of attachment (8, 9, 12–14, 16, 23). Some contradictory findings regarding the effects of orthodontic appliances on periodontal health are partially because of the heterogeneity of the materials and differences in the research methods employed (32). According to a recent systematic review, there is no clinically significant irreversible periodontal tissue destruction as a consequence of placement of orthodontic appliances (33).

Specific long-term clinical and radiographic findings support the fact that periodontal disease develops in regions where orthodontic bands are placed and leads to statistically significant loss of attachment (approximately 0.5 mm) (34, 35). A comparative clinical trial concluded that molars with bands present greater gingival inflammation, plaque accumulation and loss of attachment compared to bonded molars (34). Mechanical irritation from the band or from remnants of the bonding cement, along with ‘trapped’ plaque have been implicated (8). However, controversy exists in this issue as short-term clinical studies revealed a negative influence in subgingival ecosystem but no loss of attachment (14, 36), while other comparative studies concluded to no difference in microbial or clinical periodontal parameters concerning banding compared to bonding (13, 23). Additionally, a recent study could not identify mature biofilm on bands obtained after the end of orthodontic treatment (37).

Orthodontic treatment considerations

There is no contraindication for orthodontic treatment in adults with severe periodontal condition. On the contrary, sometimes orthodontics may be necessary to improve the possibilities of restoring a deteriorated dentition (30). In patients with reduced periodontium, the periodontal ligament surface that receives forces is diminished, and the biological and biomechanical
conditions differ when compared to teeth with normal periodontal support. In periodontally compromised teeth, the centre of resistance is displaced apically following the anatomical elements of the periodontium, thus resulting in the expression of greater moments during force application and an increase in the extrusion component of the applied force (38).

The use of condign biomechanical systems and units for increased anchorage is essential for additional control of tooth position especially in the vertical dimension (38). Skeletal anchorage devices such as orthodontic mini-screws, mini-plates or even dental implants that serve as anchorage units are used especially when the present teeth are inappropriate. Additionally, mini-screws can be used for anchorage in adjunctive orthodontic treatment when the patient does not want full fixed appliances. The desired force is applied directly or indirectly to the skeletal anchorage unit, allowing better control of movements in three dimensions with little or no loss of anchorage (39). Alternatively, the use of occlusal forces (e.g. bite plates or occlusal splints) may sometimes be a valuable help for vertical control of the position of teeth, as well as for anchorage enhancement or for disocclusion of selected teeth facilitating planned tooth movement.

Treatment should be performed with the simplest possible orthodontic systems to avoid circumstances that favour increased dental plaque accumulation, which will happen inevitably to a certain degree in most cases. One precaution is to avoid using wire loops and elastomeric ligatures and remove immediately the excess of bonding material during bracket placement. Self-ligating brackets or wire ligatures are considered preferable, instead of elastomeric ligatures, as the latter favour plaque accumulation and certain periopathogens deleterious to gingival conditions (11, 40). However, a comparative clinical study on 100 subjects did not find a significant difference concerning plaque accumulation and periodontal parameters between conventional brackets with elastomeric ligatures and self-ligating brackets (41). A short-term comparative clinical study revealed that bracket design also has a significant impact on bacterial load and on periodontal parameters, but this has to be further investigated with long-term studies (42). Despite the inconclusive results presented in the literature, bonding instead of banding the molars appears to be a safer solution for reasons previously stated. In patients with intact periodontium, treatment with the Invisalign system seems to be more favourable for periodontal reasons compared to labially or lingually fixed appliances (43, 44).

Orthodontic tooth movement in a compromised periodontium

Movement of teeth with infrabony defects

Orthodontic movement of teeth with infrabony defects towards the lesion can be successfully accomplished in the absence of inflammation and adequate control of the bacterial plaque. Although there is little evidence in humans, a well-designed recent clinical trial on 10 subjects has shown that orthodontic tooth movement towards the infrabony defect combined with intrusion and surgical periodontal therapy results in significant clinical attachment gain and in radiographic bone fill. Appliance of orthodontic forces was almost immediate 10 days after surgical periodontal treatment (45).

Certain animal studies agree with the evidence from humans. On rats, tooth movement into the infrabony defect resulted in a decrease in the defect and subsequent bone fill (46, 47). On the other hand, studies on dogs (31, 48, 49) and other primate studies (50) agree that in an inflammation-free environment, there is elimination of the endosseous defect, without attachment gain, but with a long epithelial junction. It should be noted that in animal studies the repair of the bony defects could be solely attributed to the metabolic characteristics of the bone tissue of each species, which may differ significantly from the human alveolar bone metabolism.

Orthodontic extrusion

A recent clinical study on 10 orthodontically treated patients with intact periodontium concluded that extrusion of mandibular incisors resulted in displacement of the gingival margin and the mucogingival junction by 80% and 52.5%, respectively, of the total amount of extrusion (51). These observations are also corroborated by animal studies that have shown similar results; during extrusion, the relation between the bone margin and the cementoenamel junction remains unchanged (52); the free gingiva follows the tooth 90% and the attached gingiva 80% of the distance, while the mucogingival junction remains in the same position (53). Thus, in cases where movement of bone margin and attachment along with the tooth is not
desirable (as in crown-root fractures), there is a need for periodical circumferential supracrestal fiberotomy at the start and every 2 weeks during orthodontic extrusion (54).

According to experimental studies and clinical reports, orthodontic extrusion of teeth with one or two wall-infrabony defects results in a more favourable position of the connective tissue attachment and reduction in the defect (55–57). Despite the lack of strong evidence, these are considered important findings, as it is known that the presence of one-wall infrabony defect is a contraindication for guided tissue regeneration (GTR) techniques and that in wide infrabony defects the prognosis of these procedures is poor (3).

Orthodontic extrusion of non-restorable teeth prior to implant placement appears to be a viable alternative for conventional bone augmentation procedures in implant recipient sites. It is suggested to apply low constant forces, with a rate of extrusion not >2 mm per month and labial root torque to increase the buccolingual thickness of the alveolar ridge. The retention period before tooth extraction should exceed 1 month. The total treatment time is possibly shorter compared to surgical augmentation. Further research is necessary to clinically compare the results of this procedure with the conventional approach to determine added benefits (58).

Orthodontic intrusion

In 2007, Erkan et al. (19) concluded that during orthodontic intrusion of lower incisors in patients with intact periodontium, the gingival margin and the mucogingival junction moves apically 79% and 62% of total intrusion, respectively. Regarding periodontally affected teeth, sufficient clinical data suggest that intrusion of teeth can considerably improve the level of attachment when there is absolute control of inflammation and bacterial biofilms (30, 45, 59–61) (Fig. 2a and d). These beneficial results were also found to be considerably stable in long term (12-year follow-up) in periodontally compromised patients (30). In 2004, Re et al. (61) reported similar findings, as they noted 50% reduction in recessions after intrusion of periodontally compromised teeth, independent of the width of gingiva. The use of light forces (5–15 gr per tooth) is recommended to move teeth efficiently and probably reduce the amount of root resorption (59). This is of capital importance in teeth with reduced periodontium as the specific implication results in further loss of periodontal support and increase in crown-root ratio.

Similar results were reported, in primates where the gingiva followed the tooth, 60% of the total intrusion distance, provided there was adequate control of bacterial plaque (62). The importance of the plaque control during intrusion was denoted in an animal study on dogs where teeth intrusion in presence of bacterial plaque led to the creation of infrabony defect and loss of attachment (63).

There is no clear indication concerning the timing of GTR in cases of teeth that require orthodontic intrusion. Selected case reports mention that the implementation of GTR procedures before orthodontic intrusion results in the formation of new bone and attachment gain (64, 65). Other reports suggest that intrusion may deepen a certain osseous defect and improve blood circulation creating better conditions for GTR procedures (66, 67).

Molar uprighting

Orthodontic uprighting of mesially tipped molars is accompanied by the elimination of osseous defects.
Moreover, there is improvement in pocket probing depth and in crown-root ratio (68). However, in molars with furcation involvement, there is an increased risk of aggravation of the periodontal problem during the orthodontic uprighting procedure (69). A valid alternative for a tipped mandibular molar is to split the tooth into two roots that (one or both) can be moved orthodontically into new positions, even though this is considered to be a difficult procedure (70).

**Movement in edentulous areas**

Orthodontic movement of teeth in edentulous areas with reduced alveolar ridge height is usually possible with minimal loss of alveolar bone (71, 72). The movement should be parallel and performed with low orthodontic forces. However, even under optimal conditions, further loss of bony support can be detected (73). In cases of reduced buccolingual width of the alveolar ridge, tooth movement through cortical bone may be retarded and also buccal and lingual bone dehiscences may develop. In such cases, bone augmentation procedures to increase the alveolar bone width have been suggested before orthodontic movement (64).

Experimental studies on dogs confirm the beneficial effects of the bodily movement of the tooth into the defect. More precisely, the tooth side displaced towards the defect (pressure side) presents an increase in the alveolar bone height, while on the tension side the bone level remains unaltered (74). It should be noted that in all animal experiments the bony defects are relatively recent with neither much loss of alveolar bone height and buccolingual width, nor installation of cortical bone as it frequently occurs after long term in dental extraction sites.

**Labial tooth movement/proclination**

These movements represent the most viable method to resolve crowding and are frequently considered to produce gingival recession especially in the region of lower incisors (75–77). It is stated that lingual tooth movement results in increased labiolingual width of labial gingiva and slight incisal migration of gingival margin, while labial movement has the opposite impact. The most important predisposing factor for the development of gingival recession during or following orthodontic treatment is the reduced thickness of soft tissue and bone in the region (78, 79). It is believed that if the orthodontic movement is performed within the genetically and/or functionally predetermined ‘bone envelope’ of the tooth, there is no risk of recession (80).

In 2002, Djeu et al. (75) in a retrospective clinical trial did not find a correlation between orthodontic labial inclination of mandibular central incisors and age with gingival recession. Similar results were reported in 2001 by Artun and Grobety (81), on a sample of adolescents with pre-treatment dentoalveolar retrusion. In the same line, Ruf et al. in 1998 (82), in 98 children and adolescents did not find a significant correlation between proclination of mandibular incisors caused by Herbst appliance and gingival recession. Concerning adults, a longitudinal study published in 1987 (83) showed significant correlation between the incidence and the severity of recession with excessive proclination (>10°) of mandibular incisors. Three years after the end of active treatment, the observed changes were minimal indicating a stable condition. Melsen and Allais in 2005 (76) concluded that the factors related to the development or aggravation of recessions in adult orthodontic patients are the presence of baseline recession, gingival biotype, width of keratinized gingiva and visual gingival inflammation. Yared et al. in 2006 (77) stated that in adults subjected to orthodontic treatment, the factors associated to the incidence and severity of gingival recession of mandibular central incisors are final inclination (>95°) and free gingival margin thickness (<0.5 mm), with thickness having greater relevance to recession than final inclination. However, a recent longitudinal study by Ari-Demirkaya and Ilhan in 2008 (21), in adults with mandibular prognathism subjected to orthognathic surgery, concluded that the decompensation process that requires excessive labial tipping of the mandibular incisors did not have any negative effect on periodontal structures. The above-mentioned studies lend support to the ‘bone envelope’ theory.

Labial tooth movement or tooth proclination per se does not cause gingival recession, but in specific cases can result in thin soft tissues or bone dehiscences that comprise low-resistance regions to inflammation or trauma (79). This statement is corroborated by studies on primates (84) and dogs (85, 86). Based on similar observations, several authors suggest that the thickness of periodontal tissues should be surgically increased before orthodontic tooth movement when it is esti-
mated that it will cause bone dehiscence (76, 79, 86). On the other hand, animal studies have shown that no such precaution is necessary for lingual movement of labially displaced teeth with dehiscences, as it leads to new bone formation and soft tissue thickness augmentation (87, 88). Usually, in these cases, even in the presence of recession, the need for periodontal intervention should be evaluated after the completion of orthodontic treatment (79). However, in 2000 Pini Prato et al. (89, 90) compared surgically treated versus nonsurgically treated cases with buccally erupted premolars and recommended that in buccally erupted teeth mucogingival interceptive surgery should be accomplished before orthodontic therapy to maintain the width of keratinized gingiva in the long term. Given the controversy, it seems that the issue of the optimal timing to perform recession coverage or soft tissue thickness augmentation in an overall treatment plan needs further scientific support by randomised, controlled clinical studies.

**Periodontal treatment schedule**

When planning orthodontic treatment in adults with a history of periodontal disease, it is suggested to allow 2–6 months from the end of periodontal therapy until bracket placement, for periodontal tissue remodelling, restoration of health and evaluation of patient’s compliance. The patient should practise sound oral hygiene and fully understand the potential risks in case of non-compliance (91). It should be kept in mind that the critical pocket depth for maintaining periodontal health with ordinary oral hygiene is 5–6 mm (92).

Regenerative periodontal techniques (periodontal therapy with GTR or enamel matrix derivatives) are usually implemented before orthodontic treatment (10 days–4 months) to create favourable preorthodontic conditions in complex clinical scenarios. Case reports and case series, implementing this approach, report encouraging results (64, 65, 93–95) (Fig. 3). Nevertheless, other reports suggest that GTR can also be performed after orthodontic treatment when it is estimated that the planned tooth movements will create a better environment for the performance and effectiveness of the technique (66, 67). The timing of GTR remains to be clarified with adequate clinical studies.

In case of thin periodontal tissues, the width of soft periodontal tissues must be enhanced prior to labial orthodontic tooth movement, when it is estimated that otherwise the planned movement will result in the development of bone dehiscence (76, 79, 86). However, in cases of lingual movement of teeth with thin periodontal tissues, there is no clear recommendation as both the approaches (before or after orthodontic treatment) need further investigation. The determination of the optimal timing for implementing preventive mucogingival surgery in an overall treatment plan as well as the optimal timing for applying orthodontic forces (e.g. in early healing phase or 6 months after surgery) need to be further investigated with randomised comparative clinical studies.

During orthodontic treatment, professional cleaning and examination of periodontal tissues should be performed routinely (91). The specific interval varies for each patient (few weeks to 6 months), and it should be determined considering the analysis of risk factors for periodontal disease and the planned tooth movements. Thorough tooth cleaning and scaling is suggested at short intervals when intrusion and new attachment is attempted (59). If the patient fails to maintain high level of oral hygiene, orthodontic treatment should be interrupted.

Fig. 3. Guided tissue regeneration (GTR) procedure followed by orthodontic treatment. (a) Pre-treatment radiographic condition. (b) Four months after GTR procedure in the mandibular central incisors’ region – just before orthodontic treatment. (c) Four years after the end of orthodontic treatment and the placement of the retainer, sufficient bone support of the mandibular left central incisor is maintained.
oral hygiene instructions for reducing the risk of recession, because plaque removal and tooth cleaning will be more easily performed. Also, patients should be introduced to a programme of regular follow-up visits to the periodontist and the orthodontist. The timing between follow-up visits is prescribed by the team according to the severity of the patient's pre-treatment condition and the prognosis of the post-treatment condition.

**Interdisciplinary management of aesthetic problems**

Three aesthetically unpleasant defects may need confrontation during orthodontic treatment: (i) irregularity in vertical position of gingival margins, (ii) loss of interdental papilla and (iii) gummy smile. These problems may require an interdisciplinary approach including periodontal surgery, enameloplasty, restorative procedures, tooth movements and various combinations of the above or other interventions.

**Uneven gingival margins**

Ideally, in an aesthetic smile, the gingival margin of the maxillary centrals should lay 1 mm below their cementoenamel junction and be at the same level as the margins of the cuspids. Those of the lateral incisors should be 1–2 mm lower than the margins of the adjacent teeth (98).

According to Kokich (98), the proper management of uneven gingival margins should be based on the analysis of the following criteria. First of all, it must be examined if the discrepancy is visible during talk or smile. If not, any intervention is considered overtreatment. When the problem is visible and the patient wants to restore it, the clinician must proceed with an evaluation of probing depth of the dentogingival sulcus of the teeth involved. If the probing depth is different, a gingivectomy may correct the problem. If not, evaluation of clinical crown length should follow to determine whether extrusion of the tooth with the longer clinical crown and subsequent grinding of its incisal edge will end in the desirable result. Finally, it must be evaluated if the gingival margin discrepancy is caused by passive eruption of the tooth (Fig. 2a), which might be followed by abrasion of its incisal edge. The overerupted teeth should be intruded with light orthodontic forces (Fig. 2). Orthodontic intrusion should be accomplished 6 months prior appliance removal to reduce risk of relapse (99). Possible restorative needs of the patient must be taken into consideration.

**Missing interdental papilla**

Another aesthetic problem that may require an interdisciplinary approach is the missing interdental papilla. In an average adult orthodontic population of 337 subjects, the prevalence of post-treatment open gingival embrasures in the maxillary incisors region was 38%. The same study, in a subsample of 119 patients, found that increased distance from the alveolar bone to the interproximal contact, shorter and more incisally positioned interproximal contacts, increased embrasure area and divergent or triangular-shaped crown forms are parameters associated with open gingival embrasures after orthodontic therapy, while post-treatment maxillary central incisor root angulation is slightly convergent in normal gingival embrasures (100). Also, according to a recent cross-sectional study, in randomly selected periodontal patients, the intraradicular distance between adjacent teeth and the distance from the base of the contact area to the bone crest affect the form and the shape of the interdental papilla (101).

Usually, when the papilla is lost as a result of advanced periodontal disease which involves loss of interdental alveolar crest, the aesthetic improvement in the situation requires a combination of enameloplasty (interproximal reduction), tooth movement and selective addition of composite resin (98). After proximal recontouring and orthodontic teeth approximation, the interdental soft tissues are compressed and form a new papilla (Fig. 2). If this is not enough for the remodelled tissue to cover the area of the papilla, direct-bonding resin can be added to lower the contact point and create the illusion of a healthier papilla.

Loss of interdental papilla may also result from diverging roots of adjacent teeth (100). In this case, the inclination of the roots must be evaluated through a periapical radiograph, followed by proper alignment of teeth. If the aesthetic appearance is not fully restored, the option of enameloplasty can be adopted (98).

Some patients have wide, triangular or bell-shaped teeth. Thus, the contact point lies at the incisal edge of the tooth resulting in the development of black triangles (100). Interproximal enamel reduction along with closure of the resultant diastema is sufficient in most cases to restore the missing papilla (98).
Gummy smile

In conformity to the present aesthetic standards, maxillary gingival display in an attractive adult smile will range between 1 and 2 mm. The specific parameter is increased in children and is reduced progressively with ageing (102). Clinicians should always consider patients' age in diagnosis and treatment planning of gummy smile (103). Increased gingival exposure may be attributed to different causes, which designate the appropriate management: vertical growth of the maxilla, retardation of the physiological apical migration of gingival margins, extrusion of maxillary anterior teeth and anatomical considerations.

Patients with excessive vertical growth of the maxilla usually present clinical crowns with normal dimensions and healthy gingiva. In growing patients, growth modification should be considered to inhibit vertical growth with orthopaedic forces, while management of this condition in adults possibly demands orthognathic surgery including Le Fort I osteotomy and maxillary impaction (104).

Certain patients present significant retardation of the physiological apical migration of gingival margins, which occurs during childhood and adolescence until the margins occupy their adult position (97, 98). These patients usually present thick gingival biotype or fibroid gingival tissues and probing depth of gingival sulcus of approximately 3–4 mm, sometimes even without clinical signs of inflammation. Main clinical features of this type of gummy smile are the short clinical crowns and the apparently increased labiolingual thickness of gingival tissues. This condition is most of the times evident in patients who are 12–15 years of age and is an indication for mucogingival aesthetic surgery, as normal gingival margin migration may require several years to be completed (98). However, when the aesthetic problem is not severe enough, aesthetic interventions to reshape or reposition gingival margins should be postponed and re-evaluated in early adulthood, because in adolescence significant alterations of the shape and the position of gingival level are likely to occur (96, 97).

Sometimes a gummy smile may be attributed to extrusion of maxillary anterior teeth. It frequently happens in Angle class II, division 2 malocclusions. The indicated treatment usually includes orthodontic intrusion of maxillary incisors, which is expected to eliminate the gummy smile (105).

In 2003, Sarver and Ackerman (106) stated that gummy smile caused by decreased philtrum height of the upper lip may be effectively corrected by V-Y cheiloplasty, practically covering the gummy smile with the upper lip. In the same direction, Polo in 2008 (107) recommended the use of Botox for the neuromuscular correction of excessive gingival display on smiling achieving satisfactory, but transitory results. The long-term effect of these approaches needs further testing before recommending them in clinical practice.

Prevention of relapse

Relapse of orthodontic treatment has been attributed to increased elasticity of gingival tissues that are compressed towards the direction of tooth movement (108). Remodelling of supra-alveolar fibres continues to take place even after a period of 4–6 months (109). It seems that after the end of orthodontic treatment, the retention period should exceed 12 months to provide appropriate time for remodelling of the periodontal fibres (110).

Certain authors report that the stability attributed to soft periodontal tissues can be accomplished by the following factors: (i) orthodontic overcorrection, (ii) adjunctive periodontal surgery, (iii) combination of the above (1, 111) and (iv) long-term fixed retention. Overcorrection is beyond the scope of this article and thus will not be further discussed.

Minor periodontal surgery could be beneficial in particular cases. After the orthodontic closure of diastemata subsequent to extractions, there is increased tendency for relapse and reappearance of diastema between the approximated teeth. Surgical removal of the stressed interdental soft tissues after closure of the diastema seems to prevent relapse (112). In cases of maxillary midline diastema, it is often advisable to perform a frenectomy after the orthodontic closure to alleviate relapse. However, this approach presupposes a sound diagnosis, as there is a general consensus among scientists regarding the existence of a cause–effect relationship between the presence of thick frenum with high insertion and the maxillary midline diastema (113). The circumferential fiberotomy of supracrestal gingival fibres has been proposed for preventing relapse of teeth that were severely rotated prior to treatment. This procedure alleviates relapse without harmful long-term effects in periodontal health (111, 114). Incisions at the labial or lingual side of teeth should be avoided.
when the gingival biotype is thin, because there is risk of recession. Bisection of the interdental papilla by two vertical incisions (labially and lingually) extending from below the tip of the papilla to 1–2 mm below the level of the alveolar crest can be a good alternative for these cases (115). This technique is less invasive and safer for the periodontal tissues; therefore, it is the best choice for the anterior aesthetic zone.

The long-term results of interproximal reduction combined with circumferential fiberotomy in preventing orthodontic treatment relapse were investigated by Boese in 1980 (111). This retrospective clinical study on 40 patients treated for crowding reported that interproximal reduction and fiberotomy resulted in remarkable long-term stability and healthy periodontal tissues without the need of additional retention measures.

Every action that intends to prevent relapse should be performed immediately after the completion of orthodontic movement. Supportive surgical procedures of soft periodontal tissues are usually performed at the final stage of orthodontic treatment, few weeks prior to appliance removal. It is essential to retain teeth in their desired position at least for a few weeks during healing, either using the same orthodontic appliances (passive) or with a retainer (1).

Permanent retention of the result of orthodontic treatment is indispensable in patients with significantly reduced periodontal support (27). Probably, the most appropriate method for retention is the coaxial multi-stranded stainless steel wire retainer bonded to the lingual side of each tooth (Fig. 3c). This retainer is easy to fabricate, not visible, and it allows teeth to retain their physiological mobility (116). Despite that certain clinical studies demonstrate a negative influence of lingual fixed retainers in periodontal parameters (117, 118), other studies demonstrate that in the long-term this does not result in clinically significant changes (117, 119). Removable retainers should be avoided, because they can exert forces that cause uncontrollable jiggling to the teeth with unpredictable consequences on the periodontal tissues (38). In patients with loss of teeth or occlusal trauma, progressive mobility, migration or pain on function, retention should be accomplished by prosthetic reconstruction. Usually, conventional partial restorations (120), resin-bonded fixed partial dentures (30) and splints (30, 120) are placed. As demonstrated by a recent report, the use of fibre-reinforced composite resin (121) may be an equally effective, but much less invasive alternative.

Conclusions

Harmonious cooperation of the general dentist, the periodontist and the orthodontist offers great possibilities for the treatment of combined orthodontic–periodontal problems. Undoubtedly, application of oral hygiene measures is difficult during orthodontic treatment. Orthodontic treatment along with patient’s compliance and absence of periodontal inflammation can provide satisfactory results without causing irreversible damage to periodontal tissues. Furthermore, orthodontic treatment can expand the possibilities of periodontal therapy in certain patients, contributing to better control of microbiota, reducing the potentially hazardous forces applied to teeth and finally improving the overall prognosis. Participation of the periodontist is also essential, either in management of orthodontic–periodontal problems or in specific interventions aiming to prevent orthodontic treatment’s relapse.

Comprehensive knowledge of the fields of periodontology and orthodontics along with close co-operation among clinicians widen the spectrum of the available treatment options in many circumstances. Usually, the interdisciplinary approach leads to an optimal qualitative, functional and aesthetic management, providing the best treatment plan in complex clinical situations.

Despite the great significance of co-operation between orthodontists and periodontists, in particular aspects of combined orthodontic–periodontal treatment analysed in the present review, there is considerable lack of sound scientific evidence. The decision regarding the time of intervention and the sequence of periodontal and orthodontic procedures is sometimes inevitably based on clinical experience, published case reports or case series and subsequent arbitrary assumptions. Therefore, there is a strong need for further research in certain directions through well-designed studies to provide patients with evidence-based treatment.

References


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