Interrelationship between Periodontics and Adult Orthodontics

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There is a wide range of indications for orthodontic tooth movements aimed at improving the prognosis of malpositioned teeth in the mixed dentition and of teeth affected with periodontal disease. New regenerative periodontal treatment procedures (membrane technique, application of enamel matrix derivates) have provided greater opportunities for gaining new attachment and have improved the preorthodontic conditions for moving teeth into infrabony defects or for vertical movements of teeth with reduced bone support. The benefits and problems of a combined periodontal / orthodontic treatment approach are discussed with respect to preorthodontic mucosal grafting, guided tissue regeneration, loss of interdental gingiva, correction of crowding, reorienting of migrated and flared incisors, and gaining new abutment teeth by distalizing free-end premolars.

Key words: adult orthodontics, GTR technique, crowding, molar uprighting, pathologic tooth migration, premolar distalization

There are many links between periodontology and orthodontics. After all, every orthodontic intervention has a periodontal dimension: orthodontic biomechanics and treatment planning are basically determined by periodontal factors such as the length and shape of the roots, the width and height of the alveolar bone, and the structure of the gingiva.

The spectrum of specific interdisciplinary interrelationships covers long-term effects of orthodontic therapy on the gingiva, attachment level and root integrity, the general periodontally-protective effect of orthodontic therapy in the mixed dentition, and orthodontic measures designed to support periodontal treatment.

This paper concentrates on the complex aspects of a combined periodontal / orthodontic treatment approach in adults.

Fundamental Considerations

The individual periodontal prognosis can be favorably influenced by a wide range of orthodontic effects:

- Attachment gain by intrusion or by improved faciolingual tooth position
- Elimination of furcation defects: hemisection → premolarization with subsequent sagittal root movement
- Improvement of the crestal and interdental bone structure: correction of crowding, uprighting of tipped teeth
- Correction of pathologic tooth migration and spacing
- Preimplantologic bone reconstruction: extrusion of non-retainable teeth.

To achieve these periodontal / orthodontic treatment goals, consideration must be given to the altered biological and pathologic condition at the outset of treatment. This interdisciplinary approach

Fig. 1a Within comprehensive orthodontic therapy (43-year-old woman), the lower incisors are to be intruded and labially tipped. Mucosal grafting is indicated preorthodontically because of the thin, fragile soft tissue covering.

Fig. 1b Intraoperative finding: palatal mucosal graft of about 1 mm thickness.

Fig. 1c A dense broad gingiva-periosteum mantle protects the osseous remodeling processes during orthodontic tooth movement.

Fig. 1d Postorthodontic finding: healthy periodontal situation, reduced gingival recession at the left central incisor.

thus requires profound experience of bone biology, periodontal disease and biomechanics of tooth movement (Diedrich and Erpenstein, 1984). The following aspects are of special importance:

- Lack of influence on sutural and condylar growth zones
- Age involution of the periodontium
- Specific periodontal findings: topography of tooth and bone, atrophied alveolar process, recessus of the sinus, frenulum, periodontitis (attachment loss, activity and course).

The topography of teeth / alveolar bone / gingiva, especially the preorthodontic width of the alveolar bone and the thickness of the gingiva, influences the extent of faciolingual tooth movements. The prerequisite for continuous relocation of the alveolar bone is a balance between periodontal resorption and periosteal apposition on the pressure side. If there is a delay or imbalance in periosteal bone formation, bone dehiscences may occur, followed by gingival recessions. Critical local findings are: narrow alveolar process and a thin, fragile gingiva over prominent roots. These constitute a clear-cut indication for a free mucosal graft prior to labiolingual tooth movements (Fig. 1) (Boyd, 1978; Diedrich, 1990; Engelking and Zachrisson, 1982; Gieger, 1980; Wennström, 1990). The widening of the covering soft tissue means that the bone remodeling processes are not impaired and the osteoblastic activity of the periosteum is maintained. An analogous problem arises when moving teeth into vertically and / or horizontally atrophied alveolar ridges. Experimental and clinical findings prove that such orthodontic movement is feasible

Fig. 2a Midline diastema with a broad, deeply inserting frenulum.

Fig. 2b After excision of the dense collagen fiber bundles, the v-shaped soft tissue defect is filled and reconstructed with an inlay graft (palatal mucosa).

Fig. 2c Finding after orthodontic space closure: the interdental gingiva shows an almost physiologic architecture; interproximal enamel reduction in the contact area might have improved the esthetic result, but the patient refused any subtractive odontoplasty.

and that reconstruction of the alveolar bone is induced (Diedrich and Erpenstein, 1984; Diedrich et al, 1996; Horn and T*urley, 1984; Lindskog-Stokland et al, 1993; Wehrbein et al, 1990; Wehrbein et al, 1995; Wennström, 1990), subject to the tent-shaped stretched gingiva and mucosa in front of the moving tooth not breaking down. In the case of missing or thin attached gingiva, the soft tissue volume should be augmented preorthodontically. An additional indication for a gingival graft exists in those cases where there is a broad diastema in combination with a dense, deeply inserting frenulum. Histologically, such a frenulum is characterized by an interrupted pattern of transseptal collagen fibers running into the midpalatal suture. Conventional frenectomy to eliminate the solid fiber bundles leads to a V-shaped soft tissue defect. Orthodontic space closure would create a gingival invagination and an ugly dark triangle, especially in cases of advanced attachment loss. It is therefore advantageous to fill the soft tissue defect with a mucosal graft after excision of the connective tissue fibers in order to reconstruct a physiologic gingival architecture (Fig. 2).

Periodontitis is another important factor in orthodontic therapy. Numerous clinical and experimental studies (Ericsson et al, 1977; Ericsson, 1986; Melsen et al, 1989; Vanarsdall, 1977) have shown that, along with the correct biomechanics, control of marginal inflammation before and during orthodontic tooth movement is a key factor in successful treatment.

Pre-existing attachment loss has three effects on orthodontic biomechanics:

- The reduced root surface / reactive alveolar bone ratio requires an adaptation of force magnitude
- The apical shifting of the centre of resistance entails a different force system (M / F ratio) in order to specify the desired type of tooth movement
- Periodontally affected teeth imply a decreased anchorage quality so that undesirable side effects are more difficult to control. Mini-implants may help to solve anchorage problems (Fritz et al, 2003).

The activity and prognosis of periodontal disease also influence the indication and outcome of orthodontic measures. Comprehensive orthodontic therapy should routinely be restricted to slowly progressing chronic periodontitis (CP). Teeth with a questionable prognosis (attachment loss up to the apical third of the root, furcation involvement grade III, aggressive periodontitis (AP)) should be treated orthodontically in exceptional cases only. It is therefore absolutely essential to exhaust all modern diagnostic means of detecting the severity and course of periodontal breakdown.

Another aspect of crucial relevance to orthodontic tooth movement is the question of whether only a defect-filling repair or extensive structural and functional regeneration is achieved after periodontal surgery.

Purely reparative wound healing constitutes an unfavorable precondition for planned orthodontic translation and intrusion movements.

In an experimental study in animals, Polson et al (1984) generated angular bony defects that then underwent conventional periodontal treatment (root planing, pocket elimination by flap surgery). The test teeth were then moved translatorily either through the bony pocket (pressure side) or away from the defect (tension side). After completion of orthodontic treatment, the angular defects on the pressure side were no longer radiologically verifiable. However, histologic examination revealed a thin epithelial layer interposed between the entire instrumented root surface and the alveolar bone. On the tension side the wedge-shaped bone morphology was flattened, the alveolar crest was located apically of the deepest point of root instrumentation, and the entire instrumented part of the root was covered by an epithelial layer. These micromorphologic findings confirmed that orthodontic tooth movement had no positive effect on the connective tissue level.

With regard to intrusive movements after conventional flap surgery, histologic reports are controversial: Diedrich et al (1992) found a thin epithelial coating down to the marking notch (deepest point of root planing) at intruded root segments. In association with intense infiltration of round cells, the junctional epithelium even proliferated below the alveolar crest.

A histologic study by Melsen et al (1988) revealed that partial new formation of root cementum and connective tissue attachment is possible at intruded teeth, providing the orthodontic therapy is performed under marginal infection-free conditions.

In a recent study by Diedrich et al (2003) the orthodontic relevance of new procedures in regenerative periodontal therapy (membrane technique, enamel matrix proteins) was investigated: three-wall bony defects were artificially generated and colonized by periodontopathogenic microorganisms. After regenerative periodontal surgery (scaling, combination of Emdogain® and resorbable Vicryl® membrane) the test teeth were either intruded or moved bodily through the defects. The qualitative and morphometric histologic findings revealed extensive periodontal regeneration at the intruded root segments and on the tension sides and in the control group. Cemento- and osseoneogenesis yielded mean values of 70–80%, whereas values for epithelial downgrowth were low (Fig. 3). The bony regeneration on the pressure side was markedly reduced. However, nearly 70% new formation of root cementum with Sharpey's fibers was also recorded.

These regenerative procedures have obviously not only enriched the possibilities of periodontal therapy but also decisively improved the preconditions for moving periodontally affected teeth: on the tension side new supracrestal and periodontal fibers are prone to transmit the orthodontic force stimulus to the alveolar bone. This is beneficial for ex / intrusion of teeth with infraalveolar defects or furcation involvement. On the pressure side, it seems possible to move teeth into and through bony defects and to gain new attachment simultaneously. Recent clinical findings support this hypothesis (Fig. 4).

Treatment Systematics

The systematics of a combined periodontal / orthodontic treatment approach is summarized in Table 1.

Preorthodontic Phase

Preorthodontically, the emphasis is on reducing marginal inflammation, augmenting the soft tissue volume in patients with critical mucogingival findings, and improving hygiene conditions through caries therapy and temporary restorations.

The control of periodontal infection by oral hygiene instruction, professional plaque removal and root planing is a fundamental prerequisite for subsequent orthodontic therapy. Many studies have shown that teeth with a reduced but healthy periodontium can be moved without further attachment loss. On the other hand inflammatory periodontal destruction is accelerated by plaque-infected teeth with destroyed connective tissue

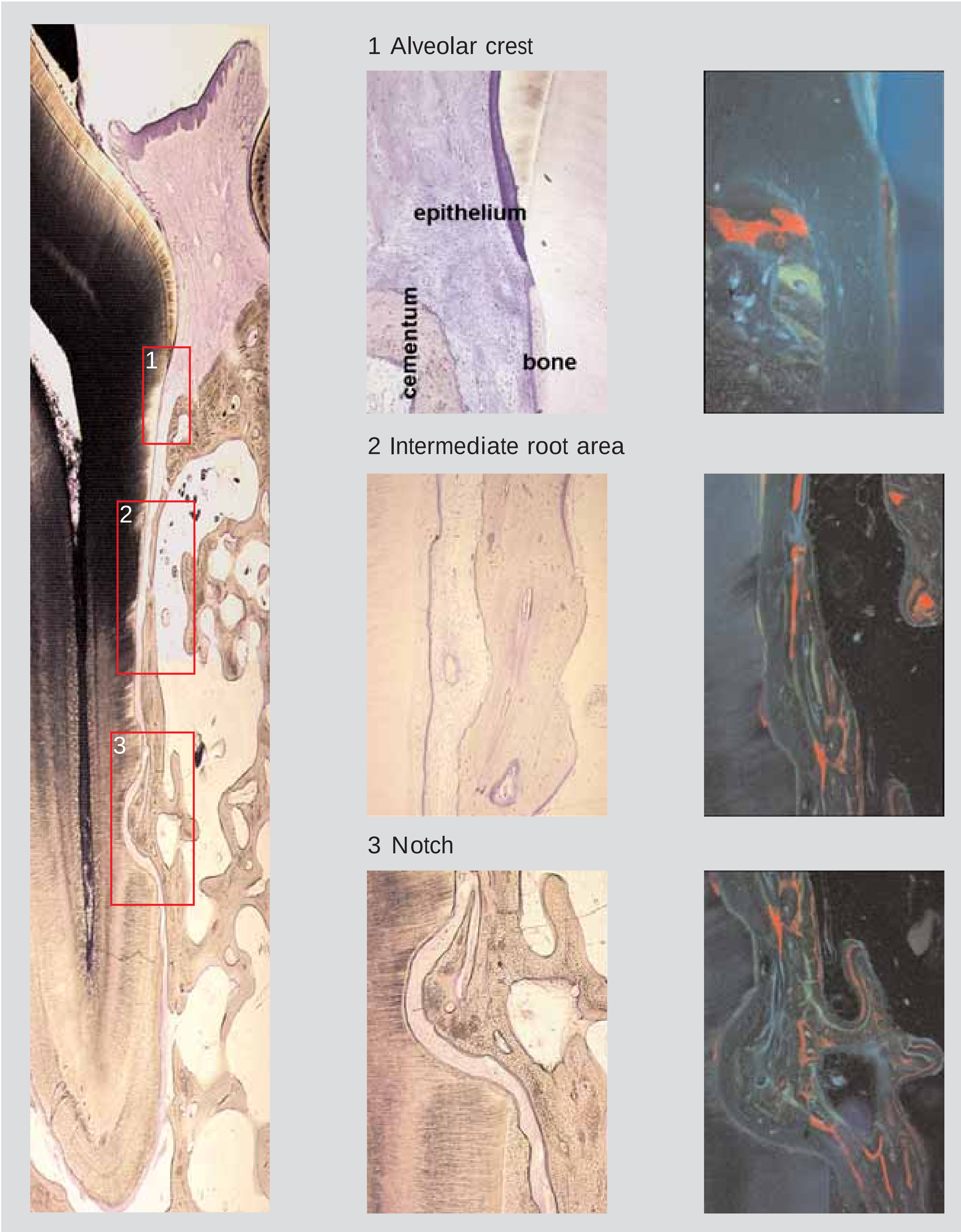


Fig. 3 Histologic view of a periodontally affected root which was orthodontically intruded after mechanical / chemical debridement and regenerative therapy (Emdogain®); survey and magnified details of the notch area and the intermediate and crestal root area in comparison with analogous sequentially labeled findings: extensive periodontal regeneration in accordance with orthodontically induced remodeling (notch = deepest point of root instrumentation), from Diedrich (2003).

Fig. 4a Pathologic tooth migration as a result of an advanced periodontal lesion (56-year-old woman).

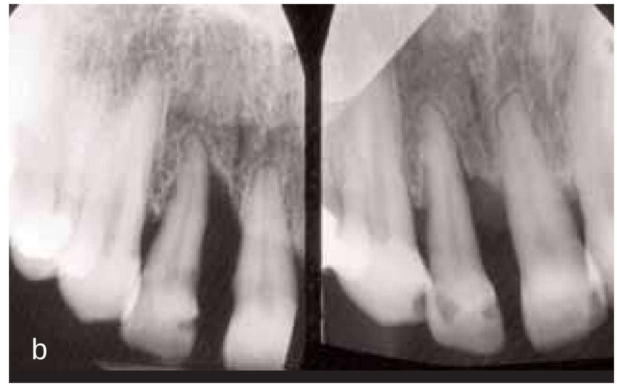


Fig. 4b Severe intraosseous defect between the right lateral and the central incisor (left radiograph). Three months after GTR with a Gore-Tex® membrane, partial reossification is evident, possibly with new attachment (right radiograph).

Fig. 4c A calculated force system from a TMA® sectional archwire controls space closure and intrusion of the lateral incisor.

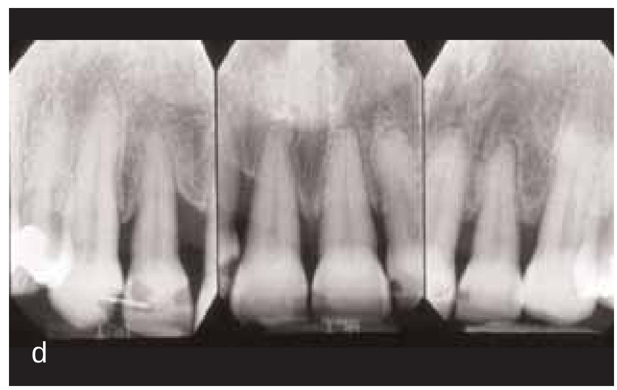


Fig. 4d Retention period after 6 months of orthodontic tooth movement indicating no root resorptions and a consolidated alveolar crest. A titanium pin was inserted from canine to incisor for permanent stabilization.

attachment (Årtun and Urbye, 1988; Boyd et al, 1989; Diedrich et al, 1992; Ericsson et al, 1977; Wennström, 1993).

Initial periodontal debridement (non-surgical, subgingival root instrumentation) leads to tissue repair with reduced probing depths and a favorable shift in the composition of the subgingival microflora. A healing period of 4–6 months is recommended before orthodontic tooth movements are initiated (Zachrisson, 1996).

If periodontal regeneration is indicated, a surgical approach is inevitable. Resective bone surgery during flap surgery is contraindicated because orthodontically induced remodeling processes may have a positive influence on osseous topography. Orthodontic treatment can be started 4–6 weeks after the regenerative periodontal therapy; the interaction of progressing regenerative wound healing and orthodontic tissue remodeling may result in additional attachment gain.

Orthodontic Phase

The orthodontic therapy is determined by two key factors:

- Findings-oriented biomechanics, calculation of active and reactive forces as well as moments as far as possible
- Continuous monitoring of periodontal health.

Thorough planning of biomechanics reduces the risk of root resorptions as well as of bone and gingival dehiscences. A further loss of bone support or attachment induced by uncontrolled force systems should be avoided in all events – especially in patients with periodontally affected teeth.

Table 1 Systematics of periodontal / orthodontic measures in adults

1. Preorthodontic phase – Reduction of marginal infection • plaque control, scaling, root debridement • new attachment procedures – Augmentation of soft tissue volume • free mucosal graft, connective tissue graft – Improvement of oral hygiene status • caries therapy • temporary restorations – Elimination of functional disorders → therapeutic position of mandible
2. Orthodontic phase – findings-oriented biomechanics – continuous monitoring of periodontal health
3. Postorthodontic phase – retention > 6 months – periodontal re-evaluation – definitive restorative therapy – recall schedule

Maintenance of periodontal health requires meticulous plaque removal in all hygiene-critical areas: bracket periphery, and interproximal and gingival tooth surfaces. If uncontrollable aggravation of the periodontal destruction occurs or if the patient's oral hygiene deteriorates, orthodontic therapy has to be stopped to ensure a reasonable risk / benefit ratio.

Postorthodontic Phase

The postorthodontic retention phase should last at least six months to permit complete mineralization of osteoid tissues. Only then can the periodontal status be re-evaluated and a decision made on definitive prosthetic measures and the individual retention strategy. For many reasons postorthodontic stability requires semi-permanent or permanent retention:

- to prevent the risk of relapse
- to offset any imbalance of soft tissue / reduced bone support
- to eliminate secondary occlusal trauma
- to improve masticatory comfort in the presence of increased tooth mobility.

Fixed lingual retainers, passive plates or acrylic foils serve for semi-permanent stabilization, while intracoronal titanium pins are suitable for permanent retention (see Fig. 4d).

Therapeutic Spectrum

Orthodontic therapy in patients with a periodontally affected dentition is often based on different, partially overlapping indications: improvement of dentofacial esthetics, support of periodontal therapy, and facilitation of prosthetic measures.

Improvement of Dentofacial Esthetics

The focus of esthetic interest is on the correction of pathologic tooth migration in the anterior region and the maintenance or preservation of interdental papillae.

Flaring of upper incisors is a common symptom of advanced periodontal destruction. Its incidence, closely correlated with the extent of the attachment loss, is up to 60% (Martinez-Canut et al, 1997). Various pathogenic factors underlying tooth migration are discussed (Profitt, 1978; Selwyn, 1973; Towfighi et al, 1997):

- Disturbed proprioceptive cybernetic system between soft tissue (lip, tongue) and reduced periodontal attachment apparatus
- Pressure of inflammatory granulation tissue in intraosseous defects
- Tension of healthy, contralateral periodontal fibers
- Habits
- Posterior bite collapse through tooth loss and tipping.

Because flared incisors are also mostly extruded, the focus of orthodontic therapy lies on pure intrusion for esthetic and periodontal reasons. Application of the intrusive force distal to the centre of resistance induces a combined tooth movement: intrusion plus retraction. With conical tooth morphology, interproximal enamel reduction (stripping) is a great help in compensating any loss of interdental papillae (see below).

As a single measure or as an integral part of a multidisciplinary rehabilitation schedule, the reorientation of migrated upper incisors is an essential orthodontic contribution to esthetic dentistry (Fig. 5). The presence of interdental gingiva, particularly between the upper central incisors, is a key factor

Figs. 5a, b Spacing in the upper front region due to advanced periodontitis. The patient's treatment motive was based on disturbed dentofacial esthetics.

Fig. 5c Papilla preservation flap, scaling and root debridement including application of citric acid.

Fig. 5d Covering the intraosseous defect with a resorbable Vicryl® membrane (polyglactine 910).

Fig. 5e Additional application of Emdogain® (xenogenic enamel matrix derivate).

for a harmonious dentition and an attractive smile. With advanced periodontitis, soft tissue loss and shrinkage after periodontal therapy often lead to recession of interdental papillae. These dark empty interproximal areas have a negative impact on the patient's appearance and speech.

The guideline for treatment strategy is based on the clinical and metric findings of Tarnow et al (1992): maintenance of the interdental papilla was directly correlated with the distance from the contact point to the alveolar crest. If the distance was 5 mm or less, nearly all interproximal areas were filled with gingiva; when the distance was 6 mm or more, papilla preservation was reduced to 56%. No papilla was present from a distance of 10 mm. Therefore, apart from plastic periodontal surgery and additive restorative measures, the focus is on only two fundamental treatment alternatives:

- Reduction of the increased contact point / bone distance by regeneration of the interradicular periodontium (GTR, GBR)
- Apical positioning of the contact point by stripping and subsequent orthodontic space closure.

This adjunctive orthodontic therapy favors papilla reconstruction through compression and lengthening of the interdental soft tissue (Fig. 6).

Figs. 5f, g The markedly improved dentofacial esthetics are evident after 6 months of orthodontic treatment (started 6 weeks after surgery).

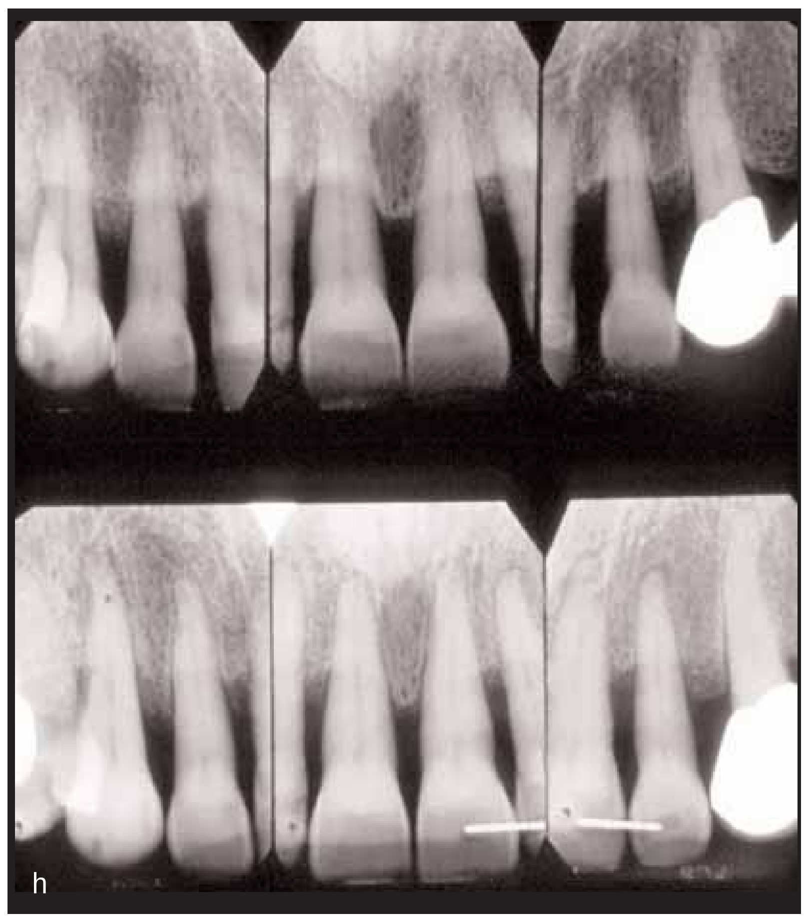


Fig. 5h Comparison of the radiographic findings before and after the combined treatment approach: no root resorption and a partially regenerated alveolar crest, especially at the interradicular septa 11 / 21 and 22 / 23.

Additionally, orthodontic intrusion of upper incisors helps to shift residual dark interdental triangles beyond the smile line.

Support of Periodontal Therapy

Apart from attachment gain in combination with regenerative periodontal therapy, orthodontic tooth movements may improve the interradicular and crestal bone structure. Typical examples are correction of crowding and molar uprighting.

Fundamentally, crowding and root proximity impair the topography of the gingiva and the alveolar bone: coronally the marginal gingiva assumes a non-physiologic contour, and the narrowed interproximal area alters the structure of the interdental

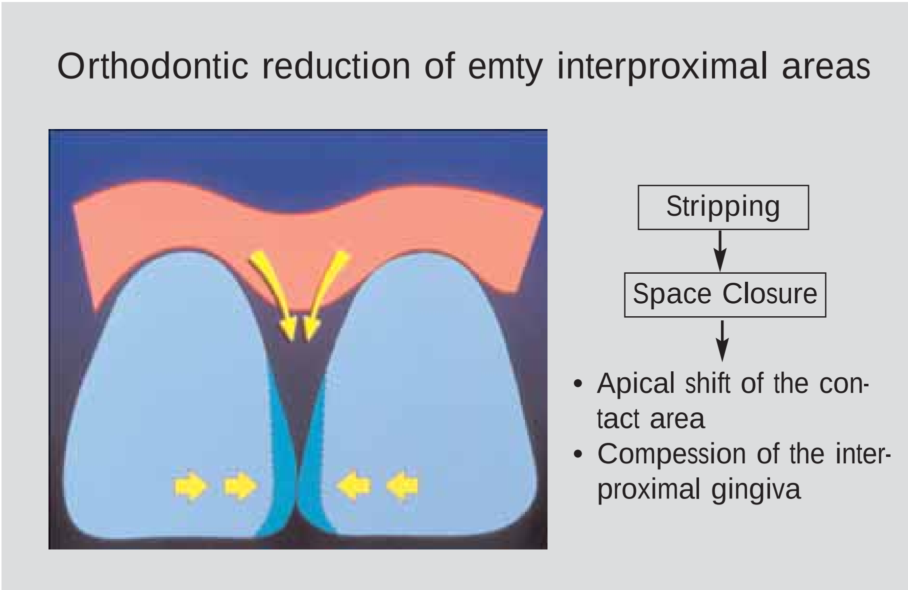


Fig. 6 Diagram showing the positive effect of stripping and subsequent orthodontic space closure to support papilla reconstruction: reduction in the contact point / alveolar crest distance and compression of the interdental soft tissue result in the papilla becoming everted.

gingiva, causing compression of the papilla and reduced connective tissue stroma between the epithelial ledges. Radicularly, pronounced crowding entails thin septa with reduced cancellous bone and vascularization. The interradicular bone may be absent in some areas, with resulting fusion of the periodontal ligament of adjacent roots (Fig. 7) Diedrich, 2000; Giavannoli, 1981). Kramer (1987) regards this special topography of root proximity as less resistant to bacterial invasion of periodontal tissue.

Histomorphologically the transition from gingivitis to periodontitis is characterized by lysis of the connective tissue attachment and downgrowth of the junctional epithelium, with the integrity of a dense layer of transseptal fiber bundles performing an important barrier function against microbial invasion. Furthermore, the pronounced vascularization of broad bone septa creates a good basis for immunologic defense reactions against toxins of microorganisms. If these defense mechanisms break down and initial periodontal lesions penetrate the transseptal fiber systems, the morphology of bone destruction depends on the course of the blood vessels (Akiyoshi and Mori, 1967; Glickman and Carranza, 1990).

In narrow interdental areas with compressed, loose connective tissue and septum peaks with little cancellous bone and vascularization, the bacterial periodontal infection spreads along the vessel channels flowing laterally into the periodontal ligament. The perivascular action radius of inflammatory invasion and tissue destruction reaches 1.5 to 0.5 mm (Schröder, 1982).

These topographic conditions encourage a rapid loss of crestal septum. Analogically this pattern of destruction affects thin orofacial bone lamellae: the inflammation penetrates via periosteal and periodontal blood vessels into deeper bone marrow spaces, inducing rapid and marked marginal bone destruction. The perivascular action radius of the bacterial infection is initially less detrimental in the presence of greater bone volume (interdental, oral, buccal). Two additional factors increase the biological reactivity:

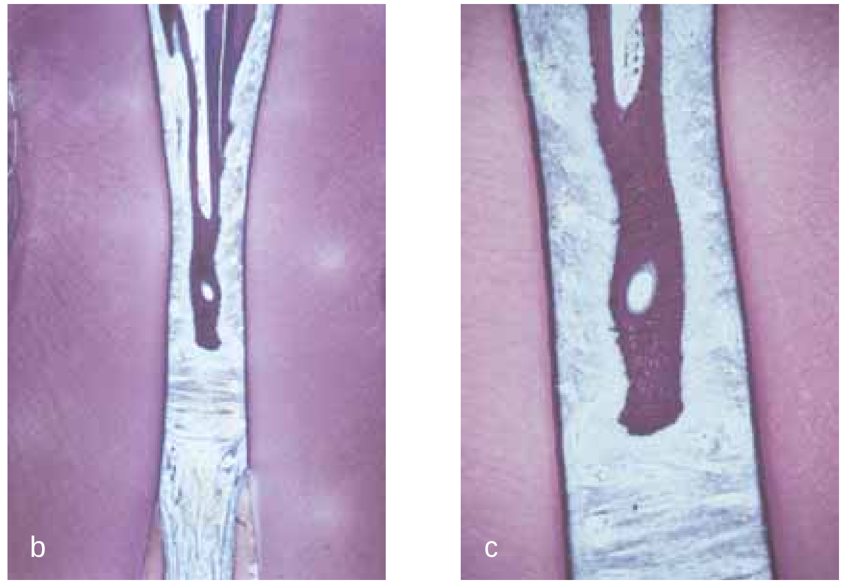
- Barrier function of densely oriented collagen fiber bundles in the gingiva
- Copious vascularization of marrow spaces creates a good basis for cellular / humoral defense against infection.

Kramer's conclusive thesis (Kramer, 1987) that the unfavorable gingival / osseous topography of root proximity impairs periodontal resistance is still discussed controversially (Årtun et al, 1987; Giavannoli, 1981; Heins and Wieder, 1986; Heins et al, 1983; Tal, 1984; Waerhug, 1980). Recent findings suggest that the following positive effects can be expected from correction of orthodontic crowding:

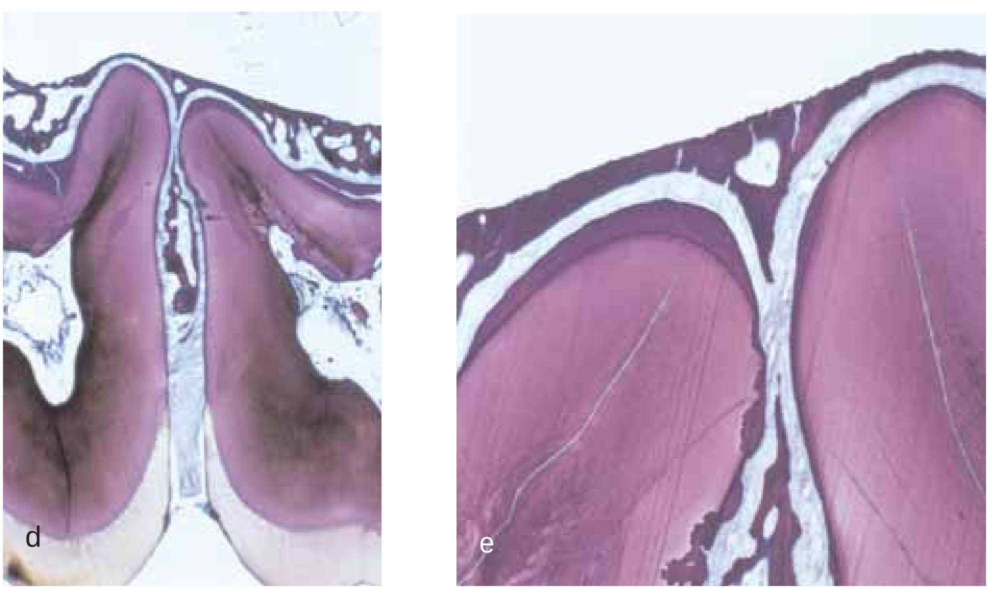
- Better access for oral hygiene
- Improved morphology of soft and hard periodontal tissues (Fig. 8)

Figs. 7a-e Comparison of differently structured septa, from Diedrich (2000).

Fig. 7a The left broader septum shows wide marrow spaces and rich vascularization, while the right narrower septum consists predominantly of cortical bone (human specimen, survey; toluidine blue staining).



Figs. 7b, c Detail magnification of the narrow interdental area with characteristic structural changes of the gingiva and alveolar bone: compressed papilla, scarce connective tissue stroma between epithelial ledges, interradicular bone poor in spongiosa (original magnification 6.4 x and 25.6 x respectively).



Figs. 7d, e Apical septum configuration: because of root proximity there is a localized fuse of adjacent periodontal ligament in the apical area (survey and detail magnification 25.6 x).

- Simplified mechanical and surgical therapy (scaling, root planing, curettage)
- More favorable conditions for periodontal regeneration.

A typical example of the negative periodontal effect of unfavorable axial inclination is the lower second molar tipped mesially into an untreated extraction site. Apart from the functional and prosthetic disadvantages (non-axial occlusal forces, narrowed pontic space, difficulty in tooth preparation etc.), the tipped molar implies a periodontal problem: the mesial alveolar crest slants apically, thus creating an acute-angled osseous contour. In the event of severe tipping, the marginal gingiva

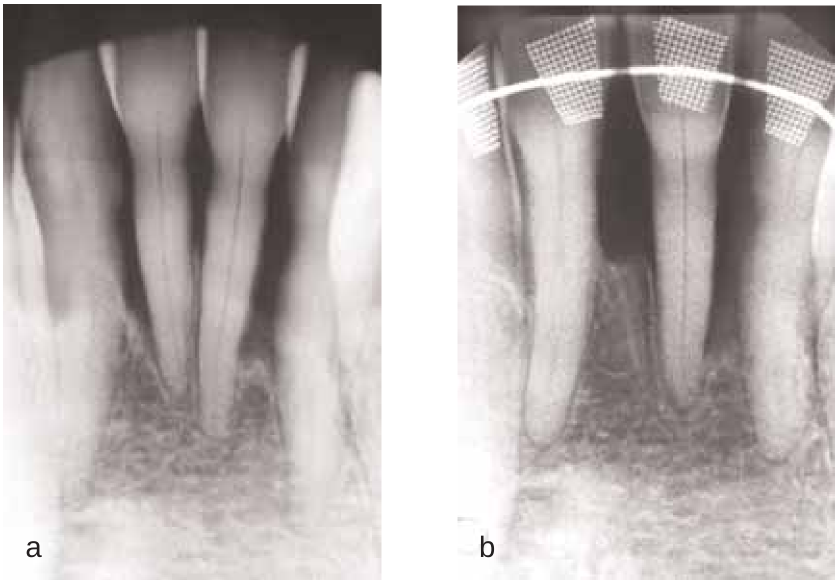


Fig. 8a Anterior crowding and root proximity in the lower jaw (59-year-old man): the initial radiograph shows advanced, almost 80% bone destruction distally to both central incisors and a wafer-thin mesial septum. This septum reaches vertically up to the middle of both roots.

Fig. 8b After extraction of the right lateral incisor, space-closure was performed within 4 months. In the retention phase the gain of interdental bone becomes evident: a broad septum between teeth 42 / 31, from the preorthodontically thin mesial bone lamella, apposition and remodeling have induced considerable reconstruction of the septum.

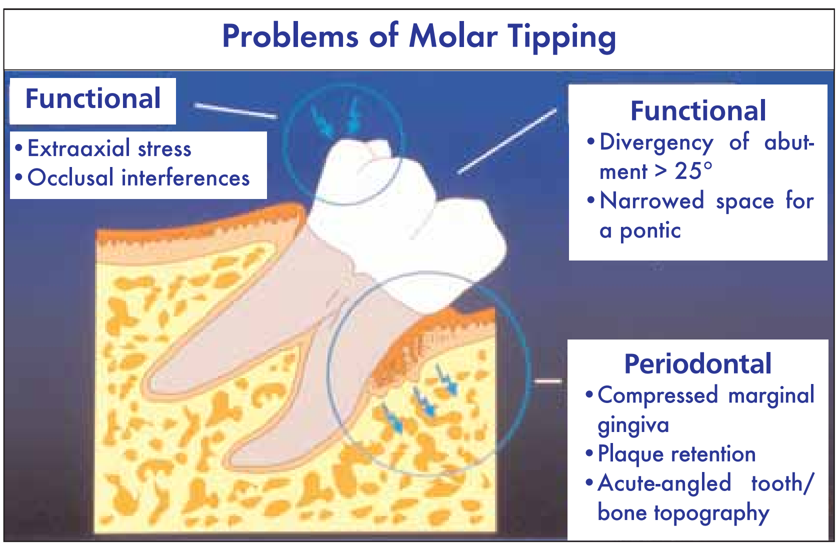


Fig. 9 Problems associated with mesially inclined molars.

on the mesial side is often compressed and hypertrophied due to plaque-induced inflammation. This morphologic alteration predisposes to the development of periodontal breakdown (Fig. 9).

In a histologic investigation of human specimens, signs of root resorption were frequently found on the marginal alveolar crest at the mesial face of tipped molars. These resorptions were not correlated with periodontal inflammation and may have been due to unphysiologic occlusal stress (Wehrbein and Diedrich, 2001).

Orthodontic uprighting of inclined molars induces a decisive improvement in periodontal and preprosthetic conditions (Diedrich, 1986; Lang, 1977; Vanarsdall, 1985; Wagenberg et al, 1980, 1986) (Fig. 10).

In a clinical study Wehrbein and Diedrich (1992) examined the effects of molar uprighting. Five parameters – probing depth, bone level, plaque index, sulcus bleeding index, and tooth mobility (Periotest®) – were evaluated before, during and after orthodontic correction. The resulting better accessibility for oral hygiene, especially in the mesial region of the uprighted molar, was found to result in a significant decrease in probing depth, plaque accumulation, and sulcus bleeding. Comparison of the pre- and postorthodontic findings revealed that tooth mobility was also signifi-

Fig. 10 Sequence of uprighting a mesially tipped second molar: initial finding with a profound mesial intraosseous defect, probing depth 10 mm. After periodontal therapy (GTR) and subsequent orthodontic uprighting the probing depth on the mesial side was reduced to 3 mm. The prognosis of the abutment tooth was markedly improved.

cantly reduced, with the attachment level remaining unchanged. The reduction in tooth mobility may be explained by the improved tooth position against occlusal forces.

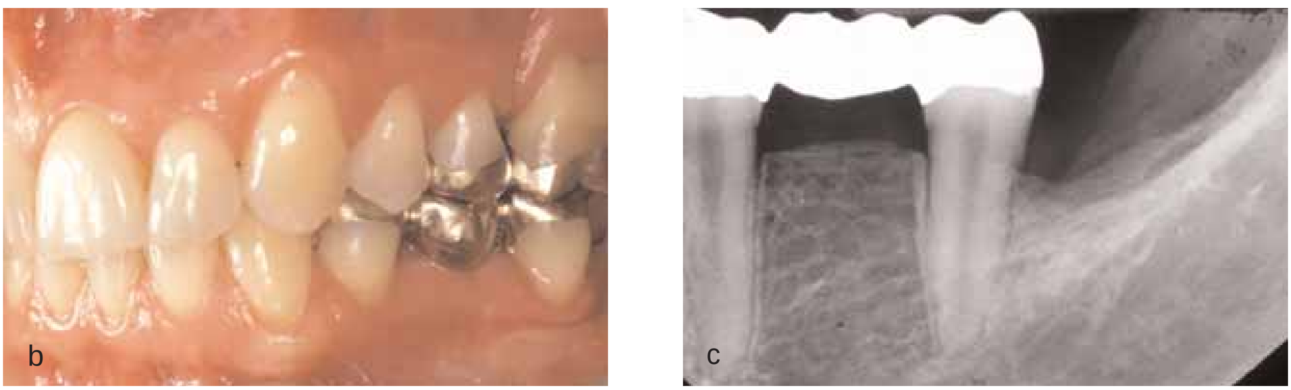
Another aspect is the orthodontic gain of distal abutment teeth: missing distal molars are a frequent finding in a periodontally affected dentition. Apart from implants, suitable orthodontic treatment options should be evaluated to avoid a partial denture. A distal bridge abutment can be obtained by orthodontic distalization of free-end premolars, by sagittal movement of hemisected molar roots, or by alignment of impacted molars.

The distalization of a free-end premolar, recommended by Diedrich and Erpenstein (1984) and by Vanarsdall (1985) has proved a prognostically favorable alternative to an implant. A retrospective long-term study (Diedrich et al, 1996) evaluated 32 distalized premolars serving as posterior abutment teeth for fixed restorations. The mean orthodontic distalizing distance was more than 9 mm and the investigation period up to 14 years (Fig. 11). The follow-up examination revealed that none of the premolar abutments was lost and all teeth had retained their vitality. The periodontal parameters (probing depth, sulcus bleeding, attachment level) showed no marked detrimental effects, so that a distalized premolar should be given preference over an implant abutment in view of its distinctly higher survival rate and the positive periodontal and functional findings.

CONCLUSIONS

The wide range of interrelations between periodontology and orthodontics shows that, besides the preventive significance in the mixed dentition, another focal point is the comprehensive rehabilitation of periodontally affected patients. With

Fig. 11a After extraction of tooth 26 the second molar is to be mesialized. In the lower jaw the second premolar is distalized 13.5 mm into the atrophied alveolar process to gain an end-standing abutment.



Figs. 11b, c Findings after orthodontic and prosthetic therapy: reconstructed alveolar bone; minimal, lateral root resorption disto-crestally.

Fig. 11d Control finding after 18 years; the distalized premolar shows periodontal integrity and vitality.

increasing experience in adult orthodontics and regenerative periodontology, setting therapeutic limits becomes increasingly difficult. It is fundamentally impossible to define in exact metric terms the probing depth or attachment loss up to which orthodontic tooth movement is feasible. The fact is rather that the periodontal / orthodontic treatment goal can only be defined by weighing up a number of different factors in each individual finding: esthetics, function, risks of orthodontic tooth movement, biomechanical considerations, and periodontal prognosis.

REFERENCES

Akiyoshi M, Mori K: Marginal periodontitis: A histological study of the incipient stage. J Periodontol 1967; 38: 45–52.

Årtun J, Urbye KS: The effect of orthodontic treatment on periodontal bone support in patients with advanced loss of marginal periodontium. Am J Orthod Dentofacial Orthop 1988; 93: 143–148.

Årtun J, Kokich VG, Osterberg SK: Long-term effect of root proximity on periodontal health after orthodontic treatment. Am J Orthod Dentofacial Orthop 1987; 91: 125–130.

Boyd RL: Mucogingival considerations and their relationship to orthodontics. J Periodontol 1978; 49: 67–76.

Boyd RL, Leggott PJ, Quinn RS, Eakle WS, Chambers D: Periodontal implications of orthodontic treatment in adults with reduced or normal periodontal tissues versus those of adolescents. Am J Orthod 1989; 96: 191–198.

Brown IS: The effect of orthodontic therapy on certain types of periodontal defects. J Periodontol 1973; 44: 742–756.

Diedrich P: Die Aufrichtung gekippter Molaren als präprothetische und parodontitisprophylaktische Maßnahme. Dtsch Zahnärztl Z 1986; 41: 159–163.

Diedrich P: Grenzen der kieferorthopädischen Behandlung im parodontal geschädigten Gebiss. Dtsch Zahnärztl Z 1990; 45: 131–135.

Diedrich P, Erpenstein H: Die Distalisierung endständiger Prämolaren zur Vermeidung von Freiendsätteln. Dtsch Zahnärztl Z 1984; 39: 644–649.

1Diedrich P, Wehrbein H, Schneider B: Zur Problematik der orthodontischen Intrusion parodontal erkrankter Zähne. Parodontologie 1992; 2: 87–102.

Diedrich P, Fuhrmann RAW, Wehrbein H, Erpenstein H: Distal movement of premolars to provide posterior abutments for missing molars. Am J Orthod Dentofacial Orthop 1996; 109: 355–360.

Diedrich P: Periodontal relevance of anterior crowding. J Orofac Orthop 2000; 61: 69–79.

Diedrich P: Die Bewegung von parodontal geschädigten Zähnen nach guided tissue regeneration (GTR) – eine tierexperimentelle Pilotstudie. J Orofac Orthop 2003; 64: 214–227.

Engelking G, Zachrisson BU: Effects of incisor repositioning on the monkey periodontium after expansion through the cortical plate. Am J Orthod 1982; 83: 23–32.

Ericsson I, Thilander B, Lindhe J, Okamoto H: The effect of orthodontic tilting movements on the periodontal tissues of infected and non-infected dentitions in dogs. J Clin Periodontol 1977; 4: 278–293.

Ericsson I: The combined effects of plaque and physical stress on the periodontal tissues. J Clin Periodontol 1986; 13: 918–922.

Fritz U, Diedrich P, Ehmer A: Implantatgestützte orthodontische Verankerung. ZM 93 16.11.2003; 22.

Geiger AM: Mucogingival problems and the movement of mandibular incisors. Am J Orthod 1980; 78: 511–527.

Giovannoli JL: Que faut-il penser des proximités radiculaires? Rev Orthop Dento Faciale 1981; 15: 387–414.

Glickman J, Carranza FA: Clinical periodontology, chapter 16: Extension of inflammation from the gingiva to the supporting periodontal tissues. Philadelphia: Saunders, 1990; 235–243.

Heins PJ, Wieder SM: A histologic study of the width and nature of interradicular spaces in human adult premolars and molars. J Dent Res 1986; 65: 948–951.Heins PJ, Thomas RG, Newton JW: The relationship of interradicular width and alveolar bone loss. A radiometric study of a periodontitis population. J Periodontol 1983; 59: 73–79.

Horn BM, Turley PK: The effect of space closure of the mandibular first molar area in adults. Am J Orthod 1984; 85: 457–469.

Kramer G: Betrachtungen über den Wurzelengstand. Int J Parodontol Restaurat Zahnheilk 1987; 6: 9–34.

Lang NP: Das präprothetische Aufrichten von gekippten unteren Molaren im Hinblick Auf den parodontalen Zustand. Schweiz Monatsschr Zahnheilkd 1977; 87: 560–569.

Lindskog-Stokland B, Wennström JL, Nyman S, Thilander B: Orthodontic tooth movement into edentulous areas with reduced bone height. An experimental study in the dog. Eur J Orthod 1993; 15: 89–96.

Martinez-Canut P, Carrasquer A, Magan R, Lorca A: A study on factors associated with pathological tooth migration. J Clin Periodontol 1997; 24: 492–497.

Melsen B, Agerbæk N, Eriksen J, Terp S: New attachment through periodontal treatment and orthodontic intrusion. Am J Orthod Dentofacial Orthop 1988; 94: 104–116.

Melsen B, Agerbæk N, Makenstam G: Intrusion of incisors in adult patients with marginal bone loss. Am J Orthod Dentofacial Orthop 1989; 96: 232–241.

Profitt WR: Equilibrium theory revisited: Factors influencing position of teeth. Angle Orthod 1978; 48: 175–186.

Polson A, Caton J, Polson AP, Nyman S, Novak J, Reed B: Periodontal response after tooth movement into intrabony defects. J Periodontol 1984; 55: 197–202.

Schröder HE: Pathobiologie oraler Strukturen: Zähne, Pulpa, Parodont. Kap. Parodontitis. Basel: Karger 1983; 155–169.

Selwyn SL: An assessment of patients with periodontally involved migrated incisors. J Dent 1973; 1: 153–157.

Tal H: Relationship between the interproximal distance of roots and the prevalence of intrabony pockets. J Periodontol 1984; 55: 604–607.

Tarnow DP, Magner AW, Fletcher P: The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal papilla. J Periodontol 1992; 63: 995–996.

Towfighi PP, Brunsvold MA, Storey AT, Arnold RM, Willman DE, McMahan CA: Pathologic migration of anterior teeth in patients with moderate to severe periodontitis. J Periodontol 1997; 68: 967–972.

Vanarsdall RL: Uprighting the inclined mandibular molar in preparation for restorative treatment. Contin dent educ, vol 1, no. 2. Philadelphia: University of Pennsylvania Press 1977.

Vanarsdall RL: Correction of periodontal problems through orthodontic treatment. In: Hösl E, Baldauf A, Diernberger R, Grosse P (eds). Orthodontics and periodontics. Chicago: Quintessence 1985.

Waerhaug J: Eruption of teeth into crowded position, loss of attachment and downgrowth of subgingival plaque. Am J Orthod 1980; 78: 453–459.

Wagenberg BD, Eskow RN, Langner B: Orthodontic procedures that improve periodontal prognosis. J Am Dent Assoc 1980; 100: 370–373.

Wagenberg BD, Eskow RN, Langner B: Orthodontics: A solution for the advanced periodontal or restorative problem. Int J Periodontics Restorative Dent 1986; 6: 36–45.
Wehrbein H, Rieß H, Mayer R, Schneider B, Diedrich P: Körperliche Zahnbewegung in atrophierte Kieferabschnitte. Dtsch Zahnärztl Z 1990; 45: 168–171.
Wehrbein H, Diedrich P: Parodontalbefunde bei der Aufrichtung gekippter Molaren. Dtsch Zahnärztl Z 1992; 47: 326–329.
Wehrbein H, Fuhrmann RAW, Diedrich P: Human histologic tissue response after long-term orthodontic tooth movement. Am J Orthod Dentofacial Orthop 1995; 107: 360–371.
Wehrbein H, Diedrich P: Mesio-marginal findings at tilted molars. A histological-histomorphometric study. Eur J Orthod 2001; 23: 663–670.
Wennström JL: The significance of the width and thickness of the gingiva in orthodontic treatment. Dtsch Zahnärztl Z 1990; 45: 136–141.
Wennström JL, Lindskog-Stokland B, Nyman S, Thilander B: Periodontal tissue response to orthodontic movement of teeth with infrabony pockets. Am J Orthod Dentofacial Orthop 1993; 103: 313–319.
Zachrisson BU: Clinical implications of recent orthodontic-periodontic research findings. Semin Orthod 1996; 2: 4–12.

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