Periodontics and Orthodontics: Low Forces, Expansion, Protraction and Control of Gingival Recession

Abstract

Background: The periodontal aspects of orthodontics are reviewed with an emphasis on arch expansion and management of crowding in the lower anterior segment.

Gingival Recession: Gingival biotype (width of keratinized tissue) and bone morphotype (thickness of labial bone) are the critical diagnostic factors for prevention and treatment of gingival recession. Optimal post-treatment conditions are: 1. dentition positioned in the center of the alveolar ridge, 2. axial loading, 3. circumferential bone support 1–2mm below the cementoenamel junction (CEJ), and 4. alveolar bone at least 1mm thick on the labial and lingual surfaces of the root.

Arch Expansion: For non-extraction treatment of crowding, increasing arch width helps control labial tipping of the incisors. Recent animal studies reveal that very low archwire force (5cN or g-force), interacting with the resistance cheeks and lips, results in moment that produces buccal translation of molars and the alveolar process. These data help explain the mechanism of slow arch expansion with passive self-ligating (PSL) brackets and small diameter copper nickel titanium (CuNiTi) archwires.

Gingival Grafting: Gingival grafts are not indicated for moderate recession problems related to poor alignment that can be corrected with orthodontics. Free gingival grafts can prevent further recession but combined soft tissue and bone grafts with enamel matrix derivative are required to restore the periodontium. Periodontal grafts can be performed before, during or after orthodontics.

Conclusion: Very low force is necessary for expansion of the alveolar process. Prospective surgical augmentation is indicated if tooth movement poses a significant risk for gingival recession. Prevention is preferred over surgical intervention. (J Digital Orthod 2018;52:4-19)

Key words:
Gingival biotype, bone morphotype, free gingival graft, combined soft and hard tissue graft, very low forces, archwire expansion, prevention, gingival recession

Introduction

Gingival recession is defined as the displacement of the marginal soft tissue in an apical direction, relative to the cementoenamel junction (*CEJ*). Labial, lingual and interproximal areas may be affected.[1] The resulting root exposure may be unesthetic, sensitive to cold, and/or susceptible to root caries.[2,3] There is an age-related increase in this problem both in severity and prevalence, as evidenced by 88% of adults 65 years of age or older experiencing gingival recession.[4] Recession occurs under both high and low standards of

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oral hygiene.[5,6] The labial of mandibular incisors and buccal of maxillary molars are the most frequently affected surfaces,[7] but all buccolingual (*facially*) prominent teeth are susceptible.[8] The etiology for gingival recession is multifactorial and orthodontic tooth movement may be a factor.[1,9,10] Several studies have demonstrated a relationship between gingival recession and orthodontics,[11-13] but controversy persists.[14] Periodontal disease,[15] gingival recession[4,5] and alveolar bone dehiscences[16] are endemic problems for adults. Gingival recession during or after orthodontic treatment is a significant clinical problem, so preventative measures are very important. At the pre-treatment consultation, particularly for Class III malocclusion, it is important to explain the potential for long-term mucogingival and occlusal problems, even for malocclusions treated at an early age.[10,17] The purpose of present article is to evaluate beneficial and detrimental effects of orthodontic treatment on gingival tissue.

International dental nomenclature can be confusing, so a modified Palmer notation is preferred. Quadrants are upper right (*UR*), upper left (*UL*), lower right (*LR*) and lower left (*LL*). Permanent teeth in each quadrant are numbered 1 to 8 from the midline.

Gingival Biotype and Bone Morphotype

The optimal conditions for periodontal health are: 1. each tooth well aligned in the center of the alveolar ridge, 2. axial loading, 3. circumferential bone support 1–2mm below the CEJ, and 4. alveolar bone at least 1mm thick on the labial and lingual surfaces of the root. Recession is defined as an apical migration of the gingival margin in an apical direction along the root surface. Patients with good oral hygiene may have gingival recession on the buccal or labial surfaces.[9] Poor oral hygiene is commonly associated with generalized recession.[15] Two important anatomical factors for gingival recession are: 1. gingival biotype which is the soft tissue dimension, particularly width, and 2. bone morphotype, defined as the thickness of the buccal plate of bone.[16,17] It is important to appreciate that gingival recession is a clinical manifestation of an underlying alveolar bone problem. Alveolar bone dehiscence is not necessarily associated with gingival recession, but it is a high risk condition. On the other hand, gingival recession is always related to a loss of alveolar crest.[16,17] There is a correlation between gingival recession and bone dehiscence, confirmed by surgical exposure.[18] These data are consistent with strict physiologic and anatomic boundaries for periodontally healthy teeth, i.e. the alveolar envelope.

It is commonly believed that the alveolar envelope defines the limits of tooth movement.[4-8] If violated, periodontal support and alveolar bone level are compromised. However, it is still unclear if these boundaries can be expanded therapeutically without adversely affecting the periodontium. No specific relationship between the amount of orthodontic tooth movement and gingival recession is established. Moreover, human studies have shown that near 87% of buccal bony walls are <1mm.[19,20] A cone beam computed tomography (*CBCT*) study in Asians documented that the frequency of dehiscence ranged from 9.9-51.6% for anterior to 3.1-53.6% for posterior teeth, respectively.[21] Those data suggest that the alveolar envelope may not be adequate to support orthodontic treatment for many patients. However, orthodontic movement, including incisor proclination, does not always result in gingival recession.[22,23] Thin bony width alone is not sufficient to predict further gingival recession, so the importance of the gingival biotype (*soft tissue envelope*) is a critical consideration.

The thickness but not the apicocoronal height of keratinized tissue is the important factor.[13,24] In addition, a weak positive correlation has been reported between gingival biotype and bone morphotype (*thickness of labial bone*).[25] A patient may have a thick, wide band of keratinized gingiva that is supported by deficient alveolar bone. Patients with a thin periodontal biotype are more prone to gingival recession after orthodontic treatment.[26] A thick gingival biotype may reduce the prevalence of orthodontically-induced gingival recession, even though there is a thin bone morphotype. Thus, when gingival biotype is thin, all types of orthodontic movement are risky.[24]

Expansion and Protraction

There are a number of predisposing risk actors for gingival recession associated with orthodontic treatment.[27] Buccolingual tooth position and tooth movement in the frontal plane affects gingival margin stability via thickness and width of keratinized gingiva.[13,28] There is usually a wider band of keratinized gingiva when teeth are positioned to the lingual rather than labial. Buccolingual tooth position affects the spatial distribution of gingival tissue. Orthodontic tooth movement in a facial direction, that thins the facial soft tissue, can result in bone dehiscence; subsequent gingival inflammation or toothbrush abrasion can result in gingival recession.[24,29] On the contrary moving teeth lingually tends to thicken both the gingival margin and labial plate of bone so the periodontium is more resistant to gingival recession (*Fig. 1*).[13,30]

There is an increasing trend toward nonextraction treatment in orthodontics.[31] Rather than removing teeth, crowding is managed by increasing the arch length with expansion of the buccal segments, and labial tipping of anterior teeth. Rapid maxillary expansion is directed at a skeletal increase in arch length, but heavy loads are applied to the teeth anchoring the expander. This problem is associated with increased risk of gingival recession and alveolar dehiscence.[32] Extraction therapy is designed to avoid unfavorable tooth movement outside the alveolar envelope, particularly arch expansion and incisor
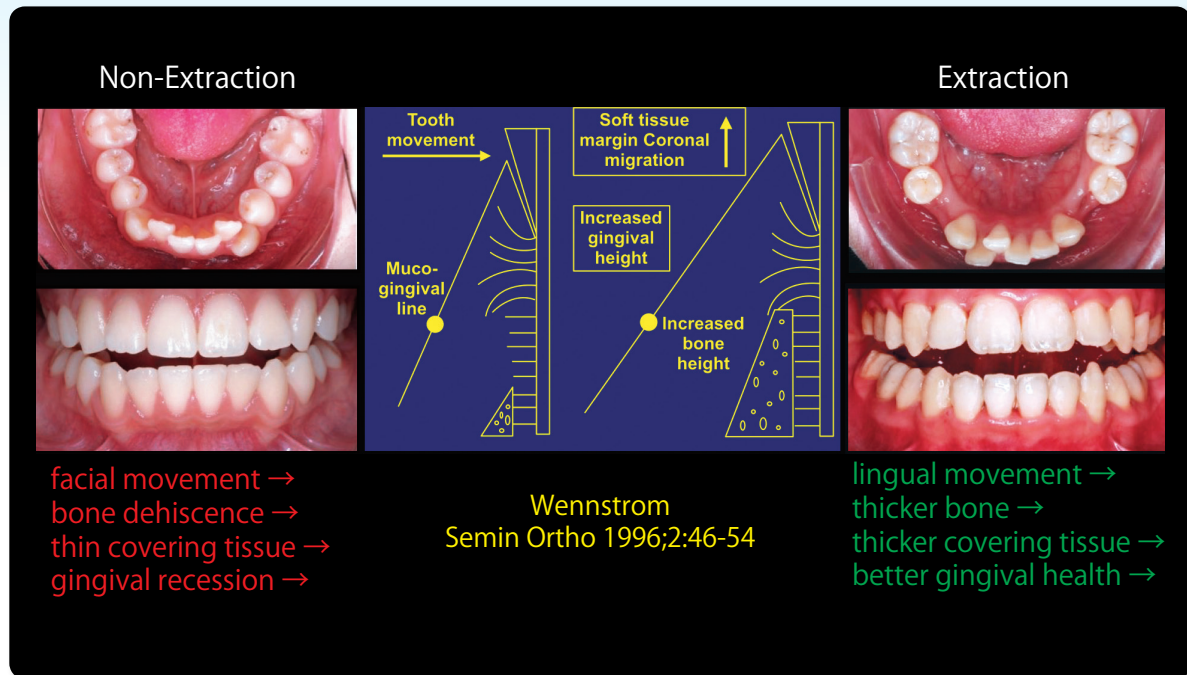
■ *Fig. 1*:

Center: *Wennstrom's diagram (1996) demonstrates the mechanism for gingival thinning as lower incisors are moved labially, and conversely for thickening as they are moved lingually.*

Left Panel: *Non-extraction treatment of lower anterior crowding thins the gingiva tissue and labial bone risking gingival recession. The biologic process is described with red font.*

Right Panel: *Following extraction of first premolars, the canines are retracted to create arch length to resolve crowding of the incisors (right panel). This approach, in addition to closure of the residual first premolar space, results in the most prominent incisors being retracted and aligned over the apical base of bone. The biologic process is described with green font. See text for details.*

proclination (*flaring*) (*Fig. 1*). An important aspect of treatment planning is to simulate the tooth movement required, with a wax set-up or 3D digital alignment. The risk of developing mucogingival problems should be assessed prospectively.[33]

Biomechanics

The magnitude of an orthodontic load affects the mechanical response of the dentoalveolar tissues, i.e. a tooth moving 'through' rather than 'with' bone.[34,35] Moving a tooth through bone is a concept that relates to applying heavy or tipping forces that cause necrosis (*hyalinazation*) of the periodontal ligament (*PDL*) in the path of tooth movement.[36] The localized PDL hyalinization halts tooth movement[35,37] until undermining resorption restores the continuity of the PDL.[34,36] On the other hand, a light bodily load (*force balanced with a moment*) is designed to translate a tooth, or an entire arch, while minimizing PDL necrosis.[38] This approach results in continuous, frontal bone resorption in the path of tooth movement (*compression side*), as well as bone apposition on the tension side of the PDL.[35]

In addition the subperiosteal surfaces of the facial aspect of the alveolar process are osteogenic, in the path of tooth movement (*concave flexure*), and osteoclastic on the trailing surface due to convex flexure and disuse atrophy.[36]

Clinical application of heavy tipping loads (*forces and/or moments*) tend to tip a tooth or teeth, and concentrate force at the cervical region of the periodontium, i.e. alveolar bone crest and epithelial attachment. Mechanical overload of these sensitive periodontal tissues can result in gingival recession, particularly if teeth are moved outside the anatomic boundaries of the alveolar process (*alveolar envelope*).[37]

Moving teeth beyond the alveolar envelope is often desirable clinically, but it is a challenging bone physiology problem. Numerous anecdotal case reports[39] and clinical presentations, as shown later in this review, suggest light archwire force can expand arches without periodontal damage. Comparison of conventional twin to PSL brackets revealed that both fixed appliances have similar effects on tooth movement, except PSL brackets tended to tip maxillary molars to the buccal.[40] In a follow-up study there was no significant difference in the arch expansion achieved with PSL compared to conventional brackets.[41] Those studies[40,41] focused on a relative comparison of two bracket types, but the level, duration and nature of the loads delivered by expanded archwires were unclear for specific patients.

Because of the absence of animal studies evaluating histologic changes, it is not clear if very light loads (≤5cN) are effective for moving teeth. Recently, Utreja et al.[42] provided the first bone label data relative to expansion of the maxillary arch with a very light ("*physiologic*") load (≤5cN). Maxillary buccal segments expanded bilaterally, with little if any buccal tipping of the molars. Histologically, there was no evidence of PDL necrosis. Subperiosteal bone apposition was documented with bone labels on the buccal surfaces of the alveolar process, as well as within the mid-palatal suture. These data demonstrate that very low force is capable of maxillary dentoalveolar expansion, at least within the limits of the study. However, the loads were much lower (≤5cN) than the "*low forces*" typically utilized for conventional fixed appliances (≥25g-force).[34,36,43] Maxillary expansion, sutural growth and buccal tooth movement with the 5cN load[42] was similar to the physiologic increase in width that occurs during growth.[44,45] In understanding very low force expansion, it is important to note that the tipping force of 5cN passing through the center of molar crowns was opposed, by a resisting force at the cusp tip from the soft tissue resistance of the cheek; these mechanics produce a mechanical couple that tends to translate the molars buccally.[42] This favorable "*physiologic*" load acts on the entire dentofacial complex, resulting in a growth-like effect.[44,45] These data suggest that the issue for "*physiologic*" arch expansion is not about the type of bracket,[40,41] but about the applied load.[42] The only common fixed orthodontics appliances that routinely strive for

arch expansion with loads ≤5cN are PSL brackets activated with small diameter copper nickel titanium (*CuNiTi*) arch wires.[38,39] Theoretically any bracket can be used to apply a very small force, but the PSL concept is important for uniform load applications to specified teeth, because the wire sliding in the PSL brackets prevents binding which can easily negate or double the load to a particular tooth.[43]

Management of Crowding

During the era of relatively high therapeutic force (*1900-1980*), the stability of arch expansion was controversial. Edward H. Angle was a proponent of non-extraction treatment to expand crowded arches to achieve optimal dentofacial esthetics. He reasoned that orthodontic expansion would become stable during retention because the skeleton adapts to the functional loading of an ideally aligned dentition.[43] By the 1940s, Angle's prominent student Charles Tweed concluded from a study of 100 consecutive patients that arch expansion was unstable, and he supported premolar extraction to avoid flaring of incisors and relapse of crowding.[43] Rapid palatal expansion is common mechanics for correcting palatal constriction, but periodontal compromise remains a concern.[32,36,43] PSL brackets have no advantage in treatment duration or outcomes over conventional straight-wire appliances for management of crowded Class I malocclusion.[46] It is clear that any fixed appliance can be utilized to apply a buccal force,[40,41,43] but a uniform load within the desired therapeutic range is critical for "*physiologic*" expansion of the arch.[39,42]

There are no well documented clinical reports on the periodontal effects of arch expansion with light-force archwires, but there are numerous anecdotal reports.[39] From a soft tissue perspective, PSL brackets are used for the treatment of periodontally compromised patients,[47] but plaque accumulation beneath relatively high-profile PSL brackets must be carefully monitored.[48,49] Based on stability concerns, extraction-based orthodontic therapy (*Fig. 2A*) for management of dental crowding has prevailed for over 50 years. After very low load-detection archwires were introduced, interest returned to slowly expanding arches to treat crowding (*Fig. 2B*).[39] Light, controlled orthodontic forces were directed at

■ *Fig. 2:*

  (A) *The left panel shows three frontal intraoral photographs documenting conventional extraction treatment of a crowded malocclusion. The upper image is pretreatment, and the middle view shows incisor alignment as space is opened with an open coil spring. The lower photograph reveals the final result with periodontal compromise in the lower incisor region as evidenced by gingiva recession and loss of interproximal papillae. Free gingival grafts (pink patches) were preformed to limit progression of the mucogingival problem.*

  (B) *The right panel of three progressive photographs documents treatment with PSL brackets and low force CuNiTi archwires. Although there was thinning of the gingiva and modest gingiva recession, the dentition was healthy and stable.*

promoting an optimal periodontal response to avoid gingival recession. Clinically, traditional brackets with stainless steel (SS) archwires and open coil springs deliver higher loads compared to small diameter CuNiTi wires designed for PSL brackets. Heavy force and excessive tipping may contribute to periodontal compromise (*Fig. 2A & Fig. 3A*). PSL brackets were developed to deliver relatively uniform, light forces to move teeth.[39] Theoretically, light loads favors the movement of teeth with bone (*Fig. 2B & Fig. 3B*).[34-36]

Patients with malocclusions often present with varying degrees of periodontal deficiency, such as thin gingival biotype and unfavorable

■ *Fig. 3*:

(A) *A panel of three intraoral photographs shows treatment of lower incisor crowding with traditional edgewise appliances. The top two views are pretreatment frontal and occlusal images, respectively. The lower image shows an over-expanded space in preparation for rotation and alignment of the LL1. Note thinning of the labial gingiva tissue in the lower incisor region.*

(B) *A panel of three intraoral photographs documents treatment with a PSL appliance for severe crowding of lower incisors with a deep curve of Spee. The top two views are pretreatment frontal and occlusal images, respectively. The lower image is the post-treatment frontal view of the lower incisors, following arch expansion and alignment with a PSL appliance. Note the healthy appearance of the gingiva.*

bone morphotype. This situation constitutes an anatomic risk for gingival recession. Some types of orthodontic tooth movement may move teeth outside the alveolar envelope. Periodontal support is compromised by dehiscence and/or gingival recession. A comprehensive evaluation of the gingival biotype and bone morphotype relative to the orthodontic treatment plan is essential, prior to initiating any type of tooth movement. Prospective periodontal grafts may be indicated for patients with pre-existing mucogingival problems, or for a treatment plan that risks attachment loss during or after orthodontic treatment.

Gingival Grafting

No graft indicted

A 9-year-1-month-old girl presented with anterior crossbite of the lower right central (*LR1*) and lateral incisors (*LR2*) (*Fig. 4A*). Mild gingival recession and thin gingival tissue were noted on the labial surface of the LR1. A gingival graft was considered prior to orthodontics because the thin gingival biotype was probably associated with a compromised bone morphotype.[16] Comprehensive clinical evaluation revealed a Class I molar relationship, good facial profile, and moderate crowding. The etiology of LR1 gingival recession was attributed to labial tipping and occlusal trauma, associated with the crossbite (*Fig. 4B*). Since the problem could be effectively managed by correcting the crossbite and aligning the LR1 in the center of the ridge, a gingival graft was not indicated. Conservative, non-

extraction treatment with a PSL appliance produced an optimal dentofacial correction with a good longterm prognosis (*Figs. 4C and 4D*). Gingival grafts are not indicated for moderate recession problems associated with malaligned teeth that can be readily corrected with orthodontics.


■ *Fig. 4A*:
"Treatment timing? Grafting of LR1 (41) before of after ortho" is a presentation slide presenting the question: Do we need to preventively graft the low gingival tissue in this case? Pretreatment evaluation of lower anterior gingival recession in a 9y1m old patient focused on the need for a free gingival graft on the LR1 (#41) prior to orthodontic treatment.

■ *Fig. 4B*:
The same patient (Fig. 4A) is shown in a panel of six images including a facial profile photograph (upper left), a panoramic radiograph (upper right), and four intraoral photographs.

Grafting after orthodontic treatment

A 24-year-7-month-old female presented with anterior open bite, Class III molar relationship, and severe crowding in both arches. The facial profile was acceptable in centric relation (C_R), and the patient was opposed to orthognathic surgery (*Fig.*
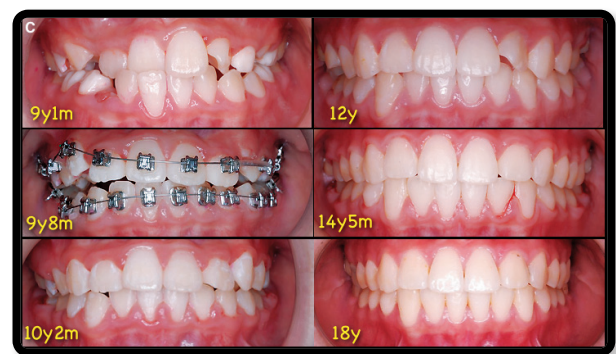


■ *Fig. 4C*:
A panel of six progressive frontal photographs document the non-extraction alignment (left vertical panel) from the start (9y1m), through active treatment (9y8m), to the finish (10y2m). The right vertical panel documents follow-up from 12-18y. The LR1 gingival recession noted at 9y1m is improved at the finish (10y2m), and remains stable through 18 years. See text for details.

■ *Fig. 4D*:
The patient (Figs. 4A-C) is shown at the 18y follow-up in a panel of six images which includes a facial profile photograph (upper left), a panoramic radiograph (upper right), and four intraoral photographs. See text for details.

5A). No CBCT imaging was available for evaluating the bone morphotype (*thickness*) in 3D, but similar Class III malocclusions show decreased labial wall thickness and an increased prevalence of alveolar bone dehiscence in the mandible (*42.6%*).[50] Class III compensated malocclusions (*Fig. 5A*) may have periodontal problems related to lingual tipping with labial root torque of the mandibular incisors. Compromised alignment relative to the apical base of bone is associated with a high prevalence of alveolar bone dehiscence. A pre-orthodontic grafting procedure was considered, but the gingival biotype of lower anterior area was adequate, so grafting was delayed until after orthodontic alignment. Following extraction of lower first molars and upper first premolars, PSL brackets with light orthodontic force were used to retract the lower premolars and canines to correct lower anterior crowding. The wire was engaged in all lower anterior brackets from the beginning of treatment (*Fig. 5B*). In retrospect, it may be wise to bypass the most displaced teeth in the initial alignment to
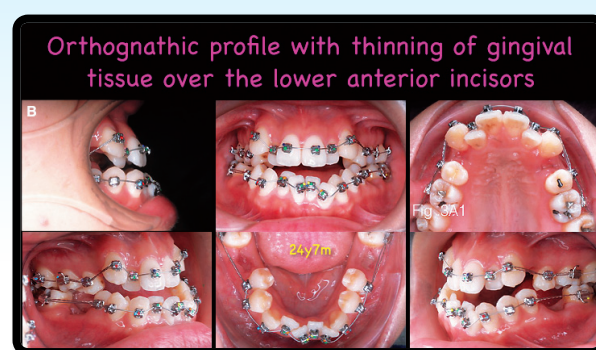
■ *Fig. 5B*:
"*Orthognathic profile with thinning of gingival tissue over the lower anterior incisors*" is documented with six intraoral photographs obtained during the active treatment at 24y7m of age. See text for details.

avoid excessive localized loads. IPR was performed as needed, and the malocclusion was corrected (*Fig. 5C*). There was concern about alveolar bone dehiscence leading to gingival recession, so a combined connective tissue and bone particle graft was performed after fixed appliances were removed (*Fig. 5D*). It is important to prospectively discuss any surgical interventions planned before, during or after orthodontic treatment. The best option for the

■ *Fig. 5A*:
"*Warning for possibility of gingival recession!*" is a slide illustrated with a panel of five images, including a facial profile photograph (upper left), frontal view of the dentition (top center), panoramic radiograph (upper right), as well as both right and left buccal intraoral photographs in the two lower photographs, respectively.

■ *Fig. 5C*:
"*Warning of possibility of gingival recession!*" is a statement illustrated at age 27y with five post-treatment images, including a facial profile photograph (upper left), frontal view of the dentition (top center), a panoramic radiograph (upper right), and both right and left buccal intraoral photographs in the two lower photographs, respectively. See text for details.

present patient was to delay the surgery because the gingival biotype was deemed adequate to maintain the gingival attachment during treatment. However, after alignment (*Fig. 5C*) the patient felt uncomfortable brushing the labial surface of the LR1 because the gingival tissue was thin and transparent. It was clear there was insufficient periodontal tissue to support long-term stability. Grafting of bone and soft tissue was performed (*Fig. 5D*) to ensure a long-term harmonious esthetic and optimal outcome.

The grafting procedure (*Fig. 5D*) for combined soft and hard tissue augmentation was: 1. subperiosteal flap elevation, 2. subepithelial connective tissue graft, 3. xenograft (*Bio-Oss® Geistlich Pharma AG, Wolhusen, Switzerland*) and 4. enamel matrix derivative (*Emdogain® Straumann Holding AG, Basel, Switzerland*). This combined approach allows for an improved esthetic result and helps ensure longterm periodontal stability (*Fig. 5E*).[51]

■ *Fig. 5D*:
A combined connective tissue, bone particulate, and enamel matrix derivative graft was performed to augment the buccal soft and hard tissue of lower anterior teeth. See text for details.

Grafting before orthodontic treatment

A 12-year-2-month-old girl was concerned about the crowding and poor masticatory function. The clinical evaluation revealed a bilateral Class III molar relationship with anterior cross-bite and an openbite tendency (*Fig. 6A*). Since the facial profile was acceptable in C$_R$, a conservative non-extraction approach was indicated and the patient was treated with a PSL bracket appliance. Duration of active treatment was about 19 months. The fixed appliances were removed at age 13-year-9-

■ *Fig. 5E*:
A panel of six intraoral photographs document the start (24y7m), finish (27y) and follow-up (29y11m) for the treatment of the patient shown in Figs. 5A-D. Three progressive frontal images are on the left, and right buccal views are on the left. Note the excellent gingival health and soft tissue contouring almost three years post-operatively. See text for details.

■ *Fig. 6A*:
"Orthognathic profile with thinning of gingival tissue over the lower anterior incisors" is illustrated in panel of six images including a facial profile photograph (upper left), a panoramic radiograph (upper right), and four intraoral photographs. See text for details.

■ *Fig. 6B*:
A panel of six progressive intraoral photographs, frontal views of both arches, show orthodontic treatment and management of gingival recession at the following intervals:
- *12y2m - Initial (upper left)*
- *13y4m - PSL brackets fixed appliance (center left)*
- *13y9m - Finish (lower left)*
- *15y2m - Occlusion relapses to an edge to edge incisal relationship. Lower 2nd premolars is extracted.*
- *21y11m - Anterior cross bite is improved but gingival recession is noted on LR6, LR1, LR4, LL1, LL3, LL4 and LL6.*
- *24y1m - Prior to follow-up orthodontic treatment, soft tissue and hard tissue grafts were place as needed.*

■ *Fig. 6D*:
A panel of six left buccal intraoral photographs show the same progressive sequence as Fig. 6B
- *12y2m - Initial (upper left)*
- *13y4m - PSL brackets fixed appliance (center left)*
- *13y9m - Finish (lower left)*
- *15y2m - Occlusion relapses to an edge to edge incisal relationship. Lower 2nd premolars are extracted.*
- *21y11m - Anterior cross bite is improved but gingival recession is noted on LR6, LR1, LR4, LL1, LL3, LL4 and LL6.*
- *24y1m - Prior to follow-up orthodontic treatment, soft tissue and hard tissue grafts were place as needed.*

■ *Fig. 6C*:
*A similar panel of six right buccal intraoral photographs show the same progressive sequence:*
- *12y2m - Initial (upper left)*
- *13y4m - PSL brackets fixed appliance (center left)*
- *13y9m - Finish (lower left)*
- *15y2m - Occlusion relapses to an edge to edge incisal relationship. Lower 2nd premolars are extracted.*
- *21y11m - Anterior cross bite is improved but gingival recession is noted on LR6, LR1, LR4, LL1, LL3, LL4 and LL6.*
- *24y1m - Prior to follow-up orthodontic treatment, soft tissue and hard tissue grafts were place as needed.*

months (*Figs. 6B-D*). Eight years later at age 21-year-2-months, the Class III malocclusion had relapsed and mucogingival problems were noted labial to the lower incisors. The stability problem was deemed genetically-mediated late mandibular growth, resulting in lingual tipping of lower anterior teeth and labial prominence of the roots (*loss of torque*). In the lower arch, progressive gingival recession was noted from premolar to premolar, in addition to a thin gingival biotype probably associated with dehiscence buccal to the first molars (*Figs. 6B-D*). The patient desired retreatment, so the first priority was to augment the mucogingival defects prior to any additional tooth movement. Since gingival recession is an alveolar bone problem, a combined soft and hard tissue augmentation procedure was planned

■ *Fig. 6E*:

A progressive panel, of four paired frontal and left buccal photographs, document free gingival grafts in preparation for comprehensive periodontal augmentation: UL is the preoperative view, UR is the surgical preparation to the graft sites, LR shows free gingival grafts suture into position, and LR documents the post-operative outcome.
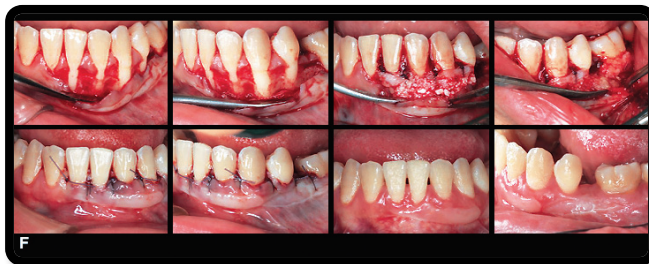
■ *Fig. 6F*:

A similar progressive panel of four paired frontal and left buccal photographs document a composite connective tissue, bone and enamel matrix graft in the same areas prepared with the free gingival grafts in Fig. 6E (1-6 area): UL the flap is reflected, UR graft materials are placed, LR shows surgical closure and suturing, and LR documents the post-operative outcome.

■ *Fig. 6G*:

The same sequence as illustrated in Fig. 6F is performed on the lower right side for teeth LR1-6.

■ *Fig. 6H*:

A vertical panel of buccal and front images document: preoperative condition (21y11m, upper three views), post-operative outcome (24y1m, center three views), and follow-up orthodontic alignment (25y1m, lower three views). Note that the healthy periodontal condition resists gingival recession during the follow-up course of orthodontic treatment (lower 3 view panel).

utilizing a stepped approach. A free gingival graft form the LL1-6 was the initial procedure (*Fig. 6E*). Three months later a hard and soft tissue root coverage procedure was performed from LL6 to LR6 with three simultaneous grafts, as previously described (*Figs. 6F and 6G*). The improvement in the level of gingival margin and the thickness of keratinized tissue is seen at age 24-year-1-month (*Fig. 6H*) compared with pre-surgical condition (*Figs. 6B-6D*). Augmented buccal bone provides a scaffold for improved soft tissue contouring. The patient's excellent hygiene during the second course of orthodontic treatment maintained the augmented periodontal tissue (*Fig. 6H*).

Grafting during orthodontic treatment

A 25-year-2-month-old female was referred for a second opinion (*Fig 7A*). Compared to her pre-treatment records (*Fig. 7B*), the arches were being aligned with an edgewise appliance to decompensate particularly the lower dentition,

prior to orthognathic surgery. Open coil springs, used to open space in the lower anterior region, had tipped the incisors anteriorly. Thin facial gingiva was noted particularly on the LL1-4. The patient was re-evaluated with the three-rings diagnosis method for differential diagnosis of Class III malocclusion.[52] Her good (*orthognathic*) facial profile in C$_R$ indicated the skeletal Class III malocclusion could be resolved conservatively with PSL brackets and bone screw anchorage. After a careful discussion, the patient agreed to the alternative approach that involved 2

■ *Fig. 7A*:
A transfer patient with a severe Class III malocclusion is shown in a panel of six images including a facial profile photograph (upper left), a panoramic radiograph (upper right), and four intraoral photographs. Because the patient has good orthognathic profile, conservative treatment is indicated. See text for details.

■ *Fig. 7B*:
The original records are provided for the transfer patient shown in Fig. 7A. Note the good facial profile in C$_R$, Class lll relationship, open bite, deep curve of Spee, and lower anterior crowding.

infra-zygomatic crest (*IZC*) and 2 mandibular buccal shelf (*MBS*) bone screws (*Figs. 7C and 7D*). Bone screws in all four posterior quadrants were utilized as anchorage to retract and align both arches over the apical base of bone.[52,53] The lower arch was then retracted and posteriorly rotated to correct the Class III intermaxillary discrepancy.[38] The thin gingival biotype and bone morphotype of lower anterior incisors was compromised by the previous course of treatment. Periodontal augmentation as previously described was indicated to correct the gingival recession.

Skeletal Class III malocclusion with crowding usually requires extractions for optimal alignment of the dentition, and orthognathic surgery to resolve the skeletal discrepancy.[43] However, many Class III patients can be managed conservatively with an appropriate differential diagnosis, PSL brackets, and extra-alveolar bone screw anchorage.[38] Buccal segment retraction with bone screw anchorage and IPR are used to correct crowding.

Conservative treatment for Class III malocclusion is directed at avoiding extractions, orthognathic surgery, and gingival recession. IZC and MBS bone screws are effective anchorage for optimal nonextraction alignment, and intermaxillary correction as needed.[38,39,52,53] The ultimate goal of the clinician is to provide a long-term solution that is both stable and healthy. To minimize the risk of gingival recession and maximize the benefit of orthodontic treatment, the orthodontist and periodontist must both be aware of the risk factors for mucogingival problems before, during and after orthodontic treatment. Dental alignment must be

directed at not only the crowns of the teeth, but also the roots and supporting periodontium. The potential risk for mucogingival problems involves assessment of anatomical conditions, hygiene issues and the proposed orthodontic treatment. Patients should be aware of the specific risks for the treatment proposed, and any other therapeutic measures that may be required. It is recommended that these details be part of the pretreatment consultation and informed consent process.

Conclusion

Detailed analysis of the potential risk for mucogingival complications is mandatory prior to performing any type of orthodontic treatment. Arches can be expanded with low loads and PSL brackets. Pre-orthodontic gingival augmentation is not recommended for problems that are likely to improve with orthodontic alignment, but prospective surgical intervention is wise when orthodontic tooth movement entails a risk for gingival recession. Gingival recession can usually be corrected surgically, but the preferred strategy is prevention.

■ *Fig. 7C:*
The crowded Class III malocclusion at 25y2m is shown in facial profile and right buccal segment radiographs (left two images). Two IZC and two MBS bone screws were used as anchorage to align the dentition at 26y10m (right two images). Note the improvement in the facial profiles as the malocclusion is corrected.

■ *Fig. 7D:*
The original malocclusion is shown at 25y2m in the two frontal photographs on the left. Treatment progress at 26y10m shows improved alignment, but moderate gingival recession is noted on the LL1-3. Post-treatment follow-up is indicated to determine if surgical intervention is required. See text for details.

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