Nonextraction Emphasis: Space Gaining Efficiencies, Part II

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Aim: Facial orthopedics must be applied with individualized patient needs and goals in mind. This article describes some effective appliances for mandibular arch development and space gain in nonextraction therapy. Methods: Determine the appliance(s) and the most effective approach for individualized therapeutic requirements. Removable and fixed appliances are often used in tandem. Results: Mandibular arch space gains of 4 to 8 mm are consistently achieved, depending on individual facial type and arch discrepancies. The mandibular arch form and width are optimized as transverse decompensation (buccal uprighting) is achieved. Class II malocclusions have a transverse deficiency component. Expansion therapy and lateral arch development increase available space, help to unlock mandibular posture, and optimize anteroposterior development. Conclusion: Nonextraction treatment is more possible with early orthopedic and mixed dentition intervention. Transverse dimension is a treatment priority that is accomplished by reshaping the arch form and uprighting the buccal segments. Greater posterior arch width and alveolar remodeling changes can be achieved when treatment occurs before the permanent canines and premolars have erupted. The mandibular posterior transverse dimension dictates the extent of maxillary expansion that will coordinate the arches and allow optimal interdigitation. Facial harmony and balance are optimized with transverse structural and dentoalveolar space gains, resulting in improved occlusal and smile features. World J Orthod 2001;2:177–189.

Part I of this article focused upon maxillary space gaining efficiencies. Part II highlights mandibular space gaining approaches, and shares innovative concepts that have clinical possibilities. Early intervention with properly timed treatment is advised.

Mandibular Leeway Space

It is to the clinician's and the patient's advantage to preserve and utilize the vital space mandibular leeway space. Graber reported mandibular arch leeway space as 2.7 mm average per side. Effective leeway space preservation facilitates nonextraction treatment for patients. When transitional space is needed for eruption of mandibular canines and first premolars, judicious slenderizing (air rotor stripping, ARS) of adjacent contacts creates space for succedaneous teeth to erupt and be aligned without permanent tooth extraction in more than 90% of young patients.

MANDIBULAR ARCH MODIFICATION AND SPACE GAIN

Effective mandibular space enhancers include the following: Leeway space preservation; lingual arch with double wires to gain posterior space; mandibular segmental arch therapy to unlock space; reproximation (ARS); removable appliance therapy (Schwarz, Crozat, Frozat [fixed Crozat], or jack screw); lip bumper; distalizing magnets; distraction osteogenesis; and bonded occlusal composites to unlock the vertical dimension. A combination of these methods facilitates nonextraction approaches. When considering fixed and removable appliances for transverse changes, the clinician should evaluate the patient's facial pattern, orthopedic needs, alveolar remodeling potential, dentoalveolar stability, periodontal support, profile and esthetic factors, and arch-length requirements.

Cetin et al described tooth movement in all three planes of space, resulting in effective broader arch...
form. They showed impressive long-term stability and concluded that effort should not be made to maintain the arch form of the original malocclusion. Cases treated per Cetlin were found to have excellent long-term stability, even though the mandibular intercanine width was developed in every case. A compressed mandibular arch with an excessive curve of Wilson should be uprighted transversely for optimal form. This is not expanding; rather, it is uprighting the arch (lateral decompensation) for the specific facial type (ie, wider in brachyfacial patients). Expansion beyond stable guidelines fosters instability. Treatment goals should emphasize a balance of physiologic, anatomic, functional, and esthetic aspects. Howe et al and McNamara and Bradon reported that tooth size was unrelated to the amount of dental crowding. They recommended development of the arches to achieve appropriate intermolar width, rather than arch reduction by extraction therapy. During the mixed dentition, the mandibular posterior alveolar width can be remodeled and the dental arch reshaped and widened prior to eruption of the canines and premolars.

**TRANSVERSE APPLIANCE THERAPY**

A maxillary transverse hypoplasia enhances posterior segment narrowness with a compensated lower curve of Wilson and constricted arch form. The maxillary arch is the template for the mandibular arch (Fig 1). Maxillary expansion permits unlocking of the malocclusion (transverse uprighting) and development of the mandibular arch within the periodontal support. Periodontal soft tissue management prior to and during transverse correction can preserve keratinized/attached gingiva. The relationship of sulcus height relative to the cementoenamel junction (CEJ) is measured, and labial/buccal muscle attachments are also monitored. With overlapping incisors, the papillae can be deficient, contributing to a dark triangular embrasure space. Interproximal enameloplasty (contact stripping or reproximation) slenderizes tooth contours to allow aligned teeth and diminished interdental space, with improved papillary conformation and optimized interroot distance.

Orthodontic therapy can begin with a mandibular Schwarz transverse appliance. It is important to avoid lingual acrylic contact on any incisor or canine with compromised labial periodontal support (Fig 2). The clinician must be observant of any labial mucogingival deficiency or osseous abnormalities. Dental compensations are reversed, as the mandibular posterior compressed arch is buccally uprighted to normalize the curve of Wilson. Care is necessary to avoid expansion beyond the transverse guidelines, as described by Ricketts for each facial pattern (wider in brachyfacial patients, and less wide in mesofacial and dolichofacial patients). This envelope of stability determines the transverse parameter of correction (Fig 3). A mandibular occlusogram depicts the relationship of the roots to the buccal cortical bone support (Fig 4). As the mandibular arch is widened and reshaped, the incisors can be uprighted (rather than flared) within alveolar support.

Mandibular arch correction with a transverse appliance for 3 to 4 months will unlock the malocclusion and upright any lingually inclined mandibular posterior teeth. This improves the deficient occlusal vertical dimension and mobilizes teeth by initiating a favorable cellular response, indicated by slight orthodontic tooth mobility. The patient can transition into fixed therapy with little discomfort, since tooth movement has already been initiated by the Schwarz appliance, and with more available space for initial arch alignment. Once brackets are placed, the Schwarz appliance is discontinued or used only at night for 1 to 2 months to maintain the improved arch width until initial alignment and arch form are established. Alveolar widening and favorable remodeling occur when the Schwarz expansion appliance is used in the mandibular arch while deciduous molars/canines are present. Brust reported greater intercanine and intermolar widths with increased space for permanent teeth subsequent to rapid palatal expansion and mandibular Schwarz appliance therapy. Thus, fewer patients require permanent tooth extraction.

**MANDIBULAR SEGMENTAL APPROACH**

Movement of any teeth in any direction is possible in normal biologic conditions and with the proper application of pressure, as reported by Ricketts, Sellke, Gugino and Dus, Zachrisson, Sadowsky and Sellke, and this author. Segmental mechanics unlock and uncrowd anterior teeth during development of the transverse dimension. Segmentation of arches enhances the prognosis for success in smile design, with more precise placement of the incisors and, ultimately, the whole arch (see part I of this article). With a mandibular utility arch and segmental therapy, the overbite should be corrected early in treatment staging, typically with light-pressure mandibular incisor intrusion to the functional occlusal plane and normalized curve of Spee.

Optimally, the mandibular incisal edges should be about 1 to 2 mm above the lower lip vermilion at rest. The mandibular anterior can be advanced, following
Fig 1  (a) A narrow maxillary arch encourages the mandibular arch to compensate lingually. (b) the transverse appliance is used first, then brackets are placed for alignment.

Fig 2  (a) Mandibular Schwarz appliance therapy before eruption of canines and premolars. Alveolus is widened with roots uprighted within bone support. (b) Gingival graft for original keratinized tissue deficiency. (c) Final arch is upright, ideal, and stable.

Fig 3  A nonextraction case, before and after. Intercanine width increased by 3 mm, premolar width by 4 mm, and molar width by 2.6 mm. Transverse arch decompensation is achieved.

Fig 4  (a) Transverse dimension is compressed. (b) Arch is aligned, with an uprighted curve of Wilson.
their intrusion, since the labial and symphysis bony regions are of greater thickness in front of the mandibular incisors. Using a soft 0.016-inch squared utility arch with a light Ni-Ti/TMA overlay, the posterior teeth become aligned and the incisors can be intruded before advancement—an important bioprecessive principle. Minimal elastic therapy is employed, primarily at the end of treatment for interdigation.

**DOUBLE LINGUAL ARCH**

The mandibular first molars can be redirected during their upward and forward eruption, which adds bilaterally to the available arch length. Light activation, by opening the loop about 1 mm every 8 to 12 weeks on the secondary 0.028-inch wire, encourages molar distalization and better incisor alignment (Fig 5). This activation increases arch length and can advance or reposition the incisors, relative to alveolar support and radiographic guidelines (such as A-Po line; a vertical Slavicek line from lingual symphysis to occlusal plane bisecting the anterior and posterior arch components; or the incisors relative to mandibular plane angle). This pressure gradually distalizes the mandibular molars against eruptive growth, while holding the incisors upright or advancing/relocating them forward when appropriate.

**REPROXIMATION AND ENAMELOPLASTY**

ARS or slenderizing of contact areas and tooth reshaping effectively align the arches. ARS is an effective and useful clinical method for achieving space gain, when tooth morphology permits such reshaping and enamoplasty. Some patients cannot withstand advancement of the mandibular incisors nor transverse development of the arches for space gain. When periodontal support is lacking, rely upon ARS rather than excessive expansion methods to help create the needed arch length. Periodontal compromises may limit both tooth movement and prolonged orthodontic forces. Periodontal factors and sensible clinical judgment should influence decisions about how much and where to reproximate. In general, distal contours can afford more reshaping for space gain. Surfaces should be well-contoured and polished when completed (Fig 6).

**FUNCTIONAL JAW ORTHOPEDICS**

Class II malocclusion problems predominate in orthodontic practices, and typically there is a transverse deficiency. There may be a need to manage related airway or muscle imbalance factors before developing the arches transversely. Functional appliances can influence and improve mandibular skeletal deficiency (retrognathia) and related Class II malocclusion through favorable mandibular growth modification in three dimensions. However, the need to consider the surgical alternative is not necessarily eliminated. The benefits of Herbst therapy, the Fränkel appliance, Twin-blocks, Eureka or Jasper springs, the Bite-Fixer, and so on contribute to favorable and variable Class II changes. Histologic evidence supports periodic and incremental advancement for optimal Herbst appliance response in this cybernetic process. As arch space is created, less extraction therapy is required.

The Herbst appliance with a maxillary and/or mandibular expander (a mini-screw) at the midline achieves greater space gain. Mayes has written about significant Herbst (cantilever bite-jumper,Ormco, Orange, CA, USA) arch-length gains. Lai has described the maxillary molar distalization effects of Herbst therapy. Dischinger has reported intercanine width increases of 4.1 mm and intermolar width increases of 2.43 mm, with an arch perimeter increase of 7.08 mm. His results maintained equivalent or better stability than extraction therapy studies.
in addition to the advantages of broader arch form, facial harmony, pleasing lip support, and an attractive smile. To achieve Class II correction, the maxillary components must be expanded relative to the mandibular components. Forward mandibular posturing can occur with a broad maxillary arch; the mandible can then achieve its genetic growth potential. The best treatment timing for this result is in the late mixed dentition phase (Figs 7 and 8). Herbst activation guidelines, with individualized consideration of condylar positioning and mandibular propulsion, are: (1) for an overjet of 6 mm or less, the mandible should be postured forward with the incisors in an edge-to-edge relationship; (2) with overjet of 7 to 10 mm, the mandible should be postured forward two-thirds of the overjet amount; (3) if overjet is greater than 10 mm, the mandible should be postured forward one-half of the overjet amount; (4) the midline of the mandible should be centered skeletally, though the teeth may not yet be aligned to the midline.

MISSING OR IMPROPERLY POSITIONED TEETH

When a single developing tooth is improperly positioned, it can be favorably repositioned. When successful, this option retains the questionable tooth in the permanent arch, rather than losing it to extraction (Fig 9). When permanent teeth are missing, either congenitally or by previous extraction, replacement teeth are planned in the final alignment (as though treatment was to occur under nonextraction conditions) whenever possible and appropriate (Figs 10 to 12). When a patient has optimal facial proportions with undersized teeth, an extra incisor or two, or extra mandibular premolars bilaterally, will keep the mandibular anterior teeth forward for best lip harmony (Figs 13 and 14). Restorative procedures after orthodontic treatment provide optimal functional occlusion and esthetic harmony (Fig 15).

TMD ISSUES—INTERDISCIPLINARY TREATMENT

Management of craniomandibular dysfunction requires differential evaluation with appropriate and specific interdisciplinary treatment, based upon sound biologic and physiologic principles synthesized with clinical sensibility, as Grimmons and McNamara et al have documented. Transitional removable temporomandibular disorder (TMD) splints are useful for muscle reprogramming, stomatognathic comfort, maintaining a stable mandibular reference position, and arch development during occlusal finalization and/or comprehensive orthodontic approaches (Fig 16).

As Graber has stated: “Man proposes, nature disposes.” Ricketts has long emphasized the importance of whole-person concepts in a biologic continuum. Mechanistic orthodontic approaches and thinking fade, while physiologic principles prevail. We must avoid those orthodontic procedures and circumstances that eccentrically load the temporomandibular joint (TMJ) components or create unfavorable component compression. Dysfunctional patients easily destabilize and require close observation to optimize disc-condyle coordination, neuromuscular comfort, and tooth alignment with functionally balanced occlusal relationships. When parafunction is evident, mandibular incisor alignment stability is of great concern. Patients with parafunction (clenching/bruxism) benefit from an orthotic splint or nightguard, which also serves to maintain alignment.

VERTICAL DIMENSION OF OCCLUSION

The vertical dimension of occlusion varies with individual freeway space and facial type (brachyfacial patients demonstrate greater vertical dimension of occlusion than dolichofacial patients). Linder-Aronson
Fig 7  (a) Pretreatment imbalanced smile. (b) Posttreatment smile harmony. (c) Pretreatment Class II malocclusion before Herbst appliance therapy. (d) Optimized mandibular arch at posttreatment. (e) Pretreatment Class II skeletal mismatch. (f) Class I facial balance at posttreatment. (g) Superimpositions showing Class II correction with mandibular orthopedic modification and nonextraction therapy.
Fig 8  Herbst appliance with double lingual arches for achieving greater arch gain.

Fig 9  (a) Second premolar developing unfavorably.  (b) Reimplantation (nonextraction) of premolar is preferred.  (c) After transplantation; successful nonextraction approach is achieved.

Fig 10  (a) Example of arch width change with space gain.  (b) Nonextraction treatment and restorative procedures are successful.  (Two other orthodontic opinions favored incisor or premolar extractions for this patient.)
Fig 11  (a) M loops are effective space gainers. (b) Premolar space is recovered and/or restored.

Fig 12  (a) Pretreatment mandibular arch with three incisors. (b) Space is established for four incisors in final restorative plan.

Fig 13  Patient with six incisors in final result, due to excessive arch length.

Fig 14  (a) Optimal facial balance is evident in this patient. (b) Space is made for an extra premolar per lower quadrant, rather than initiating space closure, which would result in anterior teeth retraction with diminished lip support.
Fig 15  (a) Mandibular arch with partial anodontia.  (b) Maxillary arch is aligned for eventual restorations.  (c) Facemask is used to protract maxillary dentition to optimize lip support.  (d) Implants in place, awaiting restorations.  (e) Final restorations: maxillary arch fixed, mandibular arch overdenture (Prosthodontist, Dr Richard Bullock).  (f) Pretreatment smile.  (g) Posttreatment smile is dramatically better.  (h) Posttreatment profile with harmony and beauty.  (i) Superimpositions of facial, dental, and jaw changes.  

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Fig 16  (a) TMD stabilization segmental splint with expander. (b) Splint develops arch width for space gain and successful nonextraction alignment.

Fig 17  (a) Anterior bite index establishes vertical dimension of occlusion. (b) Occlusal composite bonding (turbos) on the deciduous molar(s) establishes the mandibular reference position. (c) Vertical dimension is optimized, improving facial balance.
and Woodside emphasized that arch-length analysis is not meaningful unless it is made at the optimal vertical dimension. When the vertical dimension of occlusion is excessive, as with airway incompetence and anterior open bite, the increased tony of the lower lip and chin musculature enhances the likelihood of later mandibular crowding. With overclosure, there also is muscle imbalance and mandibular anterior crowding due to deepened overbite with reduced mandibular arch perimeter. The freeway space and phonetics should be used to establish the optimal mandibular vertical dimension posture that permits increased mandibular arch perimeter.

Patients with functional overclosure often require bite-opening appliances, provisional restorations, or occlusally bonded bite-lifters (turbos) at the optimal vertical occlusal dimension (functional occlusal plane) as functional adaptation occurs. For patients in the mixed dentition, such composite bite supports can be placed on the mandibular deciduous molars for bite opening (Fig 17). This helps to establish the optimal facial height for increased vertical dimension of the occlusion, permitting the mandibular first permanent molars and alveolus to develop to the appropriate functional occlusal plane. Further space gains and optimized functional relationships can be achieved by arch width change in conjunction with overbite correction through incisor positional changes with intrusion/advancing mechanics (Fig 18).

THE FRONTAL PERSPECTIVE

The transverse perspective, as viewed from the front, deserves priority from initial assessment through the therapeutic process. In smile design, Landigade and Grummons have described facial/dental asymmetry and frontal analysis key factors. The simplified frontal analysis emphasizes the following: (1) the maxillary central midline should coincide with the skeletal midsagittal reference (MSR) line; (2) the occlusal plane should be level, or nearly so; (3) the chin location should be centered or disguised to appear neutral, or options for this correction should be offered to the patient. When taking the frontal radiograph, place a 50- to 60-mm length of 0.014-inch wire at the mesio-occlusal surface of the maxillary first molars and instruct the patient to bite together. The wire will
Fig 19  (a) Frontal analysis (Grummons simplified) for this patient.  (b) Asymmetric smile at pretreatment.  (c) Posttreatment symmetric smile.  (d) Superimpositions describe occlusal plane, Class II mandibular deficiency, and asymmetry.  (e) Patient had received a previous opinion to have premolar extraction therapy, which would have accentuated her asymmetry.  (f) Class I ideal result, after nonextraction approach with mandibular surgical lengthening and asymmetric biomechanics.18
be visible in the radiograph and allow tracing of the true maxillary occlusal plane. When tracing the posteroanterior cephalogram, reverse the image to observe it as an anteroposterior view. The radiograph then appears as the patient is viewed in casts and photographs. Observe the MSR line as it relates to facial references. If the horizontal lines do not match or intersect at the MSR, one side is higher than the other by the difference observed at the midline. Locate the chin and measure the deviation from the midline to MSR. These are key aspects of the frontal dimension that need to be effectively managed and communicated to patients (Fig 19).

RETENTION PHASE

Stability of results and analysis of treatment methods are important with comprehensive orthodontics. Irregularity in mandibular anterior alignment increases with age whether or not the patient has had orthodontic therapy. Therefore, it is important to encourage patients to wear well-fitting retainer appliances often enough for long-term maintenance of alignment. This schedule should be individualized for each patient, and may mean as much as 2 nights per week or as little as 1 night per month. The more optimally that the skeletal and dental dimensions are established, musculoskeletal function optimized, and TMD components stabilized, the more lasting the result.

CONCLUSION

Patients, parents, and colleagues have changed opinions and preferences regarding orthodontic procedures and facial esthetics. The nonextraction philosophy relates to exceptional outcome and perceived results by orthodontic patients. Extraction or nonextraction therapy for sound reasons and specific needs should leave faces and occlusions better after treatment. The priority is to optimize the smile and facial harmony with sufficient teeth in the finished functional occlusion. Orthodontic capabilities have increased with improved knowledge of dentofacial growth and refined facial orthopedic procedures, technology of tooth movement, fixed-functional appliance efficiencies, space gaining methods, and nonextraction approaches.

REFERENCES