Periodontally-Compromised Class II Malocclusion with Early Loss of Both L6s and the UL3: Class III Elastics for L6 Space Closure and Retraction of the Maxillary Arch with IZC Bone Screws

Abstract

A 42 year old female presented with a periodontally compromised, skeletal Class II Division I malocclusion that was neglected because of concern about the extensive invasive treatment that was previously recommended.

***Diagnosis**: Bilateral full-cusp Class II malocclusion was associated with facial convexity (12º), increased lower facial height (LFH 57%), protrusive maxilla (SNA 83.5º), retrusive mandible (SNB 76º), intermaxillary discrepancy (ANB 7.5º), steep mandibular plane (FMA 44.5º), anterior openbite (2-3mm), increased overjet (7.5mm), deep curve of Spee, missing upper left canine (UR3), bilateral missing lower first molars (LR6, LL6), and an upper dental midline that was deviated 3mm to the left. The Discrepancy Index (DI) was 69.*

***Etiology**: Proximal cause for this severe skeletal malocclusion was the isolated loss of lower first molars in the mixed dentition, which is pathognomonic for Molar-Incisor Hypoplasia (MIH) due to a high fever at <3 years of age. Enamel defects in affected L6s render them susceptible to rapid destruction by caries with subsequent extraction during the mixed dentition. Lack of posterior stops in occlusion when the deciduous second molars exfoliated was a functional anomaly superimposed on an inherent tendency for facial convexity and bimaxillary protrusion. Intermaxillary crowding reflected inadequate functional expansion of the jaws. The maxilla was protrusive but not sufficiently developed in width to accommodate all the teeth. This insufficent space in the upper arch resulted in a blocked-out UL3 and deviation of the upper dental midline to the left. Thus, a combination of inherent and acquired factors produced a severe skeletal malocclusion complicated by asymmetry and periodontal compromise.*

***Treatment**: Periodontal bone loss is a stress-riser in the periodontal ligament (PDL) of orthodontically-loaded teeth. Very light forces (<1N) were applied with flexible CuNiTi archwires in self-ligating brackets. Extraction in the UR4 and implant-supported prostheses to restore the missing L6s were proposed, but the patient desired conservative treatment with no implants or extractions of teeth other than the impacted UL8. Space was closed and alignment was achieved with Class III elastics and differential extra-alveolar (E-A) anchorage provided by infrazygomatic crest (IZC) bone screws to retract the entire maxilla.*

***Results**: This severe skeletal malocclusion (DI 69) was resolved with asymmetric mechanics to close space and correct the maxillary midline. Because of the missing UL3, buccal segments were Class I on the right and Class II on the left. Optimal dental correction to a CRE score of 31 was achieved with 32 months of active treatment. The L6 space closure was not retained with fixed retainers because of the periodontal risk, and the spaces reopened ~1.5mm bilaterally. The patient was well pleased with the dramatic facial and dental improvement, but the skeletal and facial results may have benefitted from additional E-A anchorage screws in the mandibular buccal shelves to intrude lower molars and decrease lower facial height. However, periodontal risk precluded that option.*

***Conclusion**: Increased experience with E-A anchorage in all four quadrants produces dramatic correction of severe skeletal malocclusions without extractions or orthognathic surgery. (Int J Orthod Implantol 2017;47:4-24)*

Key words:

Self-ligation appliance, Class II Division 1, midline off, excessive overjet, missing maxillary canine, early loss of lower molars, Molar-Incisor Hypoplasia (MIH), molar protraction, IZC bone screws, periodontally compromise, constricted maxilla, blocked-out maxillary canine

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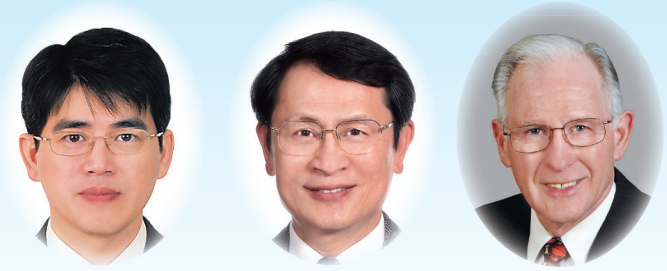


History and Etiology

A 42 year female presented with a number of long-term concerns: protrusive maxillary lip, poor dental esthetics and compromised masticatory function (*Fig. 1*). The probable etiology for the acquired aspect of the severe malocclusion was deemed: 1. Molar-Incisor Hypoplasia (*MIH*) due to high fever when she was <3 years old resulted in early loss of both L6s due to caries, 2. Mandibular Retrusion in the late transitional dentition increased the overjet, 3. Clockwise Rotation of the Occlusal Plane due to a lack of posterior centric stops in occlusion in the early permanent dentition increased the lower facial height (*LFH*), 4. Low Tongue Posture increased the axial inclination of the lower incisors, and 5. Inadequate Development of Arch Width reflects low

Fig. 1: Pre-treatment facial and intraoral photographs at 42y5m of age.

masticatory loading due to a refined diet as a child probably related to poor occlusal function (*missing L6s*). Maxillary anterior crowding may have resulted in the maxillary anterior asymmetry as follows: 1. Ectopic loss of the UL deciduous 3 (*ULd3*) when the UL2 erupted, 2. Space closed when the UL4 erupted, 3. UL3 was subsequently blocked out to the labial, and 4. Unesthetic UL3 was extracted (*Figs. 1-3*). The periodontium was subsequently compromised by impactions, tipped teeth and a probable genetic predisposition to periodontitis (*Fig. 3*).

The genetic and developmental problems described were deemed the etiology of the severe, asymmetric Class II malocclusion (*Figs. 1-5*). As an adolescent and young adult, the patient was perplexed by the complexity of the periodontal, surgical and prosthetic treatments proposed. A thorough approach to diagnosis, etiology and comprehensive treatment planning was neglected until reaching 42 years of age.

CEPHALOMETRIC			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA° (82°)	83.5°	81°	2.5°
SNB° (80°)	76°	75°	1°
ANB° (2°)	7.5°	6°	1.5°
SN-MP° (32°)	51.5°	52.5°	1°
FMA° (25°)	44.5°	45.5°	1°
DENTAL ANALYSIS			
U1 To NA mm (*4 mm*)	8 mm	1 mm	7 mm
U1 TO SN° (104°)	115°	105°	10°
L1 To NB mm (*4 mm*)	12 mm	9 mm	3 mm
L1 TO MP° (90°)	93°	82°	11°
FACIAL ANALYSIS			
E-LINE UL (*2-3 mm*)	2 mm	-2 mm	3 mm
E-LINE LL (*1-2 mm*)	2.5 mm	-1 mm	2.5 mm
%FH: Na-ANS-Gn (*53%*)	57%	57.5%	0.5%
Convexity: G-Sn-Pg' (*13°*)	12°	11°	1°

Table 1: Cephalometric summary

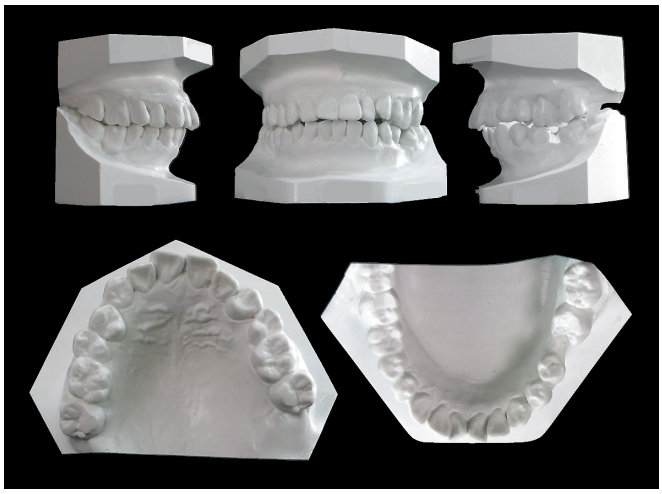


Fig. 2: Pre-treatment dental models (casts)

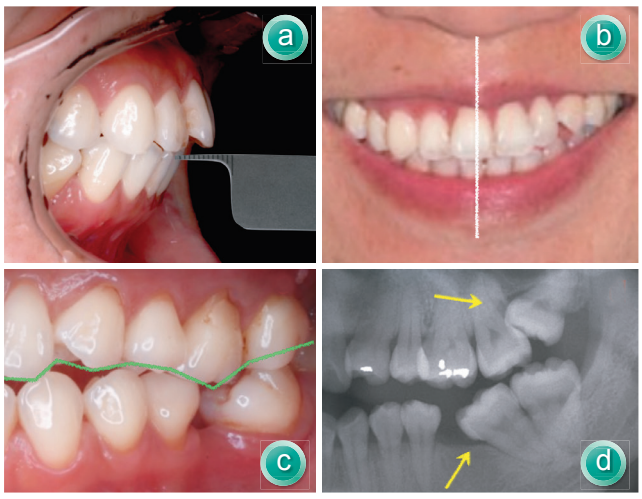


Fig. 3:
The etiology of the acquired malocclusion was a MIH-related loss of the L6s in the mixed dentition, and extraction of the UL3 after it was blocked-out due to underdevelopment of the maxillary arch. The subsequent occlusal development problems were: a. increased overjet due to a functional mandibular retrusion, b. maxillary midline deviation due to blocked out UL3, c. irregular buccal segment due to dental drift and compromised function, and d. osseous defects secondary to mesial inclination of molars (yellow arrows). See text for details.

Diagnosis

Facial:

- Length: *Oval facial form with shorter upper lip*
- Protrusion: *Convex profile with protrusive lips*
- Symmetry: *Maxillary dental midline 3mm to the left, occlusal plane cant (5mm inferior on the patient's right side)*
- Smile: *Gingival exposure has an asymmetric elevation on the right side consistent with the occlusal cant*

Skeletal:

- Intermaxillary Relationship: *Protrusive maxilla (SNA 83.5°), retrusive mandible (SNB 76°), and intermaxillary skeletal discrepancy (ANB 7.5°)*
- Mandibular Plane: *Steep (SN-MP 51.5°, FMA 44.5°) (Fig. 4 & Table. 1)*
- Vertical Dimension of Occlusion (*VDO*): *Na-ANS-Gn (57.5%) which is substantially greater than normal (~53%).*
- Symmetry: *Within normal limits (Figs. 4 and 5)*

Dental:

- Classification: *Full cusp bilateral Class II relationship*
- Overbite: *0 to -2mm*
- Overjet: *7.5mm*
- Missing/Unerupted: *LR6, LL6 and UL3 previously extracted, UL8 impacted (Fig. 5)*
- Symmetry: *Upper midline deviated 3mm to left, occlusal plane cant (Fig. 1)*

The ABO Discrepancy Index (*DI*) was 69 as documented in Worksheet 1 at the end of this report.

Specific Objectives of Treatment

Treatment objectives were to: 1. correct the facial profile, 2. align the upper dental midline. and 3. restore lower posterior occlusion.

Fig. 4:
Pre-treatment lateral cephalometric radiography reveals the classic signs of acquired malocclusion secondary to the early bilateral loss of L6s due to MIH: mandibular retrusion, increased overjet and deep curve of Spee.

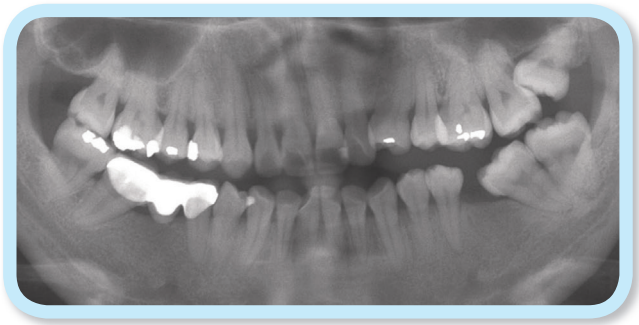


Fig. 5:
Pre-treatment panoramic radiograph shows the morphology of a functionally compensated occlusion on the right side, compared to long-term occlusal dysfunction on the left side.

Maxilla (*all three planes*):

- A - P: *Maintain*
- Vertical: *Maintain*
- Transverse: *Maintain*

Mandible (*all three planes*):

- A - P: *Maintain*
- Vertical: *Maintain*
- Transverse: *Maintain*

Maxillary Dentition:

- A - P: *Retract*
- Vertical: *Intrude*
- Inter-molar / Inter-canine Width: *Maintain*

Mandibular Dentition:

- A - P: *Maintain*
- Vertical: *Maintain*
- Inter-molar / Inter-canine Width: *Maintain*

Facial Esthetics:

- Retract both the upper and lower lips

Treatment Alternatives

The conventional approach previously presented to the patient for management of this periodontally compromised, partially edentulous, skeletal malocclusion was: 1. align the dentition over the apical base of bone, 2. correct skeletal and facial discrepancies with orthognathic surgery, and 3. restore edentulous spaces with implant-supported prostheses. The patient declined the treatment plan because she was concerned about the risks and morbidity of surgery.

A second opinion was sought to limit the surgical risk. Three increasingly challenging treatment plans were devised to manage her dental and facial needs without orthognathic surgery (*Fig. 6*):

1. **Tx Plan 1**: Extract UR4, close space for upper midline correction, orthodontic preparation and bone augmentation of L6 implant sites, and then restore the edentulous spaces with implant-supported prostheses.

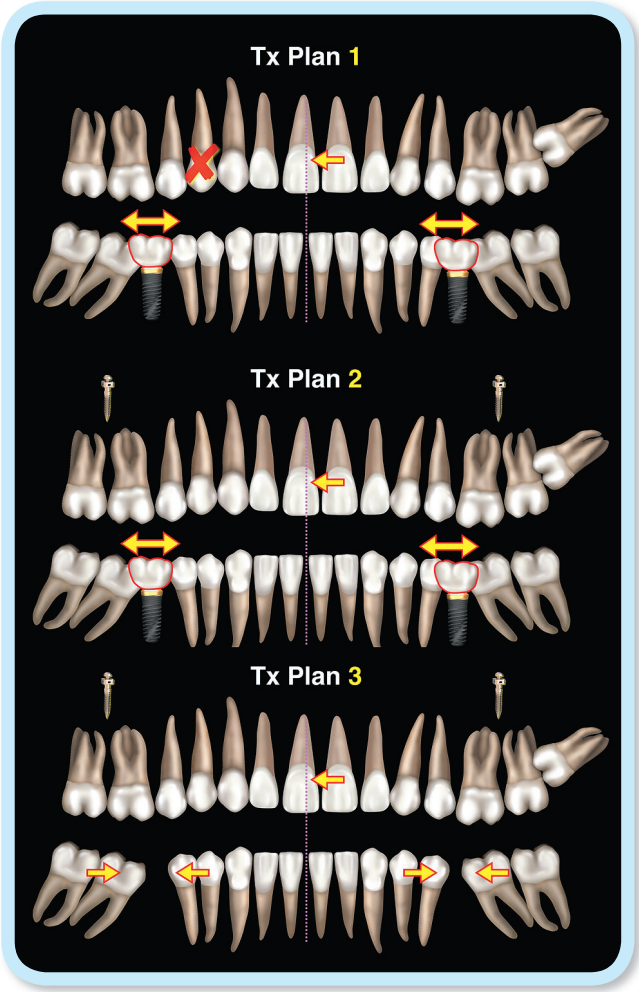


Fig. 6:
Treatment alternatives are ranked from Tx Plan 1 to 3 according to the clinical challenge presented.

2. **Tx Plan 2**: The same as Tx Plan 1 except delete the UR4 extraction, and correct the maxillary arch asymmetry with bilateral IZC screws.[1]

3. **Tx Plan 3**: The same as Tx Plan 2 except close the L6 spaces with Class III elastics and delete the implants.

The patient preferred the most conservative option (*Tx Plan 3*) despite the probability of a longer treatment time and the risk associated with extensive movement of periodontally compromised teeth. She agreed to periodontal treatment before orthodontics and to a careful long-term maintenance program after active treatment.

Treatment Progress

Pre-treatment preparation for 6 months was performed by a periodontist. During this period, the LR fixed prosthesis was removed and provisional treatment crowns were cemented on the abutments. Following pretreatment periodontal preparation, an 0.022-in slot passive self-ligating (*PSL*) appliance with standard torque brackets (*Damon Q®, Ormco, Glendora, CA.*) was bonded on all teeth in both arches, except for the LR lateral incisor. The latter was excluded because space opening with an open coil spring was required prior to bonding (*Fig. 7*). All archwires, elastics and elastomeric chains (*power chain*) were supplied by the same manufacturer.

Over the initial 5 months of the treatment, copper-nickel-titanium (*CuNiTi*) archwires progressed from 0.013-in to 0.016-in for both arches (*Fig. 8, Archwire Sequence Chart at the end of this report*). Two IZC bone screws were placed buccal to the U7s to engage

Fig. 7:
***Upper**: E-A IZC bone screws are shown in the right and left posterior maxilla.*
***Lower**: Right and left buccal views show 0.014-in CuNiTi archwires, with power chains delivering light compressive forces from the IZC 7 screws to the U4s.*

thicker bone.[1] Elastic chains anchored by the bone screws were connected to the upper first premolars bilaterally, to reduce the overjet from the beginning of active treatment (*Fig. 9, 1M*). One month later the right IZC screw loosened and was replaced. Overall progress at three months (*3M*) is shown in Fig. 9. In order to correct the lateral openbite, cross elastics (*Fox 1/4-in, 3.5-oz*) were placed from the buccal side of the upper left premolar to the lingual side of the lower left premolar in the 5th month. The following month (*6M*) the main archwires were changed to 0.014x0.025-in CuNiTi, and power chain was used to consolidate the upper anterior segment. One month later, when the 0.018x0.025-in CuNiTi archwire was placed, space was noted distal to the LR3, so intra-arch elastics (*Fox 1/4-in, 3.5-oz*) were applied to maintain constant force, but also allow good access for oral hygiene. Due to the outstanding retraction efficiency of the IZC screws, the overjet was completely corrected end-to-end at nine months (*9M in Fig. 9*). To recover a normal overjet relationship, Class III elastics (*Fox 1/4-in, 3.5-oz*) were

applied from 8-14 months (*Kangaroo 13/16-in, 4.5-oz*) and retracted lower incisors simultaneously with the upper incisors. After 10 months of active treatment, the impacted UL8 was extracted and the lower archwire was changed to 0.016x0.025-in stainless steel (*SS*). The lower posterior spaces were closed with powerchain of the lower archwire and Class III elastics (*Fig. 10*). After 16-months, the lower residual spaces were closed and the lower molars were aligned (*Figs. 8 and 10*). After the anterior spaces were closed, inter-proximal reduction (*IPR*) was performed on the lower and upper incisors to improve coronal contours and proximal contacts, as well as for eliminating black triangles.[2] Kangaroo elastics (*13/16-in, 4.5-oz*) were applied for posterior crossbite correction and space closure was maintained with elastic chains securing 0.014x0.025-in or 0.018x0.025-in CuNiTi archwires. In the 21st month, the LL8 was rebonded for rotation correction. Two months later (*23M*) bracket positions of the upper anterior six teeth were reset to a more gingival position to deepen the anterior overbite (*Fig. 9*). One month later power chains were maintained to retain space closure, while diagonal and intra-arch elastics

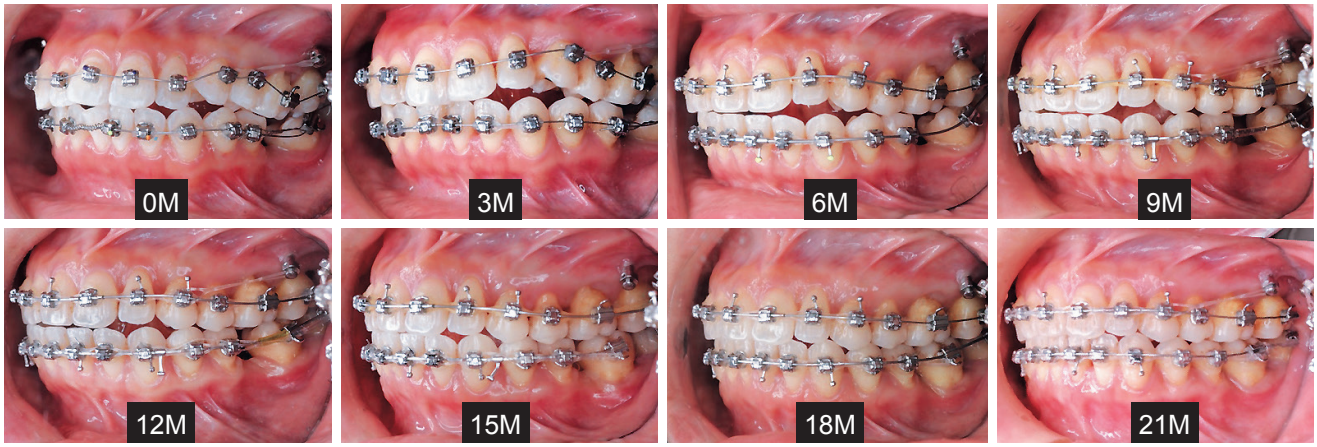


Fig. 8:
A progressive series left buccal views from the start of treatment (0M) to twenty-one months (21M) document alignment of both arches and maxillary retraction with power chains anchored with E-A IZC bone screws. See text for details.

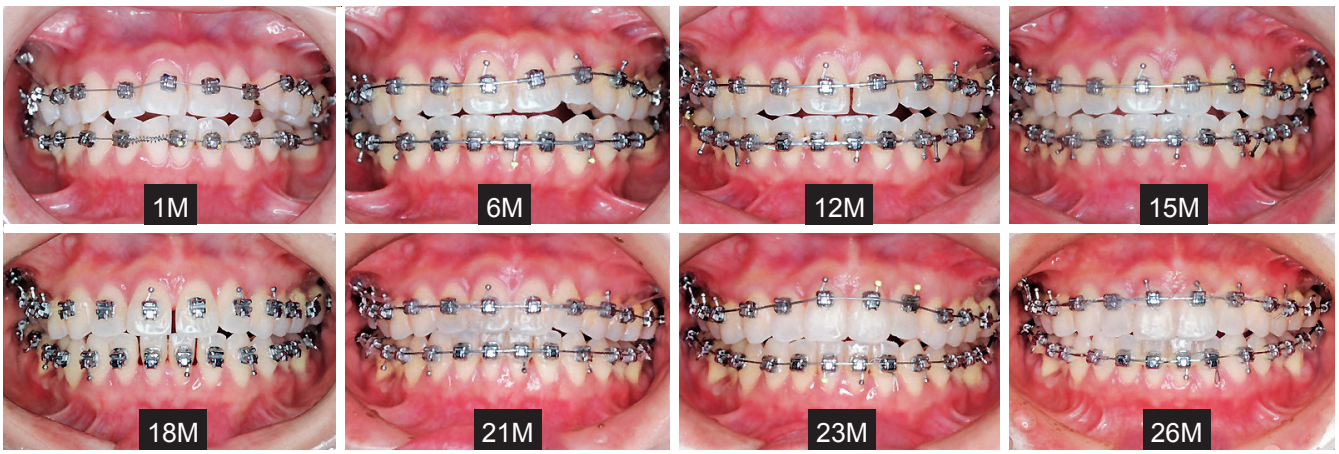


Fig. 9:
Frontal views of the arches from zero (0M) to twenty-six months (26M) show the extensive tooth movement. Upper incisor brackets were repositioned in a gingival direction at 23M to correct the overbite. See text for details.

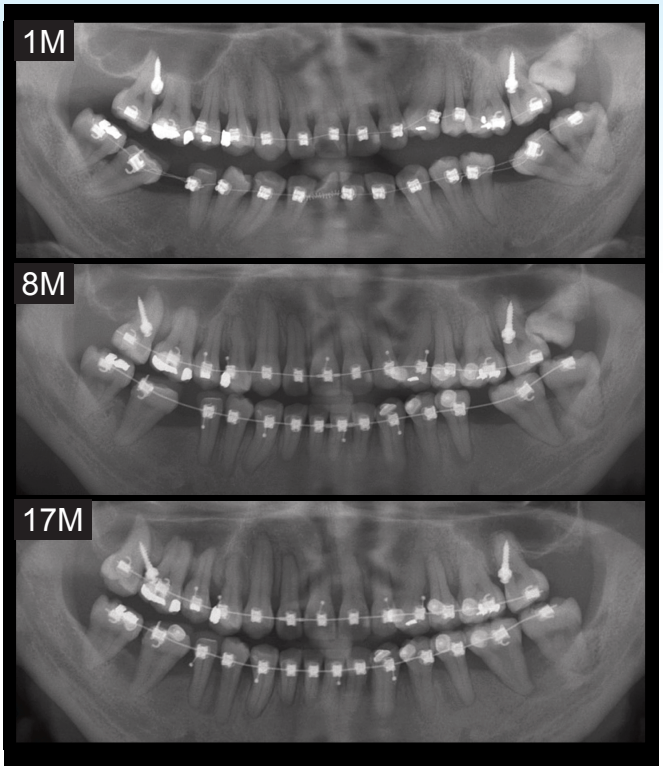


Fig. 10:
Panoramic radiographs at 1, 8 and 17 months (1M, 8M, 17M) show the positions of the IZC bone screws, extraction of the UL8, and bilateral closure of the L6 spaces. Note the change in the orientation of the right IZC bone screw; it failed and was replaced two months into treatment. See text for details.

(*Kangaroo 3/16-in, 4.5-oz*) were applied simultaneously. At 25 months into treatment, an 0.016x0.025-in stainless steel (*SS*) archwire was placed for 3 months to level the occlusal plane. Crossbite correction was continued with Kangaroo elastics (*3/16-in, 4.5-oz*) after 24 months of Class II sagittal correction (*Fig. 11*). Once the posterior transverse problem was resolved, the final detailing for midline correction and occlusal settling was accomplished with triangular elastics applied in an oblique direction (*Fox 1/4-in, 3.5-oz*) (*Fig. 12*).[3,4] After 32 months of active treatment, all fixed appliances were removed. (*Figs. 13,14 &15*).

The archwire sequence chart at the end of the report provides details for the timing, size and materials for all archwires and elastics used. It is important to note that all archwires were CuNiTi except for relatively small rectangular 0.016x0.022-in SS in the lower arch during two intervals: 1. eight months (*9-17M*) when Class III elastics were used to close the L6 spaces, and 2. three months (*25-28M*) to complete leveling of the curve of Spee and to assist with correction of

Fig. 11:
Twenty-four months into treatment cross-elastics were applied from the buccal brackets on the upper premolars and molars (upper) to the lingual buttons on the lower molars and premolars (below). See text for details.

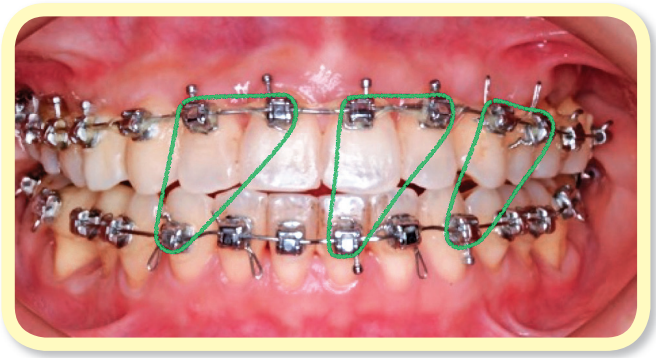


Fig. 12:
Triangle intermaxillary elastics are oriented diagonally to correct the upper midline discrepancy during the final stage of active treatment.

Fig. 13: Post-treatment facial and intraoral photographs

Fig. 14: Post-treatment dental models (casts)

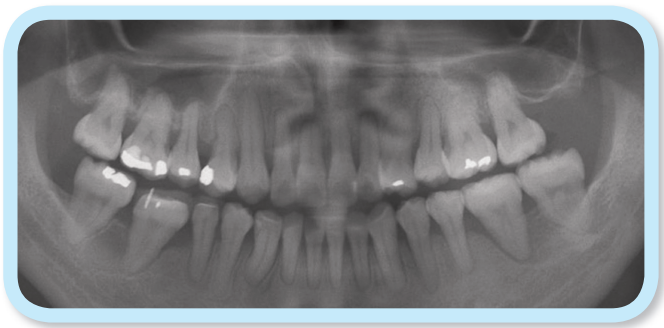


Fig. 15: Post-treatment panoramic radiograph

Fig. 16: Post-treatment lateral cephalometric radiograph

the posterior crossbite tendency (*Fig. 11*). For a fixed appliance with 0.022-in slots, these were all relatively light archwires that did not exceed 1N of force to any tooth during active treatment. The Archwire Sequence Chart at the end of this report reflects the low force treatment plan for a periodontally compromised dentition.

Results achieved

The periodontally compromised, severe skeletal malocclusion (*DI 69*) was corrected to a markedly improved facial and dental result (*CRE of 31*) with 32 months of active treatment as documented in Worksheet 2 at the end of this report. Maxillary lip protrusion was well addressed by retraction of the entire maxillary dentition, but the LFH (*VDO*)

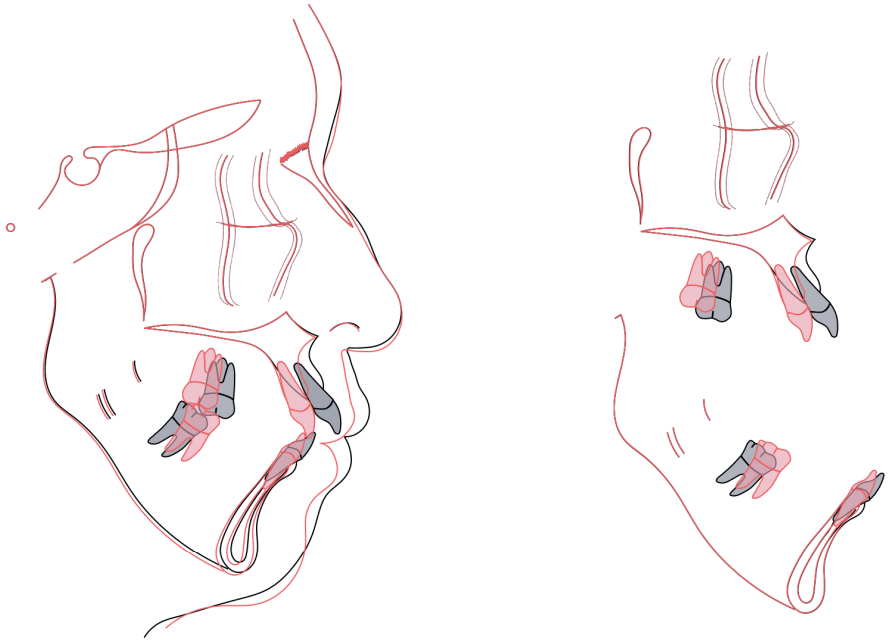


Fig. 17:
Superimposed cephalometric tracings showing dentofacial changes achieved with 32 months of active treatment (red) compared to the pre-treatment position (black). The protrusive lips have been corrected, resulting in a more balanced lower facial profile. The maxillary arch was retracted and rotated anteriorly (clockwise). The lower arch was leveled and aligned, while the missing L6 spaces were closed with CIII elastics (U6s to L3s bilaterally). Retrospective assessment reveals that the lower facial height could have been decreased by intruding the lower molars with lower posterior MBS bone screws, but intruding periodontally compromised teeth is risky. See text for details.

was opened 0.5%, which increased the FMA, SN-MP and SNB angles 1°. Despite the pleasing result for correction of a severe malocclusion, the facial convexity and mandibular retrusion remained excessive (*Figs. 16 and 17, Table 1*). The maxillary midline discrepancy was corrected, and the occlusal cant in the frontal plane was decreased (*Figs. 13-15*). The specific treatment objectives are outlined below.

Maxilla (*all three planes*):

- A - P: *Retracted*
- Vertical: *Maintained*
- Transverse: *Maintained*

Mandible (*all three planes*):

- A - P: *Retracted slightly*
- Vertical: *Opened slightly*
- Transverse: *Maintained*

Maxillary Dentition

- A - P: *The entire arch was retracted*
- Vertical: *Incisors were maintained but molars were intruded*
- Inter-molar / Inter-canine Width: *Maintained / Maintained*

Mandibular Dentition

- A - P: *Uprighted and retracted incisors, molars protracted for space closure*
- Vertical: *Molars uprighted and extruded*
- Inter-molar / Inter-canine Width: *Maintained / Maintained*

Facial Esthetics

- Normal lip profile was achieved, but the face remained long and convex (*Figs. 16 &17*)

Retention

Consistent with hygiene maintenance, the only retention was an upper Hawley and lower anterior spring retainers. To avoid plaque accumulation, no fixed retainers were placed. The patient was instructed in proper home hygiene as well as for long-term maintenance of the removable retainers. Retainer wear was full time for the first 6 months and nights only thereafter.

Final Evaluation of Treatment

Substantial improvement in the lip profile, dentition alignment and occlusal function were achieved. The ABO Cast-Radiograph Evaluation (*CRE*) was a total of 31 points.[5] The most prominent alignment deficiencies were buccolingual inclinations (*10 points*), marginal ridges discrepancies (*6 points*), lack of occlusal contacts (*4 points*) and overjet (*3 points*) (*Figs. 13-15*). See Worksheet 2 at the end of this report for CRE scoring details. The Pink & White (*P&W*) dental esthetic score was 5 points primarily because of the UL4 substitution for the missing UL3. See Worksheet 3 at the end of this report for P&W scoring details.

Free gingival graft surgery is indicated to improve the gingival recessions on the labial of the lower posterior teeth.[6] Although the extensive orthodontic treatment resolved the patient's chief complaints, the potential for long-term periodontal problems may affect long-term maintenance and stability. To avoid compromising the marginal periodontal

health of the protracted L7s, no fixed retention was utilized to maintain L6 space closure. Relapse of about 1.5mm of space opening occurred between the L5s and L7s, six months after fixed appliances were removed. Repeated space closure of missing L6 spaces is not warranted because there are no natural transeptal fibers between L5s and L7s.[7,8] If the relapsed spaces prove to be problematic, it is best to close the space restoratively as follows: 1. place separators in the interproximal areas mesial and distal to the relapsed space in the L6 area to distribute the spaces throughout the lower buccal segments, and 2. restore all interproximal contacts with restorative resin.[7,8]

Discussion

Loss of permanent teeth often results in minor problems such as spacing, tooth rotation, tilting, and migration of teeth into an edentulous space. However, missing a L6(*s*) during the transitional dentition (*<10yr of age*) exposes children to severe acquired malocclusion. When the second deciduous molars exfoliate at age 10-12, there is no posterior centric stop in occlusion on the affected side(*s*).[9,10] MIH-related loss of mandibular first molars is a common etiology for acquired Class II malocclusion, either unilateral of bilateral. Early loss of both mandibular first molars in the mixed dentition often results in a characteristic acquired malocclusion (*Fig. 4*): 1. mesially tipped second molars, 2. deep curve of Spee, 3. mandibular retrusion, and 4. decreased axial inclination of maxillary incisors, with deep-bite and/or increased overjet.[11]

When there is an abrupt loss of posterior occlusion in the late transitional stage of occlusal development, children posture the mandible anteriorly or posteriorly for occlusal function. The direction of mandibular compensation depends on the incisal relationship and the succedaneous teeth in occlusion.[12] The MIH-related scenario for the present patient was a mandibular retrusion and forward (*clockwise*) rotation of the occlusal plane resulting in an anterior openbite, increased VDO and a steep mandibular plane angle (*MPA*) (*Figs. 1-5*).

Missing L6 spaces requires a differential diagnosis to choose the optimal treatment plan for each site. If the L8 is present in the affected quadrant, space closure is often the best option, but when the L8 is absent, space opening and an implant-supported crown to restore the missing L6 is preferable. Defining the etiology of an acquired malocclusion is important for understanding the potential of a functionally retruded mandible to readapt (*"grow"*) into a more anterior position or for protraction of the remaining molars to close the space (*Figs. 10 and 17*).[11]

Asymmetry was a challenging complication (*Figs. 1-3*) that required careful consideration of the etiology for each asymmetric component. The options are to correct, accept or mask the undesirable morphology. Etiology is an important consideration for conservative correction of mandibular retrusion and/or lower posterior space closure as part of a comprehensive treatment plan. The history of previous dental treatment is an additional factor. The LR6 was previously restored with a three-unit fixed prosthesis probably because there was less tipping, no impactions and the maxillary canine was present on the right side (*Figs. 1-3*). The patient may

have an inherent right side chewing preference, but she certainly chewed on the right side after the edentulous space was restored as a young adult (*Fig. 5*). Thus, at age 42 numerous form and function anomalies associated with poor occlusal function had accumulated on the left side: 1. missing UL3, 2. maxillary midline deviation, 3. canted occlusal plane, 4. severely tipped LL7, and 5. openbite in the lateral incisor and premolar areas. A full fixed PSL appliance with IZC bone screw anchorage corrected or at least improved all of the alignment problems, but there was still a residual cant to the occlusal plane and an openbite tendency in the left premolar area. Although complete correction of the cant was possible with differential use of IZC anchorage, the additional maxillary intrusion was not warranted for a periodontally compromised patient (*Fig. 13*). The openbite tendency reflects a tongue posture problem that is probably related to the established preference for chewing on the right side (*Figs. 13 and 14*). Patients who preferentially chew on one side may compensate for the mandibular torsion on the balancing side with tongue-bracing, which may be manifest as a lateral openbite tendency.[13]

As described in the etiology section, a blocked-out maxillary canine is often a manifestation of crowding, reflecting a tooth-size to arch length discrepancy. When space is limited, emerging permanent teeth infringe on adjacent primary teeth resulting in premature exfoliation and closure of the space. Since the U3s are typically the last succedaneous teeth to emerge, they often erupt high in the labial fold because there is no room in the arch, i.e. they are "*blocked-out.*" Unilateral blocked-out U3s are often associated with maxillary midline deviations (*Figs. 1-3*), and a bilateral manifestation usually reflects severe crowding and/or anterior crossbite.[12,14] With traditional mechanics a blocked-out U3 usually requires extraction of an adjacent premolar to achieve desired form and function. However, differential IZC anchorage provides the mechanics to correct these challenging problems without extraction(*s*).[15,16]

Nonextraction correction of facial protrusion with E-A bone screw anchorage usually follows a typical pattern as shown in Fig. 18. For the first few months of treatment, lip protrusion increases as the crowding and axial inclination of the incisors are corrected (*1-*

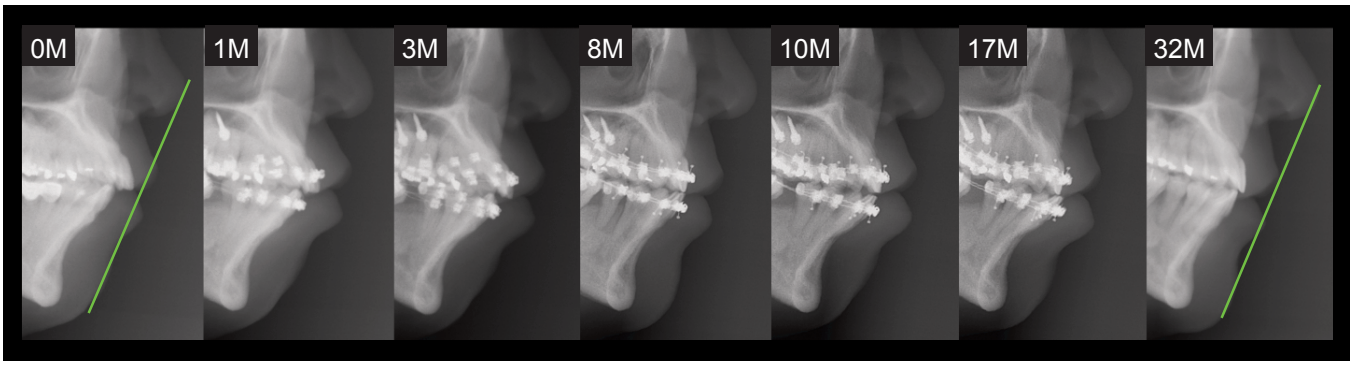


Fig. 18:
A progressive series of cephalograms from zero to thirty-two months (0-31M) shows the dental and lip relationships as the maxillary arch is retracted with IZC anchorage. Note there is increased bimaxillary protrusion during initial alignment (3M), and the overjet is end-to-end by 8M. Lower posterior space closure and continued maxillary retraction resulted in a pleasing lip profile at the end of treatment (32M). See text for details.

3M, *Fig. 18*). Lip protrusion is progressively decreased as the arches are retracted (*8-32M, Fig. 18*). It is important for patients to understand the treatment sequence so that they can consciously maintain lip competence throughout the process. If lip competence is lost during treatment there can be anterior tongue posturing and a dramatic increase in lower facial height, particularly if the mechanics include intermaxillary elastics.

As presently defined, the IZC is the inferior aspect of the zygomatic process of the maxilla. The process terminates as a ridge on the buccal aspect of the alveolar process between the first and second molars, so the most convenient bone screw sites are subdivided into IZC 6 or IZC 7, respectively (*Fig. 19*).[15] Because the cortical plate of bone is near the buccal roots of the molars, IZC bone screws are typically inserted with an inclination of 55-70°, relative to the lateral surface of the maxilla. This orientation allows the screw to pass buccal to the molar roots and then

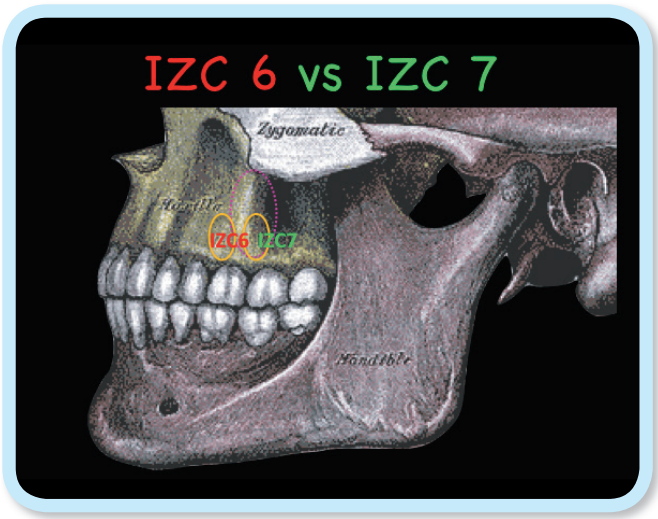


Fig. 19:
The zygomatic process of the maxilla emerges as a ridge (pink oval) from the superior aspect of the alveolar process between the U6 and U7. The most desirable sites for IZC bone screws are anterior (IZC 6) or posterior (IZC 7) to the ridge (pink circle). See text for details.

Fig. 20:
An anterior-posterior radiograph of the head shows the E-A position of the IZC bone screws. This relationship is important to avoid impingement on molar roots and to permit retraction of the entire maxillary arch en masse. See text for details.

penetrate the thick bone superior to the molars. Since the IZC screws are lateral to the the roots of the molars, they are in an extra-radicular or extra-alveolar (*E-A*) location relative to the alveolar bone supporting the roots of the maxillary molars (*Fig. 20*).[16] Compared to inter-radicular (*I-R*) miniscrews placed in the restricted space between the roots of the teeth,[17] E-A bone screws are longer (≤*14mm*), larger in diameter (*2mm*), and made of a tougher non-brittle material (*stainless steel*).

The amount of bone on the buccal surface of the IZC is highly variable. In general, bone thickness in the IZC 7 area is greater than for IZC 6, so a bone screw is less likely to impinge on the root of a tooth.[18] In addition, the present patient had a low sinus floor that tended to dip between the teeth in the posterior maxillary segments. It was necessary to place the IZC bone screws buccal to the crown of the molars which is the most desirable position to allow the molars to move mesially or distally (*Fig. 21*). There was considerably less bone in the IZC area on the right side compared to the left which was

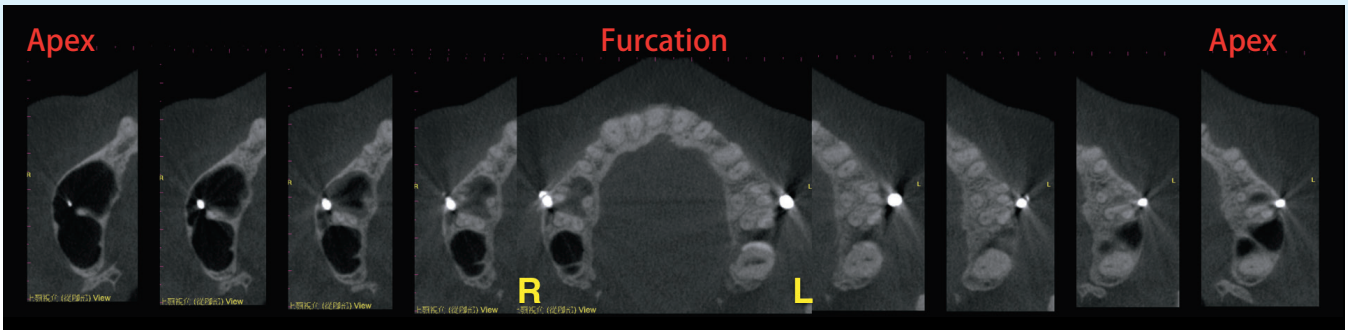


Fig. 21:
Axial cone-beam computed tomography cuts from the furcation (center) to the apex levels of the U7s show the available bone for IZC bone screws. Note that the descending maxillary sinus on the right side (R) compromises the available bone. Much of the right IZC bone screw is in or near the sinus. Although the first bone screw in the right IZC region failed after two months, it was successfully replaced in an adjacent location. See text for details.

probably a factor in the failure of the right IZC screw at two months into treatment.

Chang et al.[19] found that IZC bone screws have a low failure rate (<7%) which increased clinical confidence that IZC anchorage was adequate for correcting the maxillary midline discrepancy without extracting the UR4 (*Fig. 6*). However, the right IZC screw did fail at two months into treatment. It may be challenging to find an adequate adjacent site to replace a failed IZC screw. To help control IZC bone screw failure, the clinician must consider the following factors relative to the operative site: 1. a low sinus floor is associated with thin buccal bone, 2. young patients often have soft (*poorly mineralized*) bone, 3. excessive force must be avoided when screwing in the bone screw, 4. unstable screws present a "*drop-in sensation*" when inserted which is often a prelude to failure, 5. select an alternate site that maintains the initial angulation of the bone screw, and 6. place a palatal or mandibular buccal shelf (*MBS*) bone screw if bone in the IZC site is inadequate. Despite the relatively thin bone (*Fig. 21*) it was possible to reposition the right IZC bone screw to obtain adequate anchorage. It is clear that bone screws carefully installed in sites with low bone mass can provide good orthodontic anchorage.

The UL8 was horizontally impacted distal to the UL7 (*Fig. 5*). It was preferable to extract the impaction before commencing orthodontic treatment, but the patient was hesitant and requested a delay. The UL8 was not removed until 10 months into treatment. Despite the nearby surgery, the left IZC screw remained stable.

Occlusal irregularity in a partially edentulous patient often requires preprosthetic alignment. Intruding teeth is a concern for periodontally compromised patients, so reduction of crown height and endodontics may be preferable to orthodontic intrusion.[20] Evaluating edentulous ridge quality and quantity, relative to post-operative healing, is an important consideration for treatment planning. It is best to perform preprosthetic alignment as soon as possible because the alveolar ridge may decrease 40% in height and 60% in width during the first 6 months after tooth extraction.[21] Ridge atrophy continues but at a slower pace ultimately resulting in a dense, knife-edge ridge of cortical bone that is

difficult to resorb for space closure.[22] Atrophic ridges usually require bone augmentation before placing an implant.[23] For implant-site development, the length of the space is increased to 6mm or more with an open coil spring.[24] The ridge width and osseous contours are restored with a guided bone regeneration procedure.[25-27]

Three alternative treatment plans were considered (*Fig. 6*). The first two approaches featured implant-supported prostheses to restore the missing L6s. However, the MIH-related etiology of the malocclusion was consistent with good mesial movement potential for the L7s and 8s, either by more anterior posturing of the mandible or via tooth movement.[11] Despite the clinical challenge, lower 6 space closure was the patient's preference (*Tx Plan 3, Fig. 6*). Previous experience with conservative treatment of MIH-related acquired malocclusions[9-12] indicated space closure was a viable option, but previous reports by Roberts et al.[7,8,28] were a concern. That data indicated that lower molars have extremely high anchorage value because of the dense bone formed by the leading root when a L7 is moved mesially with conventional mechanics (*loads up to 3N per quadrant*). However, the current experience closing L6 spaces with light force (*<1N*) on flexible CuNiTi or small diameter SS archwires suggests that light loads superimposed on function are indicated for mesial movement of lower molars.[9-12,20,22,23]

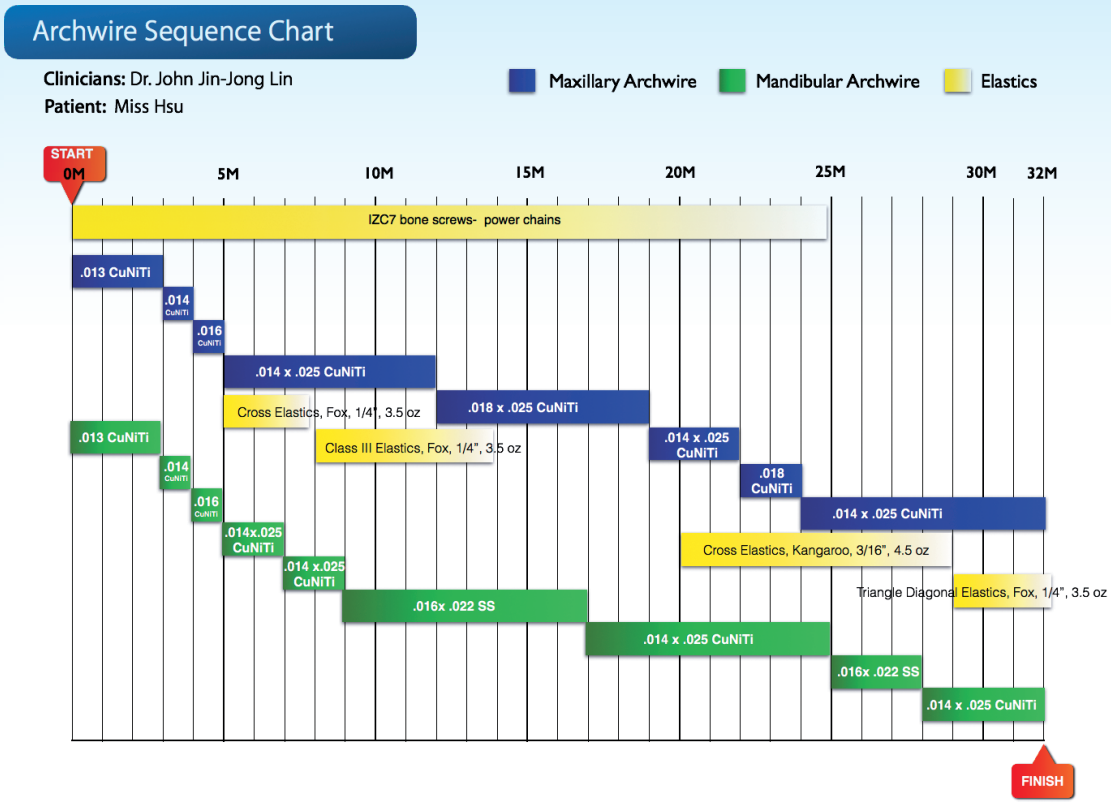
Controlling PDL stress by moving arches as segments enhances the rate of tooth movement and decreases the incidence of root resorption.[29] Control of PDL necrosis with segmental mechanics and/or multi-force archwires delivering lower loads with an increased range of action promises to deliver rates of tooth movement that are approaching the theoretical limit for osteoclast mediated bone resorption: 30-40µm/day or ~1mm/mo.[30,31]

There are three keys for successfully uprighting tipped mandibular molars and closing spaces in periodontally compromised patients:

1. Apply light continuous force to PSL brackets with CuNiTi archwires.
2. Level and align the upper arch early in treatment to avoid occlusal prematurities as lower molars are uprighted.
3. Adjust occlusal prematurites on mobile lower molars with bracket repositioning or enamel adjustment.

Conclusion

Periodontally compromised patients with skeletal malocclusions, acquired by an MIH-related loss of lower first molars during the mixed dentition, may have excellent dentofacial orthopedic potential for conservative correction, i.e. without extractions or orthognathic surgery. Carefully evaluate the periodontium and etiology of the malocclusion to devise a realistic treatment plan. To minimize PDL stress, it is advantageous to use a 3D digital bracket placement system, and multiple-force archwires with a wide range of activation for initial leveling. Avoid unnecessary adjustments that produce elevated PDL stress and necrosis: progressive archwires, bracket rebonding, and archwire detailing. Particularly for periodontally compromised patients, a PSL bracket system with light forces (*<1N*) delivered by CuNiTi or small rectangular SS archwires is indicated.



Use E-A bone screws in the posterior maxilla and mandible as needed to align the dentition in 3D over the apical base of bone. Control the facial height and protrusion by retracting, rotating and intruding the arches, as needed. The general rule for L6 edentulous areas is to close the space if the L8 is present, but if the L8 is missing open the space for an implant-supported prosthesis. Level and align the maxillary arch prior to closing space by protracting the L7s and 8s. The current patient was pleased with the dramatic improvements in lip profile and dental alignment (*Fig. 22*). However, the result could have been improved with intrusion of the lower molars to produce forward rotation of the mandible and deceased lower facial height, but intrusion of periodontally compromised teeth is risky. Clinicians are increasingly appreciating the potential for low PDL stress and orthopedically anchored mechanics for patients with a healthy periodontium. Routine correction of even severe acquired malocclusions is on the horizon.

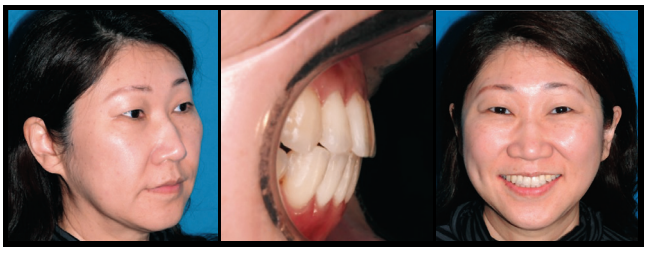


Fig. 22:
Facial and overjet photographs show the pleasing final result.

Acknowledgment

Thanks to Mr. Paul Head for proofreading this article and Dr. Rugsi's beautiful diagram.

References

1. Lin JJ. Creative Orthodontics: Blending the Damon system & TADs to manage difficult malocclusions. 2nd ed. Taiwan: Yong Chieh Enterprise Co, Ltd.; 2010.

2. Huang YH, Chang CH, Roberts WE. Treatment of bimaxillary protrusion, blocked-out canine and buccal crossbite. Int J Orthod Implantol 2014;33:66-87.
3. Steffen JM, Haltom FT. The five-cent tooth positioner. J Clin Orthod 1987;21:528-529.
4. Tseng L, Chang CH, Roberts WE. Correction of a full cusp Class II malocclusion and palatal Impingement with Intermaxillary elastics. Int J Othod Implantol 2015;38:54-72.
5. Chang CH, Roberts WE. Orthodontics Vol. 1 [E-reader version]. Hsinchu: Newton's A Ltd; 2012.
6. Su B. IBOI pink & white esthetic score. Int J Orthod Implantol 2012;28:96-101.
7. Roberts WE, Nelson CL, Goodacre CJ. Rigid implant anchorage to close a mandibular first molar extraction site. J Clin Orthod 1994;28(12):693-704.
8. Roberts WE, Marshall KJ, and Mozsary PG. Rigid endosseous implant utilized as anchorage to protract molars and close an atrophic extraction site. Angle Orthod 1990;60(2):135-152.
9. Chang MJ, Chang CH, Roberts WE. Acquired malocclusion due to early loss of permanent first molars: OBS-anchored orthodontics and implant-supported prostheses. Int J Orthod Implantol 2016;42:20-41.
10. Huang C, Chang CH, Roberts WE. Bimaxillary protrusion with missing lower first molar and upper premolar: asymmetric extractions, anchorage control and interproximal reduction. Int J Orthod Implantol 2016;44:20-41.
11. Lee A, Chang CH, Roberts WE. MIH-related loss of mandibular first molars resulted in an acquired Class II skeletal malocclusion: conservatively treated with space closure on one side and an implant-supported prosthesis on the other. Int J Orthod Implantol 2017 (In Press).
12. Yeh HY, Lin JJ, Roberts WE. Conservative adult treatment for severe Class III, openbite malocclusion with bimaxillary crowding. Int J Orthod Implantol 2014;34:12-25.
13. Roberts WE. Bone physiology, metabolism and biomechanics in orthodontic practice. In: Orthodontics: Current Principles and Techniques, Chapter 10, 5th ed. Graber LW, Vanarsdall RL Jr, Vig KWL (Eds). St. Louis: Elsevier Mosby; 2012. pp. 287-343.
14. Peng WL, Chang CH, Roberts WE. Early treatment of anterior crossbite combined with bilateral maxillary labially impacted canines. Int J Orthod Implantol 2016;44:46-60.
15. Lin JJ, Roberts WE. Guided Infra-zygomatic screws: reliable maxillary arch retraction. Int J Orthod Implantol 2017;46:4-16.
16. Lin JJ. The most effective and simplest ways of treating severe Class III, without extraction or surgery. Int J Orthod Implantol 2014;33:4-18.
17. Lin JJ. A new method of placing orthodontic bone screws in IZC. News & Trends in Orthodontics 2009;13:4-7.
18. Lin JJ, Roberts WE. CBCT imaging to diagnose and correct the failure of maxillary arch retraction with IZC screw anchorage. Int J Orthod Implantol 2014;35:4-17.
19. Chang CH, Hsu E, Lin JSY, Yeh HY, Roberts WE. Comparison of the failure rate for infrazygomatic bone screws placed in movable mucosa or attached gingiva. Int J Orthod Implantol 2017 (In Press).
20. Chang MJ, Chang CH, Roberts WE. Acquired malocclusion due to early loss of permanent first molars: OBS-anchored orthodontics and implant-supported prostheses. Int J Orthod Implantol 2016;42:20-41.
21. Bartee BK. Extraction site reconstruction for alveolar ridge preservation. Part 1: Rationale and materials selection. J Oral Implantol 2001;27:187–93.
22. Chiu GSC, Chang CH, Roberts WE. Interdisciplinary treatment for a compensated Class II partially edentulous malocclusion: orthodontic creation of a posterior implant site. Am J Orthod Dentofacial Orthop 2017 (Accepted).
23. Huang C, Su B, Chang CH, Roberts WE. Bimaxillary protrusion with missing lower first molar and upper premolar: asymmetric extractions, anchorage control and interproximal reduction. Int J Orthod Implantol 2016;44:20-41
24. Lin JJ. The wisdom of managing wisdom teeth: Part III. Methods of molar uprighting. Int J Orthod Implantol 2011;24:4-11.
25. Chiu GS, Chang CH, Roberts WE. Bimaxillary protrusion with an atrophic alveolar defect: orthodontics, autogenous chin-block graft, soft tissue augmentation, and an implant. Am J Orthod Dentofacial Orthop 2015 Jan;147(1):97-113.
26. Cooper LF, Pin-Harry OC. "Rules of Six"-diagnostic and therapeutic guidelines for single-tooth implant success. Compend Contin Educ Dent 2013 Feb;34(2):94-8, 100-1. quiz 102, 117.
27. Chang CH. The 2B-3D rule for implant planning, placement and restoration. Int J orthod Implantol 2012; 27:96-101.
28. Roberts WE, Arbuckle GR, Analoui M. Rate of translation of mandibular molars using implant-anchored mechanics. The Angle Orthod 1996;66(5):331-8.
29. Roberts WE, Viecilli RF, Chang C, Katona TR, Paydar NH. Biology of biomechanics: finite element analysis of a statically determinate system to rotate the occlusal plane for correction of skeletal Class III malocclusion. Am J Orthod Dentofacial Orthop 2015;148:943-955.
30. Roberts WE, Goodwin WC, Heiner SR. Cellular response to orthodontic force. Dent Clin North Am 1981;25:3-17.
31. Roberts WE, Smith RK, Zilberman Y, Mozsary PG, Smith RS. Osseous adaptation to continuous loading of rigid endosseous implants. Am J Orthod 1984;86:95-111.

Discrepancy Index Worksheet

TOTAL D.I. SCORE 69

OVERJET

0 mm. (edge-to-edge)	=	
1 – 3 mm.	=	0 pts.
3.1 – 5 mm.	=	2 pts.
5.1 – 7 mm.	=	3 pts.
7.1 – 9 mm.	=	4 pts. 7.5mm
> 9 mm.	=	5 pts.

Negative OJ (x-bite) 1 pt. per mm. per tooth =

Total = 4

OVERBITE

0 – 3 mm.	=	0 pts.
3.1 – 5 mm.	=	2 pts.
5.1 – 7 mm.	=	3 pts.
Impinging (100%)	=	5 pts.

Total = 0

ANTERIOR OPEN BITE

0 mm. (edge-to-edge), 1 pt. per tooth
then 1 pt. per additional full mm. per tooth

Total = 7

LATERAL OPEN BITE

2 pts. per mm. per tooth

Total = 2

CROWDING (only one arch)

1 – 3 mm.	=	1 pt.
3.1 – 5 mm.	=	2 pts.
5.1 – 7 mm.	=	4 pts.
> 7 mm.	=	7 pts.

Total = 4

5.5 mm (upper)

OCCLUSION

Class I to end on	=	0 pts.
End on Class II or III	=	2 pts. per side ____ pts.
Full Class II or III	=	4 pts. per side 8 pts.
Beyond Class II or III	=	1 pt. per mm. additional ____ pts.

Total = 8

Bilateral Full Class II

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 0

BUCCAL POSTERIOR X-BITE

2 pts. per tooth Total = 0

CEPHALOMETRICS (See Instructions)

ANB ≥ 6° or ≤ -2° 7.5° = 4 pts.

Each degree < -2° _____ x 1 pt. = _____

Each degree > 6° 1 x 1 pt. = 1

SN-MP 51.5°

≥ 38° = 2 pts.

Each degree > 38° 13 x 2 pts. = 26

≤ 26° = 1 pt.

Each degree < 26° _____ x 1 pt. = _____

1 to MP ≥ 99° = 1 pt.

Each degree > 99° _____ x 1 pt. = _____

Total = 33

OTHER (See Instructions)

Supernumerary teeth	_____ x 1 pt. =	_____
Ankylosis of perm. teeth	_____ x 2 pts. =	_____
Anomalous morphology	_____ x 2 pts. =	_____
Impaction (except 3rd molars)	_____ x 2 pts. =	_____
Midline discrepancy (≥3mm)	@ 2 pts. =	2
Missing teeth (except 3rd molars)	3 x 1 pts. =	3
Missing teeth, congenital	_____ x 2 pts. =	_____
Spacing (4 or more, per arch)	_____ x 2 pts. =	_____
Spacing (Mx cent. diastema ≥ 2mm)	@ 2 pts. =	_____
Tooth transposition	_____ x 2 pts. =	_____
Skeletal asymmetry (nonsurgical tx)	@ 3 pts. =	_____
Addl. treatment complexities	3 x 2 pts. =	6

Identify: Molar protraction x2
Periodontal compromised x1

Total = 11

IMPLANT SITE

Lip line : Low (0 pt), Medium (1 pt), High (2 pts) =_

Gingival biotype : Low-scalloped, thick (0 pt), Medium-scalloped, medium-thick (1 pt) High-scalloped, thin (2 pts) =_

Shape of tooth crowns : Rectangular (0 pt), Triangular (2 pts) =_

Bone level at adjacent teeth : ≤ 5 mm to contact point (0 pt), 5.5 to 6.5 mm to contact point (1 pt), ≥ 7mm to contact point (2 pts) =_

Bone anatomy of alveolar crest : H&V sufficient (0 pt), Deficient H, allow simultaneous augment (1 pt), Deficient H, require prior grafting (2 pts), Deficient V or Both H&V (3 pts) =_

Soft tissue anatomy : Intact (0 pt), Defective (2 pts) =_

Infection at implant site : None (0 pt), Chronic (1 pt), Acute(2 pts) =_

Total = 0

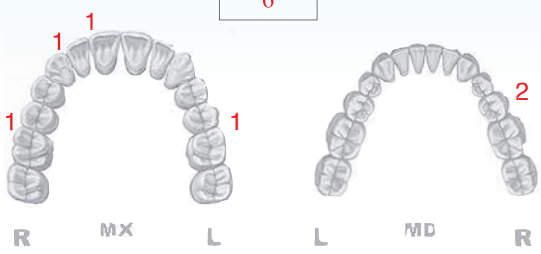
Cast-Radiograph Evaluation

Case # **Patient**

Total Score: 31

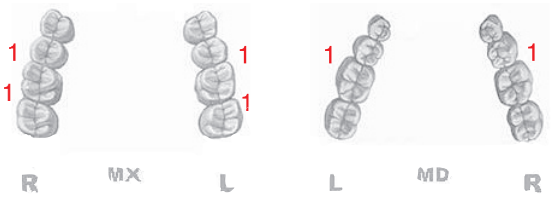
Alignment/Rotations

6



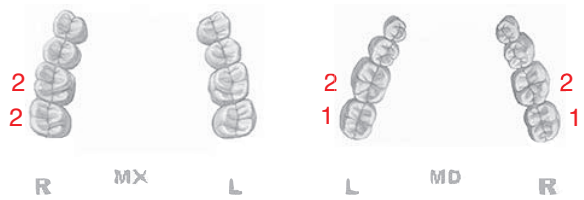
Marginal Ridges

6



Buccolingual Inclination

10

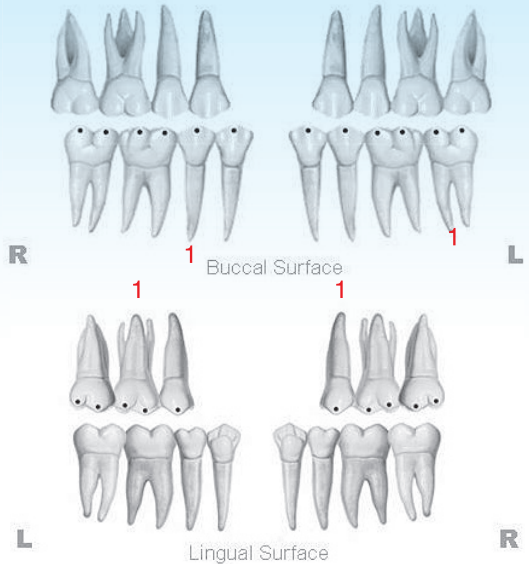


Overjet

3

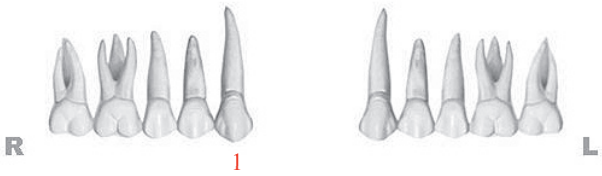
Occlusal Contacts

4



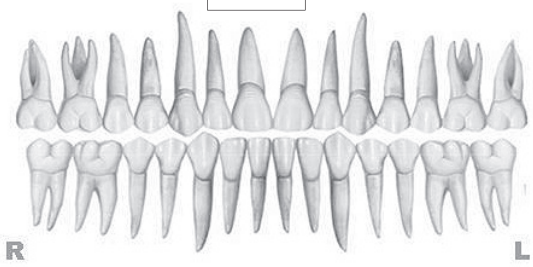
Occlusal Relationships

1



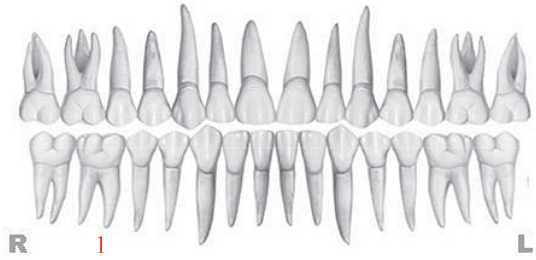
Interproximal Contacts

0



Root Angulation

1



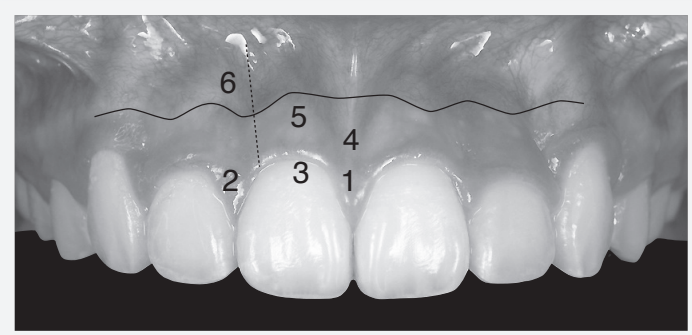
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score (Before Surgical Crown Lengthening)

Total Score: = 5

1. Pink Esthetic Score

Total = 2

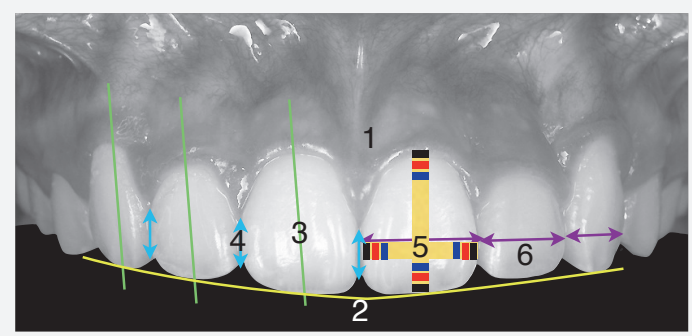


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

1. M & D Papilla	(0)	1	2
2. Keratinized Gingiva	(0)	1	2
3. Curvature of Gingival Margin	0	(1)	2
4. Level of Gingival Margin	0	(1)	2
5. Root Convexity (Torque)	(0)	1	2
6. Scar Formation	(0)	1	2

2. White Esthetic Score (for Micro-esthetics)

Total = 3



1. Midline	0	1	2
2. Incisor Curve	0	1	2
3. Axial Inclination (5°, 8°, 10°)	0	1	2
4. Contact Area (50%, 40%, 30%)	0	1	2
5. Tooth Proportion (1:0.8)	0	1	2
6. Tooth to Tooth Proportion	0	1	2

1. Midline	(0)	1	2
2. Incisor Curve	0	(1)	2
3. Axial Inclination (5°, 8°, 10°)	0	(1)	2
4. Contact Area (50%, 40%, 30%)	(0)	1	2
5. Tooth Proportion (1:0.8)	0	(1)	2
6. Tooth to Tooth Proportion	(0)	1	2