Conservative Correction of Severe Skeletal Class III Open Bite: 3 Force Vectors to Reverse the Dysplasia by Retracting and Rotating the Entire Lower Arch

Abstract

Conservative treatment (without orthognathic surgery or extractions) of severe malocclusions limits cost, morbidity and surgical complications. A twelve year history (12-24yr) for a male with a developing Class III openbite malocclusion involved conventional treatment (12-14yr), relapse (18yr), and conservative treatment (21-24yr). Cephalometric superimpositions (18-21yr) revealed a clockwise rotation of the mandibular arch with molar extrusion was the principal growth aberration contributing to the severe malocclusion (Discrepancy Index 89). Posterior skeletal (miniscrew) anchorage with a passive self-ligating (PSL) appliance reversed the etiology of the malocclusion by retracting, intruding and distally rotating the entire lower arch. Specific bracket torque selections and repositioning as needed delivered an excellent final alignment (Cast-Radiograph score of 12). The moment to force ratio (M:F) for the line of force, relative to the center of resistance (C_R) of the lower arch, determines the amount of molar retraction and intrusion. Miniscrews provide extra-alveolar (E-A) or inter-radicular (I-R) anchorage in both arches. Three miniscrew positions are proposed to retract and rotate the lower arch: 1. mandibular buccal shelf (MBS) (E-A), 2. distal to the lower first molar root (I-R), and 3. infra-zygomatic crest (IZC) (E-A). All three sites effectively retract and rotate the lower arch, but the I-R miniscrews interfere with the path of tooth movement, and the IZC screws fail to intrude the molars. Conclusions are: 1. MBS miniscrews produce an optimal line of E-A force for conservatively treating Class III openbite malocclusions to decrease lower facial height (LFH), and 2. reversing the etiology of a dentofacial dysplasia is an effective strategy for predicable conservative treatment.

Key words:

Class III, anterior open bite, temporary anchorage devices (TADs), mandibular buccal shelf (MBS) miniscrews, infrazygomatic crest (IZC) miniscrews, decreasing lower face height (LFH), forward rotation of the mandible

History

An 18 year-old male presented with a severe Class III openbite malocclusion, and a history of full fixed orthodontic treatment beginning at age 12 (*Figs. 1A and B*) that involved extraction of all four first premolars and recovery of blocked out maxillary canines. By age 18 he had relapsed to a severe Class III open bite malocclusion (*Figs. 2A and B*). Numerous decalcifications and restored carious lesions revealed a history of poor oral hygiene. The medical history was noncontributory. The patient was on recall until age 18-21yr, and then returned with a more severe sagittal and vertical discrepancy (*Figs. 3A, 3B and 3C*). He was treated (*Figs. 4A and 4B*) to a near ideal result (*Figs. 5A, 5B and 5C*). Cephalometric superimpositions document late growth (*Fig. 6*), two force vectors for skeletal traction (*Figs. 7 and 8*), and the overall result (*Fig. 9*).

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Fig. 1A:
12y/o male presents with a convex profile, retruded chin and mentalis strain.

Fig. 1B:
12y/o intraoral view reveals a modest Class III molar relationship, asymmetric anterior openbite and crowding in both arches.

Diagnosis And Etiology

Skeletal:

- SNA 79.9°, SNB 78°, ANB 1.9°
- High mandibular plane angle: *SN-MP 52.2°, FMA 43.6° tending to mask skeletal Class III*
- Facial asymmetry: *Mandible (chin point) deviated slightly to right*

Dental:

- Bilateral Class III canine and molar relationships
- Overjet 0 mm
- Anterior open bite: *8-10 mm*
- Space deficiency: *7 mm in the upper arch, 3mm in the lower arch*
- Facial, maxillary and mandibular midlines were coincident
- Arch forms: *asymmetrical in the maxilla and symmetrical in the mandible*

Fig. 2A:
18y/o (T0) is six years after the start of the initial orthodontic treatment that involved extraction of all four first premolars. Compared to the pretreatment photographs at age 12, the LFH and mentalis strain are increased.

Fig. 2B:
18y/o intraoral and panoramic radiographic views show improved dental alignment, but extensive decalcifications and caries problems are evident. The Class III malocclusion and anterior openbite have increased.

Fig. 3A:
21y2m (T1) facial photographs and cephalometric film document an overall deterioration of the facial form and the mandible is deviated to the right.

Fig. 3B: 21y2m show a further deterioration of the Class III openbite malocclusion.

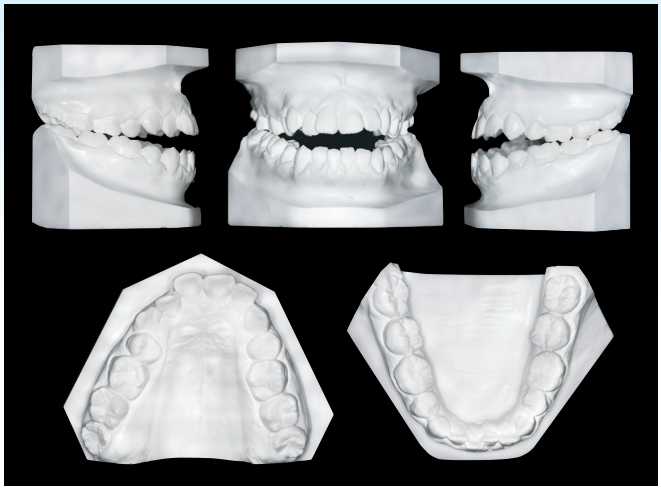

Fig. 3C:
Pre-treatment study models (casts) document a severe Class III openbite malocclusion.

Facial:

- Convex profile with retrusive chin (*mandibular deficiency*)
- Increased LFH with mentalis strain

The ABO Discrepancy Index (*DI*) was 89 as shown in the subsequent worksheet.

Treatment Objectives

Maxilla (*all three planes*):

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

Fig. 4A:
23y9m (T2) progress facial photographs and a cephalometric film show a marked improvement in facial form, but hypermentalis strain is still evident.

Fig. 4B:
23y9m progress intraoral photographs and a panoramic radiograph reveal that the malocclusion is markedly improved.

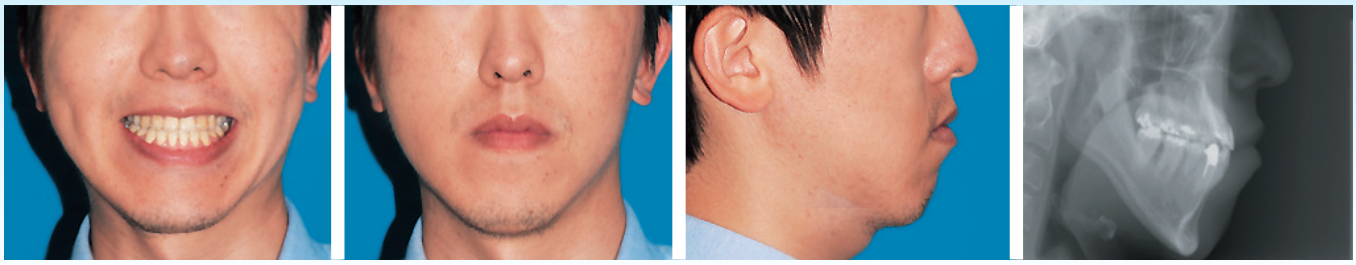

Fig. 5A: 24y11m (T3) facial views show an acceptable facial form and smile line with minimal mentalis strain.

Fig. 5B:
24y11m intraoral documentation reveals a near ideal dental alignment in three dimensions. Facial and dental midlines are coincident.

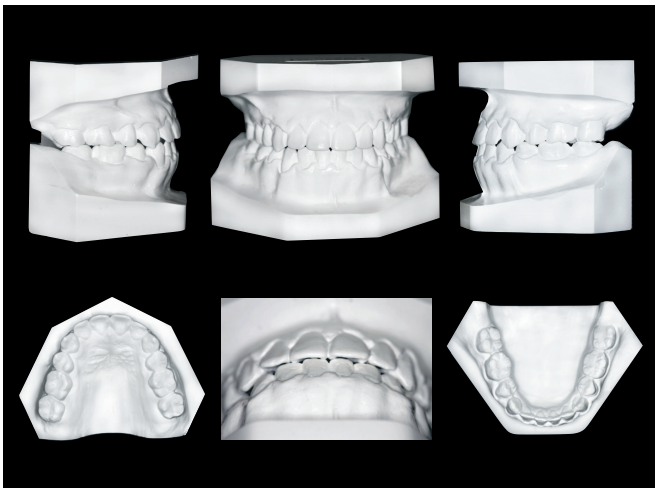

Fig. 5C:
24y11m post-treatment study casts show a near ideal dental alignment which was scored as 12 by the CRE method.

Mandible (*all three planes*):

- A – P: *Maintain*
- Vertical: *Forward rotation to decrease LFH*
- Transverse: *Maintain*

Maxillary Dentition:

- A – P: *Maintain*
- Vertical: *Maintain*
- Transverse: *Expand to correct crossbite*

Mandibular Dentition:

- A – P: *Retr action and counterclockwise rotation of the entire lower arch*

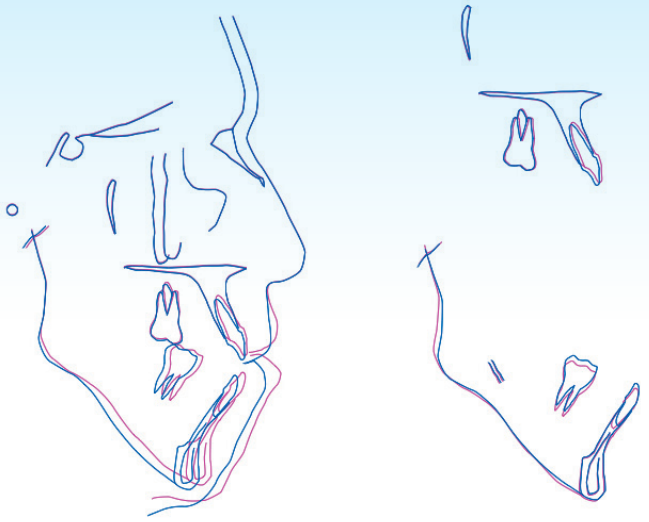

Fig. 6:
T0 (18y, pink) & T1 (21y3m, blue) cephalometric superimpositions on anterior cranial base (ACB), maxilla (Mx) and mandible (Md). Immediately prior to treatment, the principal aberration of growth was a forward rotation of the mandibular arch, resulting in molar extrusion and posterior rotation of the mandible to increase LFH and lip incompetence.

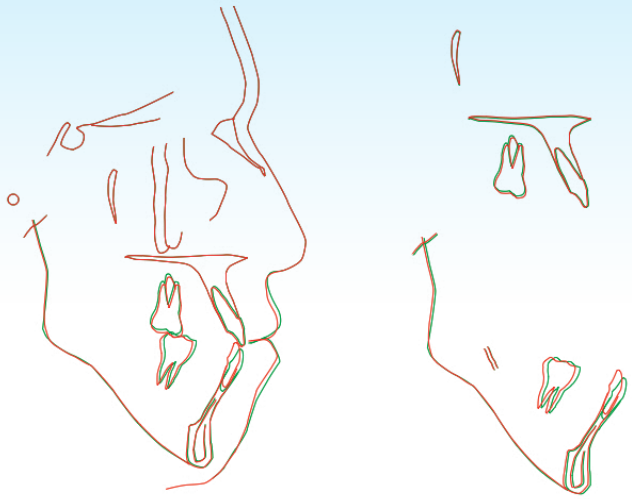

Fig. 8:
T2 (23y9m, green) vs. T3 (24y11m, red) superimpositions on ACB, Mx and Md reveal that the effect of IZC miniscrews is to retract and posteriorly rotate the lower arch. However, the vertical component to the Class III elastics line of force slightly extrudes the lower arch as it is rotating. The net effect is extrusion of the lower incisors, but no intrusion (and maybe slight extrusion) of the lower molars.

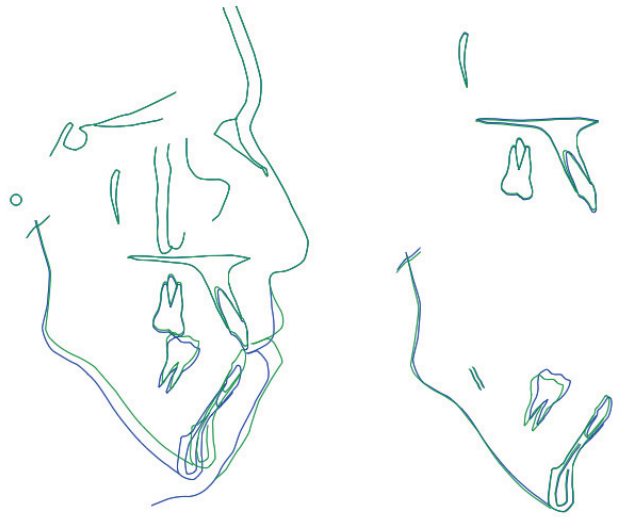

Fig. 7:
T1 (21y3m, blue) vs. T2 (23y9m, green) superimpositions on the ACB, Mx and Md document the effect of posterior mandible miniscrews in retracting and posteriorly rotating the mandibular arch. Note that the treatment effect is a reversal of the aberrant growth pattern shown in Fig. 6.

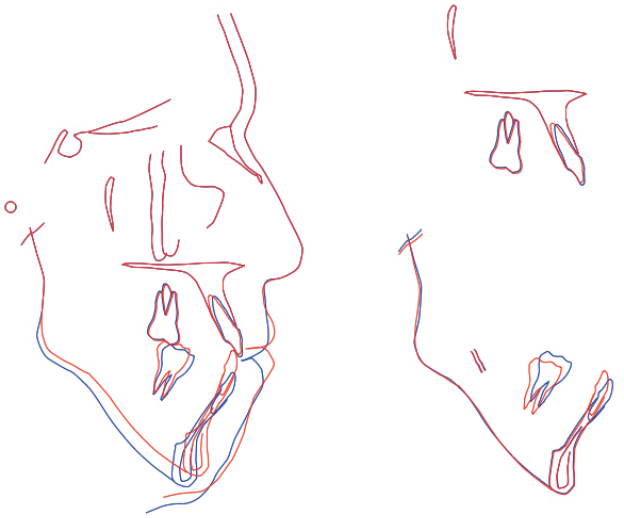

Fig. 9:
T1 (21y3m, blue) vs. T3 (24y1m, red) superimpositions on ACB, Mx and Md show the net effect for both skeletal methods for lower arch retraction. Overall, the lower arch was retracted and rotated posteriorly, resulting in incisor extrusion, molar intrusion and forward rotation of the mandible to decrease both LFH and lip incompetence.

- Vertical: *Extrude incisors, intrude molars*
- Transverse: *Decrease to correct crossbite*

Facial Esthetics:

- Decrease LFH
- Relieve hypermentalis strain

Treatment Plan

The patient rejected orthognathic surgery, but he accepted the extraction of third molars, and the use of a passive self-ligating (*PSL*) appliance with mandibular buccal shelf (*MBS*) miniscrews to provide skeletal traction to reverse his dysplastic orofacial development. The miniscrews were placed as inferiorly as possible to maximize the intrusive component for a line of force from the mandibular canines.

Appliances And Treatment Progress

After removing all four third molars at 21y2m, a full-fixed .022" slot Damon Q PSL appliance (*Ormco, Glendora, CA*) was installed. All brackets had standard torque except the lower left canine, which was bonded with a high torque bracket. The archwire sequence progressed as rapidly as possible to .019x.025" SS for arch stabilization. Beginning 2 months into treatment, posterior cross-elastics were used as needed to correct and maintain the lingual posterior crossbite until the openbite was closed. At 14mo, two 12x14 mm stainless screw miniscrews (*OrthoBoneScrew®, Newton's A, Hsinchu, Taiwan*) were inserted in the MBS as inferiorly as possible with an apically positioned flap to enhance attached gingiva (*Fig. 10*). 3 days later the MBS screws were removed due to soft tissue inflammation, and I-R miniscrews

Fig. 10:
At 22y7m, 2 x14 mm miniscrews were placed bilaterally in buccal shelves in the lower molars region. A periodontist placed the screws as inferiorly as possible with an apically positioned flap. An anterior-posterior radiographic view of the head (right) shows that the screws are in an approximately vertical position and buccal to the roots of the molars.

Fig. 11:
At 22y7m, the buccal shelf 2X14mm miniscrews (Fig. 10) were removed due to soft tissue irritation and replaced with 2X12mm miniscrews inserted in the alveolar process between the roots of the lower first and second molars. The NiTi coil springs and the triangular elastics from the miniscrews to the archwire mesial to the lower canines, was designed to retract and rotate the lower arch distally.

Buccal Shelf Screws	22y7m ~ 23y1m. Retraction of whole lower dentition and intrusion of lower molar on 19x25 SS wire by the buccal shelf screws.
IZC Screw (*Infrazygomatic Screws*)	23y9m ~ 24y11m. Retraction of whole lower dentition and tip back of lower molars on 17x25 TMA wire by the Class III elastics from the IZC screws.

■ Table 1: Major treatment stages.

12 mm in length were installed more occlusally (*Fig. 11*). The lower buccal segments were retracted and intruded with .026x.026" elastic thread and a NiTi coil spring (*Figs. 11 and 12*).

After 6mo of molar intrusion, the open bite closed significantly, but the lower second molars were tipped distally and arch retraction had creased (*Fig. 12*). A CBCT showed that the distal root of the lower right first molar was contacting the miniscrew, so both I-R miniscrews were removed. Two OBSs were installed in the maxillary IZCs (*Fig. 13*), and Class III elastics were utilized to continue the retraction of the lower arch. At 33mo, incisal contact was achieved, and buccal segments were near Class I (*Fig. 14*). At 41mo, detailing was complete so all fixed appliances were removed (*Fig. 15*). The major treatment stages for TADs anchorage are summarized in Table 1.

Results Achieved

The patient was treated to the planned result as documented by a cephalometric radiograph superimpositions showing the effects of growth, and specific types of mechanics (*Figs. 6-9*). A summary of the cephalometric measurements is provided in Table 2.

CEPHALOMETRIC			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA°	79.9°	80.4°	0.5°
SNB°	78.0°	79.7°	1.7°
ANB°	1.9°	0.7°	-1.2°
SN-MP°	52.2°	49.3°	-2.9°
FMA°	43.6°	42.5°	-1.1°
DENTAL ANALYSIS			
U1 TO NA mm	9.8 mm	8.6mm	-1.2 mm
U1 TO SN°	107.1°	111.7°	4.6°
L1 TO NB mm	11.1 mm	7.5 mm	-3.6 mm
L1 TO MP°	78.1°	66.7°	-11.4°
U1 TO PP mm	35.4 mm	35.1 mm	-0.3 mm
U6 TO PP mm	30.2 mm	29.8 mm	-0.4 mm
L1 TO MP mm	45.2 mm	47.7 mm	2.5 mm
L6 TO MP mm	34.8 mm	32.7 mm	-2.1 mm
FACIAL ANALYSIS			
E-LINE UL	-0.1 mm	-1.3 mm	-1.2 mm
E-LINE LL	3.5 mm	3.8 mm	0.3 mm

■ Table 2: Cephalometric summary

Maxilla (*all three planes*):

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

Mandible (*all three planes*):

- A – P: *Maintained*
- Vertical: *Closed ~5mm with froward mandible rotation*
- Transverse: *Maintained*

Maxillary Dentition:

- A – P: *Maintained*
- Vertical: *Maintained*
- Transverse: *Expanded to correct posterior crossbite*

Mandibular Dentition:

- A – P: *Retraction of the entire arch*
- Vertical: *Extrusion of incisors and intrusion of molars*
- Transverse: *Constricted to correct crossbite*

Facial Esthetics:

- Decreased LFH and convexity
- Relieved hypermentalis strain

Retention

Upper and lower Hawley retainers were delivered and the patient was instructed to wear them full time for the first 6 months and nights only thereafter. In addition, instructions were provided for proper home hygiene and maintenance of the retainers.

Final Evaluation Of Treatment

This severe skeletal malocclusion was treated to a near ideal result, as documented by cephalometric superimpositions (*Fig. 9*) and an excellent cast-radiograph evaluation (*CRE*) score of 12. Precise bracket selection and repositioning was effective for detailing and finishing with the PSL appliance despite the extensive movement of the mandibular arch. The pink and white (*P&W*) dental esthetic score of 5 is acceptable, considering this was a retreatment of a patient with previous decalcifications and caries (*Fig. 2B*). The patient had good oral hygiene during the latest course of treatment.

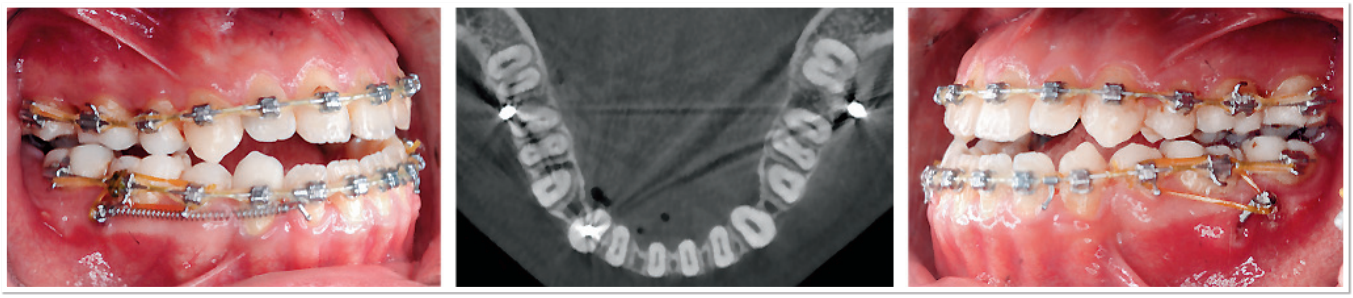

Fig. 12:
At 23y1m, evaluation of the first 6 months of lower arch retraction shows that the openbite closed ~5mm and lower molars were tipped distally. A CBCT image revealed that the distal root of the first molar was contacting the miniscrew on the right side.

Fig. 13:
At 24y2m, the lower posterior miniscrews were removed and two IZC miniscrews were inserted. Class III elastics were extended from the miniscrews to hooks on lower archwire, mesial to the canines.

Fig. 14: At 24y6m, the incisors were contacting and the buccal segments were close to Class I.

Discussion

Orthognathic surgery is usually the preferred treatment for severe Class III anterior open bite malocclusions with a deficient chin.[1,2,3] Camouflage treatment with premolar extractions is a common alternative, but it was not an option because all four first premolars had previously been extracted (*Fig. 3B*). Multiloop edgewise archwire (*MEAW*) is capable of extruding incisors,[4] but it was not selected because it is not effective for decreasing LFH and lip incompetence. In general, the patient was opposed to surgery, so he accepted the limitation that his chin deficiency would not be corrected.

The last three years of growth (*18-21yr*) was characterized by an a clockwise rotation of the lower arch that increased the Class III relationship, anterior open bite, and LFH (*Fig. 6*).

Intrusion of mandibular molars to decrease the LFH is challenging.[5,6] Microscrews, miniscrews, miniplates and osseointegrated dental implants are effective for skeletal anchorage,[7,8,9,10] but the biomechanics of each approach must be carefully analyzed. Lower posterior miniscrews (*Fig. 11*) provide a line of force superior to the center of resistance (C_R) which intrudes the molars by counterclockwise rotation of the entire lower arch (*Fig. 7*). This approach effectively reversed the etiology of the dysplasia (*Fig. 6*) and produced a near ideal result (*Figs. 5A-C and 9*).

The most significant problem encountered was the failure of the initial MBS miniscrews (*Fig. 10*). Biomechanics favor placing an E-A miniscrew deep in the buccal fold to retract, intrude and rotate the lower arch. Soft tissue irritation can be a problem in the buccal fold, so an apically positioned flap was utilized to provide attached gingiva around the miniscrew (*Fig. 10*). Unfortunately, the procedure was unsuccessful and the miniscrews were removed because of soft tissue hyperplasia. After failure of the MBS miniscrews, the second best site for the TADs was I-R site in the posterior lower arch, so the miniscrews were placed distal to the roots of first molars (*Fig. 11*). This I-R site was adequate initially, but after 6 mo of traction, the right molar root contacted the screw (*Fig. 12*) and it was necessary to remove the I-R miniscrews. The third best site for pursuing the clinical objectives was the IZC (*Fig. 13*). Although all three TADs sites were adequate for retracting the lower arch, the MBS is the preferred location for delivering a line of force with a substantial intrusive component for intruding the lower molars, without interfering with the path of tooth movement.

Fig. 15:
At 24y10m, four months of detailing and finishing achieved the final result immediately prior to removing all fixed appliances.

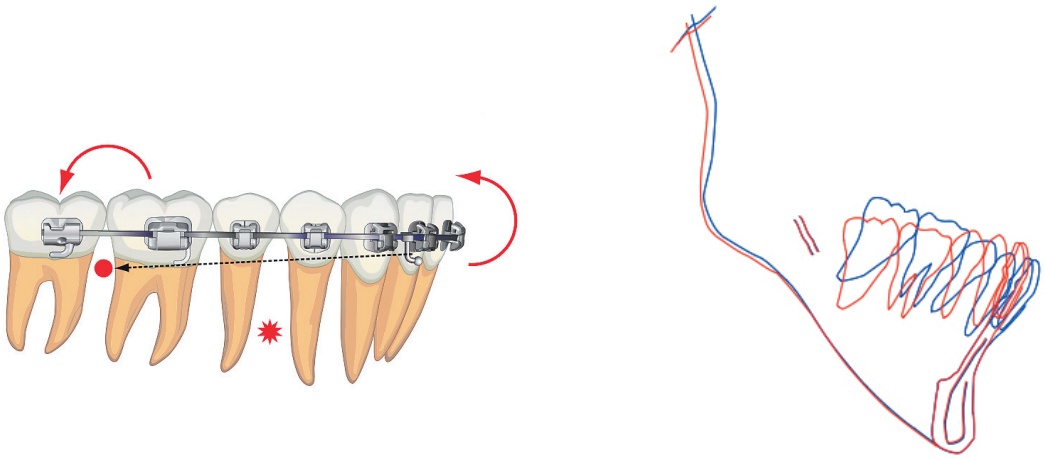

Fig. 16:
(a) Retraction of the lower arch with a buccal shelf miniscrew typically results in posterior rotation of the entire mandibular dentition. This effect is due to the line of force (black dotted line) being occlusal to the center of resistance of the arch (red star). This moment to force ratio retracts and intrudes the arch producing incisor extrusion and molar intrusion.
(b) A cephalometric superimposition on the mandible reveals that buccal shelf retraction retracts the entire lower arch and rotates it distally, thereby intruding the molars.

The soft tissue irritation problem for MBS miniscrews was investigated by Chang and Roberts.[11,12] They found that miniscrews placed in unattached mucosa were well tolerated if the head of the screw and the attached mechanics was several millimeters occlusal to the soft tissue margin. This approach produces a line of force similar to I-R miniscrews (*Fig. 16*), but since the TADs is located buccal to the roots of the molars, there is no problem with root impingement. The initial (*4 mo*) failure rate for MBS miniscrews placed in attached and unattached mucosa is currently being investigated. A reliable method for utilizing MBS miniscrews to retract, intrude and rotate the lower arch would be advantageous for the routine conservative treatment of skeletal malocclusions.[13,14]

Conclusion

MBS and IZC miniscrews are effective E-A mechanics for conservative correction of skeletal malocclusions. Although both mechanisms retract the entire mandibular arch, the MBS mechanism is more effective for intruding lower molars, decreasing the MPA and closing the VDO. The PSL appliance was effective for maintaining arch integrity and symmetry, while the lower arch was retracted and rotated to correct the Class III openbite malocclusion.

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 89

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.
> 9 mm.	=	5 pts.

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

Total = 0

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 = 34

LATERAL OPEN BITE

2 pts. per mm. per tooth

Total = 9

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 = 2

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

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 4

BUCCAL POSTERIOR X-BITE

2 pts. per tooth Total = 0

CEPHALOMETRICS (See Instructions)

ANB ≥ 6° or ≤ -2° = (4 pts.)

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

Each degree > 6° _____ x 1 pt. = _____

SN-MP

≥ 38° = (2 pts.)

Each degree > 38° 14 x 2 pts. = 28

≤ 26° = 1 pt.

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

1 to MP ≥ 99° = 1 pt.

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

Total = 28

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. =	_____
Missing teeth (except 3rd molars)	_____	x 1 pts. =	_____
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	2	x 2 pts. =	4

Identify: Conservative treatment of skeletal malocclusion without extractions or orthognathic surgery.

Total = 4

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) =_____

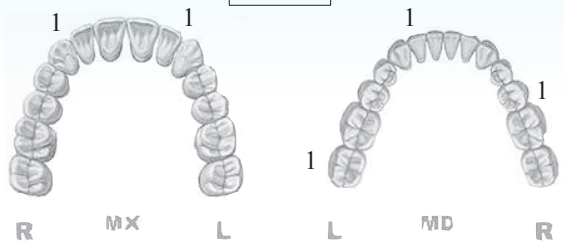
Total = 0

Cast-Radiograph Evaluation

Total Score: 12

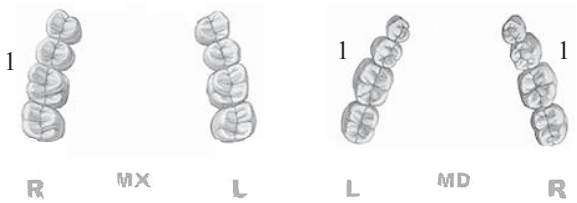
Alignment/Rotations

5



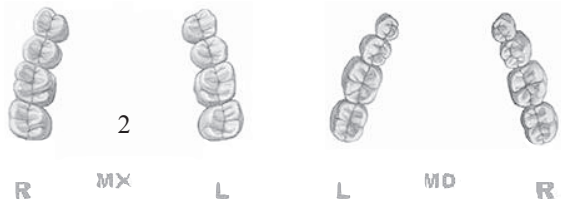
Marginal Ridges

3



Buccolingual Inclination

2

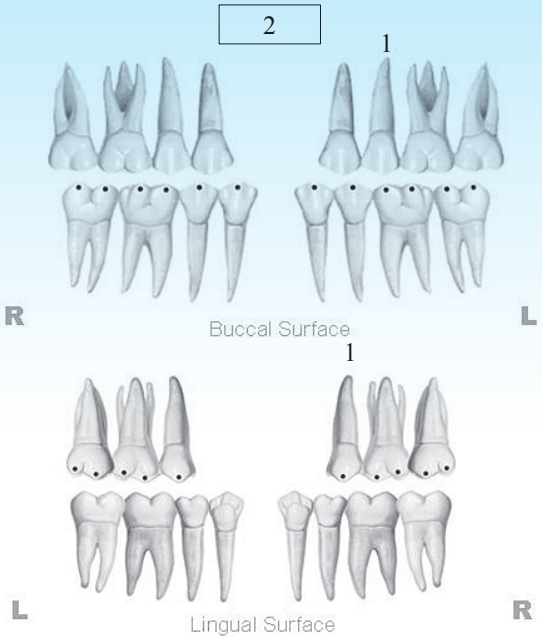


Overjet

0

Occlusal Contacts

2

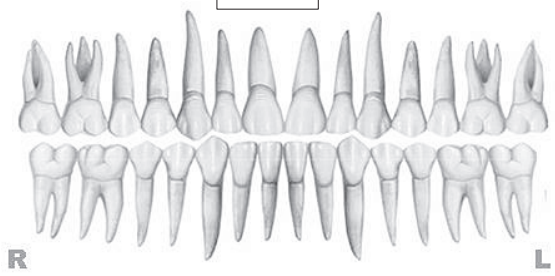


Occlusal Relationships

0

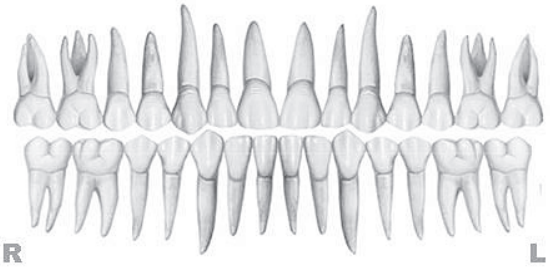
Interproximal Contacts

0



Root Angulation

0



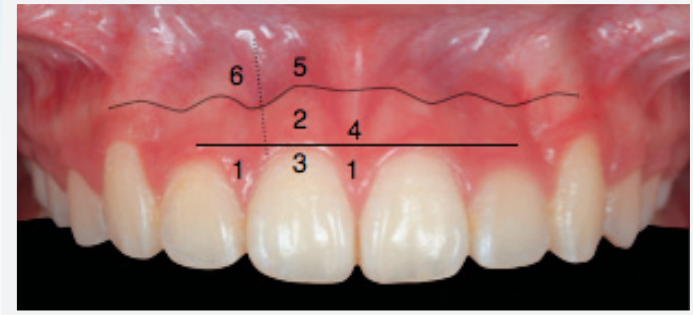
***INSTRUCTIONS:** Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.*

IBOI Pink & White Esthetic Score

Total Score: = 5

1. Pink Esthetic Score

Total = 1

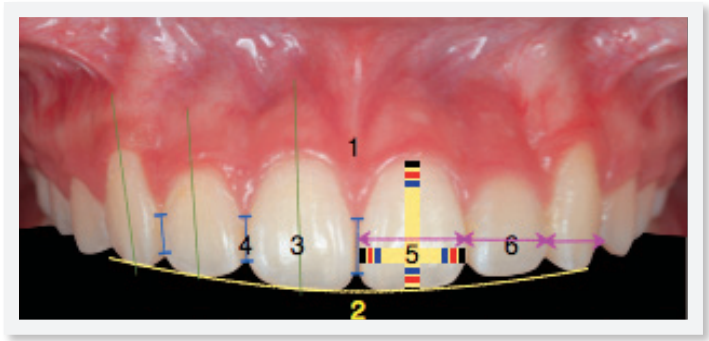


1. Mesial Papilla	0	1	2
2. Distal Papilla	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

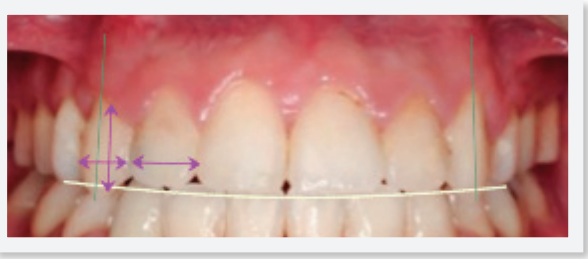
1. M & D Papillae	(0)	1	2
2. Keratinized Gingiva	(0)	1	2
3. Curvature of Gingival Margin	(0)	1	2
4. Level of Gingival Margin	0	(1)	2
5. Root Convexity (Torque)	(0)	1	2
6. Scar Formation	(0)	1	2

2. White Esthetic Score (for Micro-esthetics)

Total = 4



1. Tooth Form	0	1	2
2. Mesial & Distal Outline	0	1	2
3. Crown Margin	0	1	2
4. Translucency (Incisal thrid)	0	1	2
5. Hue & Value (Middle third)	0	1	2
6. 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