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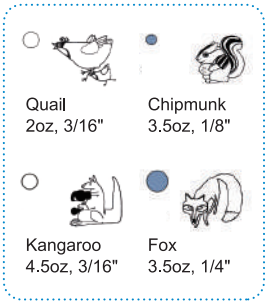

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Non-Extraction Treatment of Class III Malocclusion with Clear Aligners and Buccal Shelf Screws

Abstract

History: *An 18yr-9m-old male presented with a Class III malocclusion with negative overjet. His chief complaints were crowding and a protrusive lower lip. He previously rejected treatment with extractions or orthognathic surgery.*

Diagnosis: *The cephalometric analysis revealed skeletal Class III (SNA, 82˚; SNB, 85˚; ANB, -3˚), high mandibular angle, flared upper incisors, and retroclined lower incisors. An intraoral examination documented negative overjet, anterior crowding on both arches, and posterior buccal crossbite on U7s. The Discrepancy Index was 32 points.*

Treatment: *A camouflage, non-surgical approach without extractions was indicated. Buccal shelf (BS) bone screws (2x12-mm, OrthoBoneScrew®, iNewton, Inc., Hsinchu City, Taiwan) were used as anchorage to retract the mandibular dentition, and Class III elastics corrected the intermaxillary discrepancy. Inter-proximal reduction and arch expansion were prescribed in order to provide spaces for arch alignment.*

Results: *The facial profile was improved with a more balanced lip position. Torque control for the upper and lower incisors was excellent. After 28 months of active treatment, the skeletal Class III malocclusion was corrected to an excellent Cast-Radiograph Evaluation score of 24 points and a Pink & White dental esthetic score of 4.*

Conclusions: *When correcting skeletal Class III with camouflage treatment, spaces are usually provided through extraction, inter-proximal reduction, and/or arch expansion. However, buccal shelf bone screw anchorage combined with Class III elastics is a powerful weapon to retract the mandibular arch. (J Digital Orthod 2022;67:28-43)*

Key words:
Class III malocclusion, camouflage treatment, non-surgical treatment, buccal shelf screw, Class III elastics, clear aligner

Introduction

The dental nomenclature for this case report is a modified Palmer notation with four oral quadrants: upper right (UR), upper left (UL), lower right (LR), and lower left (LL). Teeth are numbered 1-8 from the midline in each quadrant.

The prevalence of Angle Class III malocclusion varies among and within differing ethnic groups; however, it is most common among Asians.[1] Chinese and Malaysian populations have a high prevalence of Angle Class III malocclusions: 15.69% and 16.59%, respectively. In the United States, the prevalence of Class III malocclusions is only about 1% of the total population; nevertheless, it constitutes about 5% of all orthodontic patients.[2,3]

In general, Class III malocclusions can be treated by orthodontic camouflage treatment via temporary skeletal anchorage devices (TSADs) with elastics and/or by orthognathic surgery for skeletal correction. However, due to the morbidity, potential complications, and high expense, orthognathic

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Editor-in-Chief, Journal of Digital Orthodontics (Right)

surgery is often declined by Asians. On the contrary, orthodontic camouflage treatment with TSADs is usually preferred.

This case report presents camouflage, non-extraction treatment of a Class III malocclusion using clear aligners. Despite research demonstrating limitations of aligners for correcting skeletal malocclusion,[4,5] advancement of

Fig. 1: *Pre-treatment facial and intraoral photographs*

aligner material, artificial intelligence, TSAD anchorage, and a proper design of Class III mechanics resulted in a normal occlusion and a balanced esthetic profile.

Diagnosis and Etiology

An 18-yr-old male presented for orthodontic evaluation with chief complaints of crowding and a protrusive lower lip (Fig. 1). Medical and dental histories were non-contributory. Plaster casts revealed bilateral Class III canine and molar relationships (Fig. 2). The panoramic radiograph (Fig. 3) showed all four wisdom teeth were missing.

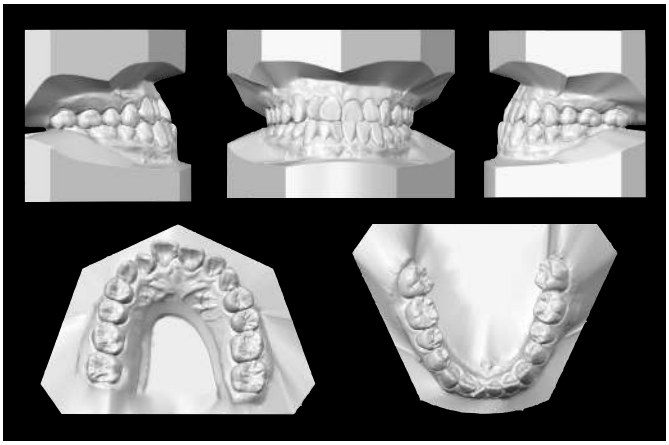


Fig. 2: *Pre-treatment study models*

Fig. 3: *Pre-treatment panoramic radiograph*

Cephalometric analysis (Table 1) revealed decreased facial convexity (G-Sn-Pg', 8˚) and a prognathic mandible (SNA, 82˚; SNB, 85˚; ANB -3˚) with a steep mandibular plane angle (SN-MP, 43˚; FMA, 36˚). The upper incisors were flared, and the lower incisors were retroclined (Fig. 4). Temporomandibular joint (TMJ) morphology was normal in the open and closed positions with no temporomandibular dysfunction (TMD) (Fig. 5). An intraoral examination revealed a negative overjet, anterior crowding in both arches, and posterior buccal crossbite on U7s (Fig. 1). The facial profile was nearly straight with a protrusive lower lip (5mm to the E-line). The

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-TX	POST-TX	DIFF.
SNA˚ (82˚)	82˚	81˚	1˚
SNB˚ (80˚)	85˚	83˚	2˚
ANB˚ (2˚)	**-3˚**	-2˚	1˚
SN-MP˚ (32˚)	**43˚**	44˚	1˚
FMA˚ (25˚)	**36˚**	37˚	1˚
DENTAL ANALYSIS			
U1 TO NA mm (4mm)	8	7	1
U1 TO SN˚ (104˚)	**133˚**	106˚	27˚
L1 TO NB mm (4mm)	3	2	1
L1 TO MP˚ (90˚)	**69˚**	65˚	4˚
FACIAL ANALYSIS			
E-LINE UL (-1mm)	-1	0	1
E-LINE LL (0mm)	5	3	2
%FH: Na-ANS-Gn (53%)	57%	58%	1%
Convexity:G-Sn-Pg' (13˚)	8˚	3˚	5˚

Table 1: *Cephalometric summary*

Fig. 4: Pre-treatment cephalometric radiograph

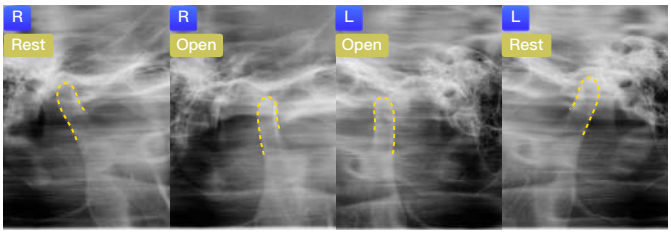


Fig. 5:
Pre-treatment transcranial radiographs of the right (R) and left (L) temporomandibular joints (TMJs) in rest and open positions. The mandibular condyles are outlined in yellow.

American Board of Orthodontics (ABO) Discrepancy Index (DI) was 32, as documented in the supplementary Worksheet 1.[6]

Treatment Objectives

1. Attain ideal overjet and overbite.
2. Achieve Class I canine and molar relationships.
3. Align both arches, and correct posterior crossbite.
4. Improve facial esthetics.

Treatment Alternatives

Option 1: A conservative, camouflage approach without extraction that retracts the mandibular arch with buccal shelf (BS) bone screw anchorage and Class III elastics. Create extra space to relieve crowding and retract the mandibular arch by performing 0.4mm inter-proximal reduction (IPR) on each tooth and expanding both maxillary and mandibular arches.

Option 2: Similar camouflage approach to option 1 adding two infrazygomatic crest (IZC) bone screws to retract the maxilla.

Option 3: Camouflage approach with extraction of all four second premolars to provide extra spaces. BS and IZC screws may be required.

Options 1 and 2 are more conservative without extraction, which is suitable for patients with dentophobia. However, expanding the mandibular arch for retraction of the mandible is challenging since the mandibular bone is denser and harder to expand. Option 3 is suitable for relieving anterior crowding, but there is the risk of torque loss on the anterior teeth, which may worsen the retroclination of the mandibular incisors for the current patient. Clear aligner and brackets were both viable for all three options. The patient rejected extraction and preferred clear aligners for better esthetics during the whole orthodontic treatment. Thus, Invisalign® therapy with option 1 protocol was chosen.

Treatment Progress

The 1st stage was designed to adapt the patient to aligners with no activation. All attachments were bonded in the 2nd stage, and the patient was instructed to use the aligner seater, Chewies. After seating the aligners, the patient should chew on the chewies for a minimum of 5 minutes each time, and the accumulated chewing time per day should be at least an hour for better aligner conformation to the dentition.

Sequential distalization, which moves one tooth at a time, was prescribed throughout the treatment for mandibular retraction, starting from the L7s. Once the L7s were moved 1/3 to 2/3 of the way, movement of the L6s were initiated, and so on. Arch expansion was indicated for both arches in order to provide extra spaces. IPR was prescribed before stages 18, 34, 41, 49, and 57 (Fig. 6).

In the 6th month of treatment (20th stage of aligners), BS screws (2x12-mm, OrthoBoneScrew®, iNewton, Inc., Hsinchu, Taiwan) were inserted for mandibular retraction, and 4.5 oz elastics (Kangaroo 3/16-in, 4.5 oz; Ormco) were hooked from L3 to the BS screw bilaterally (Fig. 7). In the 11th month of treatment (34th

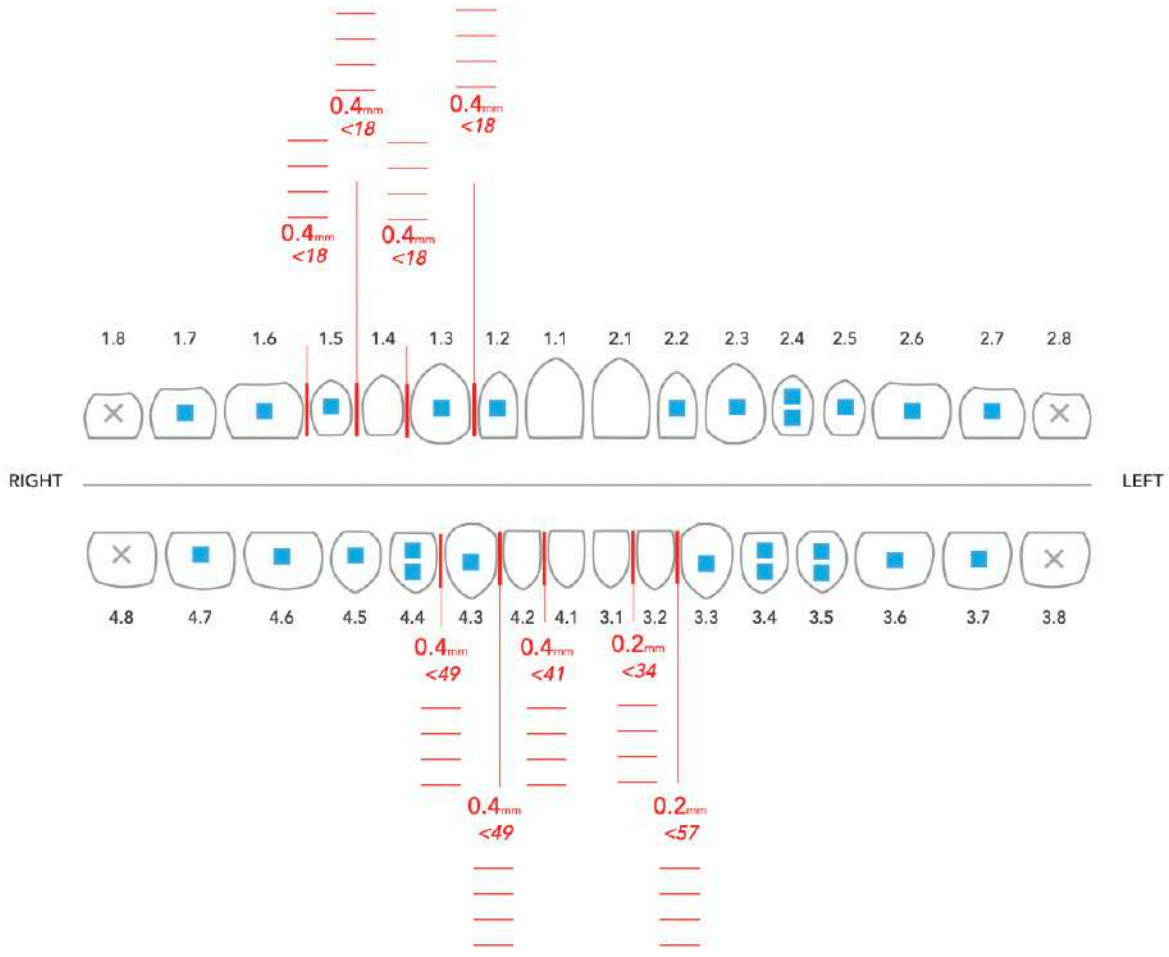


Fig. 6:
Clincheck® IPR and attachment designs. IPR was performed within the designated set of aligners to provide enough spaces for crowding relief and retraction.

stage), power ridges on L2s and L1s were added for better torque control. In the 12th month of treatment (35th stage), Class III elastics were introduced (Fox, 1/4-in, 3.5 oz; Ormco) from U6s to L3s (Fig. 7). Note the precision cuts instead of button cutouts were made on U6s in order to maximize aligner coverage on the teeth. At the end of this set of treatment, the molar relationship was nearly Class I.

After the first set of aligners (62 stages), the overjet was corrected from negative to a normal positive range. The overbite was also within normal range. Class I canine and molar relationships were achieved (Fig. 8). Note the positions of the molars in relation to the BS screws before and after mandibular retraction (Fig. 9). The BS screws were initially inserted on the buccal side between L6s and L7s. After the first set of

Fig. 7:
Intraoral photographs at 12 months of treatment. In the 6th month, BS screws were placed and elastics (Kangaroo 3/16-in, 4.5 oz; Ormco) were introduced bilaterally from L3s to the BS screws. In the 12th month, Class III elastics (Fox, 1/4-in, 3.5 oz; Ormco) were hooked bilaterally from the U6s to L3s.

Fig. 8:
62 stages of aligners were designed for the first set of treatment. Difference between predicted and achieved tooth movement (DPATM) after first set of aligners was slight thanks to good patient compliance. However, small finishing details were needed so there was one additional refinement.

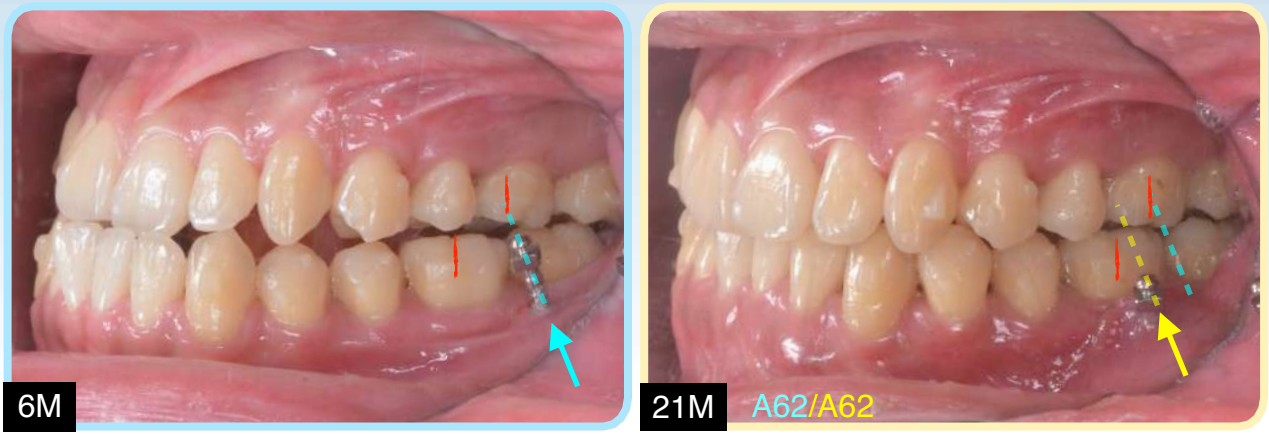


Fig. 9:
Note the relative position of the BS screw changed from between LL6 and LL7 (left; blue arrow, dotted line) to being in alignment with LL6 (right; yellow arrow, dotted line) on the buccal side, showing significant retraction of the mandibular arch.

treatment, they were positioned on the buccal side of L6s. Differences between predicted and achieved tooth movement (DPATM) were noticed at this stage (Fig. 8). Additional refinement stages were planned in order to improve partial teeth alignment (UR2 and LR1) and to expand the right side of the maxillary arch.

After the refinement, all treatment objectives were achieved. All appliances were removed, and retention was accomplished with maxillary and mandibular clear overlay retainers. Posttreatment records are shown in Figs. 10-13, and the full treatment progress is documented in Figs. 14-16.

Treatment Results

The facial profile was improved and more harmonious, with the lower lip retruded. Good dental alignment was achieved with bilateral Class I canine and molar relationships despite a minor discrepancy in the occlusal fitting of the posterior section. Anterior and posterior crossbites were both corrected, resulting in better occlusal function (Figs. 10-12). With daily oral functioning after treatment, the posterior intercuspation may be naturally improved after 6 to 12 months.

Superimposed cephalometric tracings (Fig. 13) showed that the flared maxillary incisors were corrected with good torque control. There was decreased mandibular incisor inclination (4°), which was inevitable after retracting the mandibular arch. However, the non-extraction protocol adopted for this patient successfully limited this side effect on the mandibular incisors. Furthermore, the L6s were retracted by BS screw traction and Class III elastics. The clockwise rotation of the mandible was due to the bite opening to correct the anterior crossbite. The ABO Cast-Radiograph Evaluation (CRE) score was 24 points (Worksheet 2), with major discrepancies in posterior occlusal contacts. The Pink and White esthetic score was 4 due to enlarged U1s tooth size (Worksheet 3).

Discussion

Conservative camouflage treatment for a Class III malocclusion is usually the preferred choice among

Fig. 10: *Posttreatment facial and intraoral photographs*

Fig. 11: *Posttreatment panoramic radiograph*

Fig. 12: *Posttreatment cephalometric radiograph*

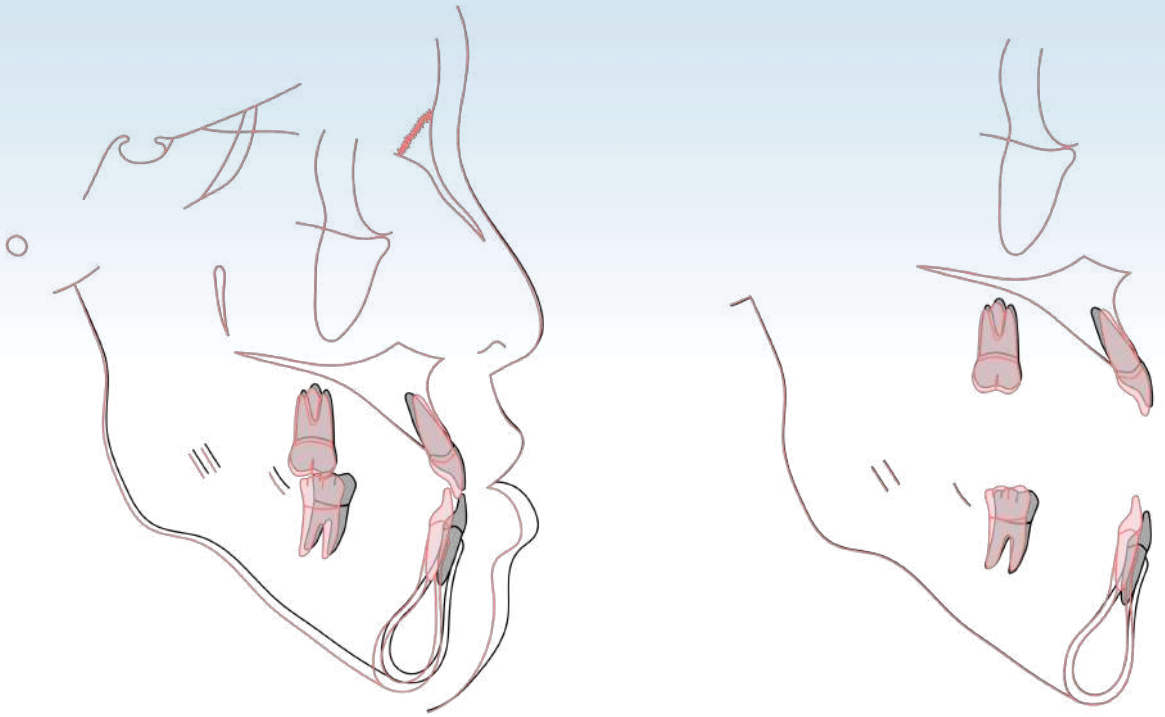


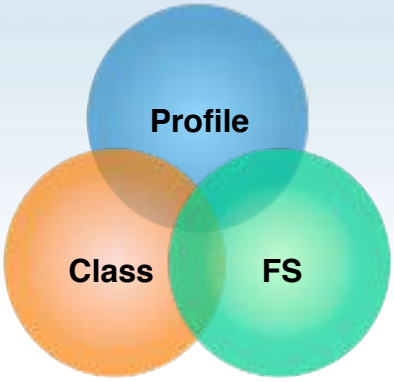
Fig. 13:
Superimposition of the cephalometric tracings before (black) and after (red) treatment documented good torque control of both maxillary and mandibular incisors, retraction of the mandibular arch, and clockwise rotation of the mandible.

Fig. 14:
Treatment progression is shown the right buccal view from the beginning (0M) to the end of treatment (28M). In the 6th month (6M), BS screws were placed with elastics (Kangaroo, 3/16-in, 4.5 oz; Ormco) hooked bilaterally to retract the mandibular arch. In the 13th month (13M), Class III elastics (Fox, 1/4-in, 3.5 oz; Ormco) were added.

Fig. 15:
Treatment progression is shown in the frontal view from the beginning (0M) to the end of treatment (28M). The first set of aligners finished in the 21st month. Refinement was carried out afterwards for additional adjustments. The overjet improved significantly throughout the treatment.

Fig. 16:
Treatment progression is shown in the left buccal view from the beginning (0M) to the end of treatment (28M). Note the relative position of BS screw from 6th month to 21st month in relation to the molars, which shows the retraction of the mandibular arch.

patients, but the treatment planning is challenging for orthodontists. The 3-Ring Diagnosis (Fig. 17) developed by John Lin is helpful for judging whether a case is suitable for camouflage treatment.[7] The three determining factors are evaluated under centric relation (C_R) position: 1. orthognathic profile, 2. buccal segments that are approximately Class I, and 3. functional shift to centric occlusion (C_O) (Fig. 17). The present case fitted none of these criteria; hence, conservative camouflage treatment was very challenging. However, as the patient preferred a non-surgical



Profile: Orthognathic profile at C_R position
Class: Canine and molar classification
FS: Functional shift ($C_O \neq C_R$)

Fig. 17:
Lin's Class III diagnostic system evaluates facial profile and molar classification in C_R, as well as the functional shift from C_R to C_O. If the profile is acceptable in C_R, molars are in or near Class I, and there is a significant functional shift, the patient usually can be effectively managed with Class III camouflage treatment.

and non-extraction treatment, Class III elastics, TSADs, and space creation were crucial.

Class III Elastics

Class III camouflage treatment with or without extraction usually involves intermaxillary Class III elastics with the whole maxillary dentition acting as anchorage to retract the mandibular dentition. According to Newton's third law of motion, the reaction force leads to protraction of the maxillary arch and labial tipping of the maxillary incisors.[8] Thus, resistant moments in the maxillary anterior segment are required via orthodontic devices.[9] An advantage of digital orthodontics is designing the torque control for individual teeth after evaluating the rotation of the whole arch. Alternatively, hooking the elastics on TSADs is another way to prevent the adverse effect of Class III elastics.

Placement of TSADs

Compared to intermaxillary Class III elastics, the osseous anchorage of TSADs to retract the mandible prevents the undesirable proclination of the maxillary incisors, which results in a more acute nasolabial angle.[10] For severe Class III patients, especially those with an open bite and proclined maxillary incisors, using Class III elastics as the main correcting mechanics is not recommended. Instead, BS screws are indicated.[11] One caution to be exercised is that if the slope of the buccal shelf is very steep, the BS screws are placed inter-radicularly. This limits the retraction effect for the whole lower arch due to the contact of the L6 distal root with the screw. However, BS screws are still very powerful in Class III treatments. Note the screw position in relation to the molars in this case (Fig. 9). The BS screw was initially inserted on the buccal side between LL6 and LL7; however, after 15 months, it was in alignment with LL6. The BS screws provided powerful anchorage to retract the mandibular arch. IZC screws are another option to avoid the undesirable proclination of maxillary incisors; they provide osseous anchorage for the Class III elastics.[12]

Providing Spaces for Arch Retraction

To relieve crowding or perform camouflage arch retraction, extra spaces in the arch are needed. Three common ways to provide extra spaces are: IPR, extraction, and arch expansion.[13]

In camouflage treatment, extraction is an effective method to produce dental compensation for the skeletal discrepancy.[14] Premolars and molars are usually the extraction options in Class III treatment.

Premolar extraction is a useful approach to relieve crowding in the anterior segment. However, the disadvantage is more distal tipping of lower incisors compared to extraction of posterior teeth.[15] Molar extraction is not useful for relieving anterior crowding, and closing extraction spaces is time-consuming, but it creates more space (10-11mm) for retraction compared to premolar extraction (7mm).[14]

Arch expansion is feasible with Invisalign® to resolve crowding and anteroposterior problems.[16,17] An 1mm increase in the inter-molar width will allow for approximately 0.6mm of space creation within the arch.[13] According to Ali et al.,[18] dental arch expansion should be limited to 2-3 mm per quadrant in order to minimize the risk of relapse and gingival recession. However, overcorrection of expansion in the maxillary posterior segment is suggested in order to achieve the desired expansion results. The accuracy of planned maxillary arch expansion with Invisalign® is 72.8%, while the accuracy for mandible was more precise, which is 87.7%.[19]

Conclusions

Skeletal Class III malocclusions often require extraction to provide space for mandibular distalization. However, when the patient refuses extraction, other methods of space creation such as IPR, arch expansion, and retraction can be adopted. When correcting anterior crossbite, buccal shelf screws and Class III elastics are viable choices to achieve a successful outcome.

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Discrepancy Index Worksheet

TOTAL D.I. SCORE: 32

OVREJET

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. 9.5mm	=	5 pts.

Negative OJ (x-bite) 1 pt. per mm. Per tooth = 2mm

Total = 2

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 = 0

LATERAL OPEN BITE

2 pts. per mm. Per tooth

Total = 0

CROWDING (only one arch)

1 - 3 mm.		=	1 pt.
3.1 - 5 mm.		=	2 pts.
5.1 - 7 mm.	6mm (upper)	=	4 pts.
> 7 mm.		=	7 pts.

Total = 1

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 = 0

BUCCAL POSTERIOR X-BITE

2 pts. Per tooth Total = 4

CEPHALOMETRICS (See Instructions)

ANB ≥ 6° or ≤ -2° = 4 pts.

Each degree < -2° 1 x 1 pt. = 1

Each degree > 6° ____ x 1 pt. = ____

SN-MP

≥ 38° = 2 pts.

Each degree > 38° 5 x 2 pts. = 10

≤ 26° = 1 pt.

Each degree < 26° ____ x 1 pt. = ____

1 to MP ≥ 99° = 1 pt.

Each degree > 99° ____ x 1 pt. = ____

ANB= -3°
SN-MP= 43°

Total = 17

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 pt.	=
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	____ x 2 pts.	=

Identify:

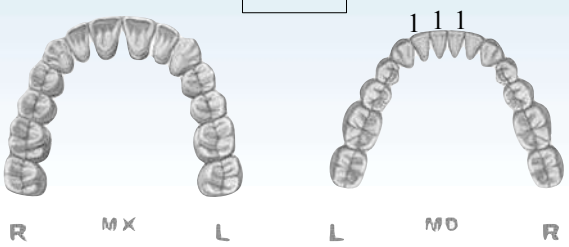
Total = 0

Cast-Radiograph Evaluation

Total Score: 24

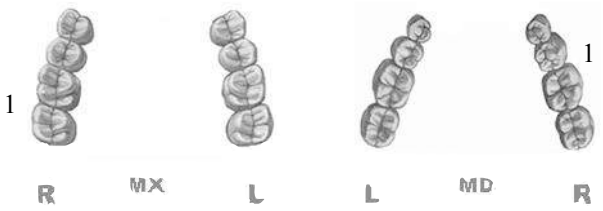
Alignment/Rotations

3



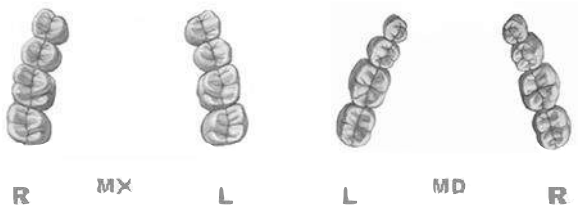
Marginal Ridges

2



Buccolingual Inclination

0

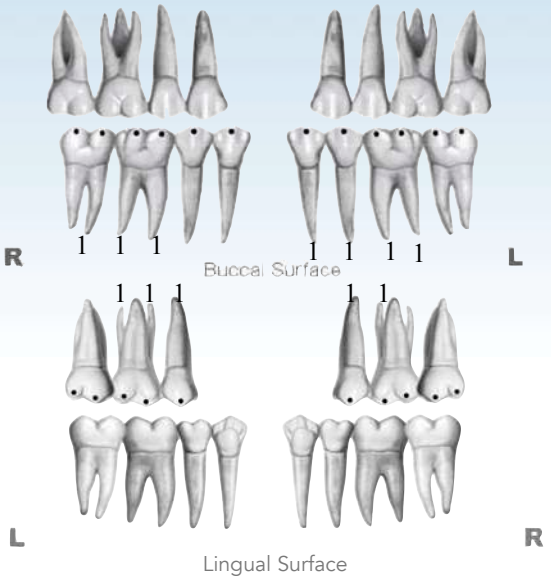


Overjet

0

Occlusal Contacts

12

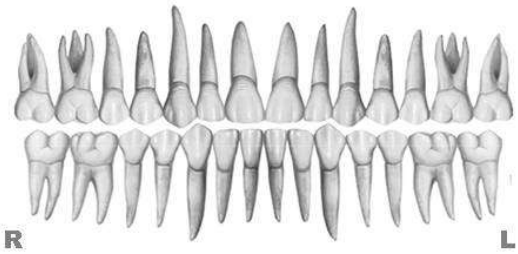


Occlusal Relationships

5

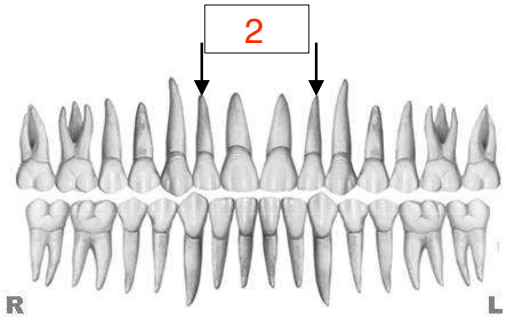
Interproximal Contacts

0



Root Angulation

2



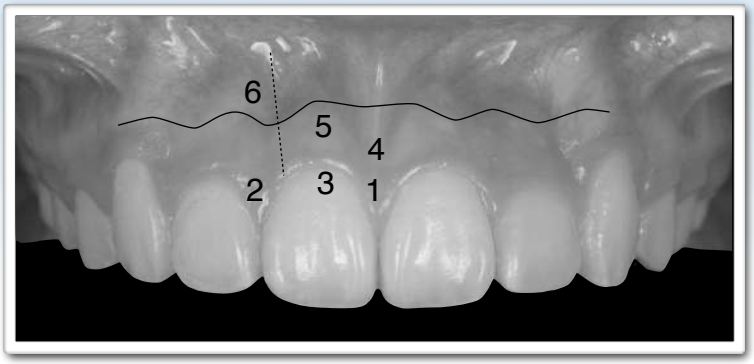
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

Total Score = 4

1. Pink Esthetic Score

Total = 0

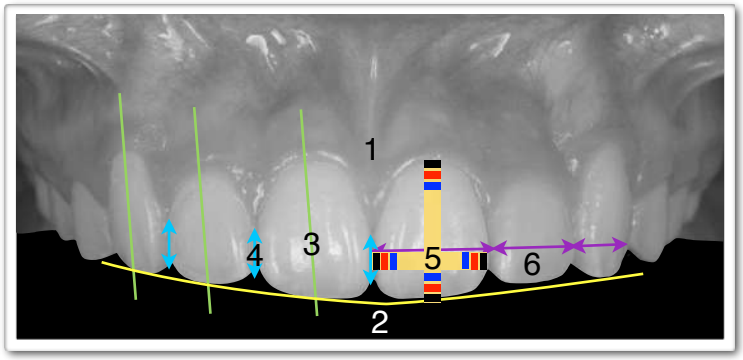


1. M & D Papillae	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

1. M & D 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-esthetic)

Total = 4



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	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	0	(1)	2
6. Tooth to Tooth Proportion	0	(1)	2

International Association for Orthodontists & Implantologists

Join the *iAOI* the future of dentistry!

About our association-iAOI

International Association of Orthodontists and Implantologists (iAOI) is the world's first professional association dedicated specifically for orthodontists and implantologists. The Association aims to promote the collaboration between these two specialties and encourage the combined treatment of orthodontic and implant therapy in order to provide better care for our patients.

How to join iAOI?

Certified members of the Association are expected to complete the following three stages of requirements.

1. Member

Doctors can go to http://iaoi.pro to apply for membership to join iAOI. Registered members will have the right to purchase a workbook in preparation for the entry exam.

2. Board eligible

All registered members can take the entry exam. Members will have an exclusive right to purchase a copy of iAOI workbook containing preparation materials for the certification exam. The examinees are expected to answer 100 randomly selected questions out of the 400 ones from the iAOI workbook. Those who score 70 points or above can become board eligible.

3. Diplomate

Board eligible members are required to present three written case reports, one of which has to be deliberated verbally. Members successfully passing both written and verbal examination will then be certified as Diplomate of iAOI.

4. Ambassador

Diplomates will have the opportunity to be invited to present six ortho-implant combined cases in the iAOI annual meeting. Afterwards, they become Ambassador of iAOI and will be awarded with a special golden plaque as the highest level of recognition in appreciation for their special contribution.

For more information on benefits and requirements of iAOI members, please visit our official website: http://iaoi.pro.

iAOI Ambassador & Diplomate

國際矯正植牙大使與院士

Ambassadors

Dr. Kenji Ojima◆

Dr. 林詩詠 Joshua Lin*▲

Dr. Diego Peydro Herrero◆

New Dr. 陳俊宏*▲ Chun-Hung Chen

Dr. 張銘珍* Ming-Jen Chang

Dr. 曾令怡*▲ Linda Tseng

Ambassador（大使）:

- * *One who has published 9+ case reports in JDO.*
- ◆ *Keynote speakers for iAOI annual workshops*
- ▲ *Case report(s) published at least once in referral journals.*
- ● *Referral journals/Research paper - 3 points*
  ABO case report - 2 points
  Clinical tip - 1 point

Diplomates

Dr. 徐玉玲 Lynn Hsu▲

Dr. 李雙安 Angle Lee▲

Dr. 蘇筌瑋 Bill Su

Dr. 葉信吟 Hsin-Yin Yeh▲

Dr. 徐重興 Eric Hsu▲

Dr. 黃育新 Yu-Hsin Huang

Dr. 黃祈 Richie Huang

Dr. 邱上珍 Grace Chiu▲

Dr. 黃瓊嫥 Sabrina Huang

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