Class III Malocclusion with Camouflage Treatment and Implant Site Development

Summary

A 28-year-old woman presented for orthodontic evaluation with a concave profile, anterior cross-bite, multiple missing teeth, and a skeletal Class III malocclusion. The ABO Discrepancy Index (DI) was 50. Because of asymmetric tooth loss in the lower arch, space was closed for a fixed prosthesis on the right side, but the left side was prepared for an implant, by moving the second premolar distally to develop a more favorable implant site. A passive self-ligating appliance, with bite turbos and bone screw anchorage, achieved optimal occlusal function and pleasing esthetics. This severe mutilated malocclusion was treated to an acceptable dental outcome in 49 months: cast-radiograph evaluation (CRE) of 32 with a pink and white dental esthetics score (P&W) of 3. (Int J Orthod Implantol;39:24-49)

Key words:
Implant site development, anterior cross-bite, Class III malocclusion, non-extraction, miniscrews, extra-alveolar anchorage.

History and Etiology

A 28-year-old female sought orthodontic treatment for a concave profile and irregular dentition (*Figs. 1 and 2*). Clinical evaluation revealed a Class III molar relationship, anterior crossbite, and a crowded maxillary anterior segment. Cephalometric radiographs before and after treatment document the conservative correction of the severe Class III skeletal relationship (*Figs. 2 and 3*). Before treatment photographs of the maxillary anterior segment show severe crowding and an anterior crossbite (*Fig. 4*). There was no contributing medical history nor known habits, but the asymmetric loss of mandibular molars was a challenging complication. The etiology of the Class III malocclusion was probably ectopic eruption of the maxillary central incisors, and the tooth loss was due to caries. Superimposition of cephalometric tracings (*Fig. 5*) document the successful dentofacial management of the severe skeletal malocclusion.

Diagnosis

Skeletal:

- Class III (*SNA 83°, SNB 87°, ANB -4°*)
- Insufficient bone height and width of the implant site in the area of tooth #19

Dental:

- Angle Classification: *Class III on both sides*
- Tooth Size to Arch Length Discrepancy: *10 mm in the maxillary arch*
- Blocked out: *teeth #6 and 11*
- Crossbite: *teeth #3-5 and #7-10*
- Missing Teeth: *#19 and 30*
- Compromised Prosthesis: *Teeth #29-31*
- American Board of Orthodontics (*ABO*) Discrepancy Index (*DI*): *50 (see subsequent work sheet)*

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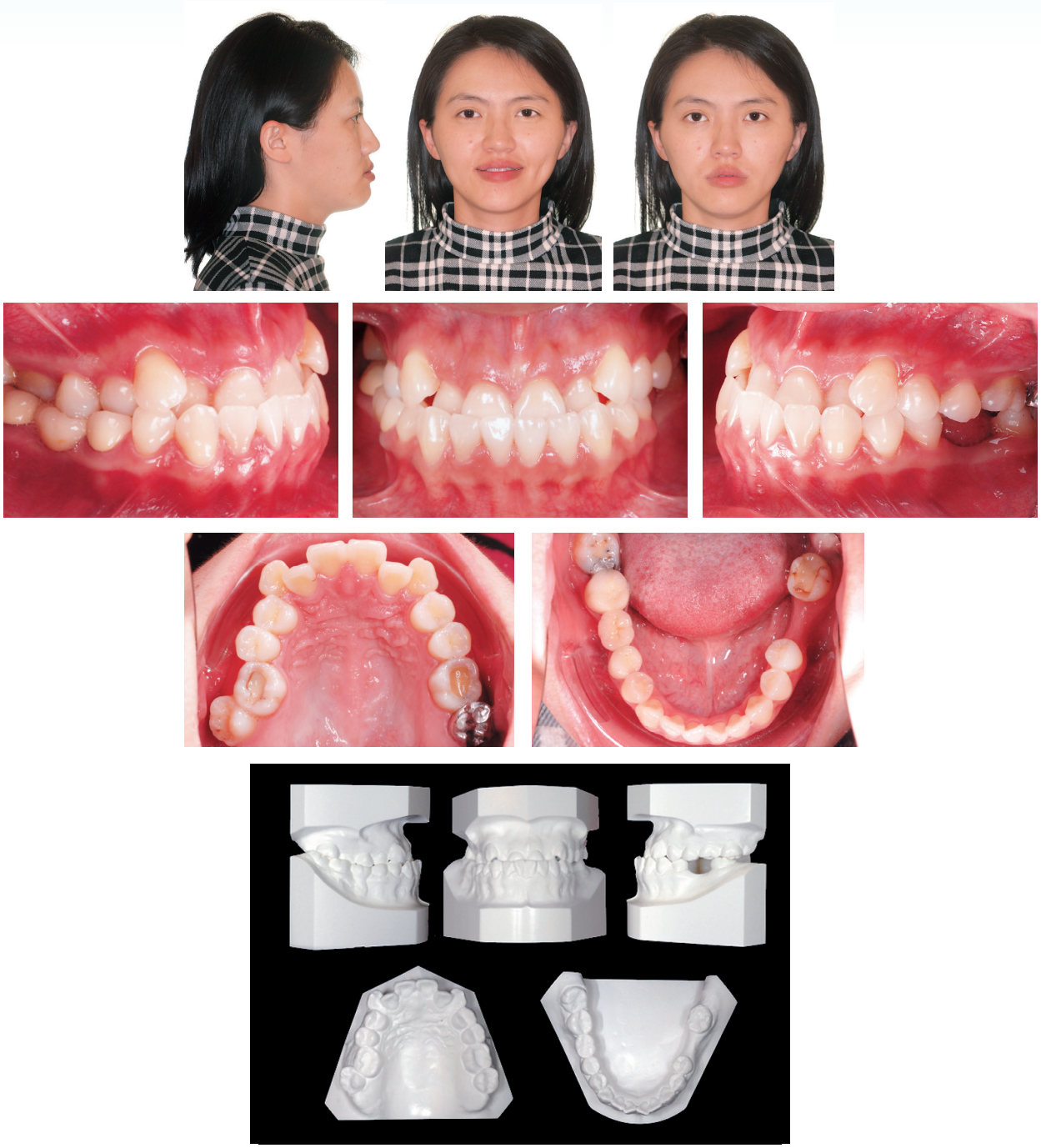


Fig. 1: Pre-treatment facial, intraoral photographs and dental models (casts)

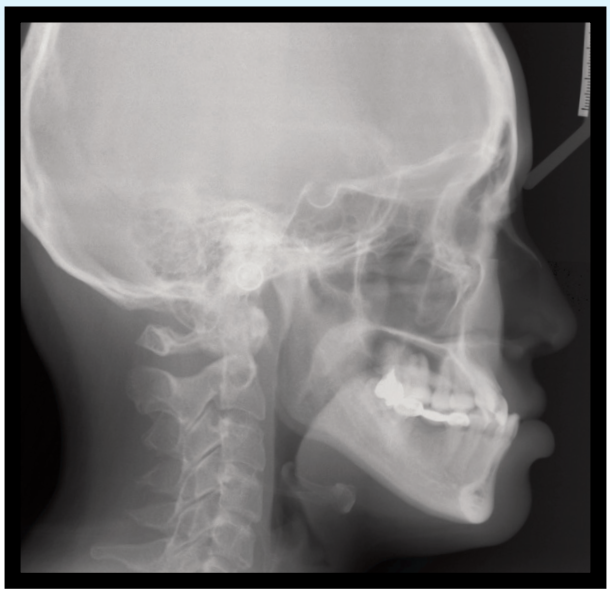


Fig. 2: Pre-treatment cephalometric radiograph

Fig. 3: Post-treatment cephalometric radiograph

Facial:

- Concave profile with protrusive lower lip

Specific Objectives of Treatment

Maxilla (*all three planes*):

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

Mandible (*all three planes*):

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

Maxillary Dentition

- A - P: *Retract molars and incisors*
- Vertical: *Maintain*
- Inter-canine Width: *Increase*

Fig. 4:
Pre-treatment photographs show maxillary crowding, anterior crossbite, and blocked-out canines.

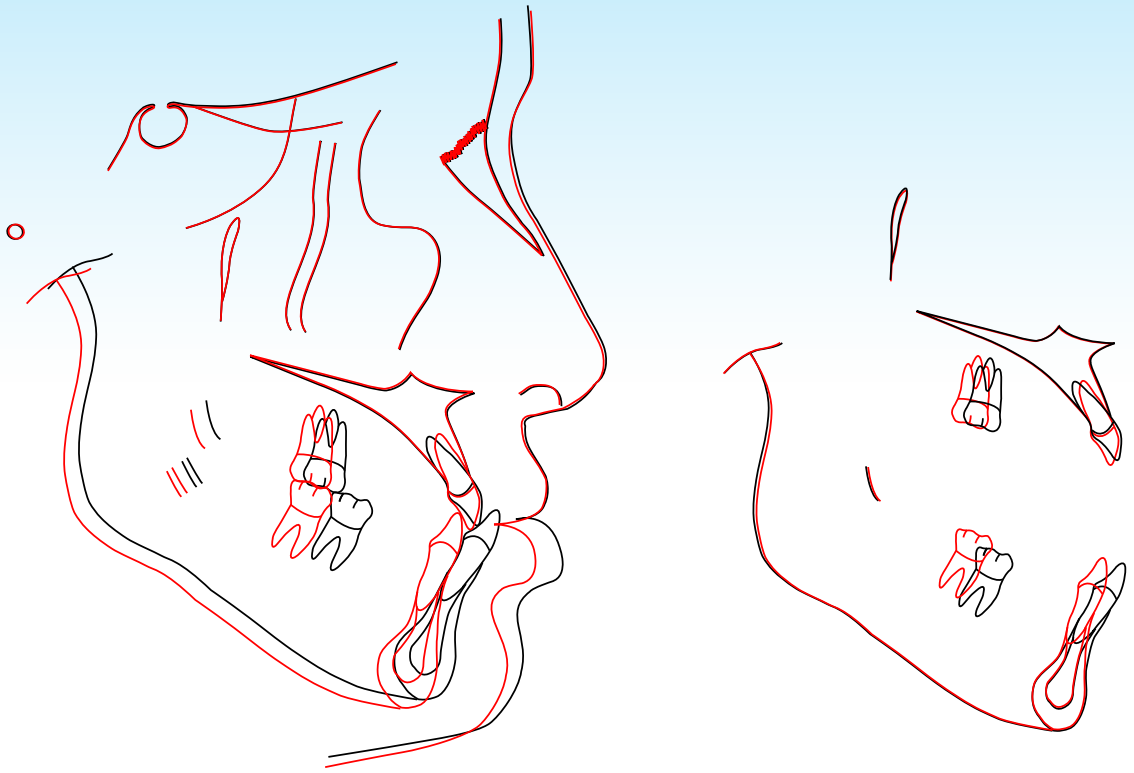


Fig. 5:
Superimposed cephalometric tracings show dentofacial changes over 49 months of treatment (red) compared to the pretreatment positions (black).

- Inter-molar Width: *Increase*
- Buccolingual Inclination: *Increase*

Mandibular Dentition

- A - P: *Retract incisors and molars*
- Vertical: *Maintain*
- Inter-canine Width / Inter-molar Width: *Maintain*
- Buccolingual Inclination: *Maintain*

Facial Esthetics:

- Correct concave profile and protrusive lower lip

Treatment Alternatives

Since the patient had a concave profile and asymmetric missing lower molars (#*17, 19 and 30*), several treatment plans were proposed. In the first scheme proposed removing the existing lower right

CEPHALOMETRIC			
SKELETAL ANALYSIS			
	PRE-Tx	*POST-Tx*	*DIFF.*
SNA°	83°	83°	0°
SNB°	87°	85°	-2°
ANB°	-4°	-2°	-2°
SN-MP°	29°	29°	0°
FMA°	22°	22°	0°
DENTAL ANALYSIS			
U1 TO NAmm	7.0mm	6.5mm	-0.5mm
U1 TO SN°	115°	112°	-3°
L1 TO NBmm	7.0mm	1.0mm	-6.0mm
L1 TO MP°	89°	80°	-9°
FACIAL ANALYSIS			
E-LINE UL	-2.0mm	-2.5mm	0.5mm
E-LINE LL	3.5mm	-1.0mm	-4.5mm

Table 1: Cephalometric summary

fixed prosthesis, extracting both the endodontically treated lower left second molar (*#18*) and the upper left second molar (*#15*), and placing an implant to replace the missing molar #19. The patient was concerned about losing two additional teeth, so she rejected it. The second treatment plan retained both molars, but as before proposed an implant-supported prosthesis to replace #19. However, the use of implants was handicapped by a narrow implant site that required bone augmentation. The patient found bone grafting to be undesirable, so another treatment modality was proposed. In the third treatment plan, the second premolar would be retracted for implant site development, thereby creating a space between the lower left premolars. This approach would produce a three premolar morphology on the lower left side, resulting in a compromised Class II molar occlusion. Also, miniscrews in the infrazygomatic (*IZC*) crests may be needed to retract the upper dentition. Accepting these limitations, the patient agreed to the third treatment plan.

Appliances and Treatment Progress

An .022" slot D3MX® fixed appliance (*Ormco Corporation, Glendora, CA*) was selected, and the following third-order adjustments were specified: standard torque brackets were bonded inversely (*upside down*) on upper incisors, and low torque brackets bonded inversely on lower incisors. The initial archwire was .014" CuNiTi.[1-4] Bite turbos composed of glass ionomer cement were bonded on the lower central incisors. After three months of alignment and leveling, the crossbite problem was resolved, and the bite turbos were removed. Then Class III early light short elastics (*2oz, 3/16"*) were applied, and in the 7th month, the arch wires were changed to .014x.025" CuNiTi. The posterior crossbite between the upper right first molar and the lower second molar was corrected by bonding a button on the palatal surface of the upper first molar, and applying a cross elastic (*3oz, 1/8"*) to the labial surface of the lower second molar. In the 12th month, the wires were changed to .017x.025" titanium molybdenum alloy (*TMA*). Space redistribution for implant site development was initiated by compressing a coil spring between the lower left premolars. Bracket repositioning to correct second order axial inclinations was performed according to a progress panoramic radiograph. Class III elastics (*3.5oz, 3/16"*) were used to correct the sagittal relationships. In the 18th month, the wire was changed to .019x.025" stainless steel (*SS*) in the upper arch and .016x.025" SS in the lower arch. At this point, the space between the lower left posterior teeth was closed, but the upper anterior teeth were flared severely. Two OrthoBoneScrews® (*Newton's A, Hsinchu City, Taiwan*) were placed bilaterally in the IZC to distalize the whole maxillary dentition.[5,6] Reshaping the contour of the maxillary and mandibular incisors was performed to eliminate the interdental dark triangles. Power chain links and power tubes were used to close the space. In the 32nd month, the space between the lower right posterior teeth was closed (*Figs. 6-9*). Consistent with principles of implant site development[7-11] and the achievement of optimal periodontal support,[12-14] the width of the edentulous ridge was increased from 4-8mm (*Fig. 10*) by retraction of the second premolar (*#20*) (*Fig. 11*).

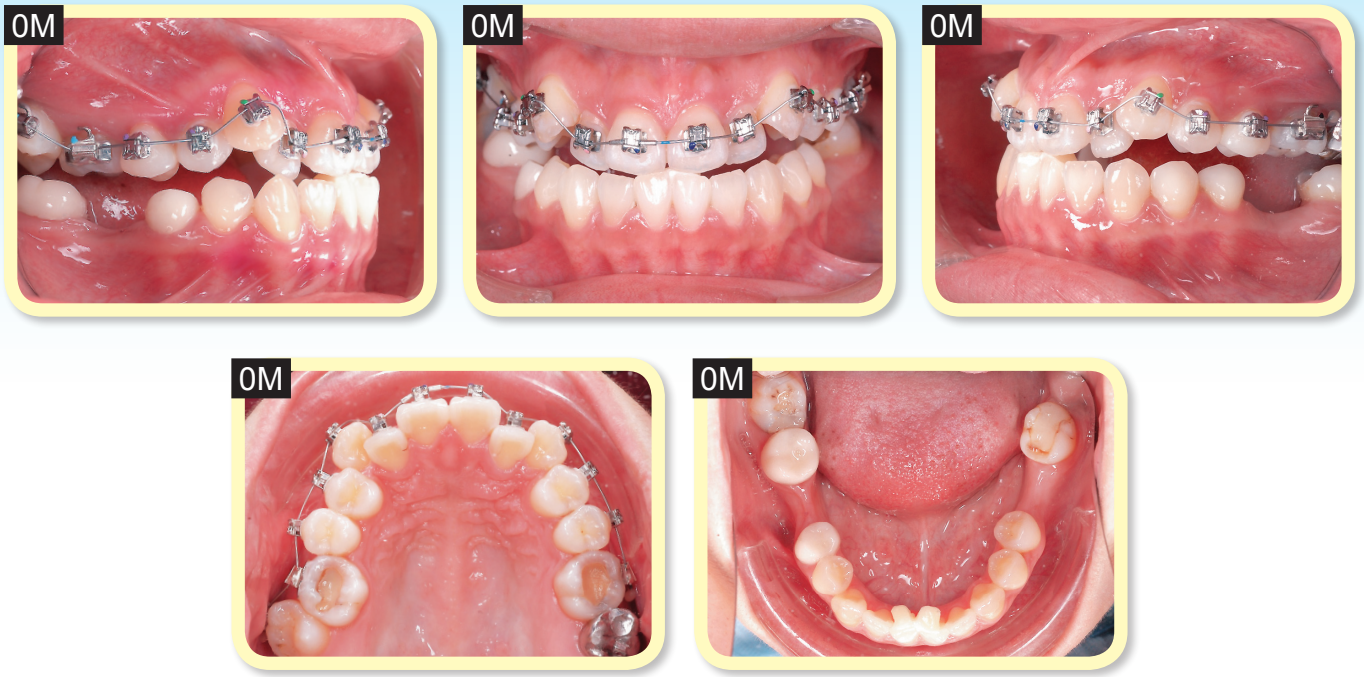


Fig. 6:
At the beginning of the treatment, brackets were bonded on the upper arch, and an .014" CuNiTi arch wire was applied. Two bite turbos were bonded on the lingual surface of the mandibular central incisors to open the bite for correction of the anterior cross bite.

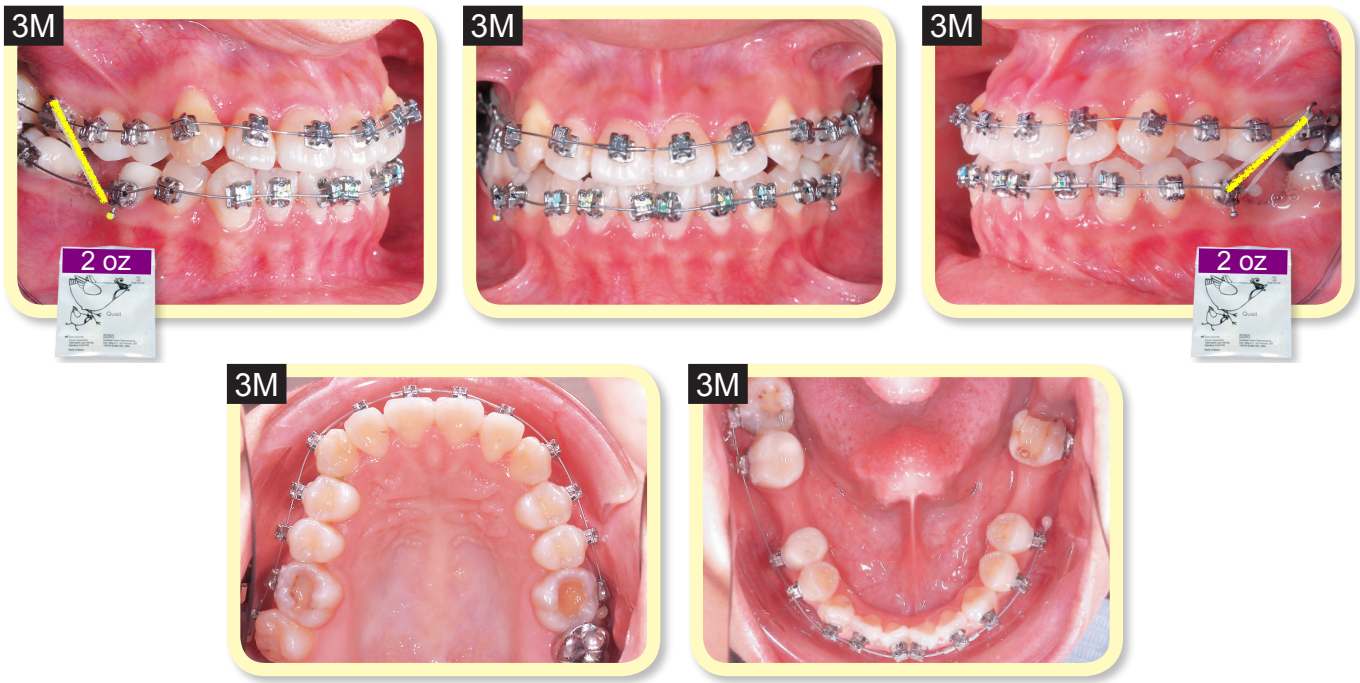


Fig. 7:
In the third month of the treatment, brackets were bonded on the lower arch, and .014" CuNiTi arch wires were applied to both arches. Class III elastics (Quail, 2oz, 3/16") were used from the maxillary first molar to the mandibular second premolar. The anterior bite turbos were removed since the cross bite had been resolved.

Fig. 8:
In the eighteenth month of the treatment, the arch wires were .016x.025" SS in the upper and .017x.025" TMA in the lower. Abundant use of class III elastics resulted in flaring of the upper incisors. The application of class III elastics were stopped and two OrthoBoneScrews were inserted on the infrazygomatic crests (IZC) bilaterally to retract the entire maxillary dentition.

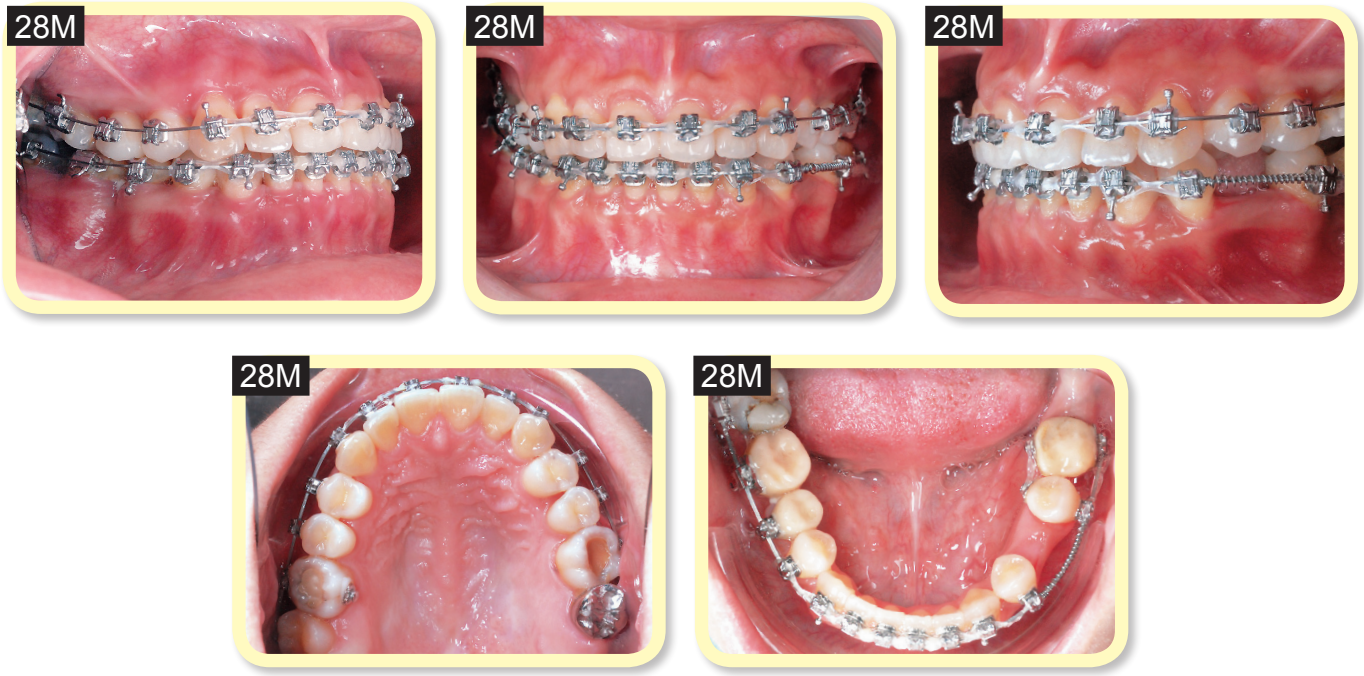
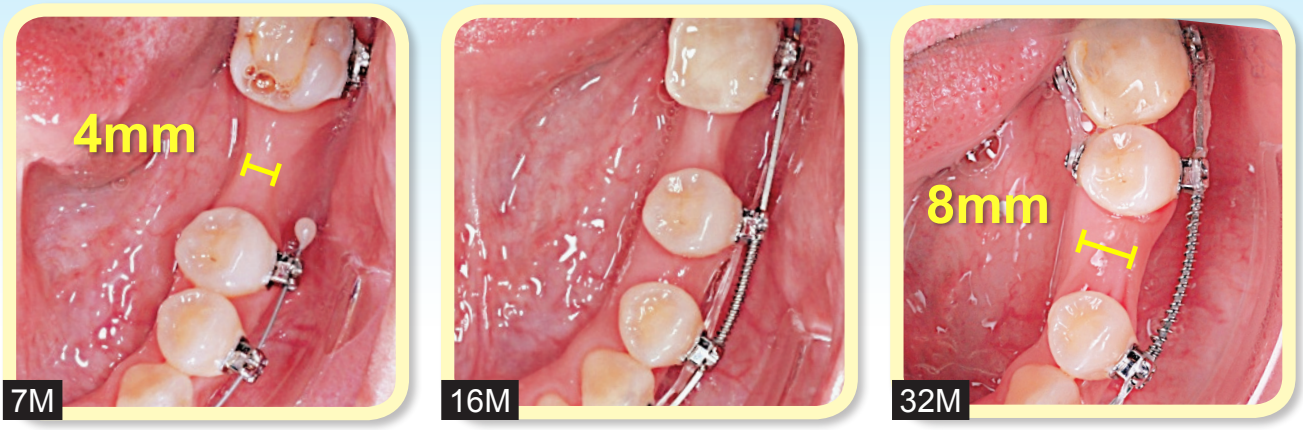
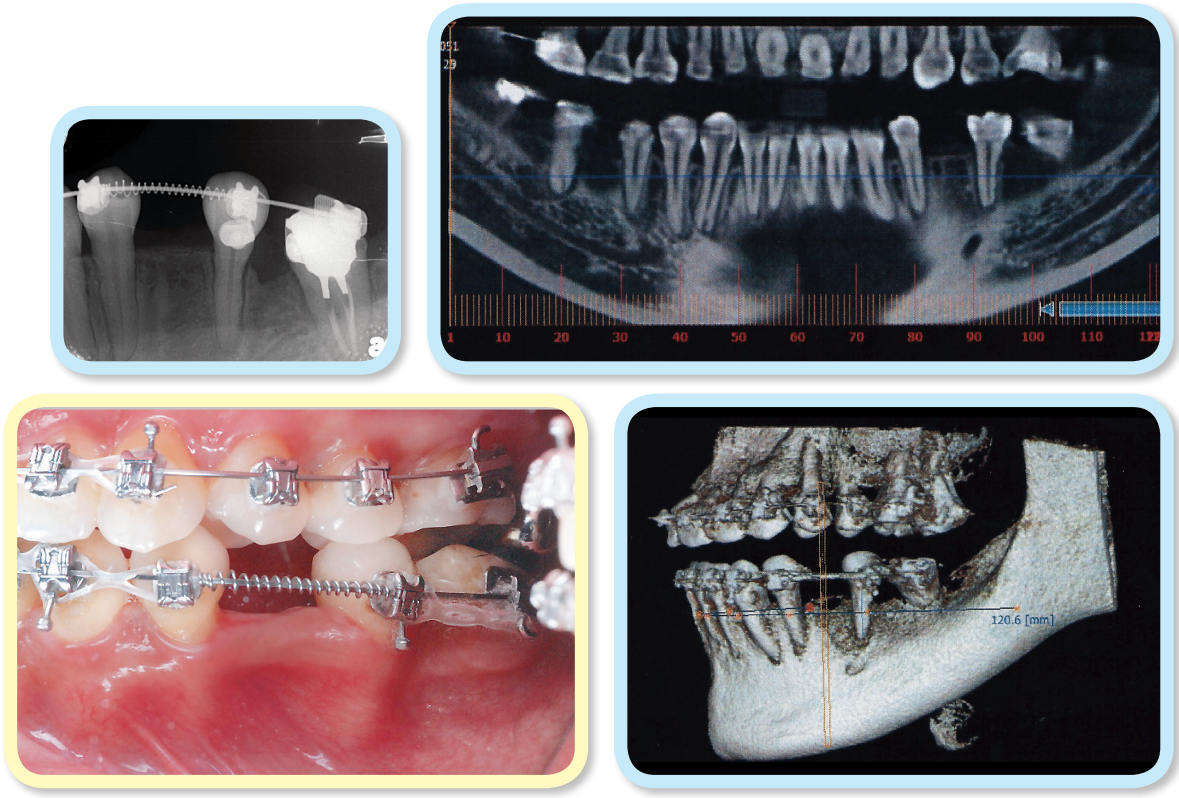


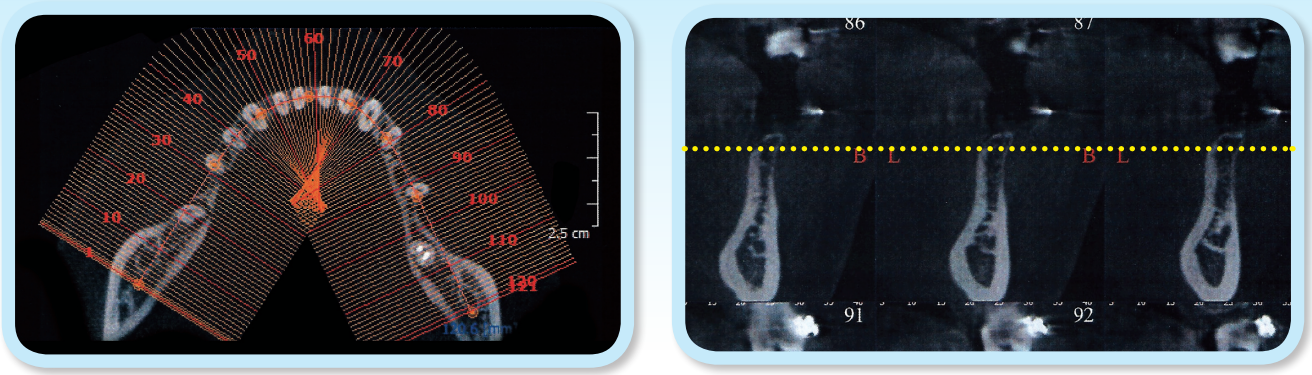
Fig. 9:
In the twenty-eight month (28M) of the treatment, the lower arch wire was .016x.025" SS. The space between the mandibular left premolars was enough for an implant.



Figs. 10:
Before the implant site development, the width of the alveolus at seven months (7M) was about 4mm and the arch wire was .014x.025"CuNiTi (left). At sixteen months (16M) space was being opened between the premolars with a compressed coil spring on a .017x.025" TMA arch wire (middle). At thirty-two months (32M) the width of the implant site was about 8mm. Thus ~24 months of the implant site development enlarged the width of the atrophic ridge from 4 to 8mm.



Figs. 11:
After the space was created (upper left and right), a concavity was noted on the buccal aspect of the implant site (lower left). A follow-up cone beam computed tomography (CBCT) image shows relatively low bone density in the implant site (lower right).



Figs. 12:
The CBCT scan (left) revealed that trimming 2mm of the irregular top of the ridge resulted in 5mm of bone width (right) to place the implant.

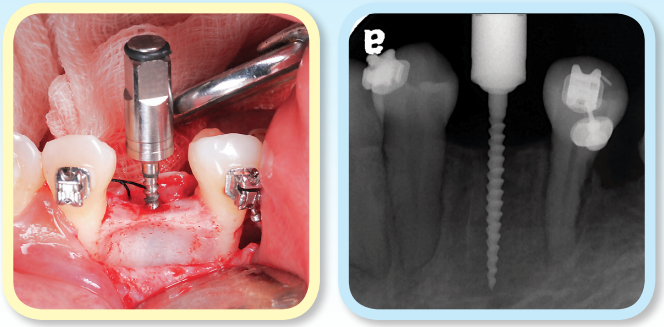
Implant Placement

A pre-operative Cone-Beam Computed Tomography (*CBCT*) scan was taken to evaluate the alveolar bone volume in the implant site (*between #28 and 29*). Also, the mental foramen was located and the depth of implantation site was decided. From the slice views, it was apparent that reducing the ridge height 2mm would result in 5mm of implant site width (*Fig. 12*). The goal was to place an implant, that was 3.5mm in diameter and 11mm in length. The surgical stent was designed for precise implant placement in three dimensions. The implant fixture was positioned 3mm below the future crown margin, with a distance of at least 1.5mm from the adjacent teeth. The 2B-3D rule for dental implant planning, placement and restoration was followed.[15] A crestal incision was performed at the lingual line angle with a No.15c scalpel. Sulcular incisions were made on the buccal and lingual sides of the adjacent teeth, followed by reflection of full-thickness mucoperiosteal flaps.

Figs. 13:
The alveolar ridge was incised with a #15 scalpel to prepare for flap reflection.

Fig. 14:
The surgical stent was fitted to guide the first lancer drill for the initial osteotomy.

After 2mm of the ridge was trimmed, the surgical stent was fitted to guide the first lancer drill for the initial osteotomy. A periapical film was taken with a surgical guide pin placed to check the long axis of the osteotomy and its distance from the adjacent teeth (*Figs. 13-15*). Following the manufacturer's



Figs. 15:
To assess the position of the initial osteotomy, a surgical guide pin was placed (left) and a periapical radiograph was taken to check the mesiodistal angulation and the distance to the adjacent teeth (right).

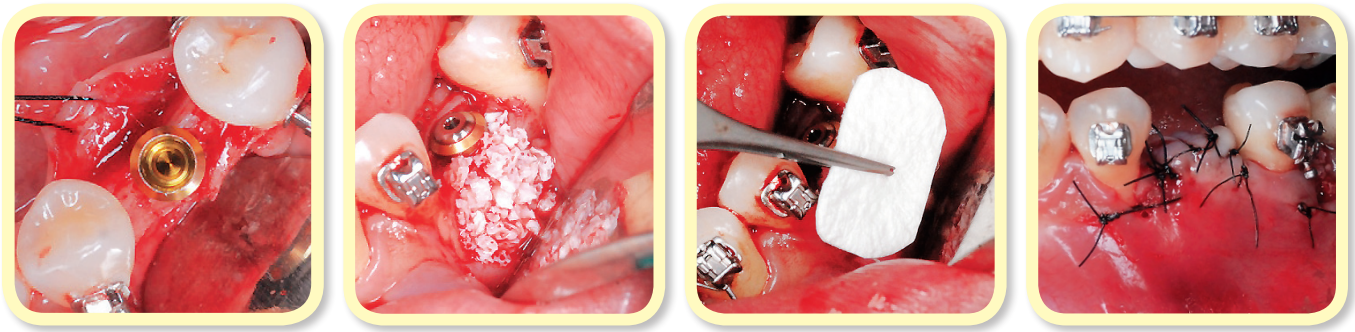
instructions the ridge was expanded step by step until the size of the expansion drill was the closest but still less than the desired implant diameter. Then, an implant fixture (*Ø3.5X8.5mm, TwStar® MegaGen® Taiwan*) was installed with a torque of 30 N-cm. After implant placement, there was a greenstick fracture noticed in the buccal plate, that was covered with a bone graft (*Bio-Oss® Geistlich Biomaterials*) and a membrane (*Lyoplant® B. Braun*), and then sutured. The flap was repositioned and closed with interrupted 5-0 nylon sutures (*Fig. 16*). Post-operative periapical radiographs were taken to check the position and angulation of the implants.

Orthodontic Finishing Stage

In the 37th month, reshaping the contour of the maxillary right incisors was performed to eliminate the interdental dark triangles. The upper right central incisor bracket was also repositioned as indicated by the panoramic film. Before de-bonding, a small interproximal space (*1-2mm*) reopened, so a fixed prosthesis was constructed to retain the corrected position. After 39 months of active treatment, all fixed appliances were removed. Upper and lower clear overlay retainers were delivered for both arches, and the patient was scheduled for the implant placement surgery.

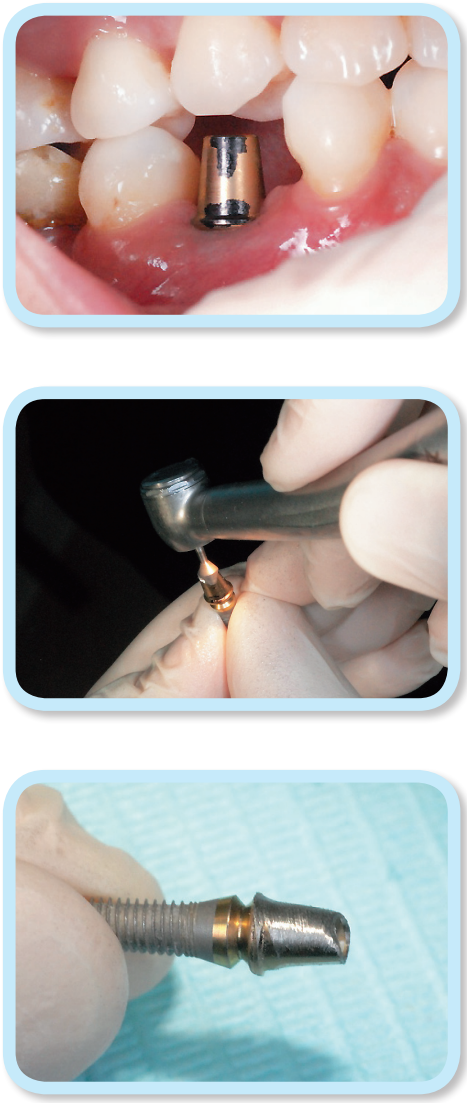
Implant Prosthesis Fabrication

Prosthesis fabrication procedures were performed about five months after the implant was installed. The post height of the abutment was marked and then reduced extra-orally with a diamond bur to achieve 2mm of occlusal clearance for the fabrication of a porcelain fused to metal crown (*Fig. 17*). The cuff height of the abutments was also marked and prepared, to conform to the soft tissue contour. Prior to making the impression,



Figs. 16:
The implant fixture was installed, but the buccal bone plate was less than 2mm thick, and a green-stick fracture was noted on the buccal surface (left). A cover screw was secured and synthetic bone graft material was gently packed over the site (center left). Then, a collagen membrane was positioned over the site (center right), extending within the incision line. The flap was repositioned and sutured (right).

the abutment screw was torqued to 35-N-cm (*Fig. 18*). The screw access hole for the abutment was fitted with a small cotton pledget and closed with a temporary sealing material (*Caviton, GC*). Double core packing impression technique was chosen. A thinner (*KnitTraxTM, #00*) gingival retraction cord for soft tissue compression was placed first. Then a thicker cord (*KnitTraxTM, #1*) for soft tissue reflection was packed in the crevice with a cord packing instrument (*Fig. 19*). When adequate tissue retraction was achieved, a direct impression was made with polyvinyl siloxane impression material. Following the impression, the retraction cords were removed, and the interocclusal index was recorded



Figs. 17:
After being marked (left), the abutment was reduced (center) and polished to provide clearance for the fabrication of the porcelain fused to metal crown (right).

Fig. 18:
Before making the impression, the abutment screw was torqued to 35-N-cm with a screw driver and a torque ratchet.

Fig. 19:
Retraction cord was positioned with a packing-placement instrument (left), and a direct impression was obtained (right).

with bite registration material. The impression was poured in type IV dental stone, and the casts were subsequently mounted on an articulator using the bite record (*Fig. 20*).

Two single, porcelain fused to metal crowns were fabricated by a commercial laboratory for the lower left second premolar and second molar. A similar fixed prosthesis was made to bridge the lower right second premolar and first molar. The marginal integrity was verified with a dental explorer and appropriate tightness of the contact area was confirmed with dental floss. After clinical adjustment and verification of fit and occlusion, the crown removing lugs on the lingual side were trimmed away. The permanent crowns and bridge were then luted into place with permanent cement (*Fig. 20*).

Results Achieved

The final dentofacial result is documented with photographs and casts in Fig. 21. The therapeutic sequence is illustrated with a series of four panoramic radiographs exposed at the following stages during the treatment: start (*0 M*), twenty-three (*23 M*), thirty-two (*32 M*), and forty-nine (*49 M*) months (*Fig. 22*).

Maxilla (*all three planes*):

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

Mandible (*all three planes*):

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

Maxillary Dentition

- A - P: *Retracted*
- Vertical: *Maintained*
- Inter-canine Width: *Maintained*
- Inter-molar Width: *Increased*
- Incisor Control: *Retracted and extruded slightly*
- Alignment: *Rotations of teeth #2 and 4*
- Marginal Ridges: *Discrepancies between teeth #2, 3, 15, and 16*

Figs. 20:
The impression was poured in type IV dental stone and sectioned for prosthesis fabrication (left). The final prostheses were completed (center). After subtle adjustments, the permanent crowns were completed and luted into place (right).

Figs. 21: Post-treatment facial, intraoral photographs and dental models (casts)

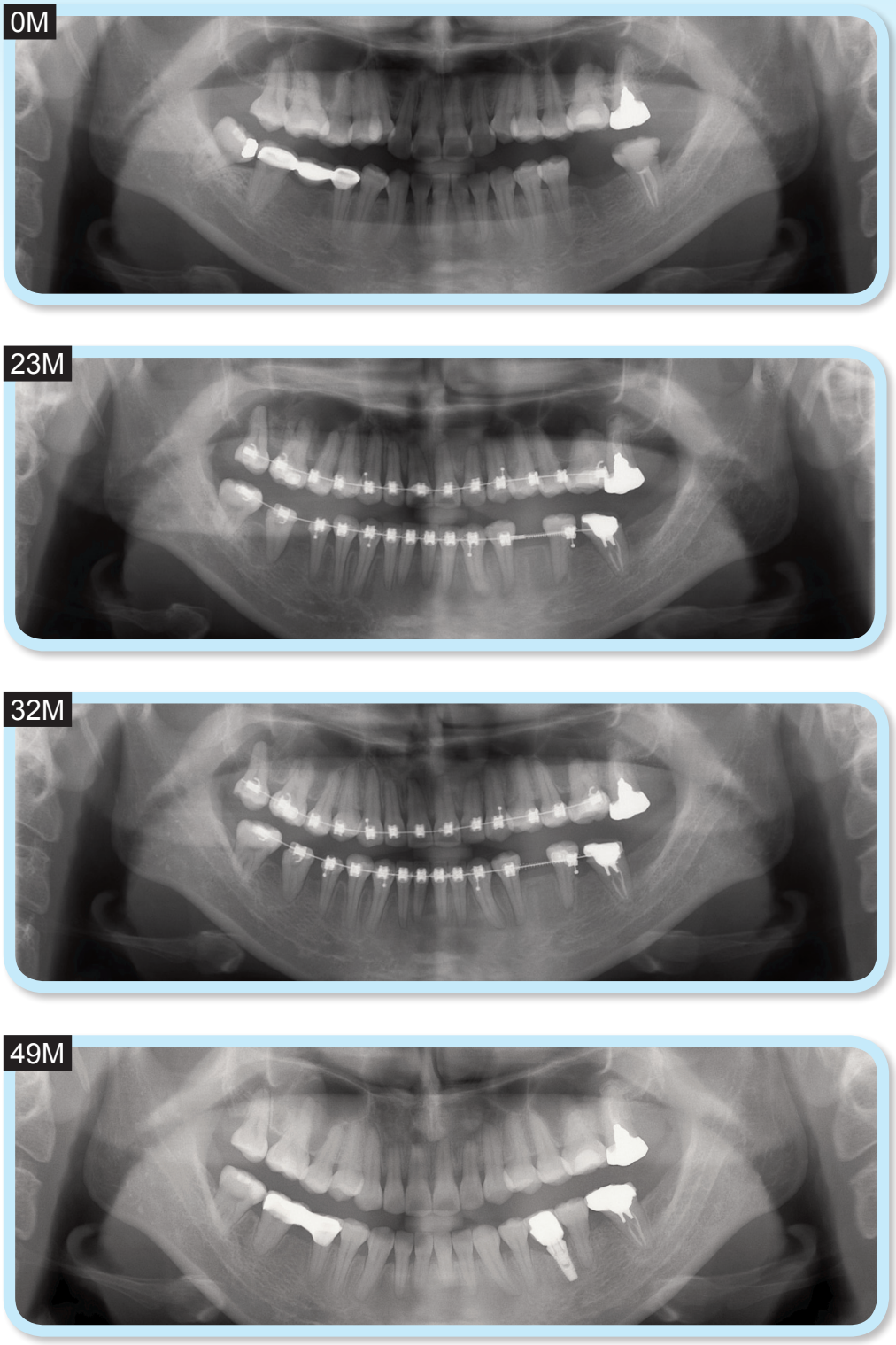


Fig. 22:
The panoramic radiographs show the progress of the treatment at the start (0M), 23 months into treatment (23M), 32 months into treatment (32M), and at the finish, following 49 months of treatment (49M).

- Buccolingual Inclination: *Flaring of teeth #2 and 15*

Mandibular Dentition

- A - P: *Retracted*
- Vertical: *Molars extruded*
- Inter-canine Width: *Decreased*
- Inter-molar Width: *Decreased slightly*
- Incisor Control: *Retracted*
- Alignment (*Rotations*): *Distal-in tooth #19, mesial in tooth #27, and mesial-out tooth #31*
- Marginal Ridges: *Discrepancy between teeth #31 and 32*
- Buccolingual Inclination: *Lingual tipping on teeth #18, 19, and 30*

Facial Esthetics:

- Lower lip retracted to significantly improve the facial profile

Retention

Upper and lower clear overlay retainers were delivered after the fixed appliances were removed. A new lower overlay retainer was made after the completion of the implant-supported crown. The patient was instructed to wear the retainers full time for the first 6 months and nights only thereafter. Home care and retainer maintenance instructions were provided.

Final Evaluation of Treatment

The final alignment was assessed at 32 points with the ABO CRE, as documented on the form that appears later in this report. This was considered an acceptable result for a severe Class III, mutilated malocclusion (*DI=50*), but it was not ideal because of the following discrepancies:

1. Alignment and rotation: 8 points were scored for the buccal positions of the second molars, and distal out rotation of the lower left canine.

2. Marginal ridge discrepancies: 6 points were scored for maxillary premolars and molars.

3. Buccolingual inclination: 10 points were scored for molar discrepancies form ideal.

4. Occlusal contacts: 2 points were scored for the absence of antagonist contacts on second molars.

5. Occlusal relationship: 3 points were scored for interdigitation problems.

6. Root Angulation: 1 point was scored for inadequate alignment of the lower left premolar region.

The Pink and White (*P&W*) score of 3 was excellent for soft and hard tissue esthetics in the maxillary anterior segment, as will be subsequently documented.

Discussion

The current difficult malocclusion (*DI 50*) was corrected with extensive interdisciplinary therapy. Some of the more important aspects of the treatment will be discussed separately.

Bracket Selection

It is well known that upper incisors flare when crowding is corrected without extractions or enamel stripping. This problem is enhanced with the use of Class III elastics. To resist these undesirable changes, low torque braces are indicted for the maxillary incisors (*Fig. 23*). A convenient method for a low torque effect is to bond standard brackets inversely (*upside down*). In this way, the torque value achieved is -12 and -8°, which helps prevent incisal flaring (*Fig. 24*). In addition, the abundant use of Class III elastics tends to tip lower incisors distally, so high torque brackets are indicated. Since there are no high torque brackets designed for lower incisors in the D3MX series, low torque brackets bonded inversely to establish the desires torque (*Fig. 24*).

Fig. 23:
Conservative (nonextraction) correction of maxillary anterior crowding and the use of class III elastics tends to flare maxillary incisors and tip mandibular incisors distally. To offset these side effects, decreased torque is required in upper incisor brackets and increased torque is required for lower incisor brackets. For pretorqued brackets, a convenient way to achieve the necessary incisor torque is to bond the incisor brackets inversely (upside down).

Maxillary	1	2	3
High	+17°	+10°	+7°
STD	+12°	+8°	0°
Low	+7°	+3°	---
Mandibular	**1**	**2**	**3**
High	---	+7°	---
STD	-1°	-1°	0°
Low	-6°	-6°	---

	1	2	3
Maxillary	-12°	-8°	0°
Mandibular	+6°	+6°	0°

Fig. 24:
The upper table lists torque values for maxillary and mandibular brackets in the D3MX series as follows: central incisor (1), lateral incisor (2) and canine (3). Inverting the standard (STD) brackets (arrows) results in the torque values listed in the lower table.

Implant Site Development

Orthodontic tooth movement through an edentulous site can increase bone height and width, and also result increased attached gingiva. The critical factor is the health and level of epithelial attachment of the tooth or teeth to be moved into the defect. Theoretically, implant site development[7] can be accomplished in any portion of the alveolar

ridge where an implant is to be placed,[8] and the regenerated bone width is directly related to the buccal-lingual dimension moved through the defect.[9] The bone created by moving a tooth through the edentulous site is relatively stable and the reduction of the alveolar width is relatively small. In a study by Kokich,[7] the loss of bone mass was less than 1% from the end of the treatment to 4 years after treatment. The reduction of the alveolar ridge width was less than 2% from the end of the therapy to 5 years after treatment. the principle of implant site development is also applicable to a narrow alveolar ridge.[10] A significant limitation of the studies cited is the variance that many investigators have noted, particularly in the posterior mandible as will be discussed below.

Consideration for The Present Patient

Before treatment, the width of the edentulous ridge was less than 3.5 mm, which was inadequate for an implant planned. Since avoiding a bone augmentation was desirable, two types of implant site development were considered. The first option was to retract the second premolar into the edentulous first molar area. The other option was to move the second molar into the edentulous space and to place an implant in the second molar area. The first option was chosen: retracting the second premolar to create space for an implant between the premolars on the left side. Advantages for this approach were better surgical access and more predicable production of adequate keratinized

	Implant Site Development *(second premolar retraction 5 -->)* *(second molar protraction <--7)*	Bone Augmentation *(first molar area)*
Orthodontic Treatment Time	Longer to retract the tooth	Less ✓
Recovery Time after Bone Augmentation	No (*sufficient bone*) or less ✓	Longer
Difficulty of Surgery	No (*sufficient bone*) or easier ✓	Complicated (*bone expansion or bone block technique*)
Occlusion	Compromised : 3 premolars + 1 molar 4 5 6 7 4 I_5 5 7 Better : 2 premolars + 2 molars 4 5 6 7 4 5 7 I_7	Best : 2 premolars + 2 molars 4 5 6 7 4 5 I_6 7 ✓

gingiva, which is crucial for maintaining the health of an implant. Another advantage in separating the premolars is maintenance of the interdental papilla. As two teeth are moved apart, the interproximal papilla remains adjacent to the tooth that is not moving, and a red patch, lined with non-keratinized sulcular epithelium, is created in the wake the tooth that is moved. This is called Atherton's Patch.[11] For an adult patient, there is little or no tooth eruption after orthodontic treatment,[11] so the interdental papilla may either fail to completely fill the interdental area, or its regeneration may not take place until long after the completion of orthodontic treatment. According to Tarnow,[12] when the distance from the contact point to the crest of bone is 5 mm or less, the papilla is present almost 100% of the time. However, Grunder[13] reports that the presence of the papilla is primarily determined by the bone support on the tooth side of a restored edentulous space. If there is sufficient soft tissue volume, its height can be increased by applying pressure interproximally to squeeze the papilla vertically, but only minor improvement can be expected with that procedure. Although the mandibular posterior segment is rarely an esthetic problem, inadequate papillae in the interdental areas may contribute to food impaction and soft tissue inflammation. All considered, retracting the second premolar was superior for implant site development compares to protracting the second molar.

However, when the flap was reflected during implant surgery, the buccal bone covering the lower left premolars was very thin, and a green-

Implant Site Development	Second Premolar Retraction (4 I_5 5 7)	Second Molar Protraction (4 5 7 I_7)
Occlusion	Compromised : 3 premolars + 1 molar 4 5 6 7 4 I_5 5 7	Better : 2 premolars + 2 molars 4 5 6 7 4 5 7 I_7 ✓
Keratinized gingiva around implant site	Normal ✓	Decreased / Insufficient
Difficulty of surgery *(implant insertion)*	Easier to approach ✓	Harder
Atherton's Patch	Between I_5 and 5 ✓ (*slightly aesthetics compromised*)	Between 7 and I_7

stick fracture was noticed on the buccal bone labial to the implant. The ridge width in the implant site was ~8mm, which is the approximately the buccal-lingual diameter of the second premolar. Since the gingival thickness was 1.5mm, the residual bone width at the crest was ~5mm, which is marginally adequate for placement of a 3.5mm diameter implant. However, for ridge widths of 4-5mm Wang[14] recommends ridge splitting or expansion to conserve bone, and guided bone regeneration (*GBR*) with a membrane covering may be necessary to optimize the osseous support. The flap design for GBR should be larger than for single implant surgery. *The conclusion from the present experience is that thin buccal bone before treatment is a contraindication for implant site development. Implant site development can create bone to widen an atrophic ridge, but it may not create enough bone for optimal implant support. Although ridge augmentation with bone block graft can be avoided by using the implant site development method, but GBR procedures might still be necessary at the time of implant surgery.*

Implant Replacement

The 3D placement of an implant in an appropriate, restoratively driven position requires careful planning. Mesiodistally, the implant should be placed in the center of the edentulous ridge, no closer than 1.5mm to the nearest tooth. From the buccolingual aspect, it is desirable to place the implant in the middle of the ridge, but it is essential to leave at least a 2mm thick bone plate on the buccal surface. If the bone width of the implant site is inadequate, bone augmentation is needed.

The fixture platform should be placed 3mm deeper than the predetermined final crown margin.[15] The angulation of the implant should be parallel to the adjacent teeth, and any discrepancy should be no larger than 15 degrees. During the initial implant healing phase, there is a delicate balance between the bone resorption and formation events that compose the modeling and remodeling aspects of wound healing. Osseointegration is achieved by remodeling the dead bone supporting the implant interface. After implant placement, primary mechanical stability is gradually replaced by the secondary biological stability achieved by remodeling the interface.[16,17] The first 2 to 3 weeks after implant placement is the most critical aspect of the healing period for humans, because the interface can be disrupted, leading to excessive mobility.

Relapse of Closed Space

Removing the existing fixed prosthesis (*Fig. 22*) from the lower right posterior segment exposed an edentulous area about 10mm in length. Since the second and third molars were present in that quadrant, space closure was indicated. Thirty-two months of molar protraction successfully closed the space, but it reopened again after only two months. There are multiple factors relating to the relapse of space closure.

Periodontal Factor: Teeth are retained in the alveolar bone by the following groups of supportive

fibers: (*1*) Circular fibers run in the free gingiva and encircle the tooth; (*2*) Dento-gingival fibers are embedded in the cementum of the supra-alveolar portion of the root and project from the cementum into the free gingival tissue; (*3*) Dento-periosteal fibers are embedded in the cementum of the supra-alveolar portion of the root but terminate in the tissue of the attached gingiva; (*4*) Transseptal fibers run straight across the interdental septum and are embedded in the cementum of adjacent teeth. When a tooth is extracted the interdental transeptal fibers are disrupted. As an extraction space is closed, the supracrestal fibers are compressed between approximating teeth, but there are no natural transeptal fibers connecting the newly contacting teeth, so the relapse of space closure is probable.[18] Atherton[11] noted that the approximating teeth appear to push and compress the gingiva, creating a fold of epithelial and connective tissue rather than moving through the soft tissue. The tissue compressed by space closure may provide force to reopen the space after it is closed. This undesirable sequelae is not a pathologic phenomenon, but just an unwanted aspect of normal physiology. Contrary to periodontal ligament, the collagen component of the supracrestal fibers has a very low rate of turnover, and may never fully adapt to the therapeutic change in tooth position. Fortunately, surgical fiberotomy and intervention to remove excess interdental soft tissue generates a scar-type healing reaction that has a positive effect on retention of space closure.

Dental Factor: Natural spacing in a dental arch presents one of the highest potentials for relapse when space is closed. Bonded buttons are effective for applying force on the lingual surface and for retaining space closure. A relapse of space closure can be addressed by re-closing the space and simultaneously performing a supracrestal fiberotomy. With respect to the present patient, fixed appliance retention of the buccal space closure was planned by restoring the approximated teeth with splinted crowns, so the less than 1.5mm of space reopening was easily resolved with a small metal pontic, bridging the two teeth. When closing large spaces, it is better to perform a gingivectomy during space closure whenever excess tissue appears in extraction site. *Tight space closure followed by surgical intervention to generate scar tissue is a practical biological method for eliminating the reopening of closed extraction sites.*

For the present patient, the blocked-out maxillary cuspids were due a severe tooth size to arch length discrepancy. Aligning the maxillary anterior segment, without extractions or enamel stripping, usually results in incisal flaring, and Class III elastic intensify the problem (*Fig. 23*). Bilateral miniscrews were used in the IZC to retract the entire maxillary arch. The camouflage treatment to correct the Class III buccal segments resulted in a final CRE score of 32 points, which deviated from ideal primarily in three categories: alignment/rotation, marginal ridges and buccolingual inclination.

Buccolingual inclination alone lost 12 points which indicates the lack of upper and lower buccal root torque, especially on second molars. Detailing with

third order wire bending is particularly important when arch widths are changed during treatment. Particularly for Class III patients with a transverse skeletal discrepancy, correction of buccal-lingual axial inclinations must be handled carefully to avoid gingival and/or bone clefting.

Alignment/rotation and marginal ridges lost 8 and 6 points, respectively. These deficiencies reflect bracket bonding problems and inadequate detailing adjustments during the final stage of treatment. It is often difficult to see these subtle changes clinically, so it is wise to collect prefinish records, particularly casts, about 6 months before the anticipated finish of treatment. The casts can then be scored with the CRE method to identify problems that can be corrected with bracket repositioning or wire bending during the finishing phase.[19-21]

Superimposition of the cephalometric tracings (*Fig. 5*) show the maxillary position was maintained, but the mandibular position was increased vertically, due to extrusion the molars. Both the maxillary and mandibular arches were retracted with extra alveolar bone screws, but the retraction was more pronounced in the lower arch because of the Class III elastics. The incisal tipping that usually results from Class III elastics was prevented by decreasing the bracket torque on maxillary incisors and increasing it for the mandibular incisors.

In conclusion, abundant application of Class III elastics, to conservatively resolve crowding in the maxillary anterior segment, typically flares the upper incisors. This problem can be resolved by decreasing the torque of the maxillary incisor brackets and then retracting the entire upper arch with bone screws placed in the IZC areas. In contrast with the conventional molar anchorage, bone screws provide osseous anchorage for dental correction that is not deleterious to the facial profile.

Conclusion

A severe skeletal malocclusion, with multiple missing teeth in the lower arch, was treated conservatively with extra-alveolar anchorage and implant therapy. Implant site development increased the width of the edentulous space, but did not produce sufficient bone for the implant, so ridge augmentation after the implant was placed was necessary with GTR.

Acknowledgment

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 44

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 = 15

OVERBITE

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

Total = 2

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.	=	4 pts.
> 7 mm.	=	7 pts.

Total = 7

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 = 3

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° _____ x 2 pts. = _____

≤ 26° = 1 pt.

Each degree < 26° 4 x 1 pt. = _____

1 to MP ≥ 99° = 1 pt.

Each degree > 99° 2 x 1 pt. = 2

Total = 0

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. =	2
Missing teeth, congenital	_____ x 2 pts. =	_____
Spacing (4 or more, per arch)	_____ x 2 pts. =	2
Spacing (Mx cent. diastema ≥ 2mm)	@ 2 pts. =	_____
Tooth transposition	_____ x 2 pts. =	_____
Skeletal asymmetry (nonsurgical tx)	@ 3 pts. =	_____
Addl. treatment complexities	_____ x 2 pts. =	2

Identify: 6 mm of excessive gingival display

Total = 6

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) = 3

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

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

Total = 3

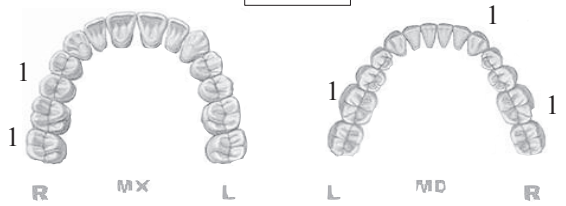
Cast-Radiograph Evaluation

POST-TREATMENT

Total Score: 32

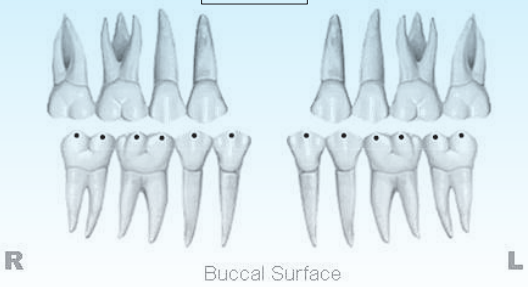
Alignment/Rotations

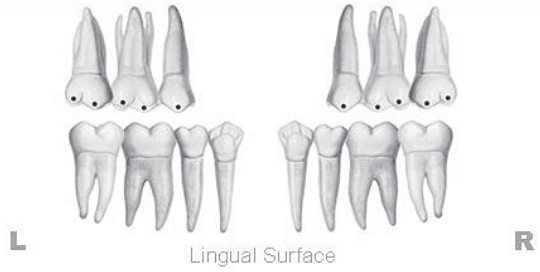
8



Occlusal Contacts

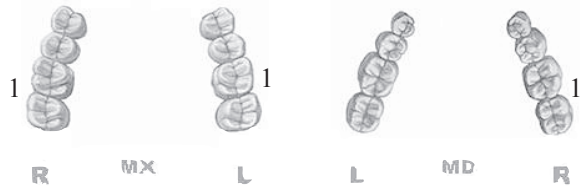
2





Marginal Ridges

6

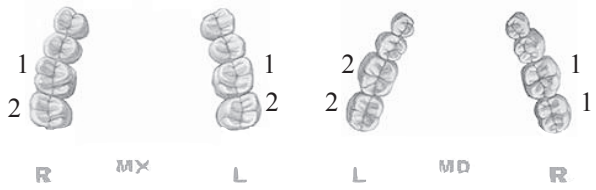


Occlusal Relationships

3

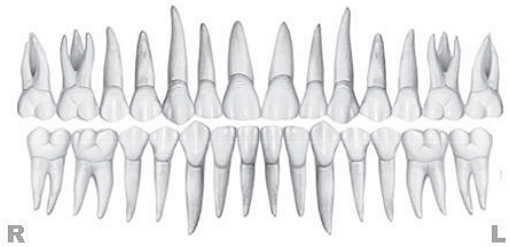
Buccolingual Inclination

10



Interproximal Contacts

0

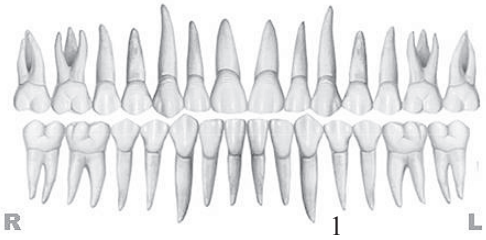


Overjet

2

Root Angulation

1



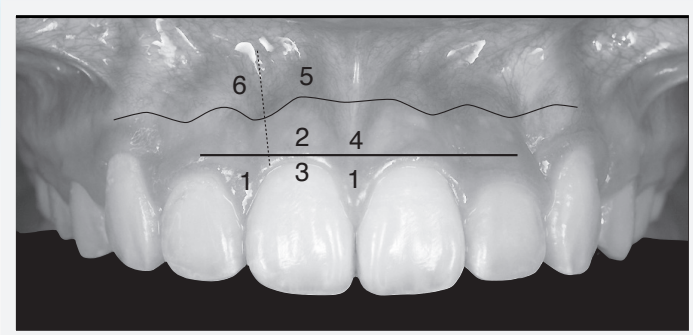
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

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

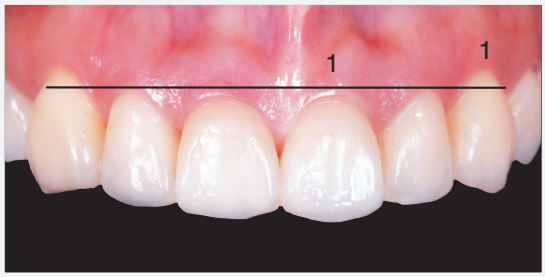
Total Score: = 3

1. Pink Esthetic Score

Total = 2



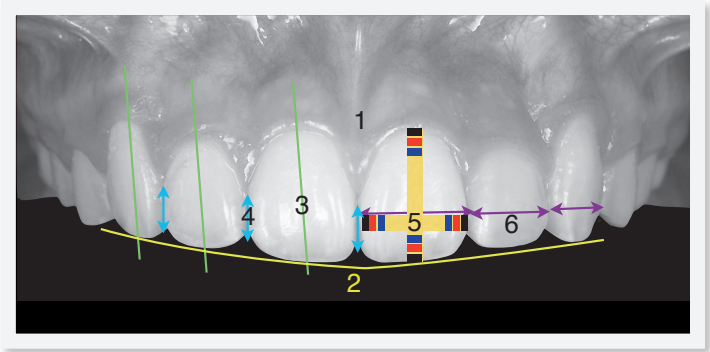
1. Mesial Papilla	0	1	2
2. Distal Papilla	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2



1. M & D 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 = 1

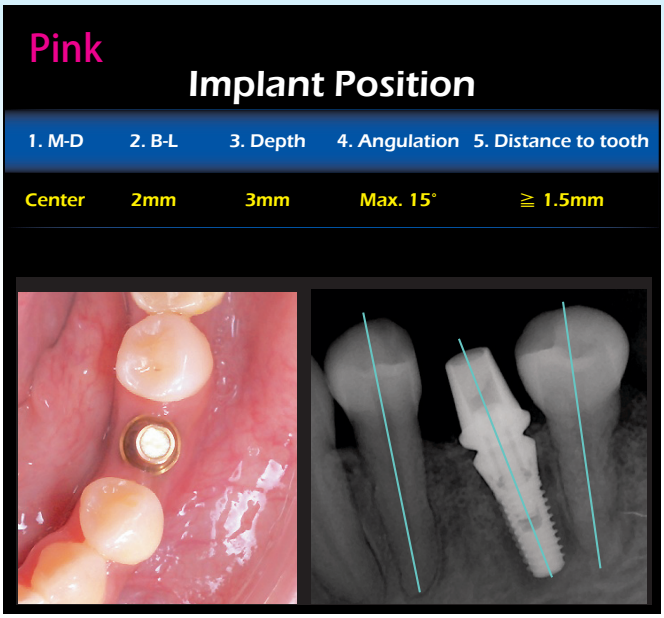


1. Midline	0	1	2
2. Incisor Curve	0	1	2
3. Axial Inclination (5°, 8°, 10°)	0	1	2
4. Contact Area (50%, 40%, 30%)	0	1	2
5. Tooth Proportion (1:0.8)	0	1	2
6. Tooth to Tooth Proportion	0	1	2

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

Implant-Abutment Transition & Position Analysis

1. Implant Position

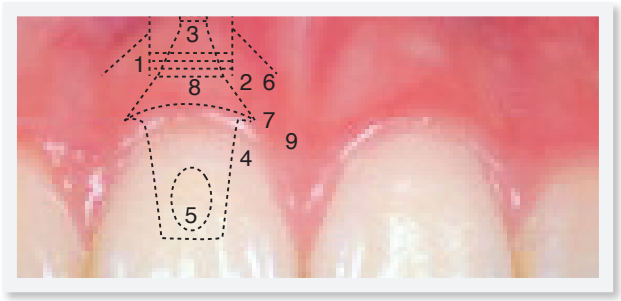


Total = 3

1. M & D (Center)	0	1	2
2. B & L (Buccal 2 mm)	0	1	2
3. Depth (3 mm)	0	1	2
4. Angulation (Max. 15°)	0	1	2
5. Distance to Adjacent Anatomy	0	1	2

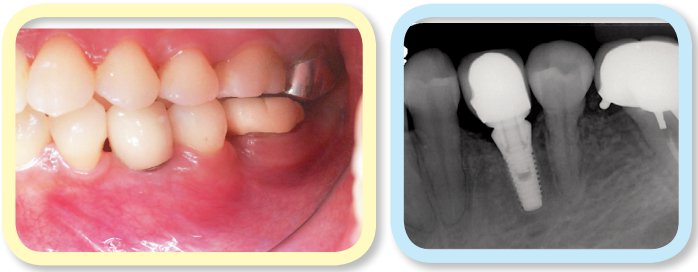
1. M & D (Center)	(0)	1	2
2. B & L (Buccal 2 mm)	(0)	1	2
3. Depth (3 mm)	(0)	1	2
4. Angulation (Max. 15°)	0	1	(2)
5. Distance to Adjacent Anatomy	0	(1)	2

2. Abutment transition Contour



E : external connection,
I : internal connection,
S : screw type,
C : cement type,
P : palatal/central,
B : buccal

1. Fixture Cervical Design	N	Y			
2. Platform Switch	N	Y			
3. I-A Connection Type	E	I			
4. Abutment Selection	S	C			
5. Screw Hole Position	P	B			
6. Marginal Bone Loss	N	Y	0	1	2
7. Modified Gingival Contour	N	Y	0	1	2
8. Gingival Height	N	Y	0	1	2
9. Crown margin fitness	N	Y	0	1	2



1. Fixture Cervical Design	N	(Y)			
2. Platform Switch	(N)	Y			
3. I-A Connection Type	E	(I)			
4. Abutment Selection	S	(C)			
5. Screw Hole Position	(P)	B			
6. Marginal Bone Loss	N	(Y)	0	(1)	2
7. Modified Gingival Contour	(N)	Y	0	1	2
8. Gingival Height	N	(Y)	0	(1)	2
9. Crown margin fitness	(N)	Y	0	1	2