Mutilated Pseudo-Class III Malocclusion with Anterior Crossbite, Knife-Edge Ridges and Periodontal Compromise: Alignment, Sinus Lift, Bone Graft, and Implant-Supported Crowns

Abstract

History: *A 25-year-old female presented for an orthodontic evaluation with a chief compliant of anterior crossbite. Medical history was noncontributory, and no records of previous dental treatment were available.*

Diagnosis and Etiology: *The prognathic facial profile was deviated 7mm to the right, and the occlusal plane was canted ~4º. Maxillary midline was deviated 2mm, and there was a 5mm functional shift to the right on closure. With the mandible in centric relation (C_R), the facial profile was acceptable. In centric occlusion (C_O), the mutilated molar relationships were asymmetric: Class II right and Class III left. The UR5 was missing, and UL6 was hopeless. Microdontia in the lower arch resulted in 2 and 7mm developmental knife-edge ridges distal to the right and left lower canines, respectively. The discrepancy index (DI) was 45 for this severe, complex malocclusion.*

Treatment: *Despite the risk factors of knife-edge ridges and compromised periodontium, the patient selected conservative, minimally invasive treatment. The occlusion was disarticulated with bite turbos to correct the crossbite with lower arch space closure and Class III elastics. The UL6 was extracted and space for an implant was opened in the UR5 area. Implants were placed to restore both missing teeth (UR5 and UL6). A sinus lift bone graft was required for the UL6. Preprosthetic alignment was completed in 23 mo, and the implant-supported prostheses (ISP) required an additional 8 mo for an overall treatment time of 31 mo.*

Outcomes: *Preprosthetic alignment and ISP corrected a severe skeletal malocclusion with a DI 45 to a pleasing facial result. Good dental alignment and esthetics were documented by a Cast-Radiograph Evaluation (CRE) score of 26, and a Pink & White dental esthetic score of 3. Consistent with the risk factors defined before treatment, moderate lateral root resorption was noted on the distal surface of the LL3, and ~1mm of bone loss occurred between the LL3 and LL4. No mobility or excessive pocket depth was noted.*

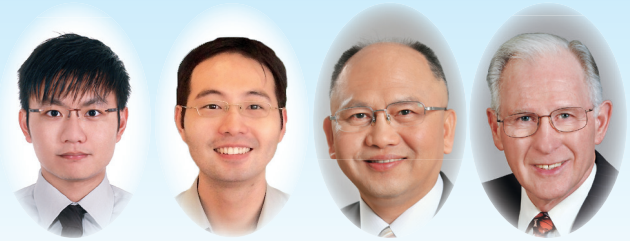
Conclusions: *A severe skeletal malocclusion with facial asymmetry, missing teeth and periodontal risk factors was treated to a pleasing camouflage result with minimal surgery. Facial asymmetry was improved without orthognathic surgery, but there was still a slight cant to the occlusal plane. Despite some root resorption, bone loss, and irregular gingival margins in the maxillary buccal segments, the patient was pleased with the result and declined further treatment. She was informed that regular follow-up care was essential to maintain her fragile periodontium. (J Digital Orthod 2018;49:26-49)*

Key words:
Adult treatment, mutilated malocclusion, interdisciplinary treatment, implant placement, functional shift, facial asymmetry, knife-edge ridge, space closure. Class II/III asymmetric malocclusion, sinus lift

Introduction

A functional shift due to dental interference may result in severe anterior crossbite and facial asymmetry.[1] This acquired anomaly may be misdiagnosed as a skeletal Class III malocclusion requiring orthognathic surgery.[2] Patients with an aversion to surgery may procrastinate and delay treatment, which contributes to the progressive severity of the malocclusion.[3,4] Contributing problems such as missing dentition, fractured

Dr. Chi Huang,
Resident, Beethoven Orthodontic Center
Editor, Journal of Digital Orthodontics (Left)
Dr. Chuanwei Su,
Director, Newton Implant Center
Associate Editor, Journal of Digital Orthodontics (Center left)
Dr. Chris Chang,
Founder, Beethoven Orthodontic Center
Publisher, Journal of Digital Orthodontics (Center right)
Dr. W. Eugene Roberts,
Editor-in-chief, Journal of Digital Orthodontics (Right)



teeth, periodontal compromise, and knife-edge atrophic ridges are best managed with comprehensive treatment. Predictable interdisciplinary care begins with a firm foundation comprised of a careful history review, comprehensive diagnosis, thorough periodontal evaluation, and assessment of the etiology.[2]

Fig. 1: Pre-treatment facial and intraoral photographs

Orthodontic patients tend to have a lower prevalence of periodontitis compared to the general population,[5] but comprehensive orthodontics can challenge the periodontium of adult patients 18 years of age or older. It is important to insure that the periodontium is healthy or at least stable prior to orthodontic treatment. In this regard, the American Board of Orthodontics (*ABO*) requires special periodontal screening for all adult patients, and also for younger patients if there are signs or symptoms of periodontal disease.[6]

The dental nomenclature for this report is a modified Palmer notation with upper (*U*) and lower (*L*) arches, right (*R*) and left (*L*) sides, and permanent teeth in each quadrant numbered from 1-8 relative to the midline.

Diagnosis and Etiology

A 25-year-old female presented for orthodontic evaluation with a chief compliant of an anterior crossbite (*Figs. 1-4*). The medical history was noncontributory, but the panoramic radiograph

Fig. 2: Smile evaluation photograph

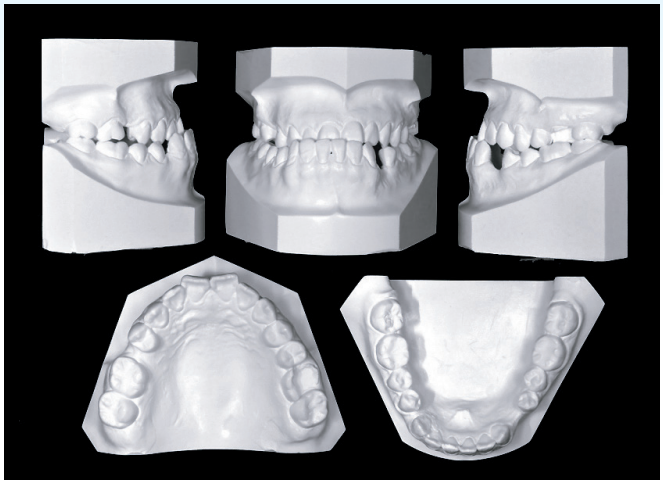


Fig. 3: Pre-treatment study models (casts)

Fig. 4: Pre-treatment lateral cephalometric radiograph

(*Fig. 5*) revealed a long history of restorative and periodontal problems. Facial examination revealed a prognathic profile with a 7mm deviation of the lower face to the right, and ~4° counterclockwise rotation of the frontal occlusal plane relative to the inter-pupillary line (*Fig. 1*). There was of a 2mm deviation of the maxillary midline to the facial

Fig. 5: Pre-treatment panoramic radiograph

midline. Closing into maximum intercuspation (C_O) required a 5mm functional shift to the right on closure (*Fig. 6*). The facial profile was flat (*0º G-SN-Pg'*) and there was markedly increase lip prominence (*-6.5mm/-5.5mm to the E-Line*). The patient's smile (*Fig. 2*) was unattractive due to the mandibular deviation, dental spaces, canted inter-commissure line (*occlusal plane*), and the absence of a smile arc.[7] There were no signs or symptoms of temporomandibular joint (*TMJ*) dysfunction (*Fig. 7*).

Analysis of the study casts (*Fig. 3*) showed mutilated molar relationships that were Class II end-on occlusion on the right side and Class III on the left. Both buccal segments were Class III in centric occlusion (C_O), with a deep anterior cross-bite (*4mm*) that was associated with negative overjet (*-3mm*). With the mandible positioned in centric relation (C_R), the incisors were in an end-to-end occlusion and the facial profile was acceptable, which indicates that conservative camouflage treatment was a viable option.

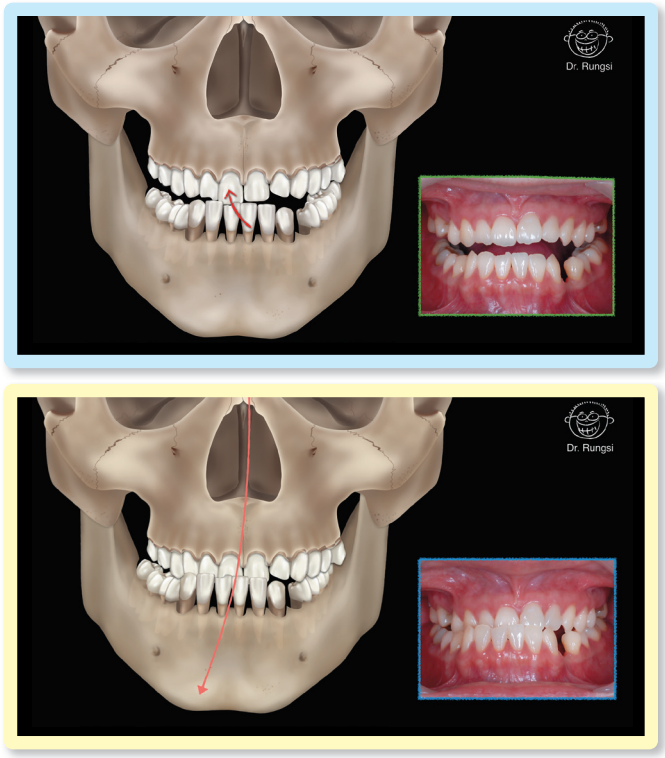


Fig. 6:
Functional shift evaluation photograph and dynamic illustration.

a. The mandible closes until the incisors contact in the C_R position. The curved red arrow shows the path of the incisal deviation on closure.

b. When closing into C_O the mandible deviates in the direction of the red curved arrow.

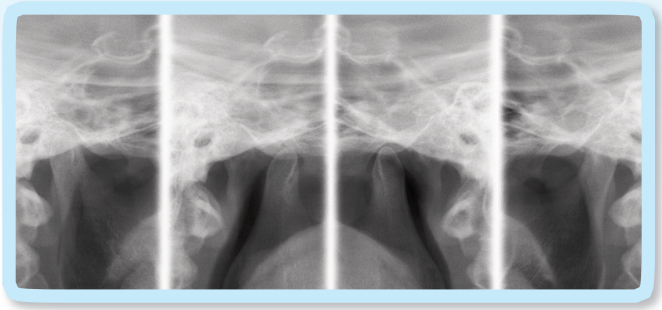


Fig. 7:
Transcranial radiographic images of the pre-treatment temporomandibular joints (TMJs) are shown from the left: R TMJ closed, R TMJ open, L TMJ open, and L TMJ closed.

Space analysis was complicated by multiple missing or severely compromised teeth, as well as an apparent microdontia in the mandibular arch. Assuming the UL6 is extracted and the LR6 is retained, there was excess space of 10mm in the upper arch and 9mm in the lower arch. The 7mm space between the LL3 and LL4 was a knife-edge ridge, probably resulting from the delayed loss of a retained primary tooth secondary to the microdontia in the lower arch (*Fig. 3*). A similar but smaller (*2mm*) knife-edge ridge was between the LR3 and LR4.

Cephalometric evaluation (*Fig. 4*) revealed decreased facial convexity (*0°*), decreased lower facial height (*LFH 49.6%*), and a negative intermaxillary relationship (*ANB -1°*), based on protrusive maxilla (*84.5°*) and mandible (*85.5°*). The mandibular plane angle was relatively flat (*SN-MP 28.5°, FMA 21.5°*), but within normal limits (*WNL*). All incisors had decreased axial inclination, 104° in the upper and 83° in the lower arch (*Table 1*). The panoramic radiograph (*Fig. 5*) showed an overall reduced bone level. The UL6 had an incomplete endodontic root fill and pulp cap, and the LR6 showed an irregular root canal filling and restoration with MTA (*Mineral Trioxide Aggregate*).

Despite evidence of an extensive history of dental problems (*Figs. 1-5*), no dental records were recovered and the patient had an incomplete recollection of previous dental treatment performed by multiple dentists. It was necessary to deduce the overall dental health and probable etiology of a malocclusion from the current records. Significant dental problems contributing to the current malocclusion were: 1. missing UR5, 2. microdontia from LL5-LR5 resulting in a 7mm atrophic knife-edge ridge between LL3 and LL4, 3. knife-edge edentulous ridge between the LL3 and LL4 , and 4. deep caries affecting at least three first permanent molars. The latter problem may be related to molar-incisor hypoplasia (*MIH*), a common

CEPHALOMETRIC SUMMARY			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA° (82°)	84.5°	84.5°	0°
SNB° (80°)	85.5°	84.5°	1°
ANB° (2°)	-1°	0°	1°
SN-MP° (32°)	28.5°	27°	1.5°
FMA° (25°)	21.5°	20°	1.5°
DENTAL ANALYSIS			
U1 To NA mm (4 mm)	0 mm	2.5 mm	2.5 mm
U1 To SN° (104°)	104°	112°	8°
L1 To NB mm (4 mm)	3.5 mm	0 mm	3.5 mm
L1 To MP° (90°)	83°	85°	2°
FACIAL ANALYSIS			
E-LINE UL (2-3 mm)	-6.5 mm	-5.5 mm	1 mm
E-LINE LL (1-2 mm)	-1.5 mm	-3.5 mm	2 mm
Convexity: G-Sn-Pg' (13°)	0°	2.5°	2.5°
%FH: Na-ANS-Gn (53%)	49.6%	49.2%	-0.4%

Table 1: Cephalometric summary

enamel defect related to high fever at <3yrs of age.[8] The isolated loss or compromise of the permanent first molars were the principal restorative concerns for the present patient.

The panoramic radiograph (*Fig. 5*) revealed generalized minor to moderate loss of alveolar bone in the lower anterior to first premolar area, but there were no other periodontal signs or symptoms. Fig. 6 shows the deviated path of closure from centric relation to the initial occlusal contact (*upper view*), followed by the functional shift to the right when full intercuspation (*centric occlusion*) is achieved. The change in position of the mandibular condyles in the open and closed positions are shown in Fig. 7.

The ABO discrepancy index (*DI*) score was 45 points for this severe acquired malocclusion. Scoring details are shown in the supplementary worksheet 1.

Treatment Objectives

1. Align both arches with a fixed, self-ligating appliance.
2. Correct anterior cross-bite and resolve the functional shift.
3. Close knife-edge edentulous spaces in the lower arch.
4. Extract upper left fractured first molar (*UL6*) ~3 mo before implant placement.
5. Align sites as needed and place implants to replace the missing UR5 and UL6.
6. Monitor the alveolar bone height in implant sites and use a sinus lift procedure for the UL6 space if needed.
7. Optimize occlusion with finishing wire bends and posterior vertical elastics.

Treatment Alternatives

The patient adamantly refused orthognathic surgery which was previously suggested by multiple orthodontists. Despite her compromised periodontium and knife-edge ridges, the patient preferred conservative camouflage treatment with minimal surgical intervention. An interdisciplinary camouflage treatment was proposed: preprosthetic orthodontic alignment, lower arch space closure, and implants to replace missing teeth (*UR5, UL6*). After discussing all the options, the patient selected the latter alternative because it was the most conservative approach that offered the potential for the result she desired. She understood that space closure in the lower arch was a risky approach because of periodontal compromise and knife-edge ridges.

In centric relation (C_R) the patient could position the mandible with the incisors in an edge to edge relationship and the buccal segments were near Class I (*Figs. 6A and 8-0M*). Since the facial profile was acceptable in the retruded position, camouflage treatment was a viable option for retracting the labially positioned lower incisors (*Fig. 4*). The latter is an important diagnostic consideration because excessive retraction of mandibular incisors can result in severe periodontal compromise.[9,10]

Treatment Progress

The 0.022-in Damon Q® (*Ormco, Glendora, CA*) passive self ligating (*PSL*) fixed appliance was selected. The maxillary central incisors and canines were bonded with low torque brackets to resist flaring when the crossbite was corrected. For the lower arch, low torque brackets were bonded upside down to achieve very high torque on the lower incisors, and high torque brackets were placed on the lower canines. Both arches were leveled and aligned with the following archwire sequence: 0.014-in CuNiTi, 0.014x0.025-in CuNiTi, 0.017x0.025-in TMA and 0.016x0.025-in SS.

In the second month of active treatment, posterior bite turbos, made with Fuji II® type II Glass Ionomer cement (*GC America, Alsip IL*), were installed on the occlusal surfaces of the mandibular second molars to open the bite. Open coil springs were used to lengthen the implant sites in the upper arch, and light short Class III elastics (*2-oz*) were used to correct the anterior cross-bite (*Fig. 8*).

After 8 months of active treatment, the anterior cross-bite was corrected. Bite turbos were progressively removed to allow posterior contact at 15 months as the curve of Spee in the lower arch was corrected (*Fig. 8*). The space for the upper implants was corrected as the lower arch space was closed. After 23 months of treatment, the implant sites were prepared (*Figs. 9 and 10*) and the occlusion was interdigitated. A cone-beam computed tomography (*CBCT*) scan was used to evaluate the bone volume and distribution for each implant site (*Figs. 10, 11R & 11L*).

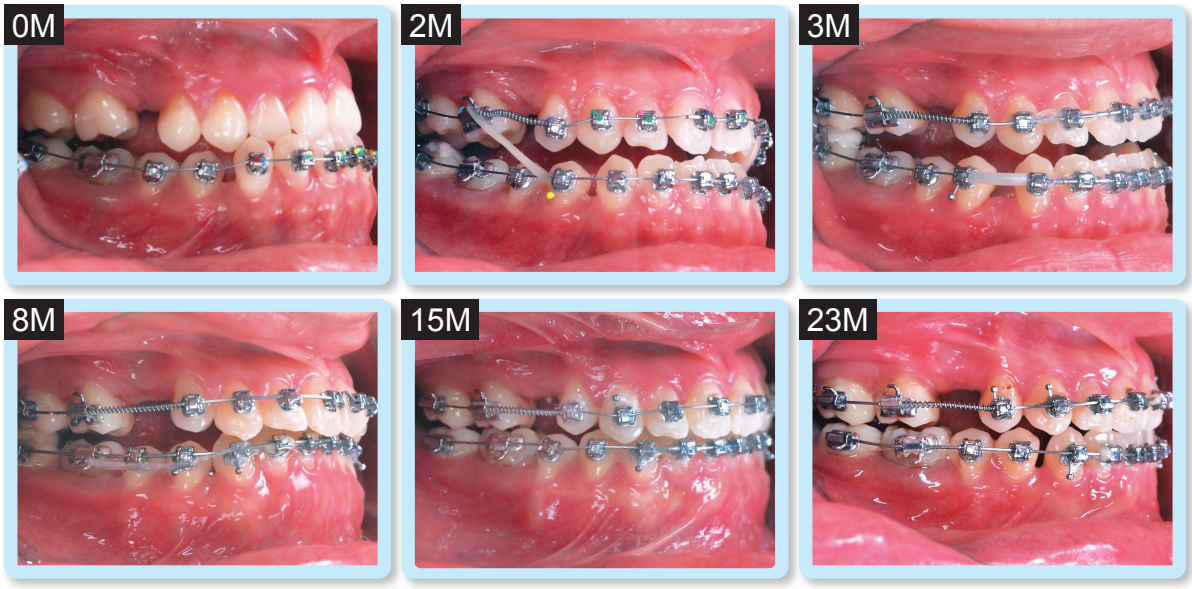


Fig. 8:
Anterior cross-bite correction is shown from zero (0M) to twenty-three months (23M) of active treatment. Note that the anterior crossbite was corrected at eight months (8M).

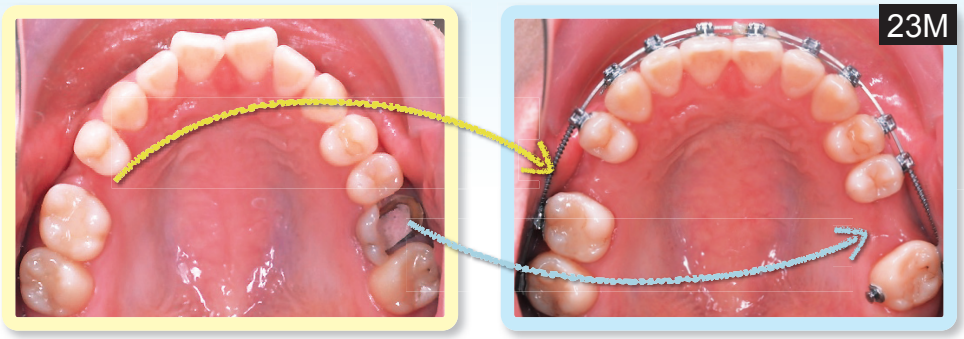


Fig. 9:
At 23 months (23M) of active treatment, the original malocclusion (left) was prepared for two implant sites: UR5 (yellow curved arrow) and UL6 (curved blue arrow).

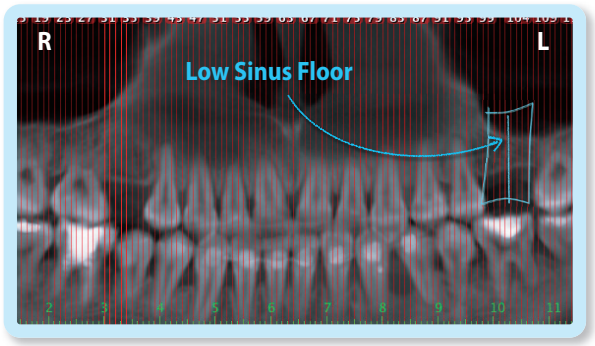


Fig. 10:
A CBCT was used to evaluate the bone volume over the implant site: the upper left with low sinus floor problem.

Implant Placement

A three-piece hardware set was used for each implant: 1. Astra OsseoSpeedTM® implant produced by Dentsply Implants, Mannheim, Germany, 2. Flared healing abutment (*HA*) marketed by the same manufacturer, and 3. Tony caps, used when implants were uncovered, were produced by Alliance Global Technology, Kaohsiung, Taiwan.

An open flap technique was used for both implants. For the UR5 implant, the drilling protocol resulted

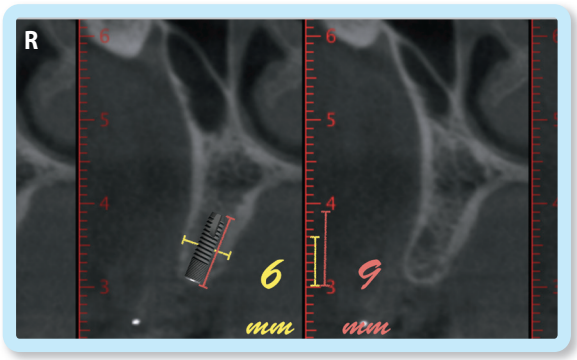


Fig. 11-R:
Slices from a CBCT show adequate bone depth (~18mm), but marginal bone width (6mm) in the UR5 site was prepared for a 4x9mm implant.

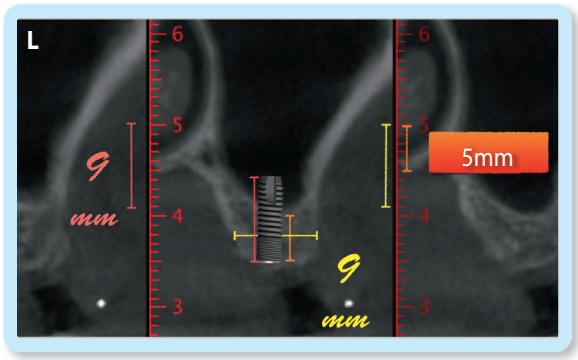
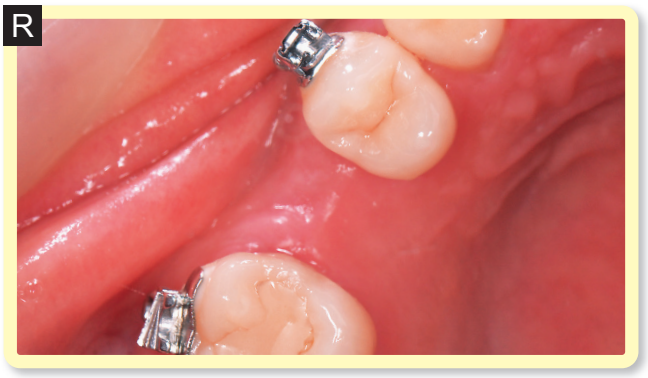


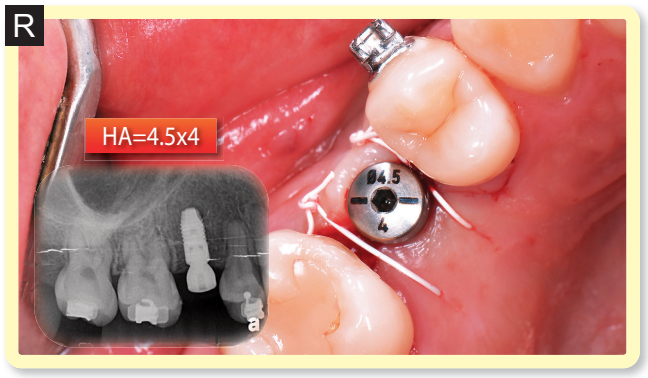
Fig. 11-L:
A CBCT slice through the UL6 site documents adequate width (9mm) but insufficient length (5mm) for a 4x9mm implant.

in only 1.5mm of buccal bone thickness, which is less than the ideal 2mm according to 2B-3D rule[11] (*2mm buccal bone thickness and 3mm apical to the crown margin*), but it was still acceptable. A 4x9mm fixture and a 4.5x4mm healing abutment (*HA*) were selected (*Figs. 12A, 12B & 12C*).

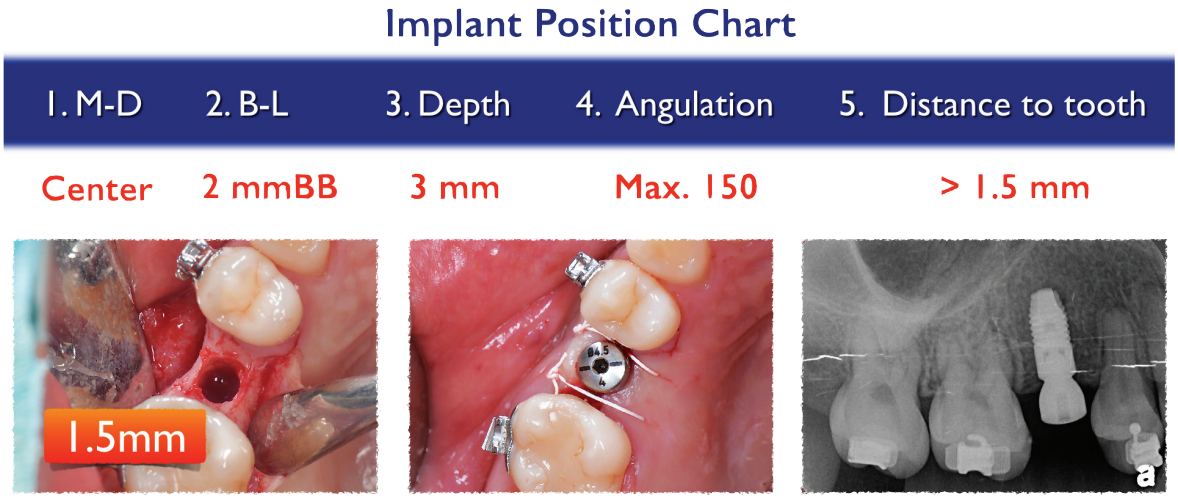
The sinus floor was low in the UL6 area (*Fig. 10*), so it was carefully evaluated with slice views from a CBCT. The ridge width was 9mm, but the vertical bone height was only 5mm (*Fig. 11-L*). Zadeh's[12] sinus lift decision making tree (*Fig. 13*) indicated the crestal approach with a standard length implant was appropriate (*Fig. 13A*). To prevent perforation into the sinus, all drills were fitted with rubber stop indicators to ensure that drill penetration was no more than 5mm. Platelet-rich fibrin (*PRF*)[13] was prepared as cushion material (*Fig. 13B*) for the sinus lift procedure.



■ *Fig. 12A:*
Pre-treatment occlusal view of the UR5 implant site.



■ *Fig. 12B:*
Post-operative view of the implant in the UR5 site shows a 4x9mm fixture with a 4.5x4mm healing abutment (HA).



■ *Fig. 12C:*
Implant position chart for the UR5 implant: all planned parameters were met except the buccal bone thickness was only 1.5mm. See text for details.

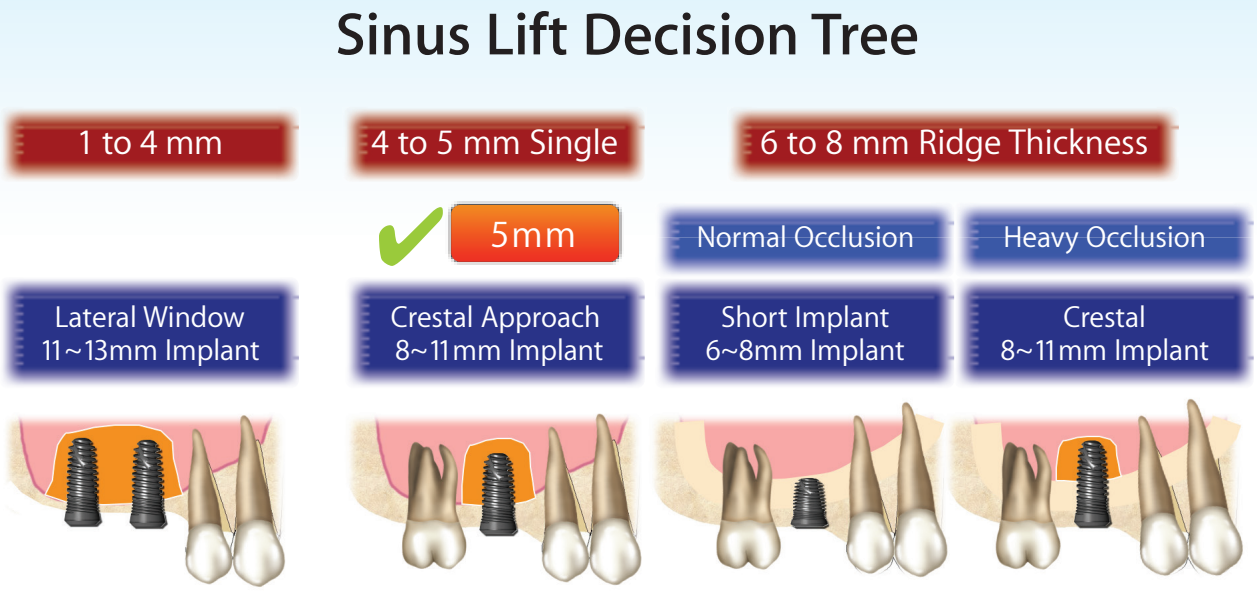


Fig. 13A:
Sinus lift decision making tree devised by Dr. Homa Zadeh shows the preferred surgical procedure and implant size according to alveolar bone thickness inferior to the sinus, and the expected occlusal load (Normal or Heavy).

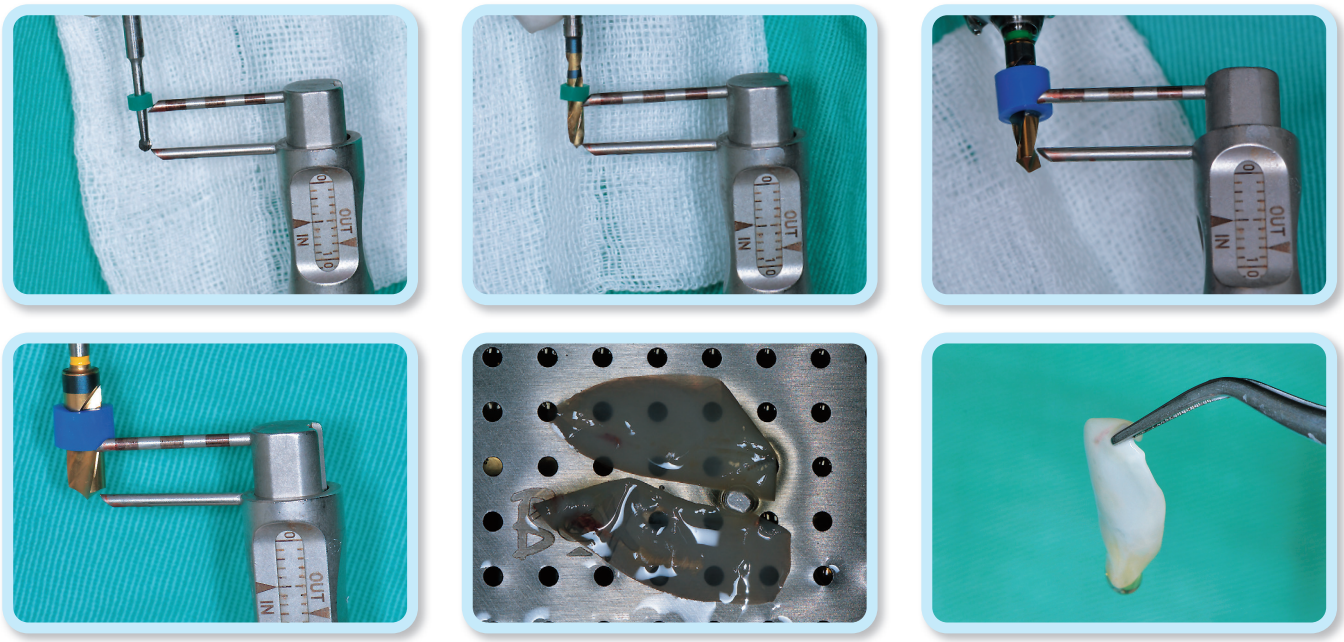
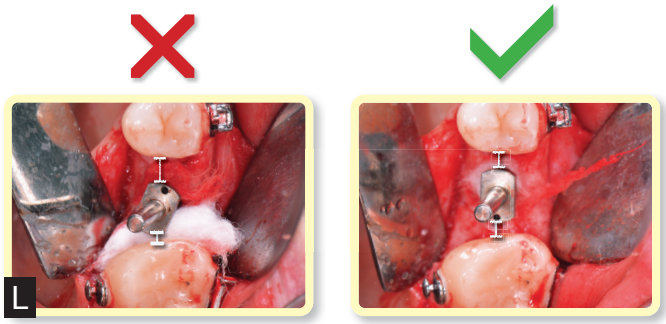


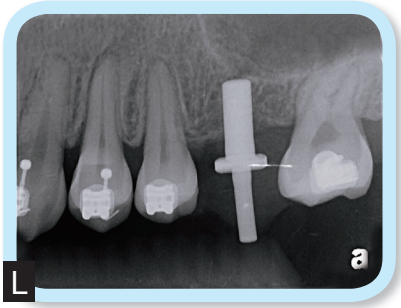
Fig. 13B:
All drill bits were fitted with a 5mm rubber stopper to prevent premature sinus violation (top 3 photographs). The maximum diameter drill was also marked at 5mm (lower left). Platelet-rich fibrin (PRF) material was prepared (lower center), into a finished specimen (lower right) to serve as a cushion material for the sinus elevation procedure. See text for details.

A radiograph with an osteotomy indicator in place showed that a slight correction was needed to achieve parallelism. A side cutting Lindemann drill (*Meisinger, Neuss, Germany*) was used to correct the direction and center the osteotomy (*Fig. 13C*).

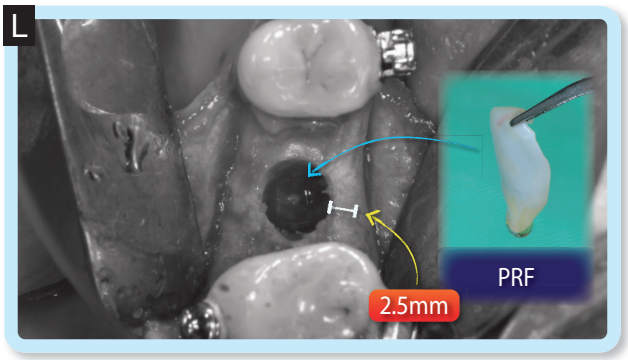
A periapical radiograph confirmed that there was no apparent sinus perforation (*Fig. 13D*). After the osteotomy was completed, buccal bone thickness was 2.5mm. The previously prepared PRF cushion was placed in the osteotomy (*Fig. 13E*), and an osteotome was used to elevate the floor of the sinus with its adjacent Schneiderian membrane (*Fig. 13F*). Freeze-dried bone allograft (*FDBA*) produced by Maxxeus Dental, Kettering OH (*USA*) was selected as the bone augmentation material. The osteotome was then used to push the FDBA into the space created by the sinus elevation. The procedure was repeated 3 times to complete the grafting of the implant site (*Fig. 13G*), and a 5x9mm fixture was screwed to place (*Fig. 13H*). To protect the bone grafted site, a cover screw sealed the submerged



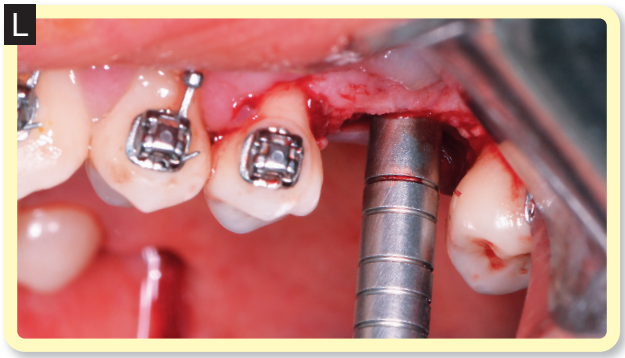
■ *Fig. 13C:*
Drilling protocols were followed and an indicator was placed to evaluate the direction of the osteotomy. The left photograph with asymmetric white bars shows that the osteotomy is not centered in the site (red X). A side cutting Lindemann drill was used to correct the direction and position (green check). See text for details.



■ *Fig. 13D:*
The initial radiograph (a) of the left (L) posterior maxilla shows an indicator inserted to the depth of the osteotomy. The sinus floor was not perforated.



■ *Fig. 13E:*
After the osteotomy width was prepared, there was 2.5mm buccal bone thickness (yellow curved arrow marking a white bar). PRF was placed into the osteotomy (blue curved arrow). See text for details.



■ *Fig. 13F:*
With PRF as cushion material in the bottom of the osteotomy, the sinus floor was fractured superiorly with an osteotome.

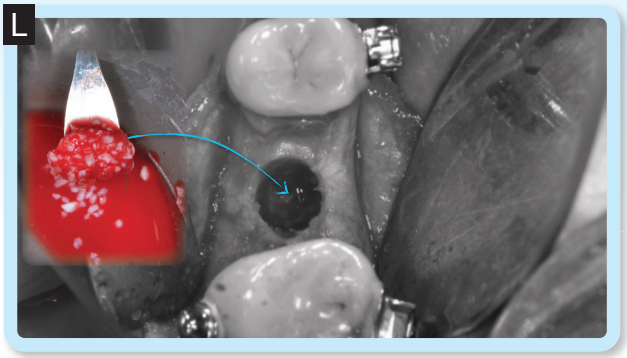


Fig. 13G:
Freeze-dried bone augmentation (FDBA) material was inserted into the osteotomy as a 4mm thick coagulum graft. The osteotome was used to compact the material into the floor of the sinus inferior to the sinus membrane. This procedure was repeated three times to complete the graft.

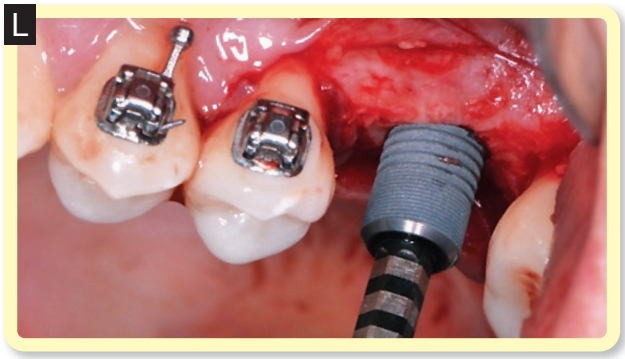


Fig. 13H:
A 5x9mm fixture was inserted into the bone-grafted osteotomy to restore the missing UL6.

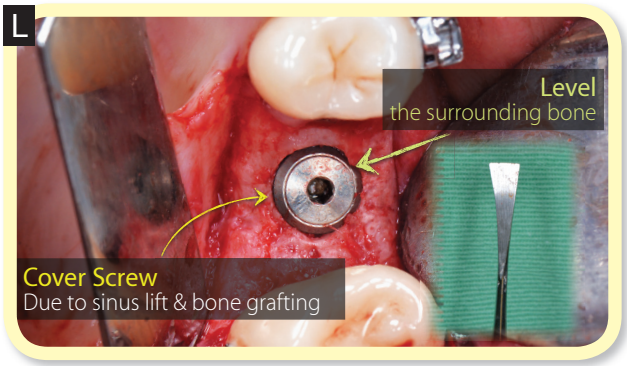


Fig. 13I:
A cover screw was used to seal the submerged UL6 fixture and a chisel was used to remove the irregular marginal bone that might interfere with the subsequent installation of the healing abutment. The soft tissue was closed over the fixture for a three month unloaded healing phase.

fixture prior to soft tissue closure (*Fig. 13I*). The bone peripheral to the implant was leveled with a chisel to assure that the healing abutment will seat firmly when the implant is uncovered (*Fig. 13I*).

Three months after surgical placement, both implants were uncovered, cover screws removed, and healing abutments were installed (*Fig. 13J*). The implant position chart (*Fig. 13K*) documents ideal placement of the UL6 implant according to the 2B-3D rule,[11] but the fixture was a little too close to the second molar (*~1.5mm*), but it was still acceptable.

One month later, 2.5mm high direct abutments with the same diameter as the respective implant were installed. A double cord gingival retraction technique was used to expose each abutment for a direct impression with polyvinyl siloxane. To prevent soft tissue overgrowth of the abutment, Tony Caps were used as substitutes for provisional crowns (*Fig. 13L*). Two weeks later, both crowns were delivered and the marginal fit was checked with an explorer and periapical radiographs (*Fig. 13M*).

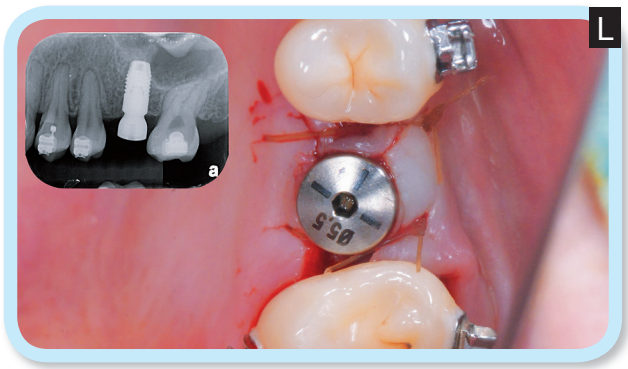


Fig. 13J:
After the three month healing phase, the cover screw on the UL6 fixture was exchanged for a 5.5x4mm healing abutment.

Implant Position Chart

1. M-D	2. B-L	3. Depth	4. Angulation	5. Distance to tooth
Center	2mmBB	3mm	Max. 15°	> 1.5mm

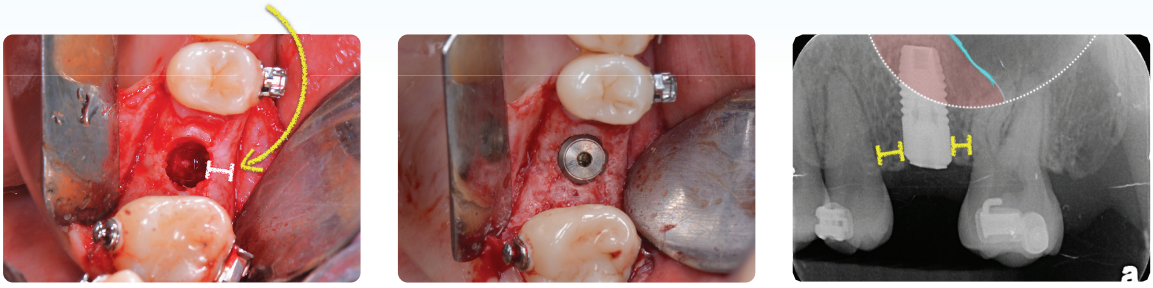


Fig. 13K:
Implant position chart for the UL6 implant shows the assessment after the fixture was placed. The yellow curved arrow and yellow bar show the buccal bone thickness was 2mm (left image). Depth and angulation were as planned (middle image). The UL6 fixture was closer than planned to the adjacent second molar (yellow bars), but the outcome was deemed acceptable (right image).

Fig. 13L:
One month after placing the healing abutments, direct abutments with 2.5mm marginal height were installed. A double cord gingival retraction technique was used to make a direct impression with polyvinyl siloxane. To prevent soft tissue overgrowth, "Tony Caps" were used as substitutes for provisional crowns.

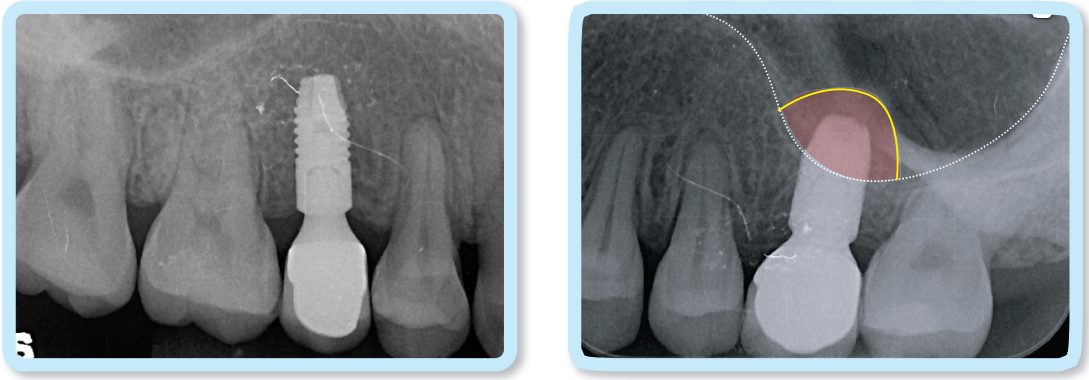


Fig. 13M:
Two weeks later, both crowns were delivered and the marginal fit was checked with periapical radiographs: UR5 on the left and UL6 on the right. The bone grafted area superior to the sinus floor (yellow line) is shaded in pink (right image).

Following 31 months of interdisciplinary treatment, maxillary and mandibular clear overlay retainers were delivered for full-time wear for the six months and nights only thereafter.

Treatment Results

The post-treatment photographs documented an improved profile and more harmonious facial esthetics. The functional shift and mandibular asymmetry were resolved. Although there was still an upward cant of the occlusal plane on the left side, the smile arc was pleasing with a more youthful facial appearance (*Fig. 14*).

The post-treatment panoramic film (*Fig. 15*) was carefully examined because of the pretreatment periodontal root resorption risk factors. Alveolar bone height for the maxillary arch was maintained and the osseous support for both maxillary posterior implants was optimal. Overall the bone support in the mandibular arch was maintained except where the knife-edge ridges were closed distal to the lower canines. There was a 1-2mm

Fig. 14: Post-treatment facial and intraoral photographs

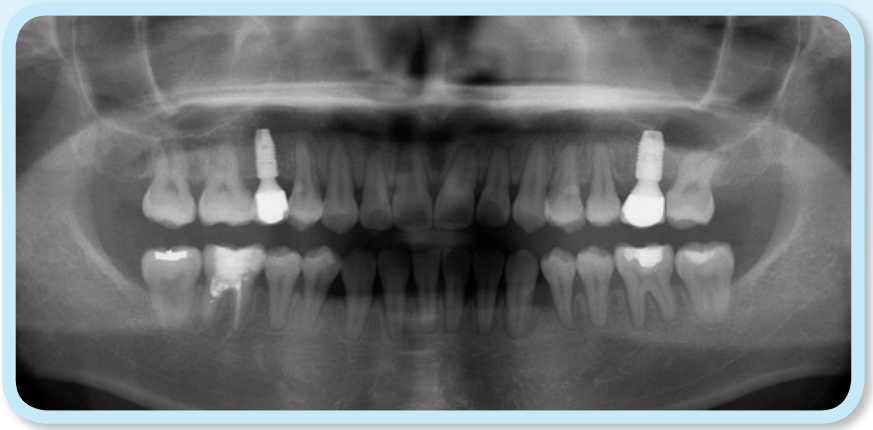


Fig. 15:
Post-treatment panoramic radiograph shows lateral root resorption on the distal of the LL3 and bone loss between the LL3 and LL4. These problems are risk factors when a knife-edge ridge is closed in a periodontally compromised patient. See text for details.

loss of bone height where the spaces were closed, and root resorption was noted along the distal root surface of the LL3 (*Fig. 15*). Clinically the affected teeth (*lower canines and first premolars*) were vital, mobility was WNL, and pocket depth was acceptable (≤*3mm*). Since the bone width was only 1.5mm on the buccal surface of the UR5 implant, long term follow-up is required.

The superimposed cephalometric tracings revealed that the axial inclination of the maxillary incisors was increased, and the maxillary molars were retracted slightly. In the mandibular arch, the molars were protracted and the incisors were retracted. The mandible was retracted about 2mm after the anterior crossbite was resolved. Ramus length and the MPA were unchanged. Cephalometric tracings documented that the lower lips were retracted to improve the concave Class III profile (*Figs. 16 &18*).

The ABO Cast-Radiograph Evaluation (*CRE*) score was 26 points (*Worksheet 2*). The major CRE discrepancies were bucco-lingual inclination (*6 points*) and occlusal

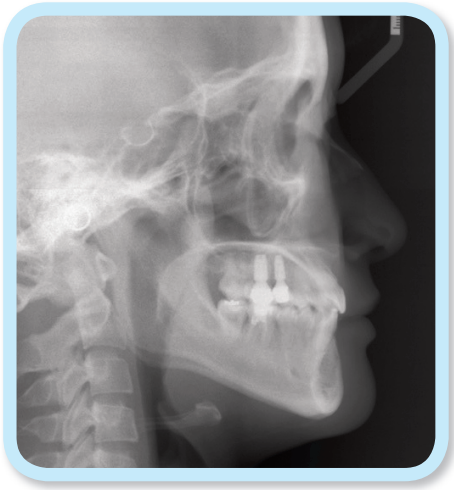


Fig. 16: Post-treatment cephalometric radiograph

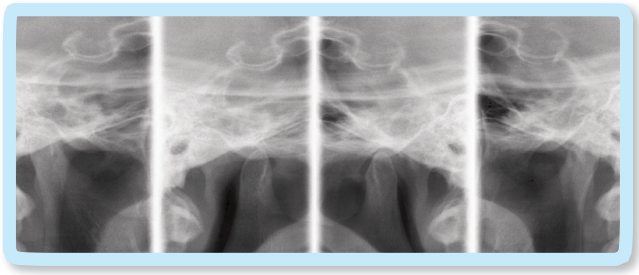


Fig. 17:
Post-treatment temporomandibular joint radiography shows four views of the TMJs: R TMJ closed, R TMJ open, L TMJ open, and L TMJ closed. Note that the condylar heads are more distally positioned in each fossa compared to pre-treatment (Fig. 7), which is consistent with correction of the functional shift in the sagittal plane (Fig. 1).

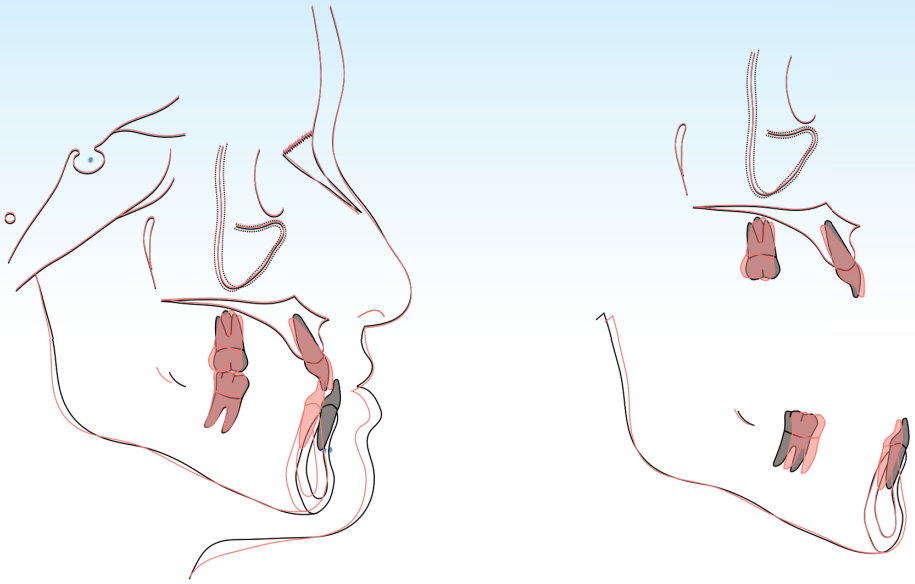


Fig. 18:
Cephalometric tracings before (black) and after (red) treatment are superimposed on the anterior cranial base (left), maxilla (upper right) and mandible (lower right). See text for details.

Fig. 19: Post-treatment study models (casts).

(*intermaxillary relationships*) scored at 8 points. For details see the CRE worksheet at the end of this report.

Discussion

The 3-Ring Diagnosis, developed by Dr. John Lin,[2] is an effective method for identifying Class III malocclusions that are amenable to conservative therapy:

1. **Profile**: Most pseudo Class III profiles in C_R are orthognathic. So if the facial profile is acceptable in the retruded position, the malocclusion is suitable for camouflage treatment (*Fig. 20*).

2. **Class**: Evaluate both the canine and first molar occlusal relationships in centric occlusion (C_O). An anterior crossbite is easier to treat when the molars are Class I in C_R (*pseudo Class III*) compared to when molars are in Class III in C_R (*true Class III*). For the present patient the bilateral molar relationships were not a full-cusp Class III (*Fig. 3*), which was favorable for conservative treatment.

3. **Functional Shift**: Diagnosing the presence or absence of a functional shift is crucial for efficient management of a skeletal malocclusion. Functional interference on closure in C_R results in an anterior shift to occlude the posterior

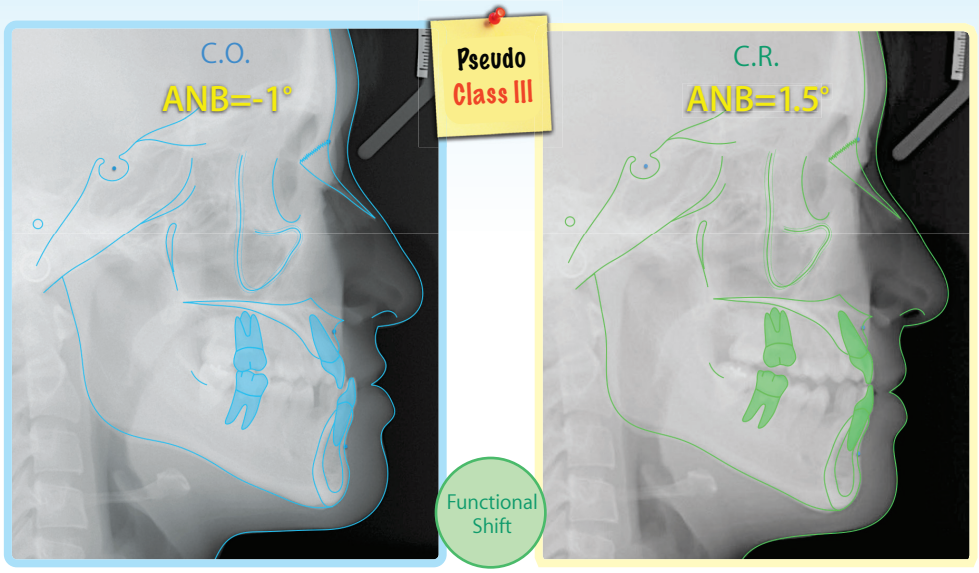


Fig. 20:
Tracings superimposed on cephalometric films in centric occlusion (C.O.) and centric relation (C.R.) are shown on the left and right, respectively. The C.O. (C_O) tracing in blue reveals an ANB -1 when the patient is in maximum intercuspation. The C.R. (C_R) tracing in green documents that ANB increases to 1.5 by eliminating the functional shift.

segments for mastication, i.e. centric occlusion (C_O). Diagnosing the sagittal discrepancy of a malocclusion in C_O may result in an incorrect appraisal that favors orthognathic surgery (*Fig. 6*). If the facial profile is acceptable in C_R, conservative camouflage treatment is indicated (*Fig. 20*).

For the present patient, conservative camouflage treatment was a viable alternative.[2] Appropriate orthodontic treatment for anterior cross-bite includes proper torque selection, bite turbos, light-force Class III elastics and open coil springs. With 8 months of active treatment, the patient's anterior cross-bite was corrected (*Fig. 8*). With a proper diagnosis and appropriate treatment plan, complex skeletal malocclusions are efficiently resolved with conservative mechanics.[3] Orthognathic surgery is unnecessary.

The etiology of the LL knife-edge ridge (*Figs. 1-3*) was deemed a developmental defect associated with microdontia, which resulted in >7mm of excess space in the lower arch. It appears that some permanent teeth in the lower anterior segment erupted into adjacent spaces rather causing the exfoliation of their primary predecessors. After the retained primary canines were lost, the edentulous areas atrophied into knife-edge ridges (*Figs. 3 and 5*). Teeth can be moved into knife-edge edentulous areas but loss of alveolar bone height and lateral root resorption on adjacent teeth are common complications.[14]

Functional interference may have contributed to alveolar bone loss in the lower anterior segment (*Fig. 5*). Clearly light force as well as careful torque control of the lower incisors and canines is

always important, but a thorough pre-treatment periodontal examination was indicated, because treatment of periodontally compromised patients is unpredictable.[7] In retrospect, the current treatment was a relatively good result for a patient with a compromised periodontium. It is unlikely that orthognathic surgery would have yielded a better periodontal result because alignment of the dentition and space closure was still necessary. Periodontal compromise and knife-edge ridges are risk factors for dental alignment and space closure.[3,14]

Twenty-three months of conservative orthodontic treatment efficiently resolved the patient's chief complaint. Correcting the functional interference and aligning the dentition improved the facial esthetics dramatically (*Fig. 21*). Restoration of the maxillary posterior dentition was best accomplished with implant supported prostheses (*crowns*). Space closure would have shortened the length of the arch complicating the crossbite correction and eliminating the occlusal antagonists for the lower second molars. Extracting the hopeless UL6 and opening space for the missing UR5 to prepare sites for implants was clearly the best option.

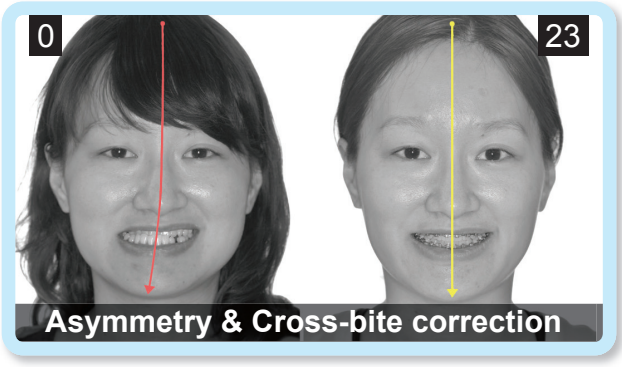


Fig. 21:
Twenty-three months (23M) of treatment corrected the facial asymmetry by eliminating the functional interference and aligning the dentition. However the occlusal plane, canted superiorly on the patient's left side, has persisted.

For the UR5 implant, 2mm of buccal bone thickness was the target to provide sufficient blood supply and bone stability.[15-19] However, there was only 1.5mm of buccal bone thickness after the implant was placed (*Fig. 12C*). Although this compromise was deemed acceptable at the time of the surgery, bone augmentation with GBR (*guided bone regeneration*) during the healing phase may have enhanced the buccal bone thickness to enhance stability, and decrease the chance of post-operative bone resorption.[11,12,14]

After the crowns for the maxillary implants were delivered, the dental and soft tissue appearance were carefully assessed with a Pink & White dental esthetics evaluation (*worksheet at the end of this care report*). The buccal tissue on both implants was deficient because the implant sites were relatively atrophic prior to fixture placement (*Fig. 9*). Consistent with patient's concern about additional surgery, the implants were placed without a previous bone and soft tissue augmentation procedures.[12,15] The gingival margins for the implant-supported crowns (*UR5, UL6*) were not consistent with the adjacent or contralateral teeth, some of which showed gingival recession.[18,20] The crown margins of UR5 and UL6 conformed to the CEJ outline, but gingival recession was evident on the UR4, UL4 and UR6 (*Figs. 22 and 23*). There are two methods for enhancing this white esthetic problem: 1. gingival grafts for the teeth with recession, and/or 2. place the implant fixtures 1mm

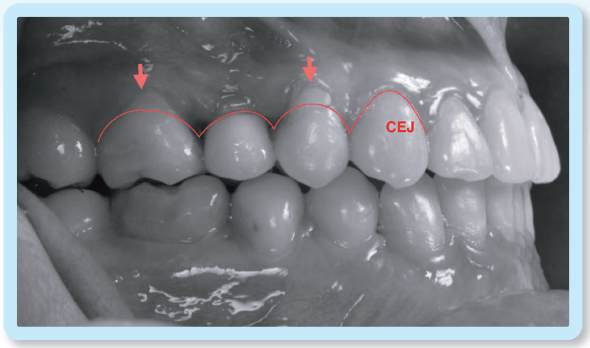


Fig. 22:
After delivery of the UR5 crown, the gingival margins for the right buccal segment were irregular relative to the CEJ contours (red line). The UR5 crown was consistent with the CEJ heights but there was gingival recession for UR4 and UR6 (red arrows), See text for details.

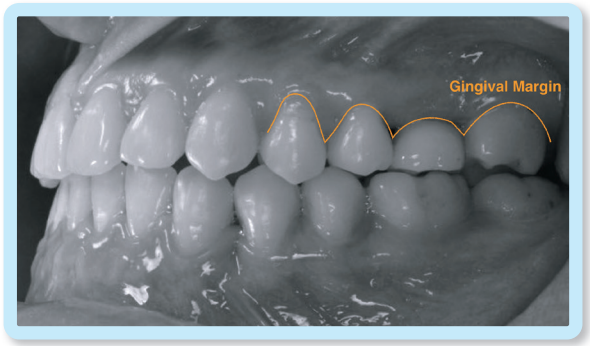


Fig. 23:
The upper gingival margins (labeled orange line) for the upper left buccal segment are irregular because the inferior margin of the UL6 crown is about 1mm more occlusal than ideal. See text for details.

deeper to decrease gingival height,[18,21] but care must be exercised to avoid a biologic width problem.[22] For the UL6 implant, intruding the fixture would be a difficult adjustment because of the sinus lift bone augmentation procedure (*Fig. 10*). However, these minor esthetic issues were of no consequence to the patient because she was satisfied with the result and preferred to avoid any additional surgery.

A major concern with the current patient was longterm followup of the pleasing result supported by compromised periodontal tissues. She was informed that careful oral hygiene and regular professional care were essential for the maintenance of the implants, and the compromised lower anterior segment, where the knife-edge ridge was closed. Unfortunately the patient failed to return for follow-up evaluation after the completion of treatment (*Figs. 14-19*), and reportedly has moved overseas. The patient was very pleased with the final esthetics, but may have failed to adequately understand that the conservative treatment she demanded was stressful for her compromised periodontium. Follow-up care is critically important for longterm maintenance. Hopefully she will pursue the followup program prescribed wherever she has chosen to live.

Clinicians are often challenged by patient preferences that conflict with the most ideal approach to managing a compromised dentition. Potential periodontal problems in adult orthodontic patients is a serious concern. The ABO noted that periodontal deterioration of patients, who appear to be stable based on routine pretreatment records, was a frequent problem for case reports presented for the clinical examination. A precedence was set by alerting the orthodontic profession that special periodontal screening is necessary for all adult patients (*18 years or older*) seeking comprehensive treatment, and any patients <18 years old with signs or symptoms of periodontal disease (*not simple gingivitis*). Periodontal pretreatment records should be taken within 6 months prior to treatment and

within 12 months following appliance removal. Post-treatment periodontal records are required on patients that start treatment as an adolescent but finish treatment at 18 years or older.

To properly evaluate patients at risk of periodontal compromise the ABO[6] requires one or more of the following methodologies for all case reports:

1. Full mouth periodontal probing prior to initiating orthodontic treatment
2. Written documentation of periodontal status, including a full periodontal charting, received from a periodontist, general or pediatric dentist.
3. Panoramic radiograph, in conjunction with vertical or conventional bitewings, and maxillary and mandibular anterior periapical radiographs
4. Full mouth series of periapical and bitewing radiographs
5. High resolution CBCT images that represent requirement #3 above

The present case report is a good example of the excellent results attainable with the coordinated interdisciplinary care afforded by orthodontics and implant dentistry. However, comprehensive treatment of patients with a compromised periodontium is unpredictable, particularly if there are episodes of active periodontitis. A healthy or at least stable periodontium is an important prerequisite for orthodontic care. The ABO method for periodontal documentation before treatment[6] is critical for determining if the patient is a good candidate for any form of comprehensive treatment. In addition, periodontally compromised patients should be carefully maintained during and after treatment.

Conclusions

A functional ($C_R \rightarrow C_O$) shift is commonly associated with crossbites. Clinical evaluation of the potential for conservative treatment of a skeletal malocclusion must be performed in C_R. If a pseudo-Class III patient has an acceptable profile in the most retruded position, there is good potential for conservative treatment. An orthodontic and implant treatment plan was the most conservative solution for this mutilated Class III patient. However, the periodontium was compromised, there were knife-edge edentulous ridges to close, and one of the implant sites was atrophic. Despite these problems the patient insisted on conservative treatment with a minimum of surgery. Camouflage treatment meets the patient's needs but there were problems with lateral root resorption and localized loss of alveolar height. A severe malocclusion (*DI 45*) was treated to a satisfying result (*CRE 26, P&W 3*) in 23 months. However, the compromised periodontium requires longterm maintenance.

Acknowledgment

Thanks to Mr. Paul Head for proofreading this article.

References

1. Bishara SE, Burkey PS, Kharouf JG. Dental and facial asymmetries: a review. Angle Orthod 1994;64(2):89–98.
2. Tseng LLY, Chang CH, Roberts WE. Diagnosis and conservative treatment of skeletal Class III malocclusion with anterior crossbite and asymmetric maxillary crowding. Am J Orthod Dentofacial Orthop 2016;149(4):555–66.
3. Yeh H, Chang CH, Roberts WE. Conservative treatment of a skeletal Class III malocclusion complicated with atrophic extraction sites and periodontal compromise. Int J Orthod Implantol 2016;42:44–59.
4. Chang M, Chang CH, Roberts WE. Acquired Malocclusion Due to Early Loss of Permanent First Molars: OBS-Anchored Orthodontics and Implant-Supported Prostheses. Int J Orthod Implantol 2016;42:20–41.
5. Sim HY, Kim HS, Jung DU, Lee JW, Han K, Yun KI. Association between orthodontic treatment and periodontal diseases: results of a national survey. Angle Orthod 2017;87(5):651-657.
6. American Board of Orthodontics (ABO) website, periodontal documentation requirements, revised March 1, 2007.
7. Sarver DM. The importance of incisor positioning in the esthetic smile: the smile arc. Am J Orthod Dentofacial Orthop 2001;120(2):98-111.
8. Lee A, Chang CH, Roberts WE. MIH-related loss of mandibular first molars resulted in an acquired Class II skeletal malocclusion: conservatively treated with space closure on one side and implant-supported prosthesis on the other. Int J Orthod Implantol 2017;47:26-48.
9. Sarikaya S, Haydar B, Ciğer S, Ariyürek M. Changes in alveolar bone thickness due to retraction of anterior teeth. Am J Orthod Dentofac Orthop 2002;122(1):15–26.
10. Melsen B. Biological reaction of alveolar bone to orthodontic tooth movement. Angle Orthod 1999;69(2):151–8.
11. Chang CH. The 2B-3D rule for implant planning, placement and restoration. Int J Orthod Implantol 2012;27:96–101.
12. Chang MJ, Chang CH, Roberts WE. Combined implant-orthodontic treatment for an acquired partially-edentulous malocclusion with bimaxillary protrusion. Int J Orthod Implantol 2012;28:38-64.
13. Dohan DM, Choukroun J, Diss A, Dohan SL, Dohan AJ, et al. Platelet-rich fibrin (PRF): A second-generation platelet concentrate. Part I: Technological concepts and evolution. Oral Surgery Oral Med Oral Pathol Oral Radiol Endod 2006;101(3):37-44.
14. Chiu GSC, Chang CH, Roberts WE. Interdisciplinary treatment for a compensated class ii partially edentulous malocclusion: orthodontic creation of a posterior implant site. Am J Orthod Dentofacial Orthop (Accepted 2016).
15. Grunder U, Spielman HP, Gaberthüel T. Implant-supported single tooth replacement in the aesthetic region: a complex challenge. Pract Periodontics Aesthet Dent 1996;8(9):835–42. Quiz 844.
16. Grunder U. Stability of the mucosal topography around single-tooth implants and adjacent teeth: 1-year results. Int J Periodontics Restorative Dent 2000;20(1):11–7.
17. Grunder U, Gracis S, Capelli M. Influence of the 3-D bone-to-implant relationship on esthetics. Int J Periodontics Restorative Dent 2005;25(2):113–9.
18. Small PN, Tarnow DP. Gingival recession around implants: a 1-year longitudinal prospective study. Int J Oral Maxillofac Implants 2000;15(4):527–32.
19. Tarnow DP, Cho SC, Wallace SS. The effect of inter-implant distance on the height of inter-implant bone crest. J Periodontol 2000;71(4):546–9.
20. Ericsson I, Nilner K, Klinge B, Glantz PO. Radiographical and histological characteristics of submerged and nonsubmerged titanium implants. An experimental study in the Labrador dog. Clin Oral Implants Res 1996;7(1):20–6.
21. Abrahamsson I, Berglundh T, Wennström J, Lindhe J. The peri-implant hard and soft tissues at different implant systems. A comparative study in the dog. Clin Oral Implants Res 1996;7(3):212–9.
22. Hermann JS, Buser D, Schenk RK, Higginbottom FL, Cochran DL. Biologic width around titanium implants. A physiologically formed and stable dimension over time. Clin Oral Implants Res 2000 Feb;11(1):1-11.

Discrepancy Index Worksheet

TOTAL D.I. SCORE 45

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 = 21

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 = 4

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 = 0

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 _____ pts.
Beyond Class II or III	=	1 pt. per mm. additional _____ pts.

Total = 4

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 2

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° _____ x 1 pt. = _____

1 to MP ≥ 99° = 1 pt.

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

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. =	2
Missing teeth (except 3rd molars)	_____ x 1 pts. =	2
Missing teeth, congenital	_____ x 2 pts. =	_____
Spacing (4 or more, per arch)	_____ x 2 pts. =	_____
Spacing (Mx cent. diastema ≥ 2mm)	@ 2 pts. =	_____
Tooth transposition	_____ x 2 pts. =	_____
Skeletal asymmetry (nonsurgical tx)	@ 3 pts. =	_____
Addl. treatment complexities	3 x 2 pts. =	6

Identify: Close 7mm knife edge.

Total = 10

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) = 2

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

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

Total = 2

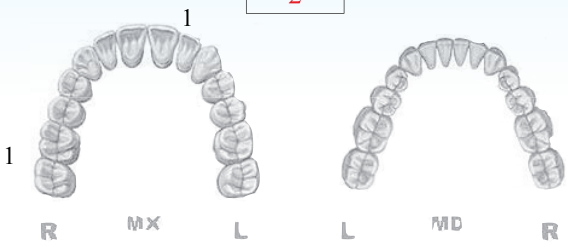
Cast-Radiograph Evaluation

Case # **Patient**

Total Score: 26

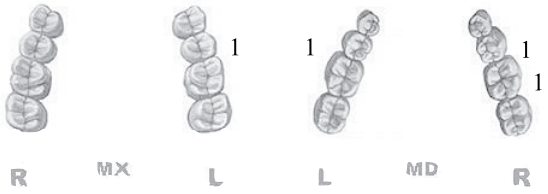
Alignment/Rotations

2



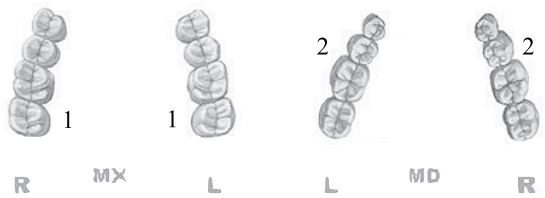
Marginal Ridges

4



Buccolingual Inclination

6

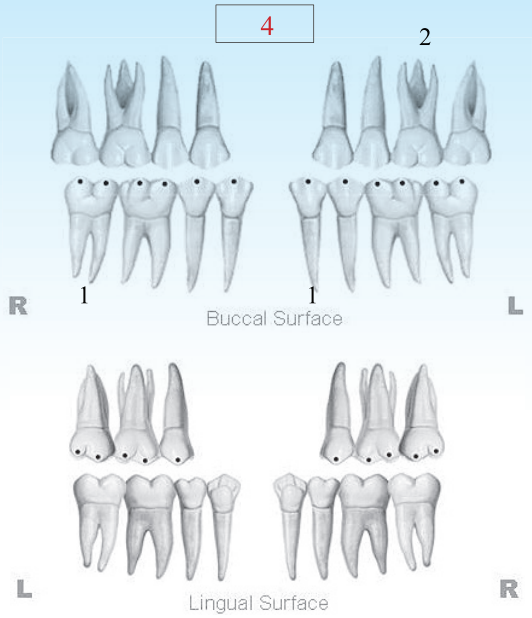


Overjet

2

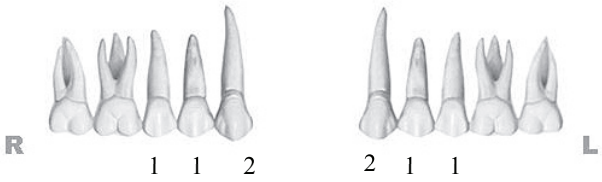
Occlusal Contacts

4



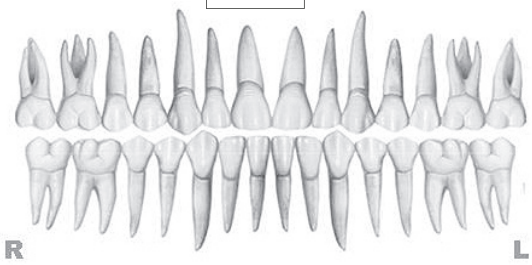
Occlusal Relationships

8



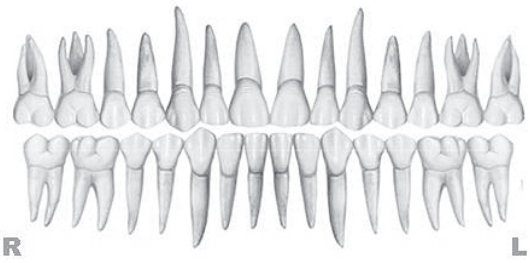
Interproximal Contacts

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 (Before Surgical Crown Lengthening)

Total Score: = 3

1. Pink Esthetic Score

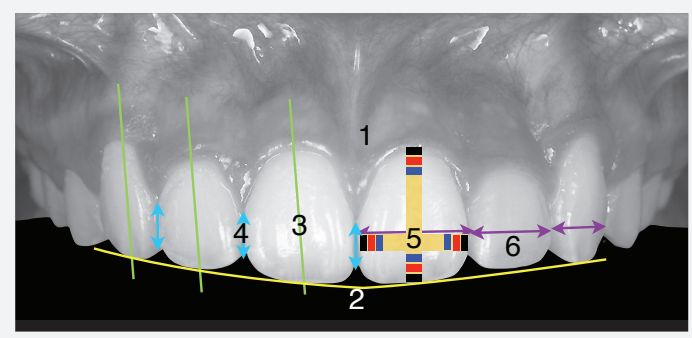
Total = 1

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

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

2. White Esthetic Score (for Micro-esthetics)

Total = 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

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