Congenital Absence and Microdontia of Second Premolars: Orthodontics, Implants and Prosthetic Dentistry

Abstract

A 31-year-5-month old male presented for orthodontic consultation to evaluate interdental spacing and an anterior deepbite. There were three congenital missing second premolars: lower left (LL), lower right (LR) and upper right (UR) quadrants. The upper left (UL) second premolar was affected by microdontia and positioned in lingual crossbite. Multiple teeth were tipped and extruded in both arches, so preprosthetic alignment was required to prepare sites to restore the missing and anomalous premolars. Orthodontic alignment and prosthetic site preparation was achieved with a full fixed passive self ligating appliance, open coil springs, and early light short Class II elastics (ELSE). Bite turbos were employed to increase the vertical dimension of occlusion (VDO). Flapless and open-flap surgical procedures were selected according to the soft tissue and bone conditions at each implant site. The implant replacing the LR second premolar was inadvertently oriented to the buccal, so a 15° angled abutment was required to correct the orientation of the preparation prior to restoration with a crown. This severe mutilated malocclusion with an American Board of Orthodontics (ABO) Discrepancy Index (DI) of 26 was treated to a pleasing functional and esthetic result in 26 months. The ABO Cast-Radiograph Evaluation (CRE) score was 27, and the Pink and White dental esthetic index was 3. (Int J Orthod Implantol 2016;43:4-27)

Key words:

Interdental spacing, congenitally missing premolars, microdontia, preprosthetic alignment, implant size selection, flap and flapless surgical techniques

History and Etiology

A 31-year-5-month male presented for interdisciplinary consultation (*Fig. 1*) with a chief complaint: unaesthetic dentition due to irregular spaces (*Figs. 2 and 3*). Clinical examination revealed an anomalous, small second premolar (*microdontia*) in the UL quadrant, that was in lingual crossbite. The other three second premolars were congenitally missing. Masticatory efficiency was compromised in the canine and premolar areas of both arches due to multiple spaces and extruded teeth (*Fig. 2*). There was no cost-effective prosthetic option for managing this severe malocclusion (*DI 26*), without preprosthetic orthodontics. An interdisciplinary treatment plan was initiated to align the dentition and consolidate space for restoration of the missing second premolars with implant-supported prostheses (*ISP*). A crown was placed on the undersized UL maxillary premolar. The patient was treated to the planned result in 26 months as documented in Figs. 4-6. Radiographic images before and after treatment are presented in Figs. 7 and 8,

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■ *Fig. 1: Pre-treatment facial photographs*

■ *Fig. 4: Post-treatment facial photographs*

■ *Fig. 2: Pre-treatment intraoral photographs*

■ *Fig. 5: Post-treatment intraoral photographs*

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

■ *Fig. 6: Post-treatment study models (casts)*

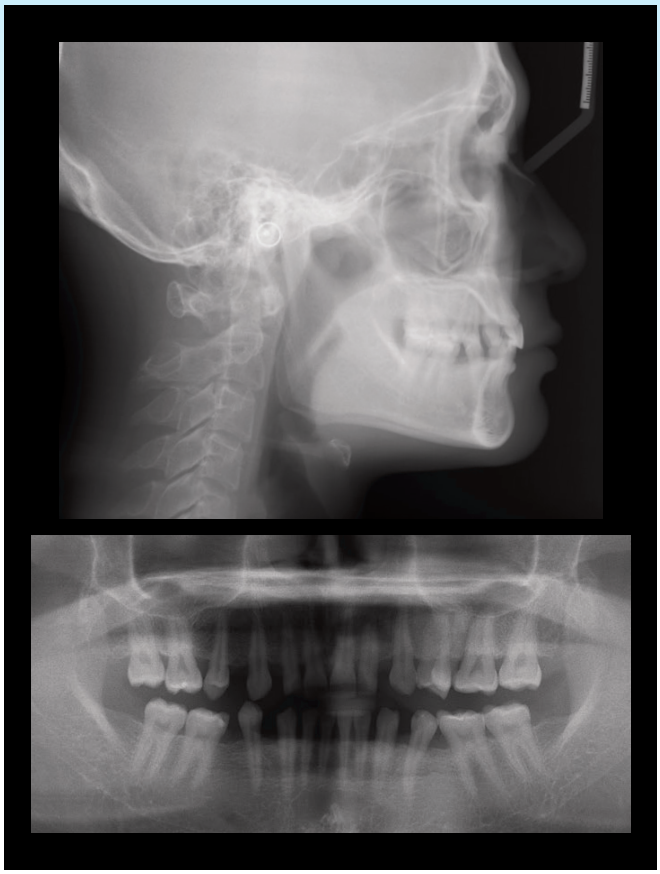

Fig. 7:
Pre-treatment lateral cephalometric and panoramic radiographs show a relatively straight profile (above) and an irregular partially edentulous dentition (below).

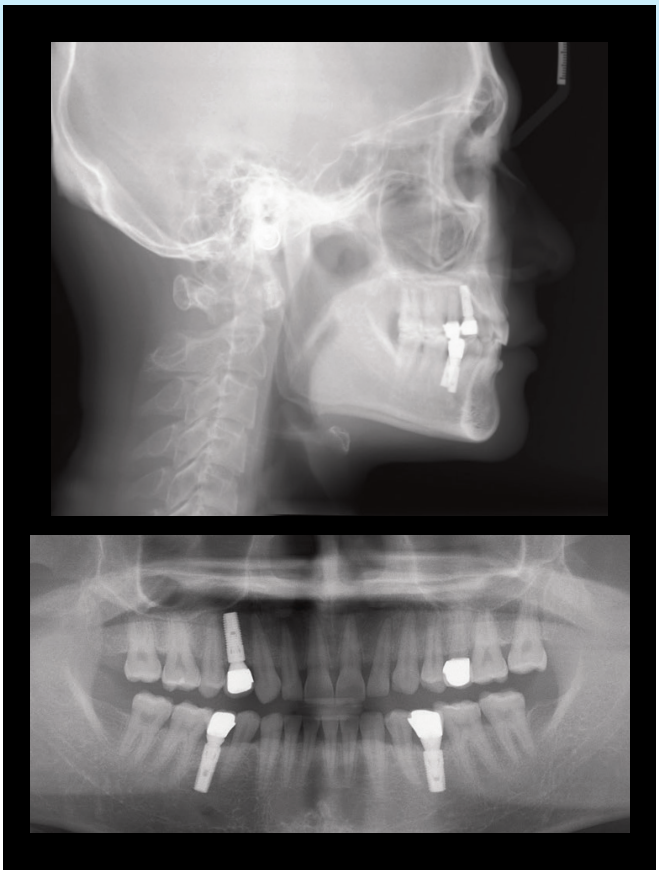

Fig. 8:
Post-treatment lateral cephalometric and panoramic radiographs document an adequate facial profile, a well aligned dentition, and three implants optimally positioned for restoration of the congenitally missing second premolars.

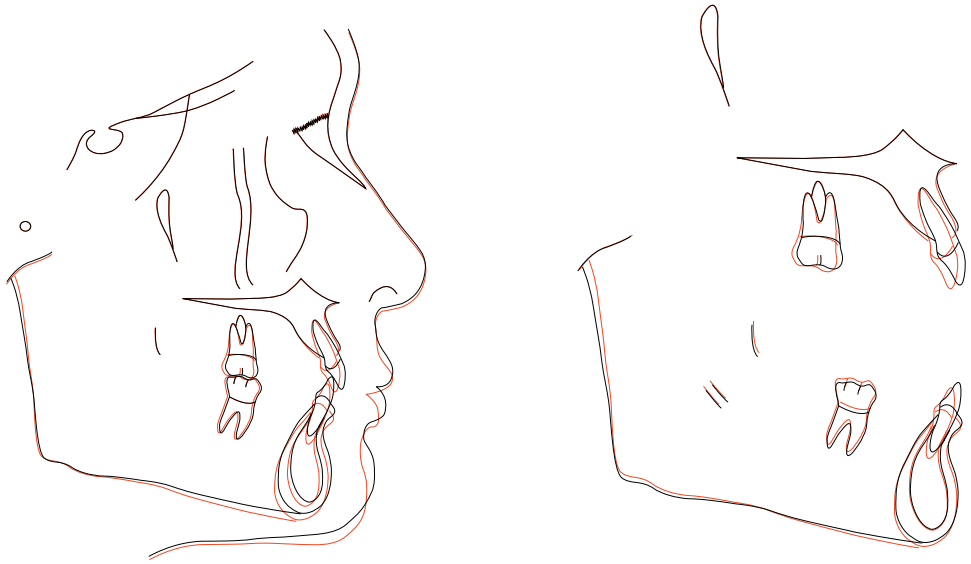

Fig. 9:
Initial (black) and finish (red) cephalometric tracings are superimposed on the anterior cranial base (left), as well as on the stable skeletal structures of the maxilla (upper right), and mandible (lower right). Note that the most significant changes were clockwise mandibular rotation to open the vertical dimension of occlusion, and slight retraction of the anterior segments to optimally align the dentition.

respectively. Cephalometric documentation is provided in Fig. 9.

Diagnosis

Skeletal:

- Skeletal Class I (*SNA 83°, SNB 83°, ANB 0°*)
- Low mandibular plane angle (*SN-MP 19°, FMA 15°*)

Dental:

- Slight Class II molar tendency bilaterally
- Three congenitally missing second premolars #5 (*UR*), 20 (*LL*), and 29 (*LR*)
- Microdontia and lingual crossbite of the upper left (*UL*) second premolar, tooth #13
- Irregular marginal ridges in both arches due to tipping and lack of antagonists (*Fig. 10*)

Fig. 10:
Multiple teeth were extruded due to a lack of appropriate occlusal antagonists. Dental alignment was inadequate for cost-effective prosthetic reconstruction.

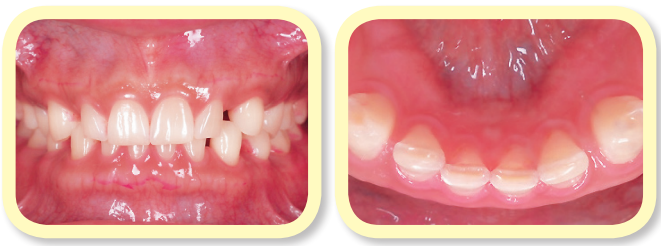

Fig. 11:
Severe attrition of the incisal edges of lower anterior teeth was attributed to abnormal function associated with the deep bite occlusion.

- Severe attrition of the incisal edges in the lower anterior segment (*Fig. 11*)
- Overbite 4mm
- Excessive curve of Spee in the lower arch

Facial:

- Relatively straight facial profile with a retruded lower lip

The American Board of Orthodontics (*ABO*) Discrepancy Index (*DI*) was 26 as shown in the subsequent worksheet.

Specific Objectives of Treatment

The principal objectives were to: 1. maintain the facial profile, 2. align marginal ridges to restore occlusal function, 3. prepare implant sites by consolidating space, and 4. achieve ideal overbite and overjet relationships.

CEPHALOMETRIC			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA°	83°	83°	0°
SNB°	83°	83°	0°
ANB°	0°	0°	0°
SN-MP°	19°	21°	2°
FMA°	15°	17°	2°
DENTAL ANALYSIS			
U1 TO NA mm	5.5 mm	3.5 mm	2 mm
U1 TO SN°	106°	100°	6°
L1 TO NB mm	3 mm	1.5 mm	1.5 mm
L1 TO MP°	99°	94.5°	4.5°
FACIAL ANALYSIS			
E-LINE UL	-2.5 mm	-2 mm	0.5 mm
E-LINE LL	-2 mm	-2.5 mm	0.5 mm

Table 1: Cephalometric summary

Maxilla (*all three planes*):

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

Mandible (*all three planes*):

- A - P: *Slight distal movement consistent with bite opening*
- Vertical: *Increase by rotating the mandible clockwise*
- Transverse: *Maintain*

Maxillary Dentition

- A - P: *Retract maxillary incisors and molars*
- Vertical: *Extrude to increase the vertical dimension*
- Preprosthetic preparation of second premolar areas

Mandibular Dentition

- A - P: *Retract lower incisors*
- Vertical: *Extrude molars and intrude incisors to correct excessive curve of Spee*
- Prepare implant sites for both missing second premolars

Facial Esthetics: Maintain

Treatment Plan

The interdisciplinary sequence begins with full fixed orthodontic alignment, with an increase the vertical dimension of occlusion (*VDO*) via anterior bite turbos (*occlusal stops*), and Class II elastics. During alignment open coil springs consolidate space in the second premolar areas. About 6 months before the end of active orthodontics treatment, place implants to replace the missing three premolars, and after orthodontics treatment is completed construct four prosthetic restorations (*single crowns*) to restore all second premolars. Retain with clear overlay retainers.

Appliances and Treatment Progress

An .022" slot self-ligating appliance Damon Q® bracket system (*Ormco, Glendora, CA*) was used for both arches along with the elastics and archwires prescribed by the same manufacturer. Standard torque brackets were bonded on upper and lower incisors. The initial arch wire was .014" CuNiTi. Bite turbos were bonded on the palatal surface of maxillary central incisors (*teeth #8 & 9*). Early light short elastics (*ELSE*) (*Quail 2oz*) were applied from the buccal surface of the lower first molars to the upper canines bilaterally (*Fig. 12*). In the 8th month of treatment, the upper arch wire was changed to .016x.025" stainless steel (*SS*) and a .017x.025" titanium molybdenum alloy (*TMA*) archwire was placed in the lower arch. In the mandible, open coil springs were compressed between the first molars and premolars to increase space for the planned protheses. In the maxilla, the open coil springs were placed between the canine and premolar on the right side to prepare the implant site and provide adequate space for the PFM

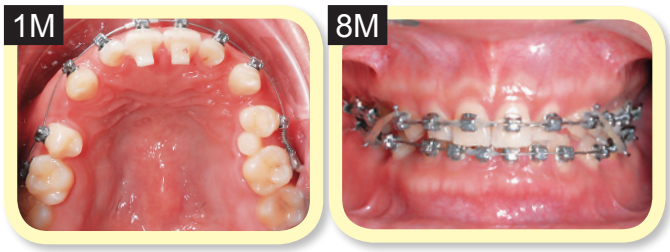

Fig. 12:
Bite turbos (premature occlusal stops) were bonded on the palatal surfaces of teeth #8 & 9. ELSE (Quail 2oz) were applied from the lower first molar to upper canine bilaterally to correct the Class II irregularity in the buccal segments.

crown on the anomalous tooth at the left side (*Fig. 13*). Thirteen months into active treatment, a cone-beam computed tomography (*CBCT*) scan was exposed to evaluate the bone volume in the implant sites (*Fig. 14*). Surgical stents were designed on the casts to guide the osteotomy for implant placement (*Fig. 15*). In the 15th month of treatment, presurgical preparation was completed (*Fig. 16*)[1], and the mucogingival junction was evaluated for each implant site to determine if there was at least 3mm of keratinized gingiva (*Fig. 17*).[2-4]

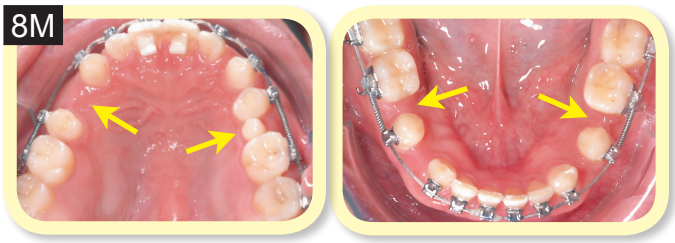

Fig. 13:
Open coil springs were placed between the first molar and first premolar in all four quadrants (black arrows) to produce adequate space for prosthetic restoration. In the 8th month, the lower arch wire was .017x.025" TMA and the upper arch wire was .016x.025" SS.

Implant Placement

A flapless surgical technique was indicated for the upper right (*UR*) implant. After injecting local anesthesia, the surgical stent was fitted into position and a surgical explorer penetrated the soft tissue to mark the central axis of the osteotomy. A soft tissue punch was used to excise a cylinder from the 3mm thick gingiva (*Fig. 18*), and a surgical stent was positioned to guide the lancer drill for a 15mm deep osteotomy. The implant preparation site had 3mm thick soft tissue and an osteotomy depth of 12mm (*Fig. 19*). A surgical guide pin was placed in the

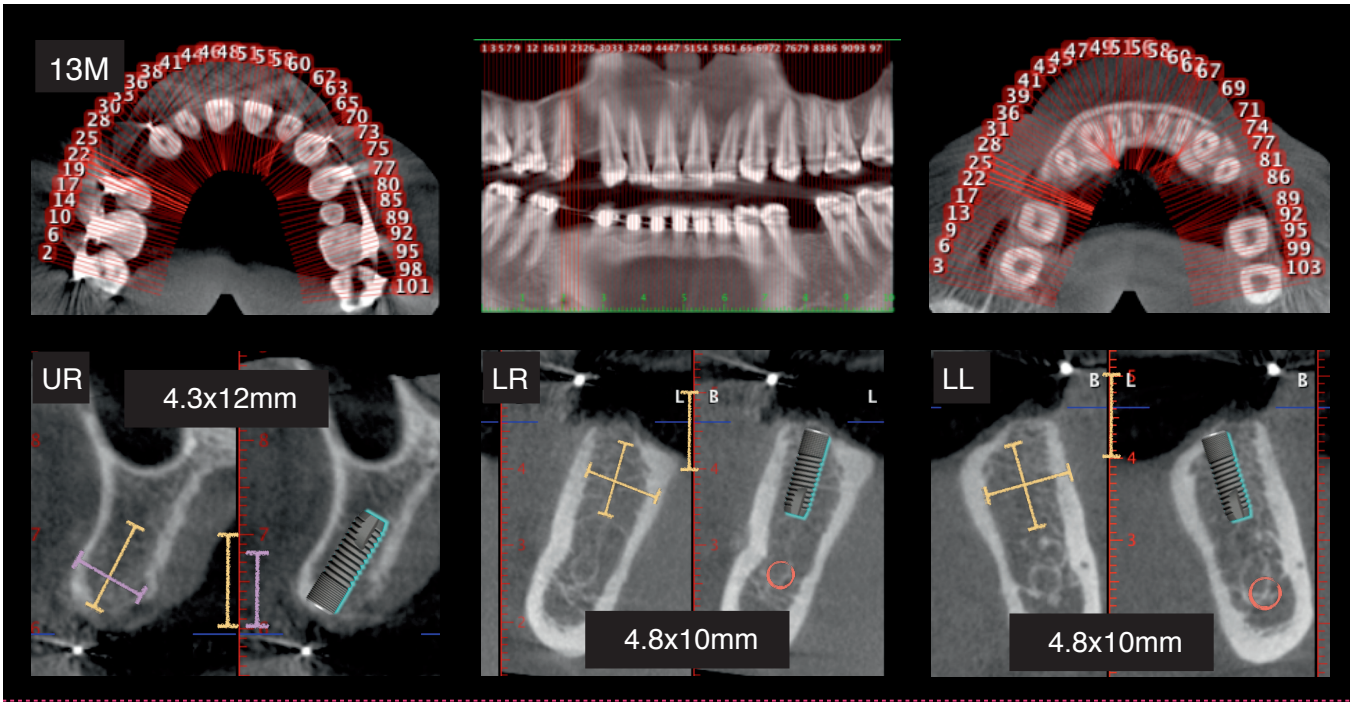

Fig. 14:
A preoperative CBCT scan assessed bone volume for the selection of appropriate implants for the three missing premolars.

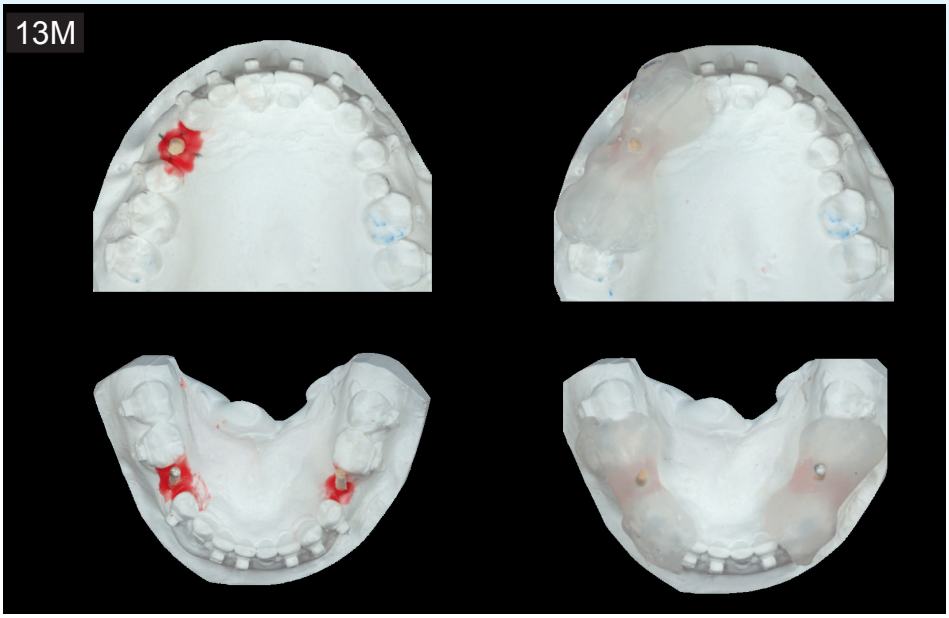

Fig. 15: At 13 months (13M) into treatment casts were obtained for construction of the surgical stents.

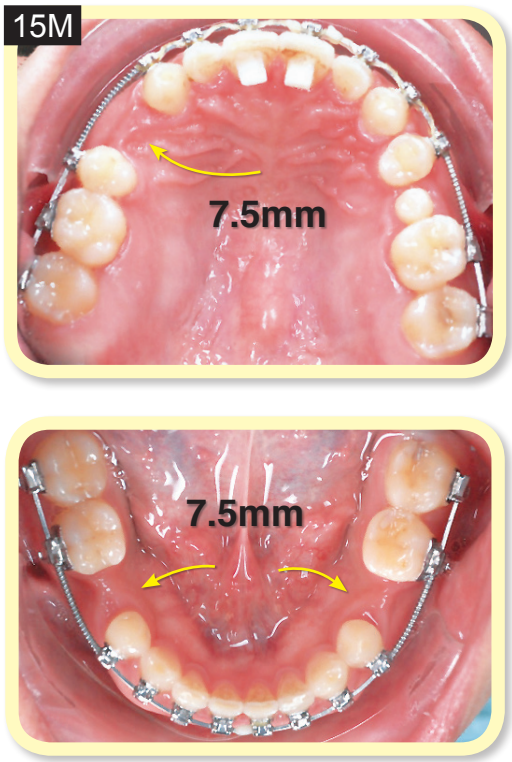

Fig. 16: After 15 months (15M) of treatment, preprosthetic preparation was completed.

preparation and a periapical x-ray was exposed to check the mesiodistal angulation of the osteotomy (*Fig. 19*). For the mandibular implant sites, flap surgery followed the 2B-3D rule (*Fig. 20*).[4,5] All three implants (*A+ system, MegaGen, Taiwan*) were installed according to the manufacturer's instructions (*Fig. 21*). Both implants on the right side were 4.3x12mm fixtures and the one in the lower left was a 4.3x10mm fixture. After each implant was placed, a 5mm healing abutment was installed. Periapical radiographs documented the final position of the implants (*Fig. 21*).[6]

Orthodontic Finishing

A panoramic radiograph was taken to evaluate the axial inclination of all teeth relative to the implants in both arches. Brackets on maligned teeth were rebonded in a position designed to achieve the

Fig. 17:
Before surgery, the location of the mucogingival junction (red line) was located to determine if there was at least a 3mm width of keratinized gingiva. The upper site (left) had adequate attached gingiva (left) but the mandibular sites were deficient on both the right and left sides, as shown in the center and right photographs, respectively.

Fig. 18:
A flapless technique was used to place an implant in the upper right second premolar area. A surgical probe was employed for soft tissue penetration to mark the central position of the future implant (left). A soft tissue punch was used to excise the gingiva (right) as indicated by the bleeding point (center).

Fig. 19:
The initial osteotomy was cut to a depth of 15mm and the drill was released from the handpiece (left). The lancer drill was removed and a surgical guide pin was inserted (center). A periapical radiograph (right) was exposed to check the mesiodistal angulation of the osteotomy.

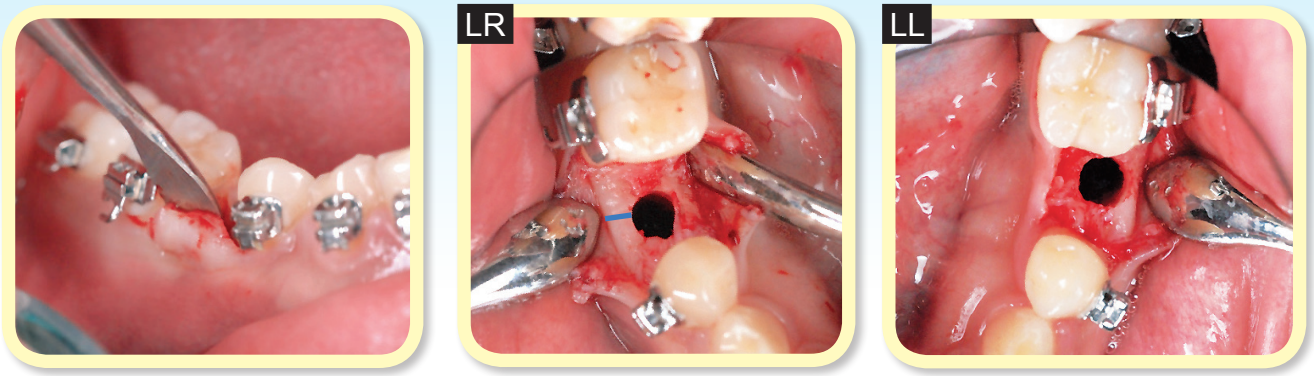

Fig. 20:
Flap surgery was performed for both of the mandibular implant sites. Soft tissue is reflected (right) and >2mm of buccal bone width (blue line) is confirmed lateral to the osteotomy (center). The contralateral osteotomy has the minimum bone width of 2mm (right).

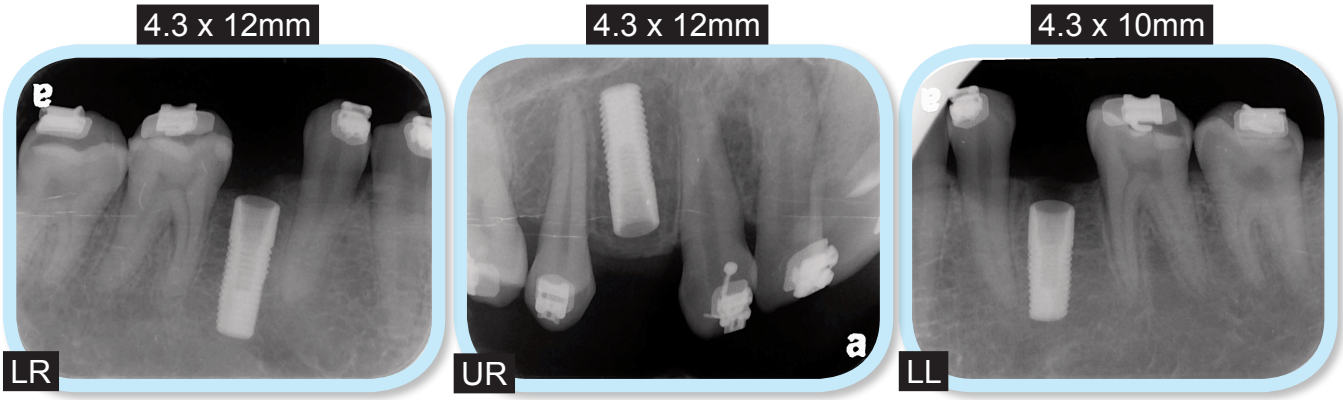

Fig. 21:
Periapical radiographs confirm adequate implant size and position for all three second premolar areas (LR, UR and LL).

desired inclinations with a straight CuNiTi archwire (*Fig. 22*). After 6 months of final finishing and implant healing, the prostheses were constructed (*Fig. 23*).

Implant Prosthesis Fabrication

Preprosthetic evaluation revealed that the LR implant was excessively oriented to the buccal. Despite the incorrect buccal-lingual angulation of the implant (*Fig. 24*), the overall position was satisfactory, so an angled abutment was indicated. Accordingly a 15˚ angled abutment with a 2mm cuff

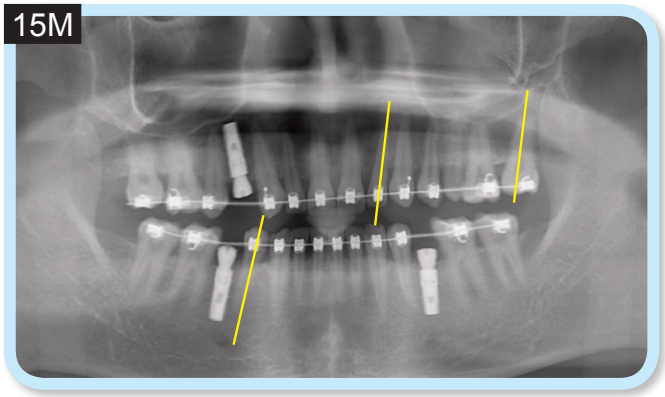

Fig. 22:
A panoramic radiograph was exposed to evaluate dental axial inclinations relative to the implants. Brackets were repositioned for the three teeth with a significant deviation from ideal inclination (yellow lines).

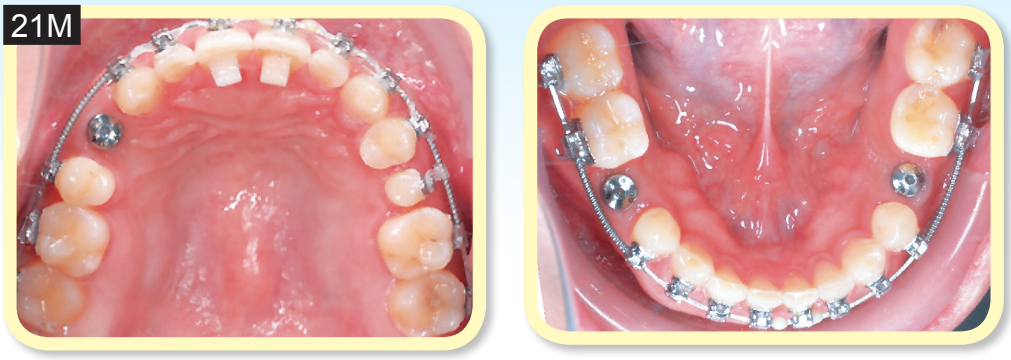

Fig. 23: Following 6 months of orthodontics finishing, the implants were sufficiently healed for prostheses fabrication.

Fig. 24:
At 21 months (21M) into treatment, the UR and LL implants have an appropriate buccolingual inclination, but the LR implant (center) was excessively tipped to the buccal.

height was selected and screwed into the fixture. The post height of the abutment was reduced to provide 2mm of occlusal clearance for prosthesis fabrication (*Fig. 25*). A double cord gingival retraction technique was used to expose each abutment for a direct impression with polyvinyl siloxane (*Fig. 26*). The impressions were poured with type IV dental stone to prepare the working cast. To prevent tissue overgrowth, a "*Tony cap*" was used as a substitute for a provisional crown as shown (*Fig. 27*). Straight post abutments with 3mm cuff height were chosen for the lower left and upper right implants (*Fig. 28*). For all of the implant abutments, a direct impression utilizing the pick-up technique was made, then fitted with an abutment analog (*Fig. 29*), and poured with type IV dental stone. A laser crown lengthening procedure was performed adjacent to the undersized upper left second premolar, which was then prepared to receive a PFM crown (*Fig. 30*). All four crowns were delivered (*Fig. 31*), and the marginal fit was checked with periapical radiographs (*Fig. 32*).

Fig. 25:
Occlusal clearance for the LR abutment was inadequate (left). The post height of the abutment was reduced to provide 2mm of occlusal clearance for fabrication of the prosthesis (center) and then repositioned into the implant to confirm adequate occlusal clearance (right).

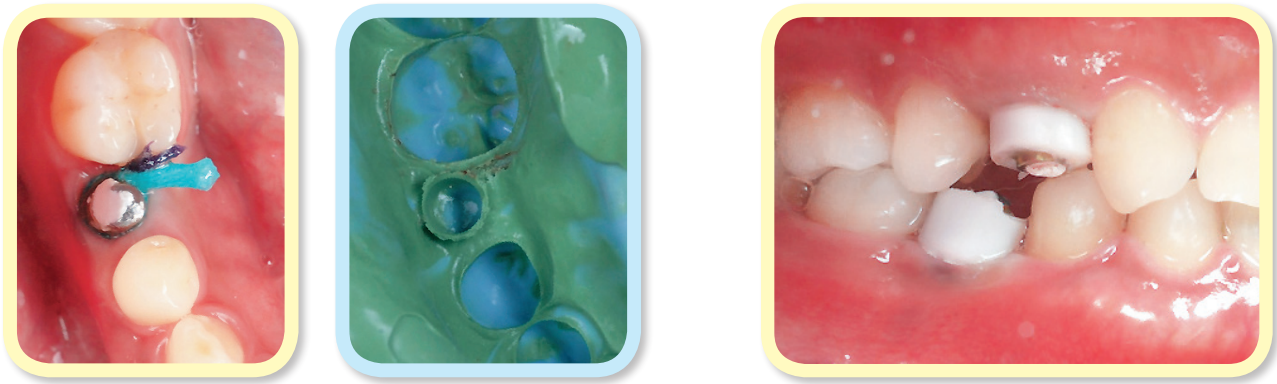

Fig. 26:
Following soft tissue retraction with the double cord technique (left), a polyvinyl siloxane impression was made (right).

Fig. 27:
To prevent soft tissue overgrowth, Tony caps were fitted on the prepared abutments.

Fig. 28:
Straight post abutments with a 3mm cuff height were used for the UR and LL implants, as shown in the left and right views, respectively.

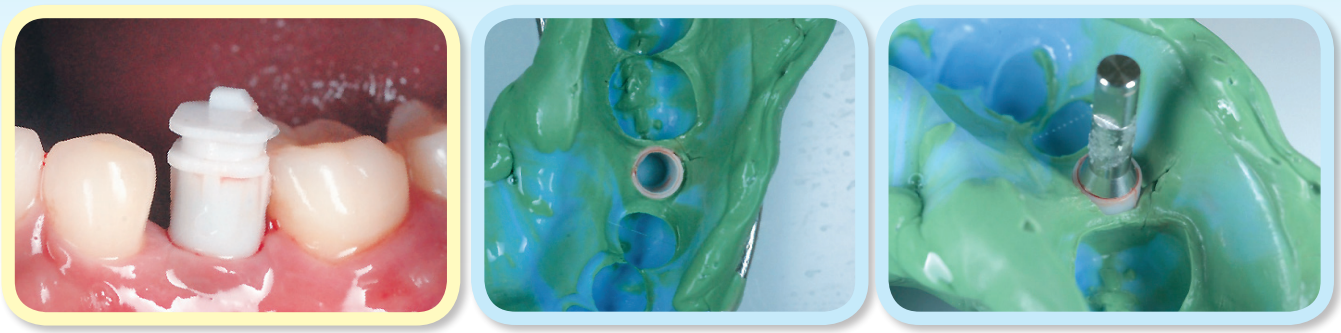

Fig. 29:
A female abutment index was fitted on the lower LL preparation (left), and a direct impression was made utilizing the pick-up technique (center). An abutment analogue was inserted into the index device (right) and the impression was poured up in stone to prepare a working cast.

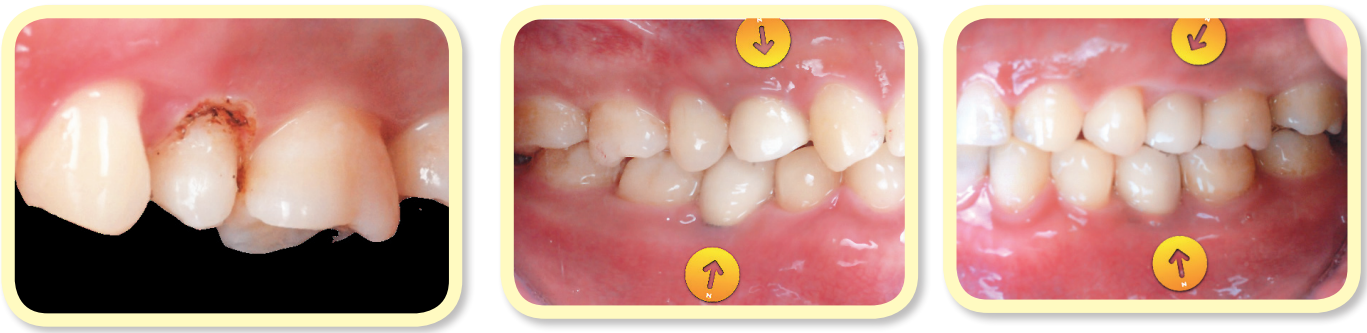

Fig. 30:
For the under-sized upper left second premolar, a laser crown lengthening procedure was performed as shown and allowed to heal, prior to making the final impression to construct the crown.

Fig. 31: All four crowns were delivered as marked by the arrows.

Fig. 32:
Periapical films were exposed to check the marginal fit of each restoration. The LR, UR and LL prostheses are shown in the left, center and right views, respectively.

Results Achieved

Maxilla (*all three planes*):

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

Mandible (*all three planes*):

- A - P: *Decreased slightly*
- Vertical: *Rotated 2° clockwise*
- Transverse: *Maintained*

Maxillary Dentition

- A - P: *Incisors retracted, molars tipped distally*
- Vertical: *Slightly increased*
- Inter-molar / Inter-canine Width: *Maintained*

Mandibular Dentition

- A - P: *Maintained*
- Vertical: *Mandibular incisors intruded and retracted, molars extruded*
- Inter-molar / Inter-canine Width: *Maintained*

Facial Esthetics: Maintained

Retention

Upper and lower clear overlay retainers were delivered, but no fixed retainers were deemed necessary. The patient was instructed to wear the overlays full time for the first month and nights only thereafter. Instructions were provided for dental hygiene as well as for the maintenance of the retainers.

Final Evaluation of Treatment

The ABO Cast-Radiograph Evaluation (*CRE*) score was 27. The CRE method is actually a negative score, summing the deviations from ideal alignment. The major discrepancies shown in Figs. 33-35 were as follows: marginal ridge discrepancies -6 points (*Fig. 33*), occlusal contacts -5 points (*Fig. 34*), significant rotations -6 points (*Fig. 35*), as well as an additional -3 points for overjet. The Pink & White Esthetic Score was 3 as detailed in the worksheet at the end of this case report. Discrepancies were 1 point for an incomplete gingival papilla, in addition to 2 points for an irregular incisal curve and abnormal tooth proportions for the right upper central incisor. The patient's facial profile was improved by increasing the VDO (*Figs. 4 and 9*) with clockwise rotation of the mandible, which increased the SN-MP angle 2°. In the upper arch, there was a slight distal tipping of the molars and about a 2mm retraction of the incisors. For the lower arch, extrusion of the molars and intrusion of the incisors was consistent with deep bite correction (*Fig. 9*).

Discussion

Diagnosis

Partially edentulous patients with substantial irregularity preclude routine prosthetic restoration. Orthodontic alignment and space consolidation is indicated to achieve an optimal, cost effective result. For the current patient, orthodontic space closure was an undesirable option because of his relatively flat facial profile. Preprosthetic alignment and space

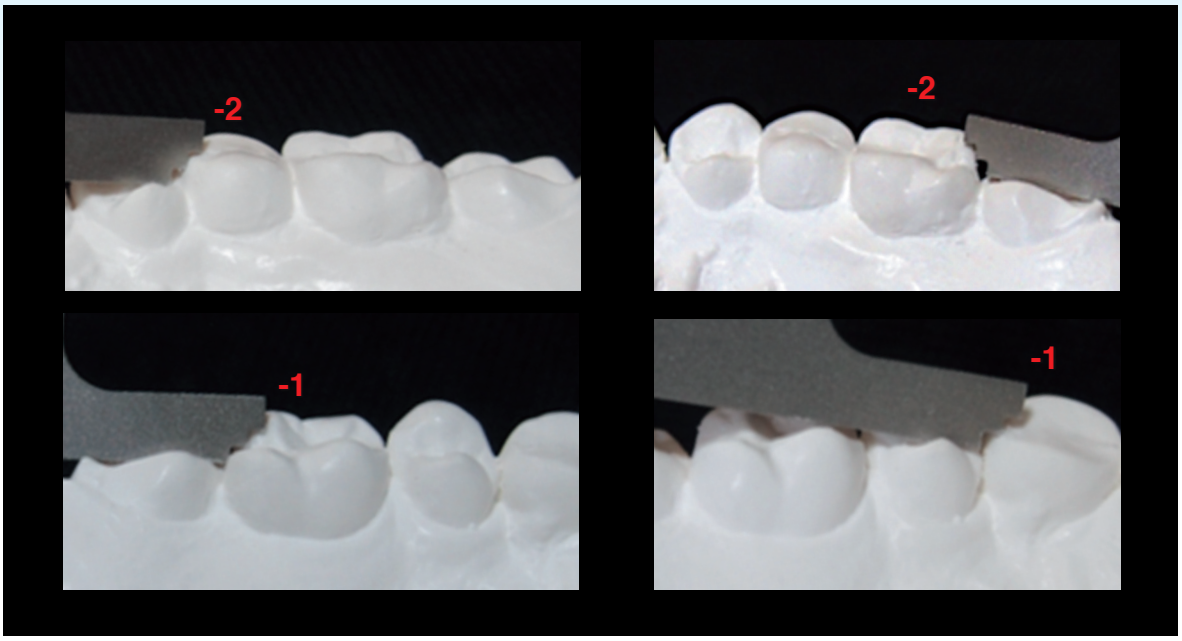

Fig. 33:
There were four marginal ridge discrepancies as marked in red that scored a total of -6 points when the American Board of Orthodontics (ABO) cast analysis was performed after treatment.

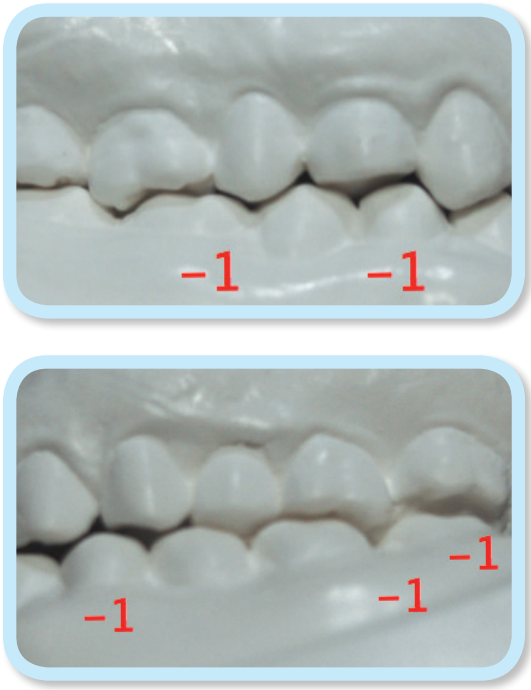

Fig. 34:
Five points were deducted as shown for lack of occlusal contacts according to the ABO scoring method.

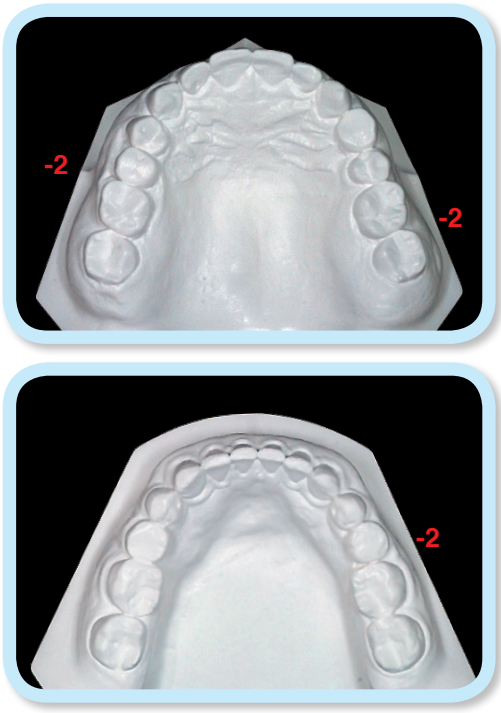

Fig. 35:
Three teeth were rotated more than 0.5mm and scored -2 point each for a total of -6 points on the ABO analysis.

management was indicated to achieve a desirable prosthetic result.

Deep bite correction

For anterior deep bite correction, anterior bite turbos were placed on the lingual surface of the upper incisors to open the bite.[7] These occlusal stops provided bite opening for increasing the clearance to place lower incisor brackets, and also served as occlusal stops to allow posterior teeth to extrude to open the bite and rotate the mandible clockwise to increase the VDO. Class II elastics assisted in steepening the plane of occlusion and supported the increase in VDO. According to Parker,[8] deep bite correction often results in not only intrusion of the incisors, but extrusion of the buccal segments, and an increased axial inclination of the incisors. This tirade was noted except for the excessive flaring of the incisors, which was prevented by orthodontic retraction of the anterior segments (*Fig. 9*).

Implant size selection

A CBCT scan provides the 3D anatomy which is critical information for selecting the size of an implant and choosing the appropriate surgical procedure. The length and diameter of a fixture has important mechanical implications, as reported by Himmlova et al.[9] From a theoretical perspective, they demonstrated that mechanical stress was focused in the crestal bone area of implants when they were loaded laterally. It has recently been demonstrated that elevated stress is directly associated with orthodontically-induced bone resorption in the path of tooth movement.[10] These dentofacial orthopedic data are consistent with the concept that elevated cervical stress[9] is associated with crestal bone loss and gingival recession (*Figs. 36-38*).

Crestal bone stress is inversely related to the length of the implant, but the curve flattens at about 10mm (*Fig. 37*), so 10-12mm implants are deemed optimal for most patients. Implant diameter is inversely related to the surface stress delivered by axial forces, because an applied axial load is distributed over a larger surface area (*Fig. 38*). Within the restraints of jaw anatomy, the theoretical stress curve suggests the optimal diameter for optimizing surface stress is ~4.0-5.0mm (*Fig. 38*). This principle is also supported at the clinical level by dentofacial orthopedics data. When an entire dental arch is moved as a segment (*determinate mechanics*), the force levels in the PDL are decreased by the large surface area of the roots to less than the level associated with pressure necrosis (*8-10kPa*).[10] Controlling PDL necrosis allowed

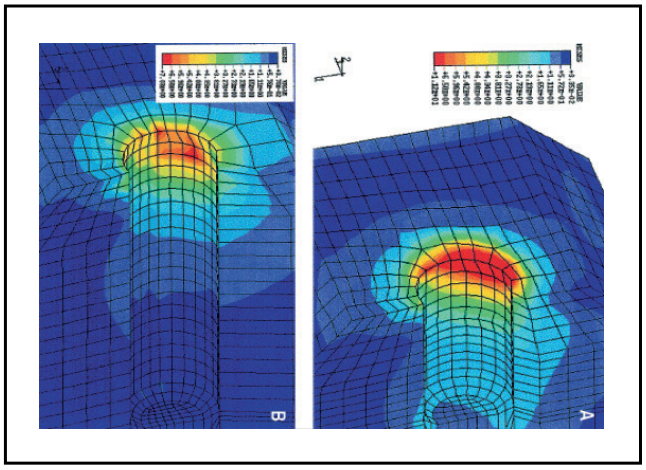

Fig. 36:
As illustrated by this finite element analysis, Himmlova et al.[9] reported that the vast majority of stress is focused on the crestal portion of implants, as documented by the red and yellow color.

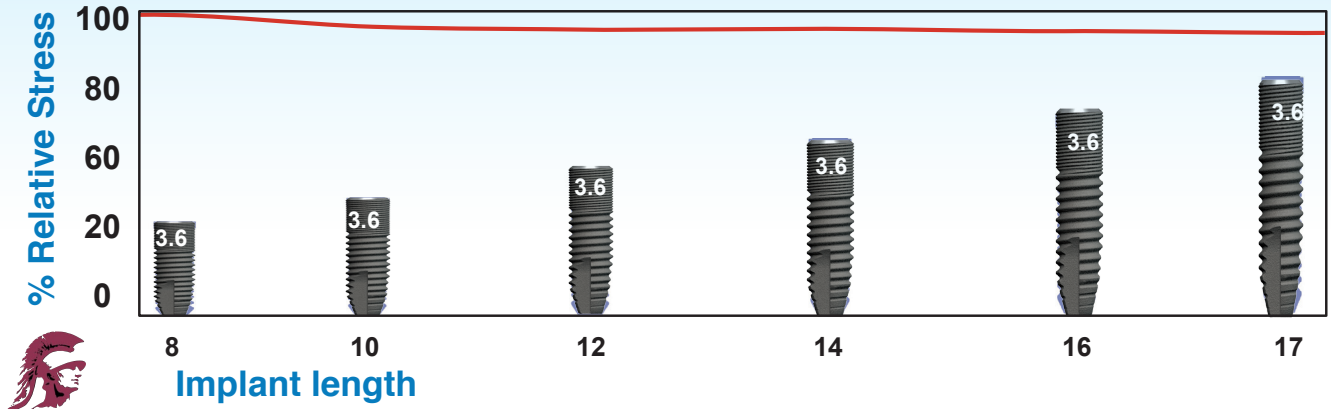

Fig. 37:
For implants of the same diameter, cervical stress (plotted as a red line) is inversely related to the length of the implant. The difference in relative stress for implants from 8 to 17mm implants is about 7.3%. Note there is little difference in the relative stress for implants 10mm or longer. For most applications, 10-12mm implants are indicated.[9]

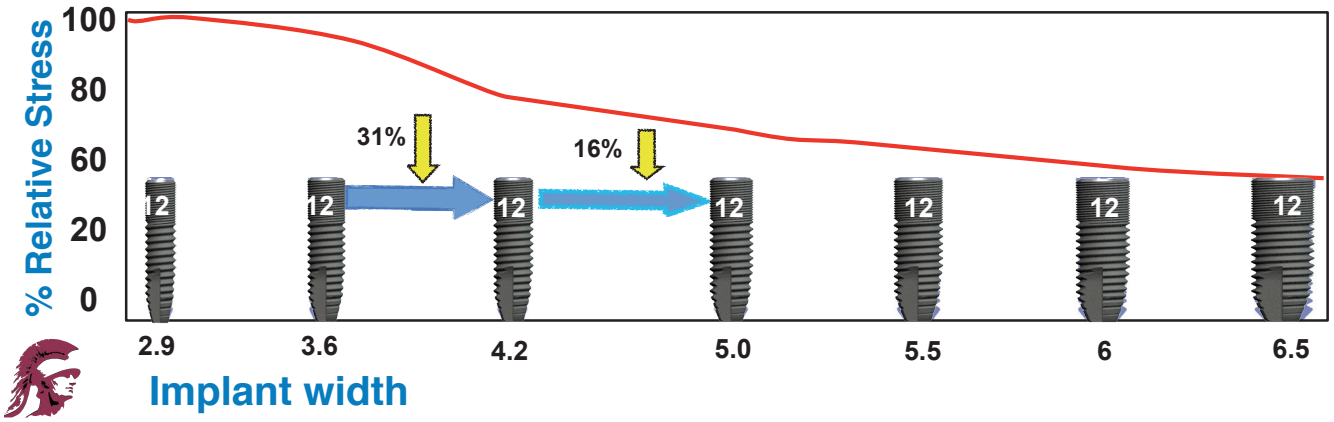

Fig. 38:
For implants 12mm in length, the relative stress at the bone margin of the fixture is inversely related to its diameter. The range of stress for implant diameters of 2.9 to 6.5mm is about 60%. The decrease in stress is about 31 and 16% as the diameter of the implant progresses from 3.6 to 4.2 and to 5.0mm, respectively. These data indicate that implant diameters of 4-5mm are indicated for most applications. See text for supporting dentofacial orthopedic data.[9]

these advanced mechanics to correct severe skeletal malocclusions conservatively, i.e. without extractions or orthognathic surgery. These data provide physiologic evidence for the prosthetic concept that stress levels are inversely related to implant surface area.

Considerations for Flapless Surgery

Implants can be placed with an open flap or flapless procedure. CBCT imaging and 3D treatment planning software are helpful for flapped procedures, but they are essential for the flapless approach, because the surgeon is operating without direct visualization of the site. Advanced

imaging and treatment planning technology have contributed to the popularization of flapless surgery among experienced implant surgeons, which is an interesting development because the method was initially designed for novice doctors.[11,12]

For implant sites with adequate soft and hard tissue, flapless surgery has numerous advantages, including: (*1*) conservation of soft tissue architecture and bone volume, (*2*) maintenance of the blood supply, (*3*) decreased operative time because of no fear reflection or sutures, (*4*) enhanced patient comfort because of less swelling and pain, and (*5*) resumption of daily oral hygiene procedures immediately.[11,12] However, the flapless approach does have some drawbacks, including: (*1*) the surgeon cannot directly visualize anatomic landmarks and vital structures, (*2*) potential for thermal damage to bone because of compromised access for external irrigation throughout the osteotomy procedure, (*3*) increased probability of an undesirable axial inclination, (*4*) inability to contour bone (*alveoloplasty*), and (*5*) difficulty in manipulating circumferential soft tissue to ensure adequate dimensions of keratinized gingiva around the implant.[11,14] Although the importance of a broad width of keratinized mucosa around implants is controversial, the preponderance of evidence suggests that 3mm of keratinized gingiva is important for long-term success.[13,14]

For the implant in the UR second premolar area, the quality and quantity of both bone and soft tissue were adequate, so the flapless technique was indicated (*Fig. 39*). The mandibular implant sites had adequate quality and quantity of bone as assessed with the CBCT scan, but the width of keratinized gingiva was inadequate, so flap surgery was selected (*Fig. 40*).

Implant position

There are 5 keys for implant placement : (*1*)

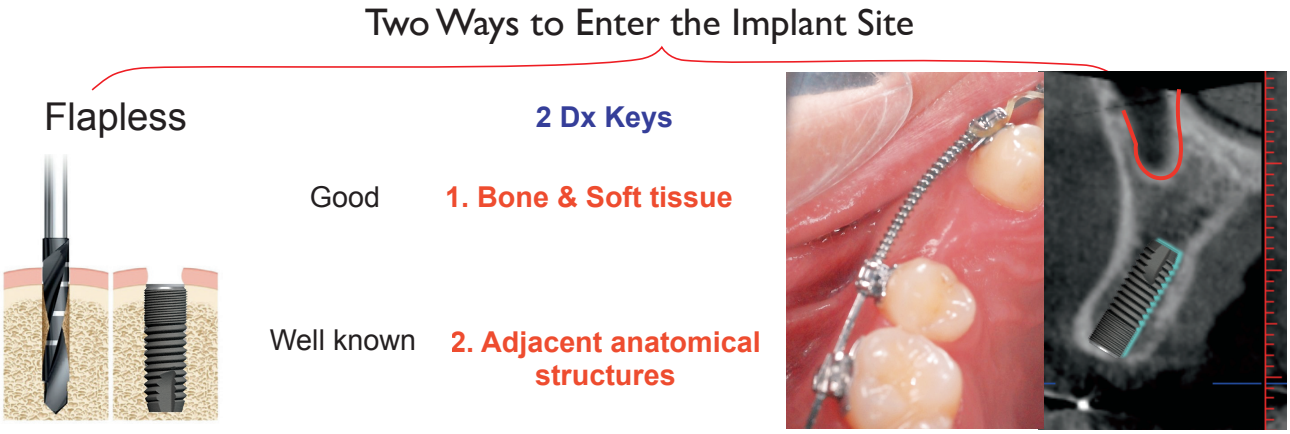

Fig. 39:
For the upper right implant, there was adequate quality and quantity of both bone and soft tissue. Since there were no anatomic restrictions, such as the floor of the sinus, the flapless technique was indicated.

mesiodistal (*M-D*) direction is optimized by placing the implant in the center of the space, (2) buccolingual (*B-L*) position requires 2mm of bone on the buccal surface of the implant to preserve an adequate blood supply, (3) depth of the fixture should be 3mm apical to the future crown margin (*2B-3D rule*),[4,5] (*4*) The axial inclination of the implant should be parallel to the adjacent teeth, and (5) the distance from the implant to adjacent teeth should be at least 1.5mm to avoid compromising the blood supply of interproximal bone. If the buccal plate of bone adjacent to the implant is less than 2mm, spontaneous bone resorption is likely, so the following remedies are proposed for marginal sites: (*a*) place the implant more lingually, (*b*) use a smaller diameter implant, and/or (*c*) increase buccal bone thickness with a cortical bone graft or guided bone regeneration (*GBR*).[15] To support the proximal bone level, the fixture should be at least 1.5mm away from the adjacent natural teeth (*as previously mentioned*), but also at least 3mm away from adjacent implants. The inter-implant bone distance is a particularly important consideration because there is no collateral circulation with the PDL and attached gingiva.[16]

Placing implants during active orthodontics treatment has distinct advantages for optimizing the implant position: 1. implant site development, 2. a temporary increase in the width of the surgical site, 3. alignment of adjacent teeth can be corrected as the implant heals, and 4. dental axial inclinations can be corrected as needed to optimize loads on implant-supported prostheses.

After 6 months of implant healing and orthodontic finishing, the current patient was evaluated for prosthesis fabrication. It is difficult to precisely evaluate the axial inclination of an implant prior to the placement of an abutment. A straight abutment revealed that the lower right implant was well positioned in the supporting tissue, but it was

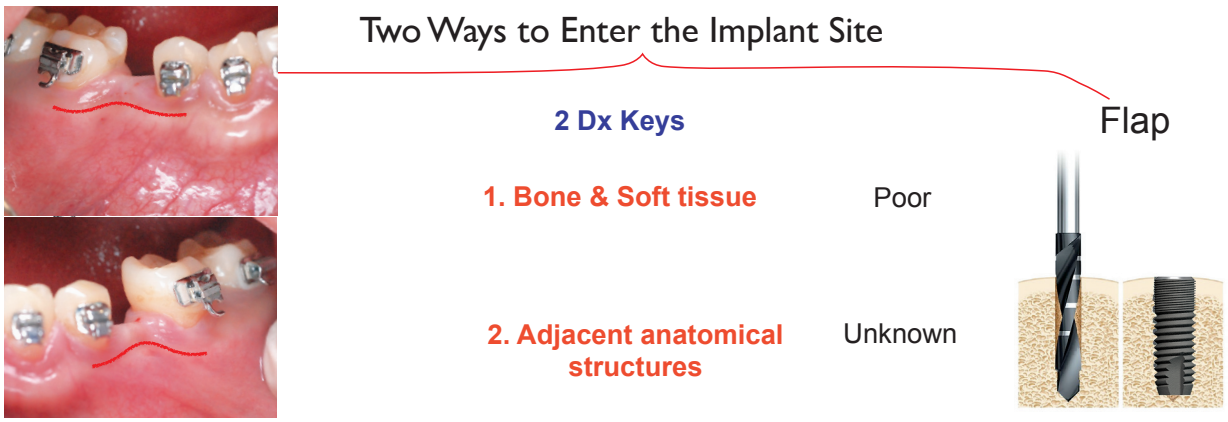

Fig. 40:
The width of keratinized gingiva at the mandibular implant sites was marginal and the precise position of the mental nerve was unknown, so a flap surgical procedure was preferable.

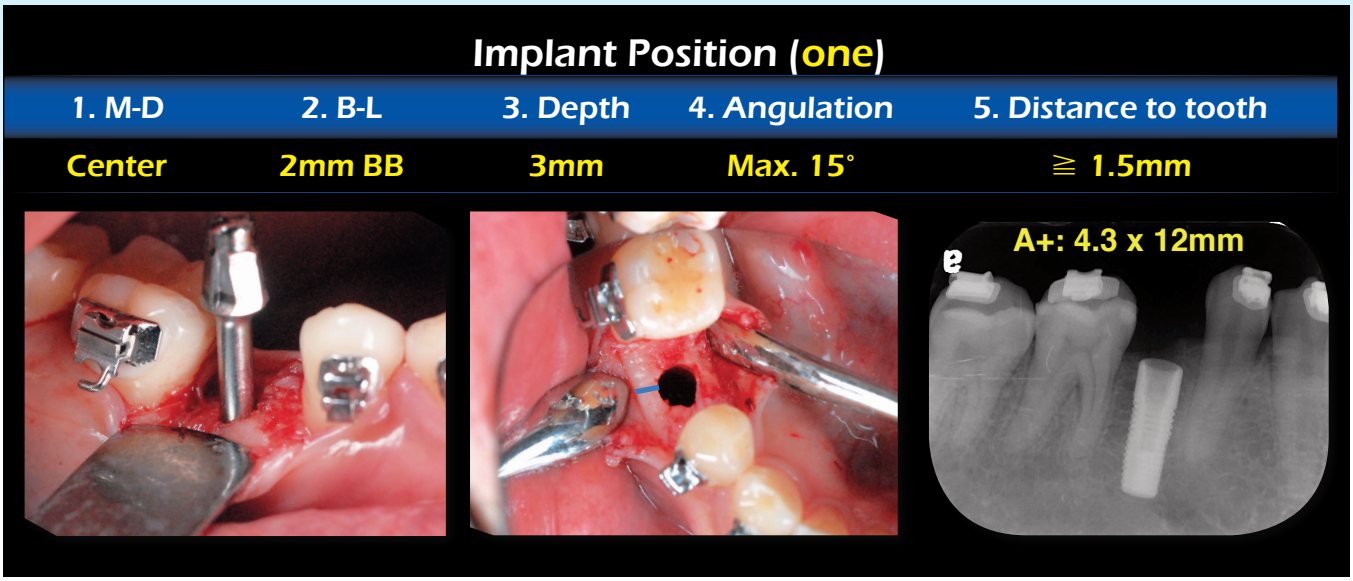

Fig. 41:
The implant placement in the lower right second premolar area (left) demonstrates that the fixture was installed in the center of M-D plane, preserving at least a 2mm thickness of bone (blue line) on the buccal surface (center). The fixture platform was 3mm apical to the expected inferior margin of the crown, and it was more than 1.5mm from adjacent teeth (right). The implant appears to be in an ideal position on the periapical film (right), but it was excessively angled to the buccal. See text for details.

Fig. 42:
An unesthetic display of the metal margin of the crown was noted at the gingival margin of the angled metal abutment on the lower right implant-supported prosthesis (arrow in the left view) compared to the contralateral area (right view). This problem was due to a lack of soft tissue thickness and height ("running room") to optimally accommodate an angled abutment.

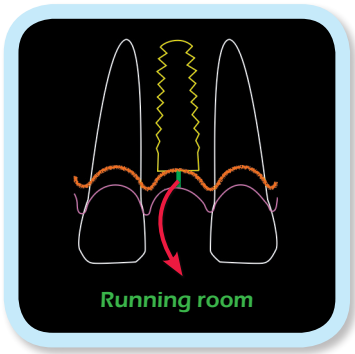

Fig. 43:
Running room is the vertical distance from the implant's prosthetic platform to the free gingival margin.

excessively oriented to the buccal (*Fig. 41*)[5,17,18] After a careful assessment, the problem was deemed manageable with an angled abutment.

Angled abutment

Ideally, implants should be placed parallel to other fixtures or adjacent teeth, and be aligned in the axial plane of the arch. However, this objective is not always achieved, so angled abutments may be necessary to facilitate prosthesis fabrication. A 15˚ angled abutment shifts the occlusal surface of a restoration about 1-1.5mm and a 25˚ abutment moves it about 2-2.5mm.[19-21] In addition, use of angled abutments can reduce treatment time, fee

for service, and the need to perform additional surgery by installing another implant or guided bone regeneration.[19] The major disadvantage is that occlusal loading on angled abutments can significantly increase bone stress and strain at the alveolar crest.[20,21] Regional overload is more significant with the decreased bone density that occurs during the healing process, and this is an important factor when considering an immediate loading protocol.[22] Despite the 3-4 fold increase in marginal bone stresses for 15-25° angled abutments, the resulting bone strain usually remains within physiological limits.[19-21] Eger et al.[23] demonstrated that the long-term success of angled abutments was equivalent to straight abutments. The implant and prosthesis survival rates associated with angled abutments was more than 95% after 3 years' of follow-up. There are no significant differences in probing depths, gingival inflammation and attachment levels between straight and angled abutments at 1 year follow-up.[23] Additional "*running room*" (*width and height of marginal gingiva*) is necessary to avoid an unesthetic gingival display of the metal angled abutment (*Figs. 42 and 43*). Increased marginal gingiva mass helps mask the abrupt change of fixture contour as the angled abutment penetrates the soft tissue. Fig. 43 is a drawing demonstrating that the current concept of "*running room*" refers to the vertical width of gingiva from the prosthetic platform of the implant to the free gingival margin. To control excessive longterm stress, the clinician should attain the best fit of all components and minimize the occlusal contact on lingual or palatal cusp inclines. It is important to carefully adjust the occlusion to avoid traumatic lateral excursions on teeth that have angulated abutments.[18-20]

Conclusion

Dentofacial orthopedic correction of a partially edentulous malocclusion can greatly simplify the prosthetic requirements. Implant size selection is a critical factor related to anatomical features of the surgical site. Additional considerations are the tooth to be restored, and the opposing occlusion. From a biomechanics perspective, the optimal implant dimensions for most edentulous sites are about 10-12mm in length and 4-5mm in width. If the M-D position of an implant is acceptable, the B-L inclination can vary up to 25° and be adequately restored with an angled abutment. Angled

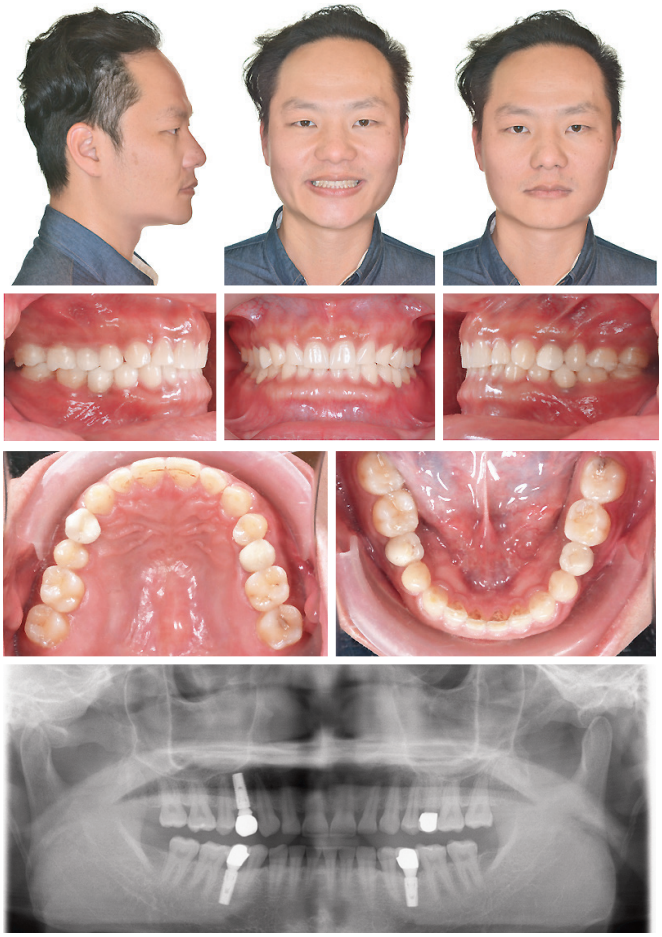

Fig. 44:
Two year follow-up records demonstrate the stability of the treatment rendered.

abutments result in increased stress at the margin of alveolar bone, but this compromise is usually within physiological limits if there is adequate bone healing prior to loading. The longterm clinical course for prostheses supported by angled and straight abutments is similar.

Acknowledgement

Thanks to teacher Paul Head for proofreading this article.

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 26

OVERJET

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

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

Total = 0

OVERBITE

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

Total = 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 = 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 = 0

LINGUAL POSTERIOR X-BITE

1 pt. per tooth Total = 1

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° 7 x 1 pt. = _____

1 to MP ≥ 99° = (1 pt.)

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

Total = 9

OTHER (See Instructions)

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

Identify: Teeth extrusion

Total = 14

IMPLANT SITE

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

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

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

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

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

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

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

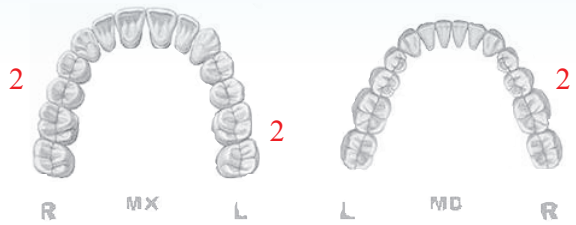
Total = 0

Cast-Radiograph Evaluation

Total Score: 27

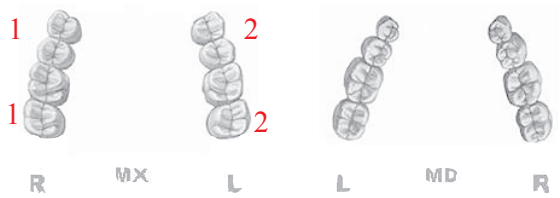
Alignment/Rotations

6



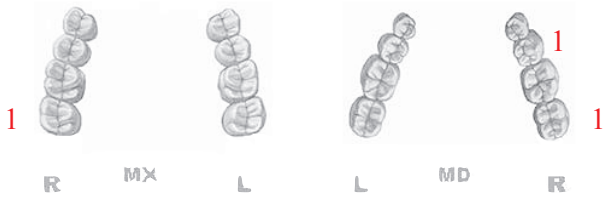
Marginal Ridges

6



Buccolingual Inclination

3

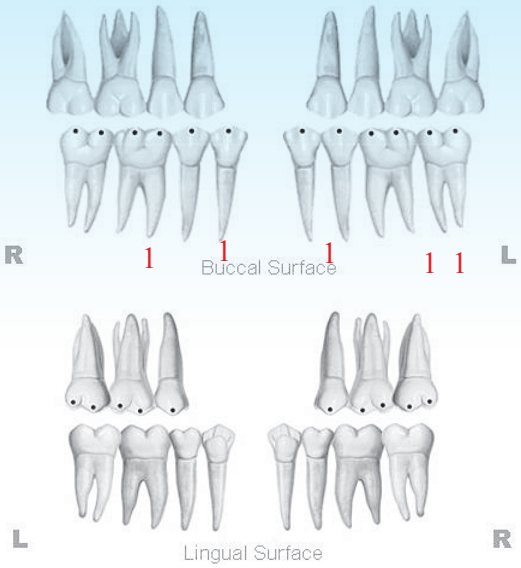


Overjet

3

Occlusal Contacts

5

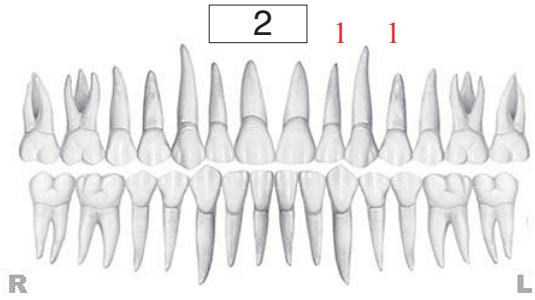


Occlusal Relationships

1

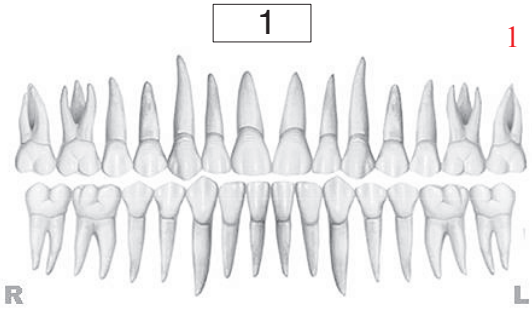
Interproximal Contacts

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

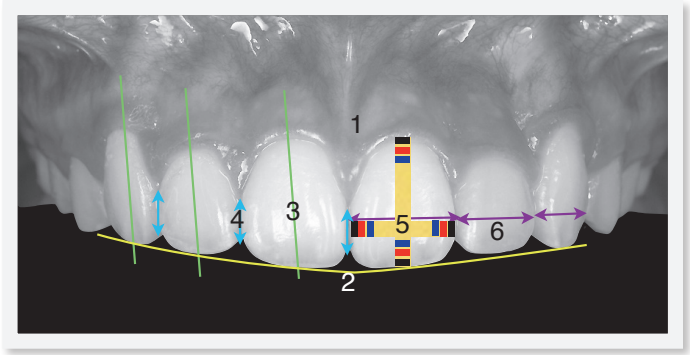
Total = 1

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

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