Combined Implant-Orthodontic Treatment for an Acquired Partially-Edentulous Malocclusion with Bimaxillary Protrusion

History and Etiology

A 31-years-old female presented for a full mouth evaluation (*Fig. 1*). Her chief concerns were bimaxillary protrusion, multiple caries, and edentulous spaces (*Figs. 2, 3*). There were no contributory medical problems. Clinical exam revealed a complex acquired malocclusion. There was a bimaxillary protrusion of the anterior segments, as well as edentulous spaces for missing maxillary right 1st molar, left 1st and 2nd premolar. Two residual root tips were noted in the maxillary right and left 1st molar areas. Deep caries were diagnosed in the mandibular right 1st premolar and 2nd molar. There were horizontally impacted mandibular third molars bilaterally (*Fig. 2*). The patient was treated to an acceptable result as documented photographically in Figs. 4-9. The cephalometric and panoramic radiographs document the pre-treatment condition (*Fig. 7*) and the post-treatment results (*Fig. 8*). The superimposed cephalometric tracings before and after treatment are shown in Fig. 9.

Fig. 1: Pretreatment facial photographs

Fig. 2: Pretreatment intraoral photographs

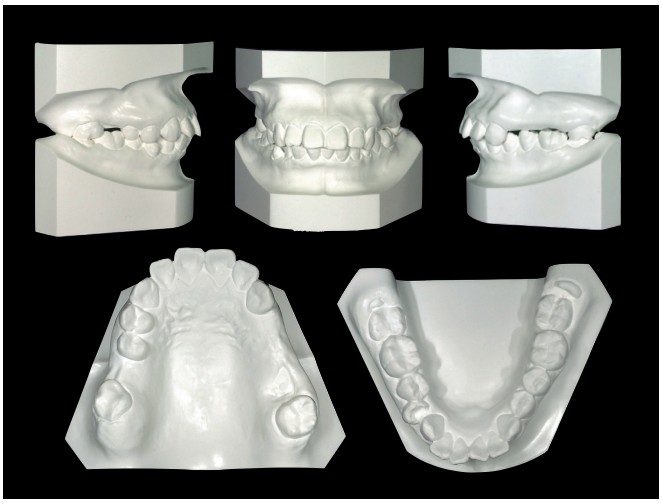

Fig. 3: Pretreatment study models

Diagnosis

Skeletal:

- Skeletal Class II (*SNA 83.5°, SNB 76.5°, ANB 7°*)
- Hyperdivergent: increased mandibular plane angle (*SN-MP 42°, FMA 35°*)

Dr. Ming-Jen Chang, Lecturer, Beethoven Orthodontic Course (right)
Dr. Chris HN Chang, Director, Beethoven Orthodontic Center (middle)
Dr. Eugene W. Roberts, Consultant,
International Journal of Orthodontics & Implantology (left)

Fig. 4: Posttreatment facial photographs

Fig. 5: Posttreatment intraoral photographs

Fig. 6: Posttreatment study models

Dental:

- Class II molar (*mutilated*), dentally compensated Class II malocclusion
- Right canine Class II, left canine Class I
- Bimaxillary protrusion of anterior segments
- Edentulous areas: maxillary right 1st molar, left 1st and 2nd premolar
- Residual roots retained in the maxillary right and left 1st molar areas
- Deep caries in the mandibular right 1st premolar and 2nd molar
- Horizontally impacted mandibular third molars, bilaterally

Facial:

- Bimaxillary protrusion with lip strain

The ABO Discrepancy Index (*DI*) was 43, with 4 more points added for deficient implant sites, as is shown in the subsequent worksheet.

Specific Objectives Of Treatment

Maxilla (*all three planes*):

- A - P: Retraction
- Vertical: Maintain
- Transverse: Maintain

Mandible (*all three planes*):

- A - P: Retraction
- Vertical: Maintain
- Transverse: Maintain

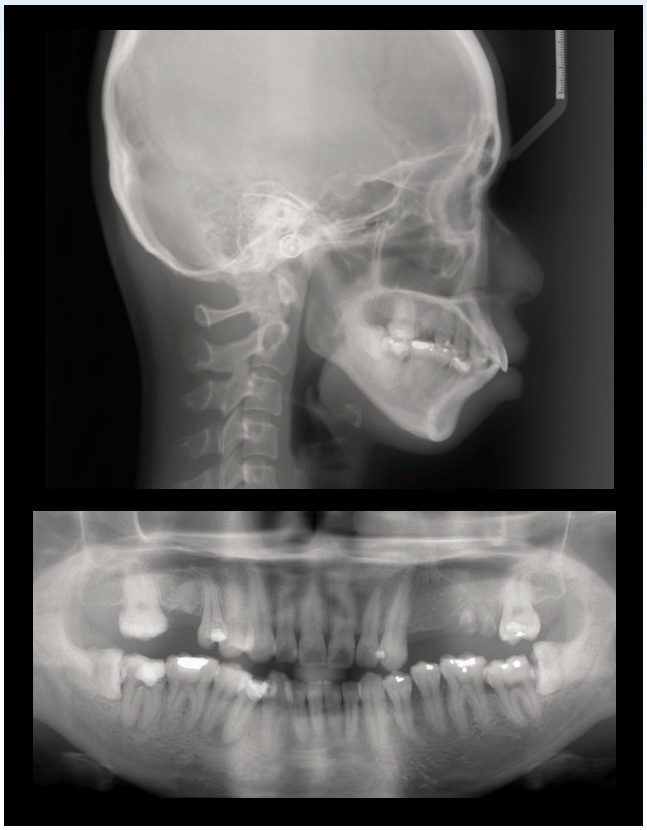

Fig. 7: Pretreatment pano and ceph radiographs

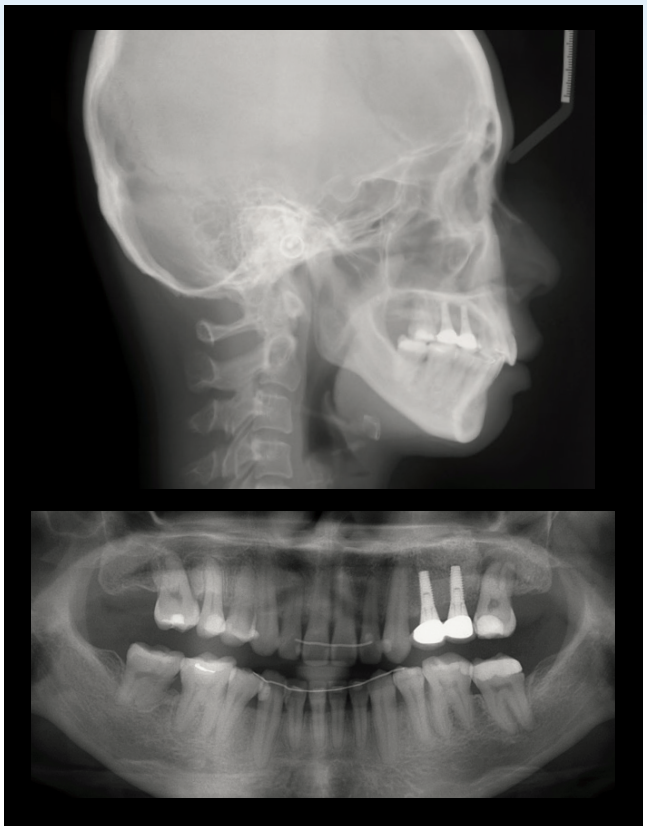

Fig. 8: Posttreatment pano and ceph radiographs

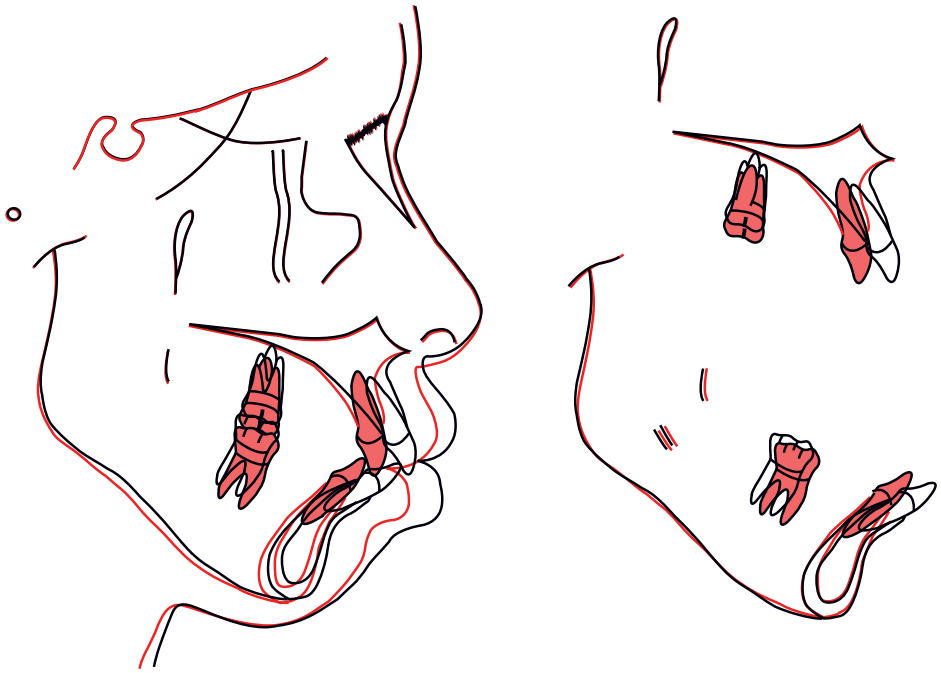

Fig. 9:

Superimposed tracings indicate that the upper anterior teeth were retracted and the molars were extruded. In addition, the lower anterior teeth were retracted and intruded while the molars were intruded and moved forward.

Maxillary Dentition

- A - P: Retract incisors and protract posterior segment
- Vertical: Maintain
- Inter-molar Width: Maintain

Mandibular Dentition

- A - P: Retract incisors
- Vertical: Maintain
- Inter-molar / Inter-canine Width: Round out the arch over the apical base of bone

Facial Esthetics: Retract upper and lower lips to enhance facial esthetics and lip competence.

Treatment Plan

- Multiple extractions: 1. residual roots of the upper right and left 1st molars, 2. lower right and left 1st premolars, and 3. right 2nd molar (*Fig. 10*)
- Orthodontic bone screws to assist in correction of maxillary anterior protrusion
- Retract incisors and close spaces with closed coil springs
- Retain an edentulous site in the upper left 1st and 2nd premolar areas to accommodate two implants (*Fig. 8*)
- Anterior bite turbos to intrude lower incisors as they are retracted
- Class II elastics to resolve the Class II occlusion
- Detailed bending and settling elastics to produce the final occlusion
- Sinus-lift bone graft to augment available bone height in the left posterior maxilla

CEPHALOMETRIC			
SKELETAL ANALYSIS			
	PRE-Tx	POST-Tx	DIFF.
SNA°	83.5°	81°	2.5°
SNB°	76.5°	76°	0.5°
ANB°	7°	5°	2°
SN-MP°	42°	41°	1°
FMA°	35°	35°	1°
DENTAL ANALYSIS			
U1 TO NA mm	6.0 mm	-1 mm	7 mm
U1 TO SN°	107°	93.5°	13.5°
L1 TO NB mm	13.0 mm	7 mm	6 mm
L1 TO MP°	113.5°	97°	16.5°
FACIAL ANALYSIS			
E-LINE UL	7 mm	2 mm	5 mm
E-LINE LL	10 mm	3 mm	7 mm

Table. Cephalometric summary

Fig. 10:

The upper right and left 1st molar's residual roots, the lower right and left 1st premolar and right 2nd molar were extracted.

Fig. 11:

The maxillary arch was bonded with high torque brackets in the anterior. segment.

Fig. 12:

The mandibular arch was bonded with high torque brackets.

Fig. 13:

The archwire was changed to a .017x.025 low friction TMA® wire in the upper arch and a .016 CuNiTi wire was placed in the lower arch. The maxillary anterior segment was ligated with a figure-eight tie of a .012" stainless steel ligature.

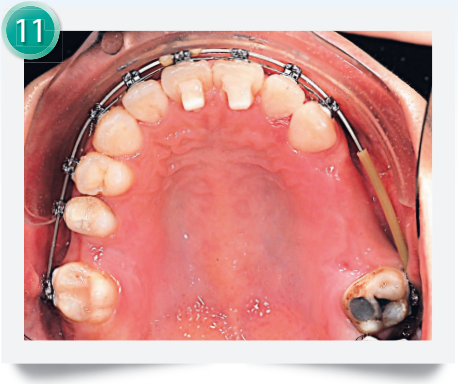

Fig. 14:

The anterior bite turbos were placed on the palatal side of maxillary central incisors to correct anterior deep bite.

- Place two implants in upper left premolar area to restore occlusal function
- Retention: 1. maxillary fixed retainer from right lateral incisor to left lateral incisor, and 2. mandibular fixed retainer from right canine to left canine, and 3. clear overlay retainers for both arches.

Appliances And Treatment Progress

The .022" slot Damon D3MX bracket system (*Ormco*) was used. The maxillary arch was bonded with high torque brackets in the anterior segment, and a .014 CuNiTi archwire was inserted (*Fig. 11*). Four months later, it was replaced with a .014x.025 NiTi archwire. After three months of initial alignment and leveling, the mandibular arch was bonded with high torque brackets and fitted with a .014 CuNiTi archwire (*Fig. 12*).

In the 6th month of the treatment, the archwires were changed to .017x.025 low friction TMA® in

the upper arch and a .016 CuNiTi in the lower arch. At the same appointment, the maxillary anterior segment was ligated with a figure-eight tie of an .012" stainless steel ligature (*Fig. 13*). Two months later the lower archwire was replaced with .014x.025 NiTi. Three months later, anterior bite turbos were placed on the palatal side of maxillary central incisors to intrude the mandibular incisors (*Fig. 14*). Class II elastics were used, from the upper canines to lower 1st molars bilaterally, to resolve the sagittal discrepancy. In the 12th month, a .019x.025 stainless steel archwire was placed on the upper arch and a .017x.025 low friction TMA was used in the lower arch. During the treatment period, the lower right 3rd molar erupted into the space of the previously extracted 2nd molar. It was bonded, and the .017x.025 low fiction TMA® archwire was extended therough the bracket to align the lower right 3rd molar (*Fig. 15*). One month later, the lower archwire was replaced with .019x.025 stainless steel, and the anterior segment was ligated with a figure-eight tie of an .012" stainless steel ligature. At the same appointment, four closed coil NiTi springs were inserted from canine to 1st molar in each quadrant, to close the edentulous spaces as prescribed (*Fig. 16*). In the 18th month, two bone screws (*2x12mm OrthoBoneScrew, Newton's A, Inc.*) were inserted into both infrazygomatic crests, and two closed coil springs (*8mm, 200g*) were attached, from upper right and left canines to the bone screws, bilaterally (*Fig. 17*).

In the 25th month, a panoramic radiograph was used to evaluate bracket positions and the spaces

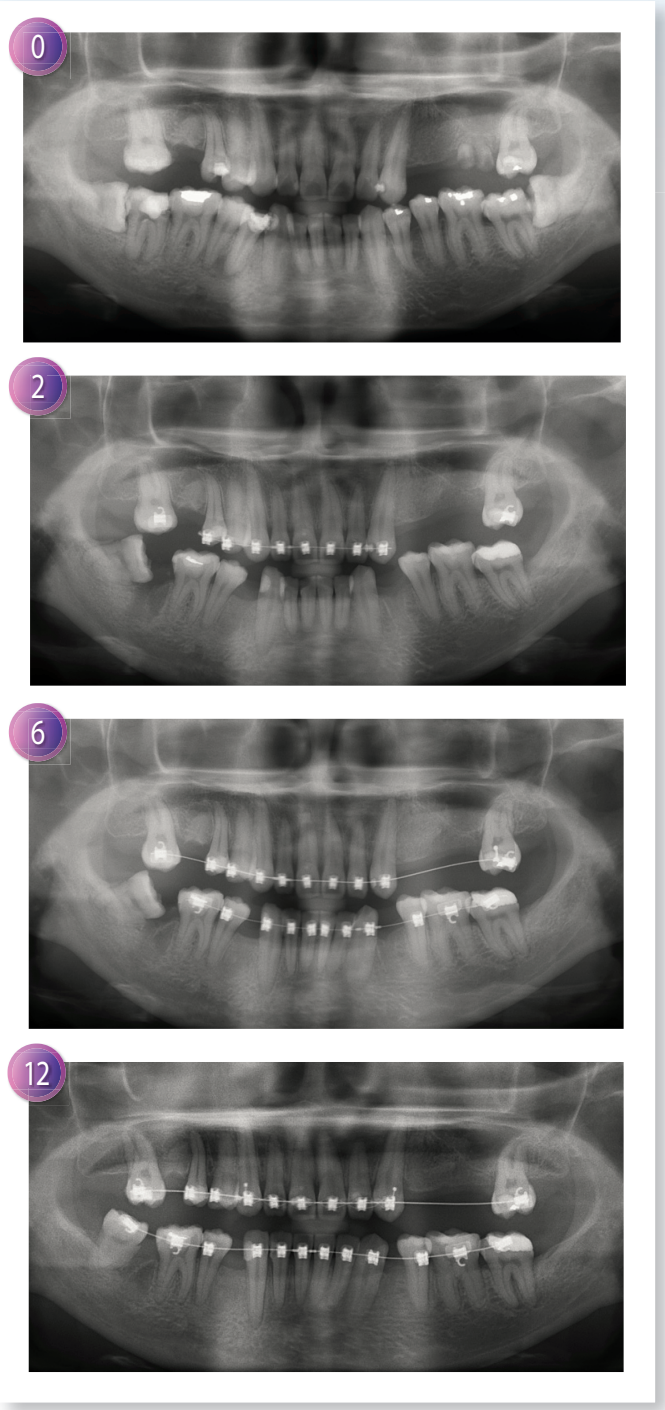

Fig. 15:

The lower right 3rd molar erupted into the space of the previously extracted 2nd molar. The changed low fiction TMA® archwire was extended to the lower right 3rd molar to align the dentition.

Fig. 16:

The closed coil springs were used to close the edentulous spaces.

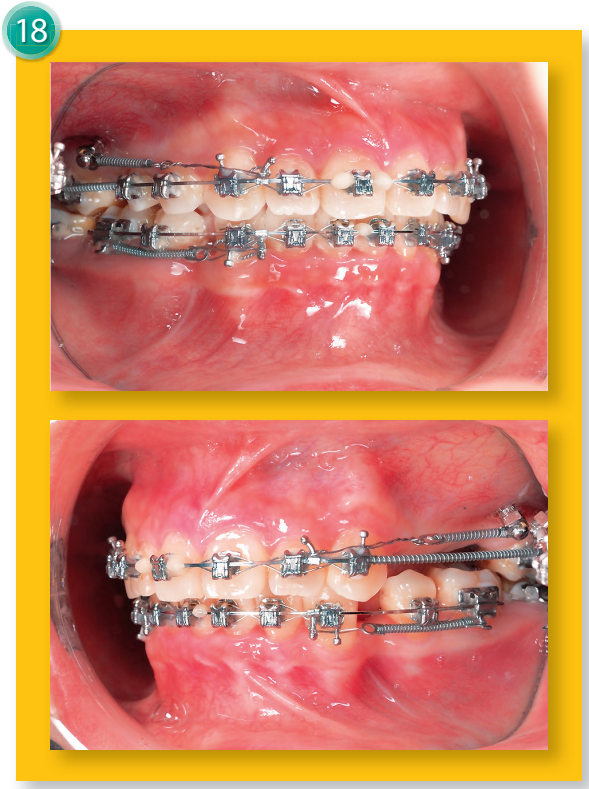

Fig. 17:

There were two closed coil springs attached from upper right and left canines to the bone screws.

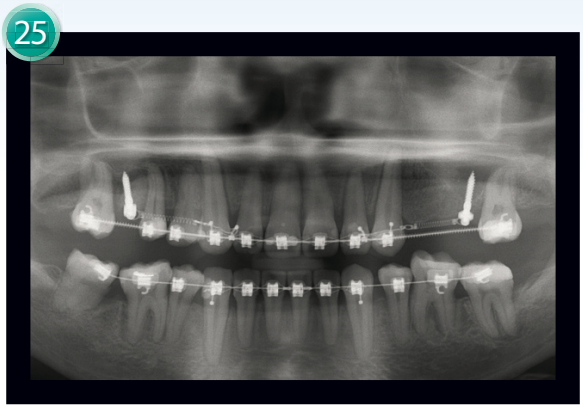

Fig. 18:

The panoramic radiograph was taken to evaluate bracket positions and the spaces for implants.

Fig. 19:

There were two buttons bonded on the palatal side of upper right 1st premolar and 2nd molar and attached with enforced power chains for closing the edentulous space. There was a space about 16.5mm over upper left 1st premolar and 2nd premolar area for implants.

for the implants (*Fig. 18*). Multiple brackets were repositioned, as needed to correct axial inclinations in the buccal segments. Also the lower left 1st molar bracket was repositioned to increase the vertical occlusal space for the planned implants.

After 34 months, a small extraction space of upper right 1st molar remained. Two buttons were bonded

Fig. 20:

There was not enough vertical space for upper side implantation. A bone screw was inserted in the upper left 2nd premolar site and restored with glass ionomer cement to help intruded supra-erupted lower left 1st molar. At the same time, the lingual cusp of lower left 1st molar was reduced to get more space for the upper implantation.

on the palatal side of upper right 1st premolar and 2nd molar. Power chains were attached between the buttons to close the space. Meanwhile, a space of 16.5mm in the upper left 1st premolar and 2nd premolar area was preserved for implants (*Fig. 19*).

In the 37th month, insufficient vertical space was available for upper left implants. A bone screw, with its head covered in glass ionomer cement, was inserted in middle of the upper left 2nd premolar ridge to provide an occlusal stop to help intrude the supra-erupted lower left 1st molar. At the same appointment, the lingual cusp of lower left 1st molar was reduced to create more space for the upper implant-supported restoration (*Fig. 20*). In the 39th month, the obstacle soft tissue between upper right 1st premolar and 2nd molar was removed with a diode laser (*Fig. 21*), and the space was closed.

After 42 months of active treatment, all appliances were removed. The preprosthetic dentition was retained with fixed anterior retainers in both arches: maxillary right lateral incisor to left lateral incisor, and mandibular right canine to left canine (*Fig. 22*). Clear overlay retainers were delivered for both arches.

Implant placement procedure

When placing implants a surgical stent is recommended to guide the precise positioning and angulation of the drill (*Fig. 23*). After a prolonged period of tooth loss, the alveolar ridge became atrophic and had insufficient bone height for implantation. Conebeam CT images demonstrate

Fig.21:
The diode laser was used to remove the obstacle soft tissue.

Fig. 22:
The corrected dentition was retained with fixed anterior retainers on both arches.

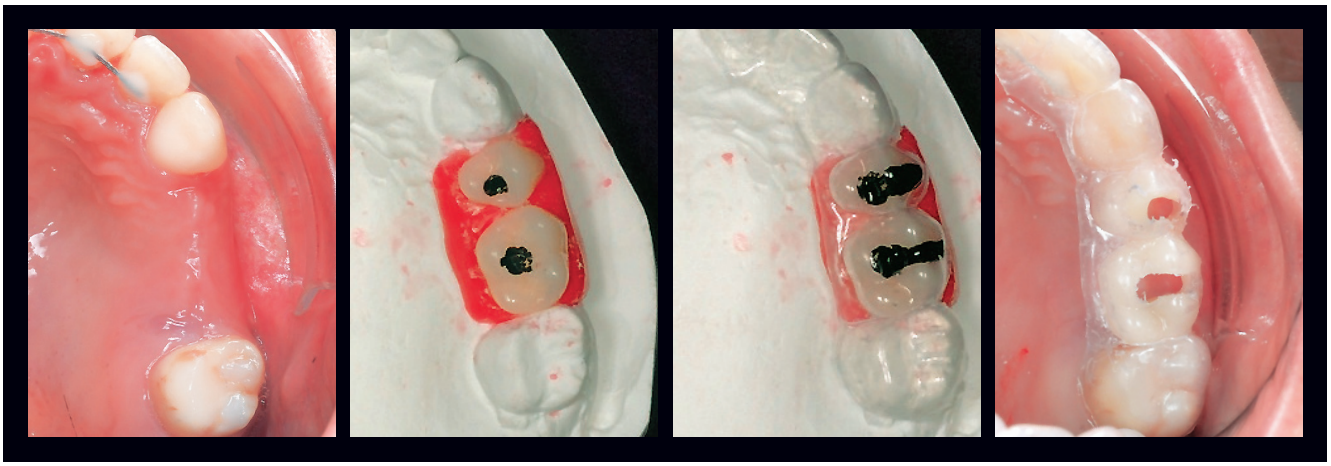

Fig. 23: Use a surgical stent to guide the correct position of implants.

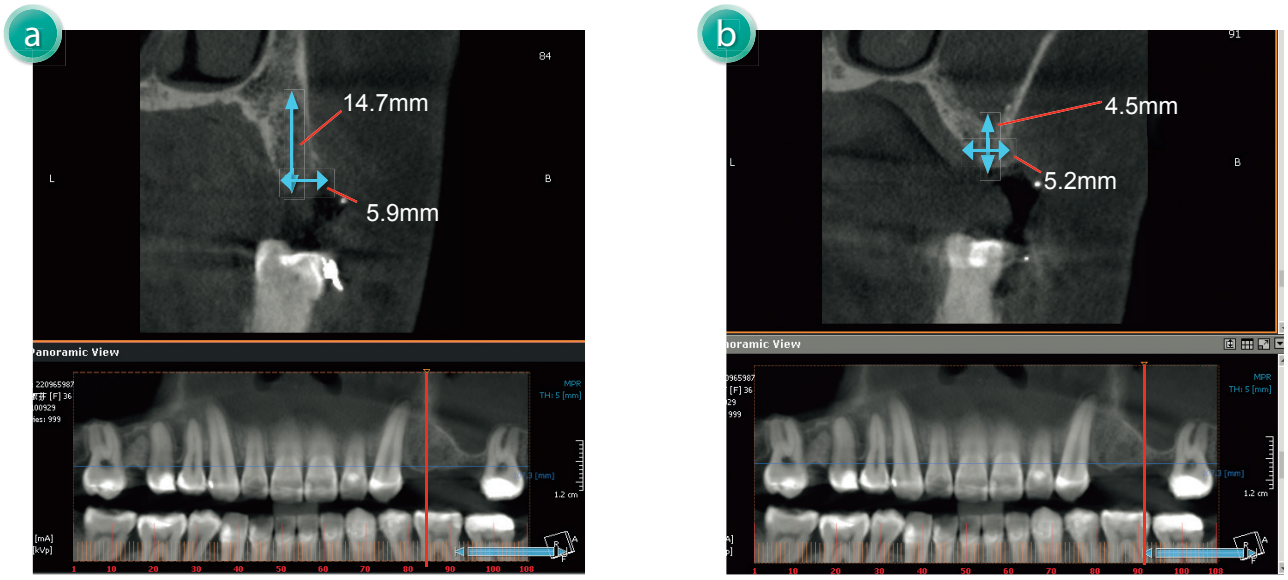

Fig. 24 a,b: After a prolonged period of tooth loss, the alveolar ridge became atrophic with insufficient bone height for implantation.

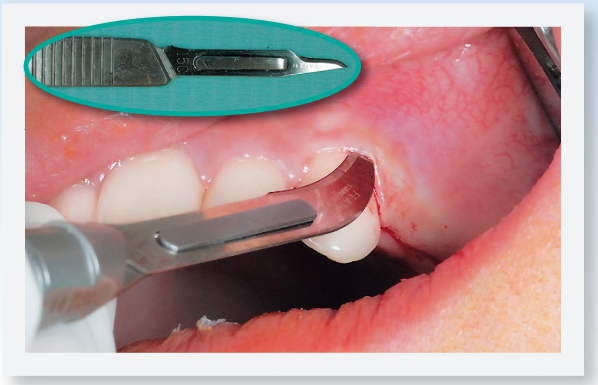

Fig. 25:

A full thickness mucoperiosteal flap, including buccal gingiva and alveolar mucosa, was raised using #12 and #15c blades.

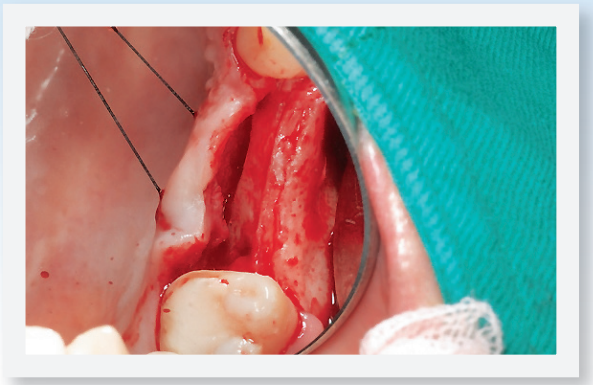

Fig. 26:

The palatal flap was tied with a needle holder and across over the mouth corner in order to obtain a clear surgical view.

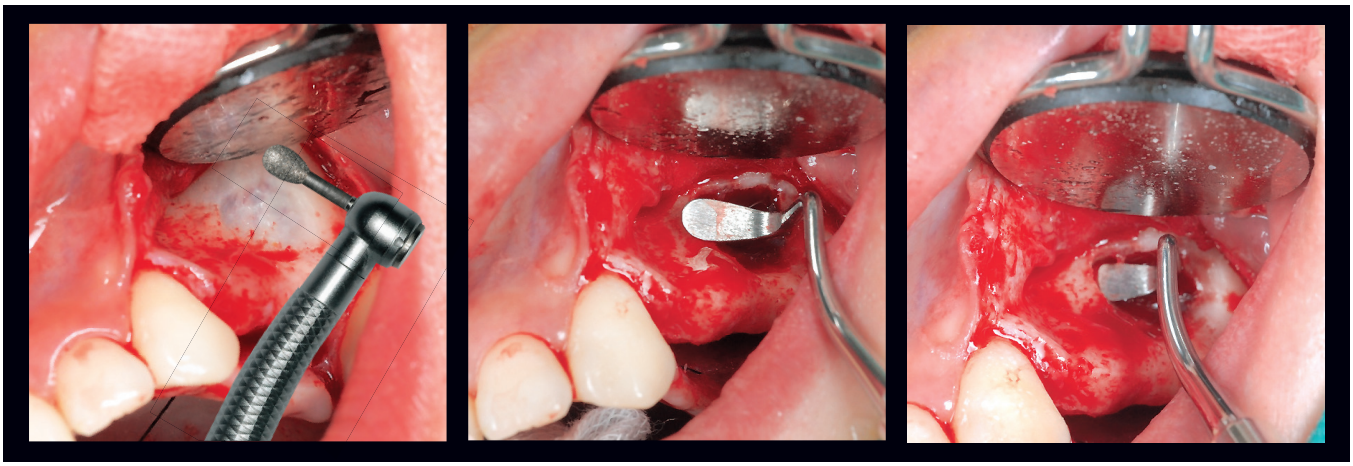

Fig. 27:

After the flap was elevated, a bony window was created in the lateral maxillary wall, and the Schneiderian membrane was elevated.

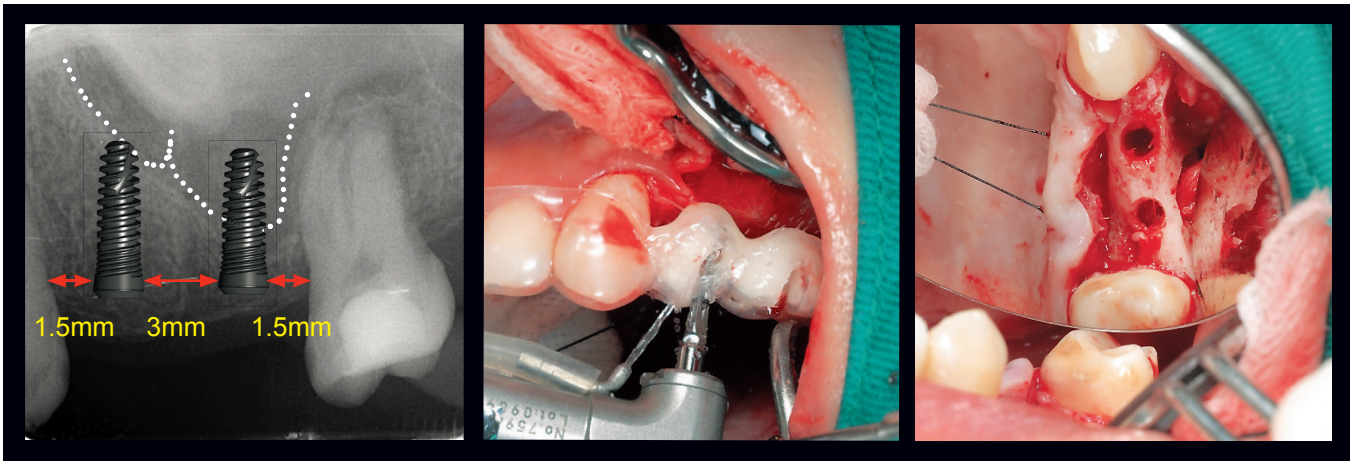

Fig. 28:

The ridge width was deemed sufficient for two 3.5 mm in diameter implants. Following the prescribed drilling protocol, two holes were drilled with the distance of 1.5mm from implant to tooth and 3mm between implants.

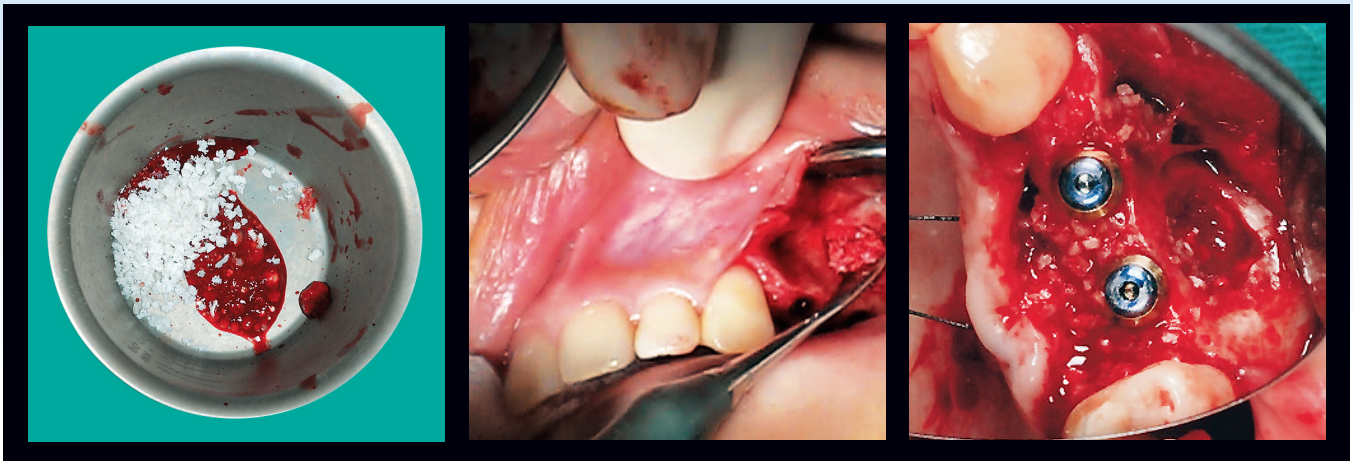

Fig. 29:

The bone grafting material (Bio-Oss®) with whole blood was poured into the space under the elevated Schneiderian membrane. After filling, two 3.5x10mm wide diameter fixtures with cover screws were placed.

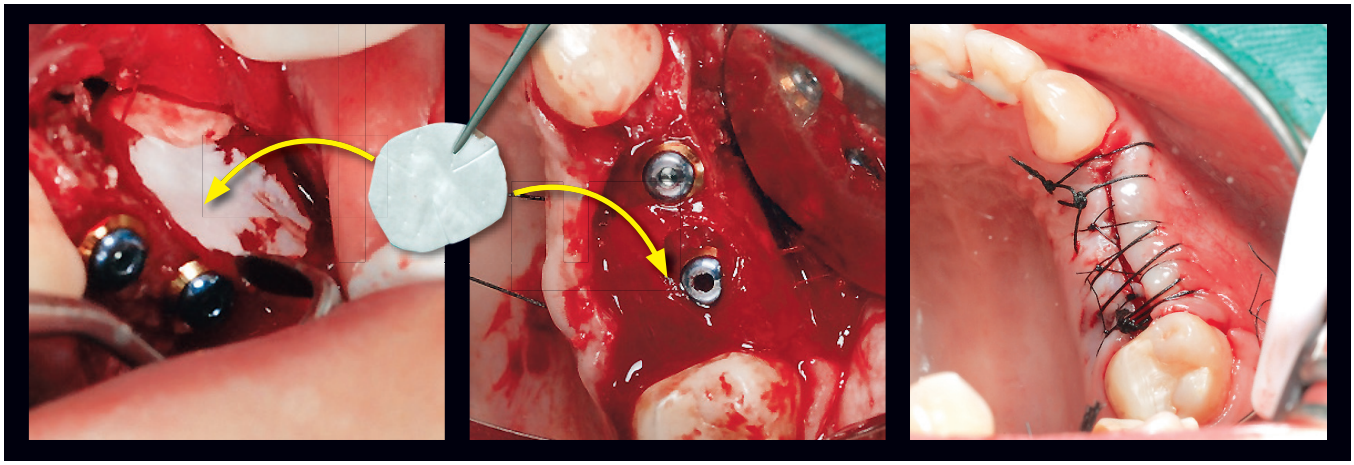

Fig. 30:

Two pieces of absorbable collagen membrane were placed between the bone graft and the Schneiderian membrane, as well as over the bony window and the palatal bone defect area. The flap was sutured with direct loop interrupted sutures (5-0 Nylon) and continuous mattress sutures (4-0 silk).

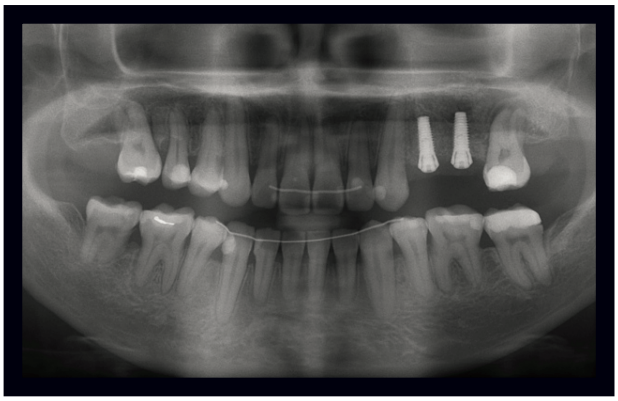

Fig. 31:

The post-surgery panoramic radiography confirmed that the accurate implant positions.

Fig. 32:

Four days after surgery, bruising was found from the patient's inferior border of the orbit to the lower border of the mandible.

the enlarged maxillary sinus anterior to the maxillary left 2nd molar (*Fig. 24*). The sinus lift procedure was indicated to increase the bone quantity in the posterior maxilla. A full thickness mucoperiosteal flap, including buccal gingiva and alveolar mucosa, was raised with #12 and #15c surgical blades (*Fig. 25*). The #12 surgical blade was used for the sulcus incision and the #15c surgical blade for mid-crestal incision. After opening of the full thickness flap, the buccal flap was sutured on the cheek. A palatal flap was secured with a needle holder and pulled to the other side of the mouth to obtain a clear surgical view of the exposed ridge (*Fig. 26*).

A trans-osseous window was created in the lateral maxillary wall with an oval diamond bur, and the Schneiderian membrane was elevated (*Fig. 27*). The length of the edentulous alveolar ridge was deemed adequate for two 3.5mm diameter implants. Following the prescribed drilling protocols, two holes were drilled. The distance from the implant to the adjacent tooth was 1.5mm and the interimplant distance was 3mm (*Fig. 28*). The bone grafting material (*Bio-Oss®*) was mixed with whole blood and the mixture was placed in the space beneath the elevated Schneiderian membrane. Two 3.5x10mm wide diameter fixtures with cover screws were placed (*Fig. 29*). Two pieces of absorbable collagen membrane were placed between the bone graft and the Schneiderian membrane, as well as over the bony window and the palatal bone defect area. The flap was sutured with direct loop interrupted sutures (*5-0 Nylon*) and continuous mattress sutures (*4-0 silk*) (*Fig. 30*).

The post-surgery panoramic radiography confirmed the accuracy of implant position (*Fig. 31*). Four days after surgery, bruising was noted from the patient's inferior border of the orbit to the lower border of the

Fig. 33:

The maxillary arch was bonded with conventional brackets from right 2nd molar to left canine. Two buttons were bonded on the palatal side of upper right 1st premolar and 2nd molar to close the residual space.

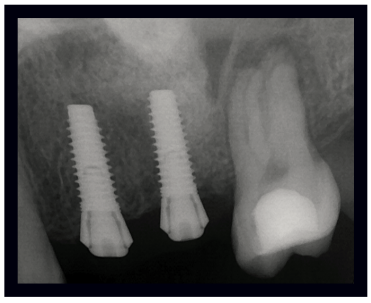

Fig. 34:

After 7 months of healing, the two implants have osseointegrated well.

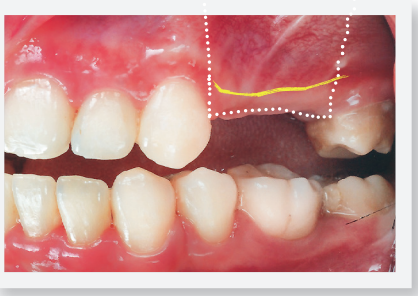

Fig. 35:

Insufficient keratinized gingiva over labial side was noticed.

Fig. 36:

A partial-full thickness mucoperiosteal flap including buccal gingiva and alveolar mucosa was raised using a #15c surgical blade.

Fig. 37:

After removing the cover screws, the marginal collar of tissue, including epithelium and granulation tissue around the fixtures, was removed.

Fig. 38:

The healing abutments were installed. The flap was repositioned apically and sutured with direct loop interrupted sutures (4-0 chromic) and horizontal mattress sutures (4-0 silk).

Fig. 39:

A periodontal dressing (Coe-Pak) was applied for wound protection and soft tissue retention.

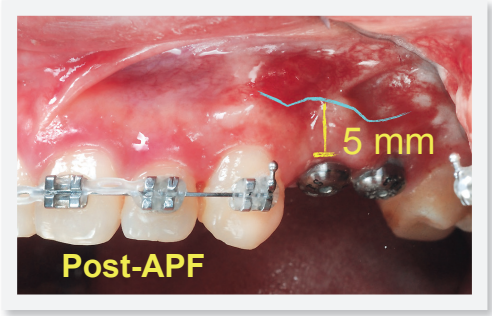

Fig. 40: *The final buccal keratinized gingiva had increased.*

mandible (*Fig. 32*). Hot compression was prescribed to reduce bruising.

Orthodontic retreatment phase

At 6 months after the implants were placed, a small space about 1mm was noted between upper right 2nd premolar and the adjacent 2nd molar. One month later, the maxillary arch was bonded with conventional brackets from right 2nd molar to left canine, and the archwire applied was a .016x.022 SS. Two buttons were also bonded on the palatal side of upper right 1st premolar and 2nd molar. Power chains were attached buccal and lingual to close the residual space (*Fig. 33*).

After 7 months of healing, the radiograph indicated two implants were well healed and osseointegrated (*Fig. 34*), but there was an inadequate amount of keratinized gingiva on the labial surface of the implants (*Fig. 35*). An apically repositioned flap was indicated to increased the dimensions of the attached gingiva on the buccal surface of the implants. A partial thickness mucoperiosteal flap of the palate and alveolar ridge was raised by a #15c surgical blade (*Fig. 36*), and continued as a vertical flap into the buccal vestibule. The flap had to be elevated beyond the mucogingival line in order to later reposition the keratinized soft tissue apically. A piece of gauze was put into the patient's mouth to ensure safety when removing the cover screws to prevent accidental swallowing. The marginal collar of tissue, including epithelium and granulation tissue around the fixtures, was removed (*Fig. 37*). After the healing abutments were installed, the flap was repositioned in a more apical position and sutured with direct loop interrupted 4-0 chromic sutures and 4-0 silk horizontal mattress sutures (*Fig. 38*). The wound was pressed with gauze, saturated

with normal saline, to prevent a submucosal dead space. A periodontal dressing (*Coe-Pak®*) was applied to protect the exposed bone and to retain soft tissue at the level of the bone crest (*Fig. 39*). Nine days later, the sutures were removed and the wound healing was satisfactory. After the apical reposition flap surgery, a 5mm width of buccal keratinized gingiva was achieved (*Fig. 40*).

After a three month period of follow-up tooth movement and soft tissue revision, all orthodontic appliances were removed, and the a maxillary fixed retainer on all teeth from the right lateral incisor to the left lateral incisor. A clear overlay retainer was delivered for the upper arch.

Implant prosthesis fabrication

One week later, the healing abutments were removed and replaced with multi-post, transmucosal abutments (*5.5mm post height and 1mm cuff width*), designed for the upper left 1st and 2nd premolars. The height of the implant abutments was adjusted to 4mm for the 1st premolar, and 4.5mm for the 2nd premolar. The buccal thickness of the abutments was reduced as needed. The torque ratchet was applied on the female screw with a force of 35 Ncm until the abutment was perfectly seated. A gingival cord was inserted into the peri-implant sulcus of both fixtures (*Fig. 41*).

Direct impressions, obtained with polyvinyl siloxane, were poured in type IV dental stone, and the casts were mounted on an articular. A metal copping was fabricated by a commercial laboratory. Margin integrity was checked with a dental explorer. Porcelain was fused to the coping and an occlusal screw access hole was retained in each abutment. After clinical adjustment, and verification of the fit and occlusion, the definitive crowns were completed. Cotton balls were placed in the screw access holes, and the crowns were luted to place with permanent cement (*Maxcem Elite, Kerr Inc.*). Finally, the screw access holes were sealed with composite resin (*Fig. 42*).

Results Achieved

Maxilla (*all three planes*):
- A - P: Retracted
- Vertical: Maintained
- Transverse: Maintained

Mandible (*all three planes*):
- A - P: Retracted
- Vertical: Maintained
- Transverse: Maintained

Maxillary Dentition
- A - P: Retracted
- Vertical: Maintained
- Inter-molar / Inter-canine Width: Maintained

Mandibular Dentition
- A - P: Retracted
- Vertical: Intruded
- Inter-molar / Inter-canine Width: Expanded

Facial Esthetics: Upper and lower lips were retracted, resulting in improved facial form.

Retention

The maxillary fixed retainer was bonded on all incisors. An anterior mandibular fixed retainer was bonded on all teeth from canine to canine. Upper and lower clear overlay retainers were delivered. The patient was instructed to wear them full time for the first 6 months and nights only thereafter. The patient was instructed in the home care and maintenance of the retainers.

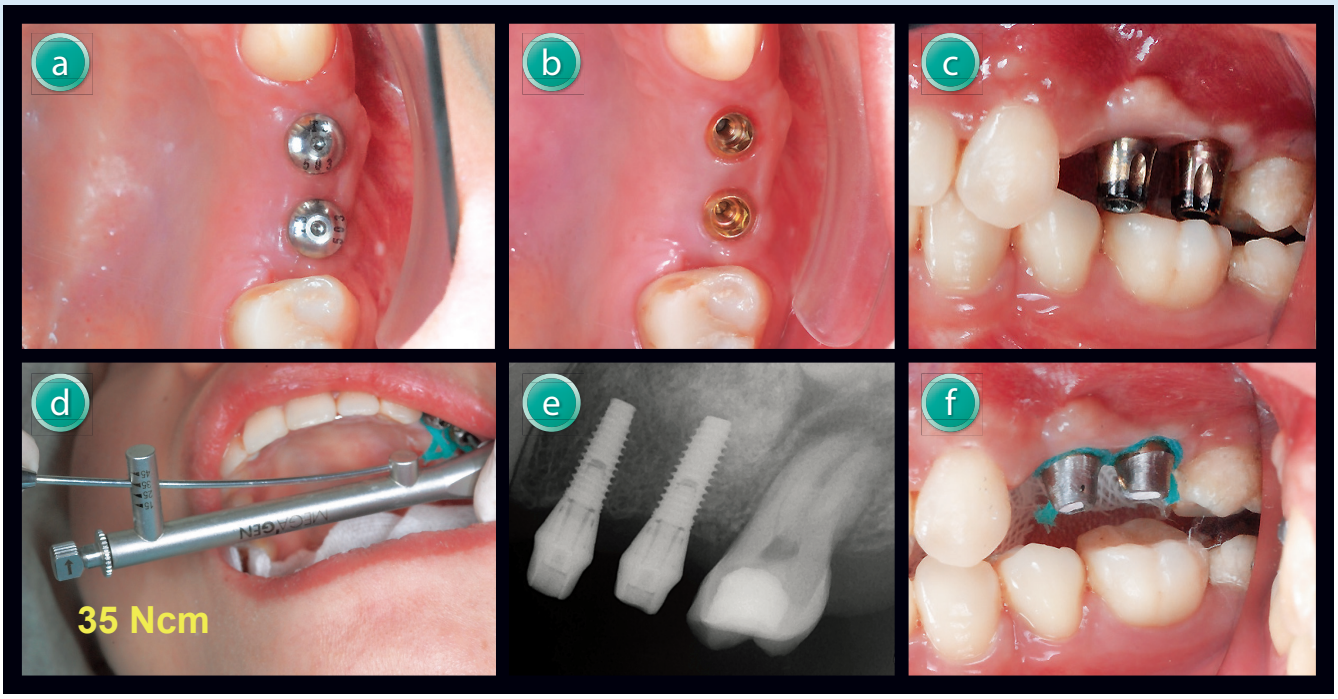

Fig. 41: a-f.

The healing abutments were removed and replaced with multi-post abutments (5.5mm post height and 1mm cuff height) from the implant fixtures of upper left 1st and 2nd premolars. The height of the implant abutments were adjusted to 4mm for #12, 4.5mm for #13 and the buccal thickness of the abutments were also reduced. After adjusting the abutment position, the torque ratchet was applied on the female screw with a force of 35 Ncm until the abutment was perfectly seated. A gingival cord was inserted into the peri-implants sulcus.

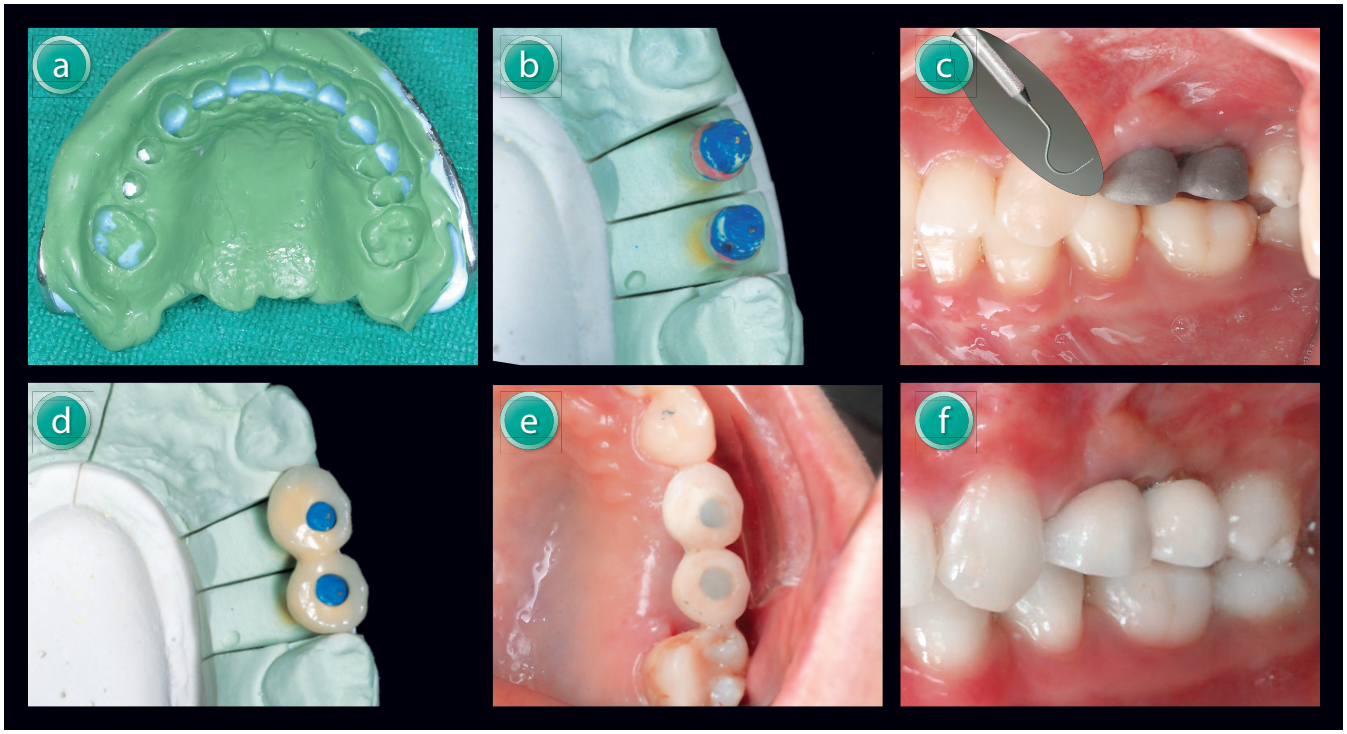

Fig. 42: a-f.

Direct impression technique was applied with polyvinyl siloxane. A cast was poured in type IV dental stone and articulated using the appropriate dental records. Metal copping were fabricated by lab technicians. The margin integrity was verified with a dental explorer. The occlusal surface was made by porcelain with a screw access hole. After adjustment and verification of the fitness and occlusion, the definitive crowns were then completed and luted to place with a permanent cement. The screw access hole was filled by composite resin.

Final Evaluation Of Treatment

The ABO Cast-Radiograph Evaluation score was 28 points for this restored, mutilated dentition. The major discrepancies were occlusal relationships (*7 points*) and alignment (*7 points*). Asymmetrical tooth loss, and an implant-supported prosthesis slightly out of occlusion (*Fig. 6*), were the major factors in the compromised final occlusal result. However, a final score of 28 points is an excellent result for a difficult, partially edentulous malocclusion that had a discrepancy index of 43, plus an additional 4 points in complexity due to the compromised implant site. Details of these scores are presented in the scoring sheets at the end of this report.

At the patient's initial consultation, it appeared that four implants would be required because of her severe malocclusion. With orthodontic space redistribution, only two implants were required (*Fig. 43*). Furthermore, orthodontics was required to correct the bimaxillary protrusion to improve facial esthetics (*Figs. 4, 9 and 43*).

Retraction of the upper and lower anterior incisors and closure of upper excessive extraction spaces for implantation resolved the patient's chief complaints. The excessive spaces of the upper and lower extraction sites were eliminated. However, long-term retention is critical to prevent relapse. Two implant-supported crowns were inserted into the edentulous spaces of upper left posterior segment to increase the patient's occlusal function.

Overall, there was significant improvement in both dental esthetics and occlusion. The profile was dramatically improved and dental esthetics were excellent.

Discussion

Conventional orthodontic treatment options for adults with class II high angle malocclusion are either extractions or orthognathic surgery. In the present case, the patient had large edentulous spaces in the maxilla and two deep carious lesions in the lower right 1st premolar and 2nd molar. Therefore, both 1st premolars and the right 2nd molar were extracted in the mandibular arch. In addition to correction of the dental Class II relationship, the other major treatment objective was to improve facial balance. The mandibular incisors were intruded and aligned over the apical base of bone, resulting in the desired esthetics and functional rehabilitation. Treatment of an adult Class II malocclusion, with extraction of mandibular premolars, requires careful anchorage control to achieve a final Class I molar-canine relationship.[1] Anchorage provided by bone screws is simpler, causes less discomfort and requires no patient cooperation, compared with traditional anchorage devices, including miniplates and head gears.[2] In addition, patients with stainless steel bone screws reported minimal problems from swelling, speech difficulty, chewing efficiecy. Direct placement of bone screws without flap surgery has a high success rate.[3]

Anterior bite turbos were placed on the palatal side of upper incisors to open the bite.[4] Ideally, it is beneficial to maximize the horizontal component and minimize the vertical component when prescribing intermaxillary elastics. Typically Class II elastics extend from the maxillary canines to the mandibular first molars. However, it is important to remember that the horizontal component of intermaxillary elastics causes rotation of the arch, because the line of force is gingival to the center of resistance of the dentition. Thus, the effect of

intermaxillary elastics must be carefully monitored during treatment.

When large spaces are closed in the arch, the accumulation of attached gingiva can be obstructive to complete space closure. Interdental soft tissue build-up may be a factor in reopening of spaces. The excess soft tissue may require surgical or laser removal.[5]

The antral (*Caldwell-Luc*) approach for sinus bone grafting has become a popular technique for vertical bone augmentation in the posterior maxilla, in preparation for implants.[6] Implant placement can be performed simultaneously with the sinus elevation procedure, or following a healing period of 6-9 months. Immediate placement during sinus elevation reduces overall healing time and eliminates another surgical procedure, both of which are desirable for most patients. Since sinus lift procedure is often essential for posterior maxillary rehabilitation, it is important for dentists to be familiar with this surgery and the manner in which the maxillary anatomy is altered.[7]

Several types of bone-graft materials are routinely used in sinus lift surgeries. Autogenous bone from the iliac crest or maxillary tuberosity may be used in some patients. However, commercial allograft products are usually the most convenient: frozen, freeze-dried and/or demineralized freeze-dried bone, as well as hydroxyapatite allograft materials.[8] Hydroxyapatite (*HA*) is a resorbable calcium phosphate material that acts as a biocompatible foundation for new bone regeneration. Some authors have found more success when HA is mixed with freeze-dried bone.[9] A variation on this technique is to place a piece of autogenous cortical bone in the sinus, inferior (*caudad*) to the bony flap, to reinforce the graft. [10,11]

The most common complication during sinus lift procedures is perforation or puncture of the sinus membrane. A tear in the membrane can provide a gateway for sinus infection. If a perforation occurs, clinicians should either repair the defect with sutures or place a patch over it. An antibiotic is prescribed to help prevent infection. The actual bone grafting procedure should be postponed until the membrane has healed. The sinus lift procedure is performed a few months later, after the membrane has healed.

After the installation of implant(*s*), host tissues may respond in one of the three scenarios: 1. acute or chronic inflammatory process, causing early implant failure; 2. formation of a fibrous connective tissue interface, leading to later implant failure, and 3. vital bone tissue formation on the surface and adjacent the implant, resulting in osseointegration.[12]

Guided bone regeneration (*GBR*) is another routinely practiced procedure to preserve or augment the alveolar ridge if there is an osseous defect. Histomorphometric analysis of biopsies revealed that more vital bone is formed in sites treated with GBR compared to sites that were left to heal spontaneously. The use of GBR to increase ridge volume is well documented, but it requires a long healing period before implants can be placed. [13] A commonly used periodontal dressing (*Coe-Pak®*) serves a variety of purposes, such as: 1. protect the wound post-operatively, 2. maintain a close adaptation of the mucosal flaps to underlying bone, which is especially useful when a flap has been repositioned apically, and 3. patient comfort. In addition, periodontal dressings help prevent post-operative bleeding and excessive formation of granulation tissue.[14] The latter is particularly helpful for interproximal healing, but it requires skill in positioning the dressing material.

A good surgical stent provides precise guidance for implant placement to achieve ideal 3D positioning within available bone. Use of stent helps to optimize the position of contact point(*s*), tooth emergence profile, and the height of the implant base. Biological width is an important consideration: there should be 1mm of gingiva sulcus and 2mm of junctional epithelium and connective tissue.[15,16] Determination of an ideal implant location should be based on the cervical contour of the planned restoration at 3 mm depth, with at least 2mm buccal of bone plate preserved. If the buccal bone plate will be less than 2 mm, there are three possibilities: 1. place the implant more lingually, 2. choose the smaller diameter implant fixture, and/or 3. augment buccal bone with a GBR procedure, to improve bone thickness.[17] Chang's 2B-3D rule provides an excellent guide for ideal implant placement (*Fig. 44*).[18,19]

If the smooth implant crest is 2 mm or more wide, two implants should be placed 3 mm apart. Since the expected crestal bone loss is less than 1.5mm, two adjacent implants, 3mm or more apart, are unlikely to result in a horizontal defect that increases sulcus depth, thereby resulting in a loss of papilla height.[20]

Geramy, et al.[21] compared the outcomes of mandibular molar crowns with three types of implant support. They reached three conclusions. First, increasing the diameter of the implant from 3.75 mm to 5 mm reduced the mesio-distal and bucco-lingual displacement of the implant/crown complex by approximately 50%, when the crown was loaded at the disto-buccal cusp tip or the distal marginal ridge. Second, the greatest reduction in mesio-distal displacement occurred with the 2-implant design. Third, the two-implant design showed a similar reduction in the bucco-lingual displacement when compared with the crown supported by a 5mm implant (*Fig. 45*). For the present case, the edentulous space after orthodontic

Fig. 43:

Four implants appeared to be required in the initial consultation without considerations for the malocclusion. If this patient didn't receive orthodontic treatment, the bimaxillary protrusion couldn't be resolved, the facial esthetic couldn't be improved. Without orthodontic space redistribution, this patient might need two more implants.

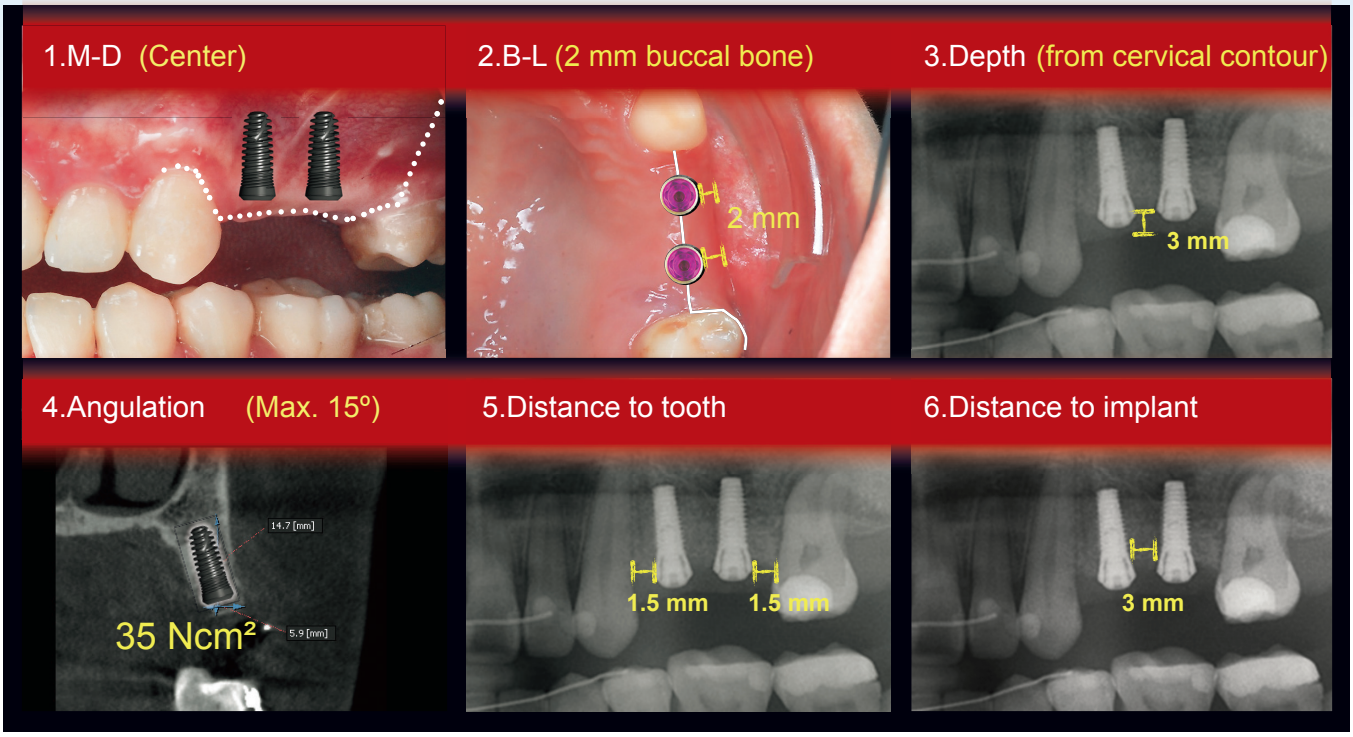

Fig. 44:

Dr. Chang suggests six factors to determine an ideal implant position as follows: 1. M-D (center), 2. B-L (2 mm buccal bone thickness), 3. Depth (3mm depth from cervical contour), 4. Angulation (max. 15°), 5. Distance to adjacent tooth / implant (≥1.5 mm), 6. Distance to adjacent implant / implant(≥ 3 mm).

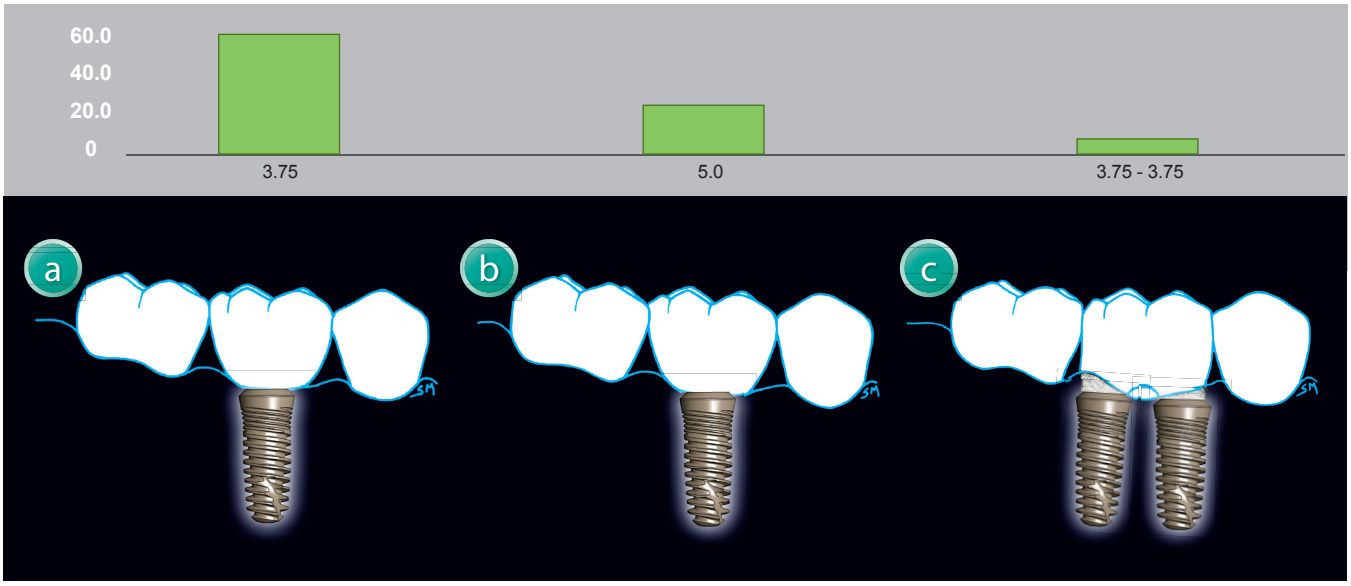

Fig. 45:

a. a mandibular molar supported by a. 3.75mm diameter implant.

b. a mandibular molar supported by a 5mm diameter implant.

c. a mandibular molar supported by two implants, each with a 3.75mm diameter.

treatment was ~15mm, so a two-implant design was suggested. Micromotion is best controlled by a wider-diameter implant-supported crown or by two implants.

The two-implant design provided less improvement in the recorded bucco-lingual displacement with off-center loading. That result suggested that centralizing the forces over the implant platform tended to reduce the potential for displacement. Occlusal forces on the implant should be directed axially as much as possible by: 1. narrowing the occlusal table, 2. maintaining maximal intercuspal contacts along the central groove of the artificial crown, and 3. eliminating eccentric occlusal contacts.

Masticatory forces acting on dental implants can result in undesirable stress in adjacent bone, which in turn can cause bone defects and the eventual failure of implants. According to the study of Himmlova et al.22 maximum stress areas were located around the implant neck. The decrease in stress was the greatest (*31.5%*) for implants with a diameter ranging from of 3.6mm to 4.2mm. Further stress reduction for the 5.0-mm implant was only 16.4%. An increase in the implant length also led to a decrease in the maximum von Mises equivalent stress values. The influence of implant length, however, was not as pronounced as that of implant diameter (*Fig. 46, 47*). Thus, this finite element study suggests that implant diameter may be a more influential factor for the reduction of masticatory stress than implant length. Implants with a diameter of 4.2 mm demonstrated an advantage in simulated stress distribution when compared with the 3.6-mm diameter implants. [22]

According to Chang's Sinus Lift Decision Tree (*Fig. 48*), the current patient had 6 to 8 mm ridge thickness and normal occlusion, therefore, a short implant of 6-8 mm was indicated.

However, for patients with 6 to 8mm ridge thickness, and heavy occlusion, the crestal approach sinus lift technique and a 8-11mm implant should be considered. For patients with a 4 to 5mm ridge thickness, but requiring only one implant, the crestal approach sinus lift technique is deemed appropriate with a 8-11 mm implant. If only 1 to 4mm of ridge thickness is available and multiple implants are required, the lateral window, sinus lift technique, combined with 11~13mm implants, is advised.

The current patient had an insufficient ridge height of only 4.5mm, so the lateral window, sinus lift technique was indicated to increase ridge thickness. The atrophic alveolar ridge complicated the subsequent implant therapy. Based on the implant selection and prosthesis design, two narrow (*3.5 mm wide*) implants of 10 mm length, combined with a splinting type prosthesis, were chosen to reduce stress on the narrow ridge. An inadequate amount of keratinized gingiva often causes gingiva inflammation and subsequent implant failure. An apically positioned flap (*APF*) is indicated when there is inadequate amount of keratinized gingiva over the implant site. A minimum of 3mm of keratinized gingiva is the usual clinical requirement. If a minimum of 3mm of attached tissue cannot be preserved, then an APF technique should be prescribed. For APF, an incision is made on the midcrestal area of the edentulous ridge with the intent of preserving as much keratinized gingiva as possible. A #15c surgical blade was used for

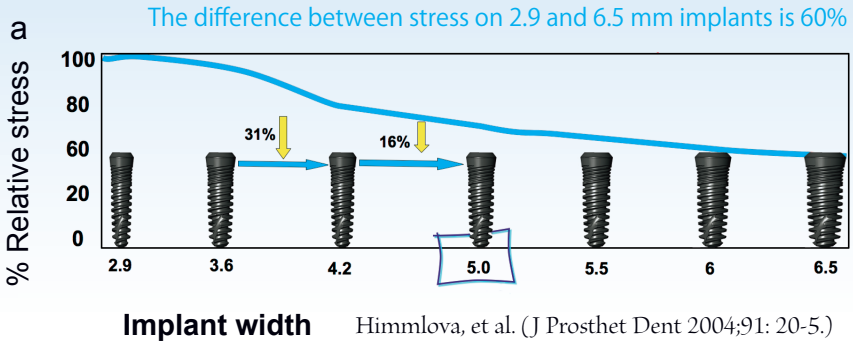

Fig. 46:

a. The finite element study stated that implant diameter may be a more influential factor for the reduction of masticatory stress than implant length. Implants with a diameter of 4.2mm demonstrated an advantage in simulated stress distribution when compared with the 3.6-mm diameter implants.

b. Distribution of von Mises equivalent stress around implants with different diameters.

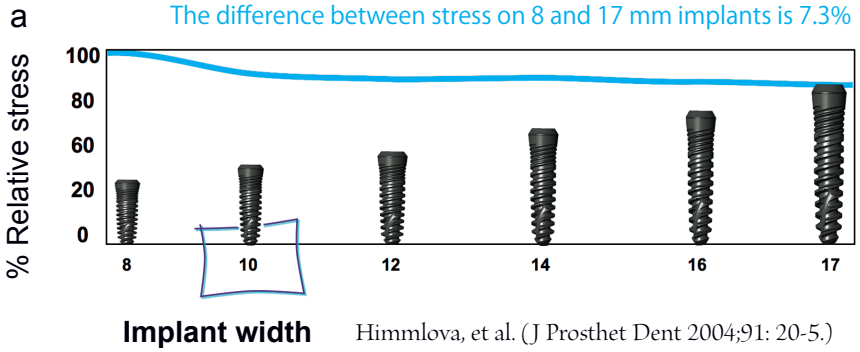

Fig. 47:

a. An increase in the implant length also led to a decrease in the maximum von Mises equivalent stress values. The influence of implant length, however, was not as pronounced as that of implant diameter.

b. Distribution of von Mises equivalent stress around implants with different length.

the lingual line angle incision method. It started with a partial thickness flap, when the incision was extended into vestibule, as a the split partial thickness flap was raised (*Fig. 49*). The pedicle flap was then apically positioned and sutured to the periosteum. A 40% shrinkage rate of keratinized gingiva is expected postoperatively. To preserve at least 3mm of the final buccal keratinized gingiva, it is necessary to create over 5mm of buccal keratinized gingiva with the APF (*Fig. 50*). [23]

In order to minimize post-operative pain and discomfort for the patient, surgical handling of tissue should be as atraumatic as possible. Precautions must be taken to avoid perforation of the flap and the sinus membrane. The bone should be kept moist during the surgery, and a tension-free primary flap closure is essential. The pain experienced by patients is mostly limited to the first days after surgery. Swelling and bruising are usually the chief post-operative sequelae. Often, swelling and bruising extend from the inferior border of the orbit to the lower border of the mandible, or even onto the neck. In order to reduce swelling, it is important to cool the area with cooling pads at least for the first 6 hours after the surgery. Occasionally, minor bleeding

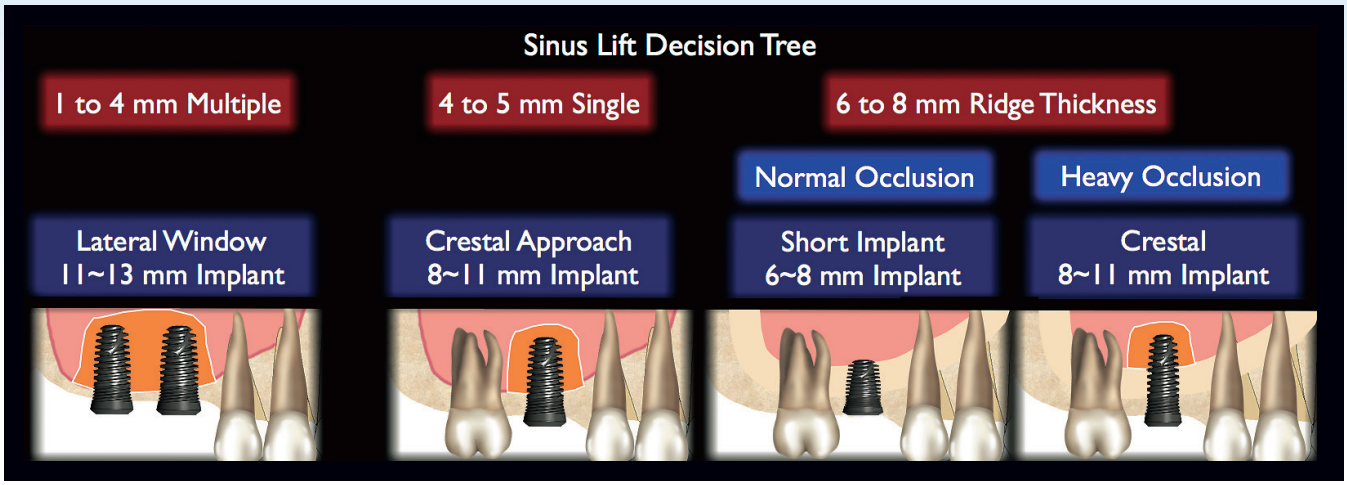

Fig. 48: Chang's Sinus Lift Decision Tree is an excellent reference for determining ideal implant placement position and size selection.

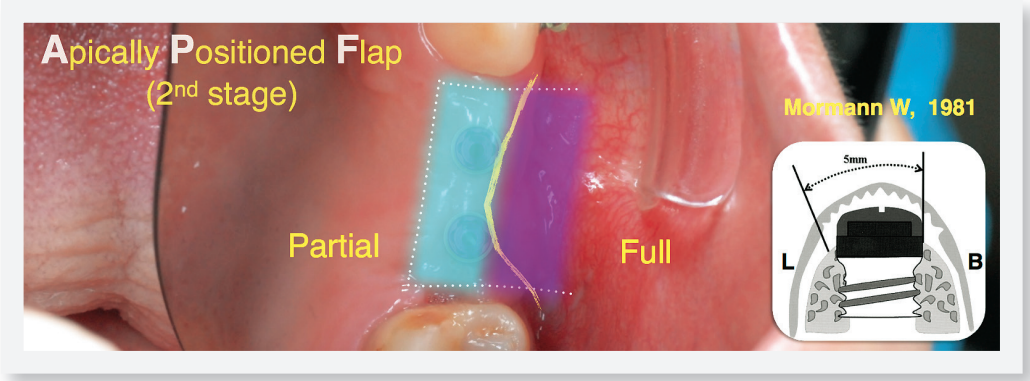

Fig. 49: The incision line (dot line) of an apically positioned flap and a partial-full thickness flap should be raised.

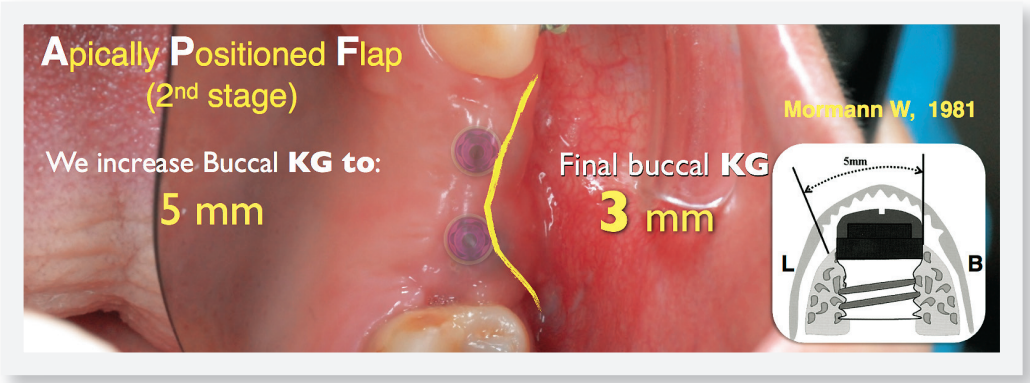

Fig. 50: The increased buccal keratinized gingiva should be over 5mm to allow for 40% shrinkage post-surgery.

DI-CRE-P&W comparative table

DI	CRE	P & W
10 ~ 19	≦ 26	≦ 6
20 ~ 29	≦ 30	≦ 6
30 ~ 39	≦ 34	≦ 6
40 ~ 49	≦ 36	≦ 6
50 ~ 70	≦ 38	≦ 6

DI: **D**iscrepancy **I**ndex; **CRE**: **C**ast-**R**adiograph **E**valuation; **P** & **W**: **P**ink & **W**hite Esthetic Score.

■ Table 2 . DI-CRE-P&W comparative table for final result evaluation in relation to case complexity.[25,29]

may arise from the nose. It is important to inform patients of potential irritation in the nasal area. In the event of sneezing, the nose should not be covered to release air pressure. After the surgery, patients are placed on antibiotic therapy. Furthermore, antiseptic rinses with 0.1–0.2% chlorhexidine twice daily are prescribed for the first three weeks after surgery.[24]

Conclusion

Full mouth evaluation of patients, with bimaxillary protrusion and multiple missing teeth, is critical for determining bracket torque selection and specifying the required implant space(s). Orthodontic treatment combined with implant therapy can achieve near ideal dental alignment, optimal intermaxillary occlusal relationships, and good facial esthetics.

The sinus lift is commonly required for bone augmentation in partially edentulous adult patients. Edentulous alveolar ridges atrophy, due to surface resorption and sinus enlargement, resulting in insufficient bone height for implantation.

An inadequate band of keratinized gingiva often results in gingiva inflammation and subsequent implant failure. An apically positioned flap (*APF*) is indicated when patients have insufficient keratinized gingiva covering the implant site. The combined orthodontics and implant treatment plan successfully resolved the patient's protrusion and closed the edentulous spaces. This difficult malocclusion (*DI = 43, Implant site = 4*) was treated to an acceptable result (*CRE = 28*)(*Table 2*). The patient and the clinician were pleased with the treatment result.

Acknowledgment

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Discrepancy Index Worksheet

TOTAL D.I. SCORE 43

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 = 2

OVERBITE

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

Total = 0

ANTERIOR OPEN BITE

0 mm. (edge-to-edge), 1 pt. per tooth
then 1 pt. per additional full mm. per tooth

Total = 0

LATERAL OPEN BITE

2 pts. per mm. per tooth

Total = 0

CROWDING (only one arch)

1 – 3 mm.	=	1 pt.
3.1 – 5 mm.	=	2 pts.
5.1 – 7 mm.	=	4 pts.
> 7 mm.	=	7 pts.

Total = 1

OCCLUSION

Class I to end on	=	0 pts.
End on Class II or III	=	2 pts. per side 2, 2 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 = 0

BUCCAL POSTERIOR X-BITE

2 pts. per tooth Total = 0

CEPHALOMETRICS (See Instructions)

ANB ≥ 6° or ≤ -2° = 4 pts. 4

Each degree < -2° 1 x 1 pt. = 1

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

SN-MP

≥ 38° = 2 pts. 2

Each degree > 38° 4 x 2 pts. = 8

≤ 26° = 1 pt.

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

1 to MP ≥ 99° = 1 pt. 1

Each degree > 99° 14 x 1 pt. = 14

Total = 30

OTHER (See Instructions)

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

Identify:

Total = 6

IMPLANT SITE

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

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

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

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

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

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

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

Total = 4

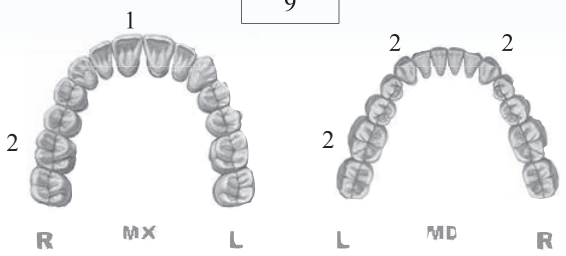
Cast-Radiograph Evaluation

Case # 1 **Patient**

Total Score: 28

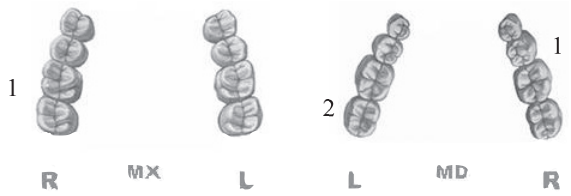
Alignment/Rotations

9



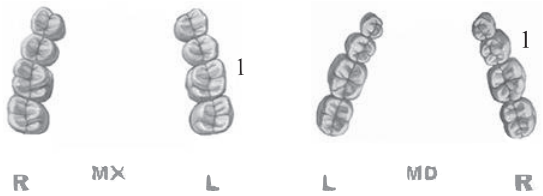
Marginal Ridges

4



Buccolingual Inclination

2

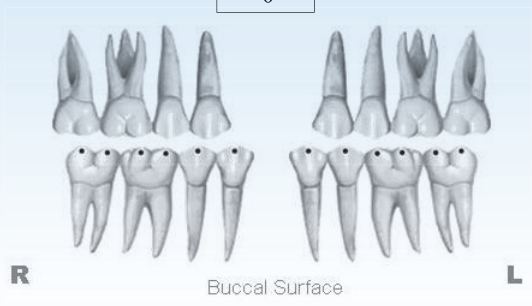


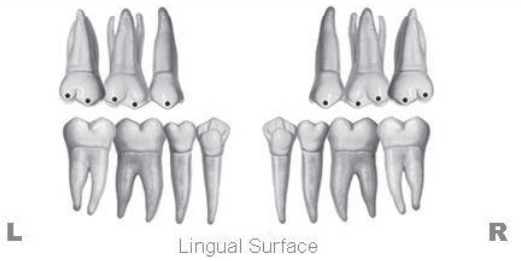
Overjet

0

Occlusal Contacts

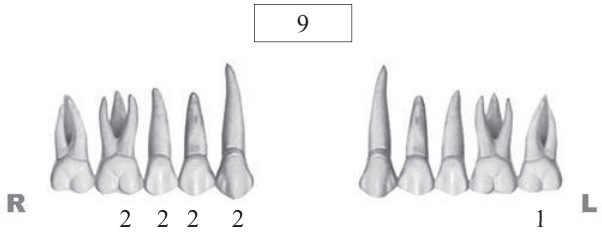
0





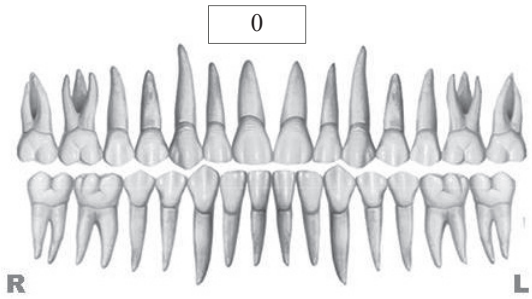
Occlusal Relationships

9



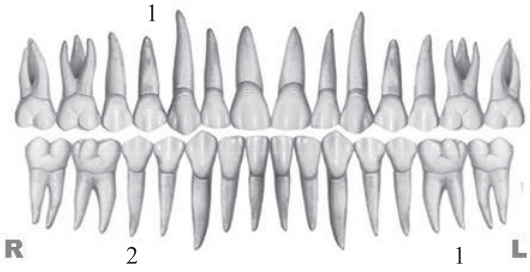
Interproximal Contacts

0



Root Angulation

4



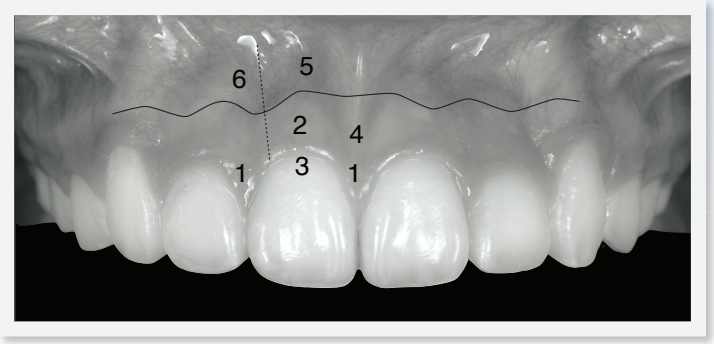
INSTRUCTIONS: Place score beside each deficient tooth and enter total score for each parameter in the white box. Mark extracted teeth with "X". Second molars should be in occlusion.

IBOI Pink & White Esthetic Score

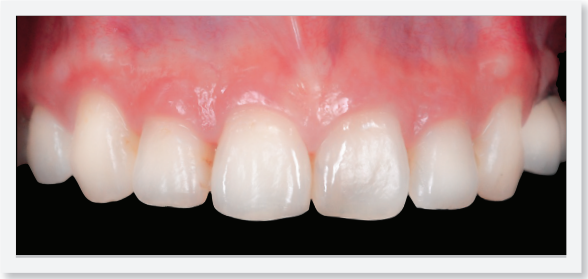
Total Score: = 3

1. Pink Esthetic Score

Total = 0

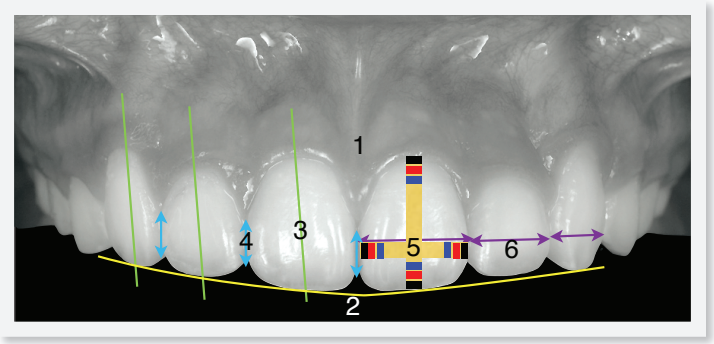


1. M&D Papilla	0	1	2
2. Keratinized Gingiva	0	1	2
3. Curvature of Gingival Margin	0	1	2
4. Level of Gingival Margin	0	1	2
5. Root Convexity (Torque)	0	1	2
6. Scar Formation	0	1	2

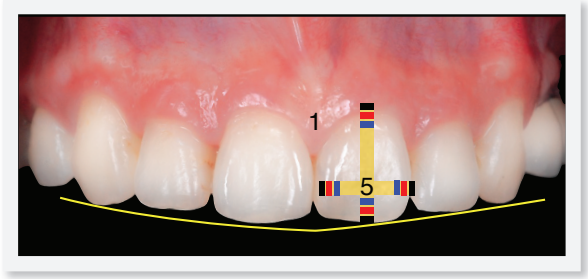


1. M&D Papilla	(0)	1	2
2. Keratinized Gingiva	(0)	1	2
3. Curvature of Gingival Margin	(0)	1	2
4. Level of Gingival Margin	(0)	1	2
5. Root Convexity (Torque)	(0)	1	2
6. Scar Formation	(0)	1	2

Total = 3



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



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