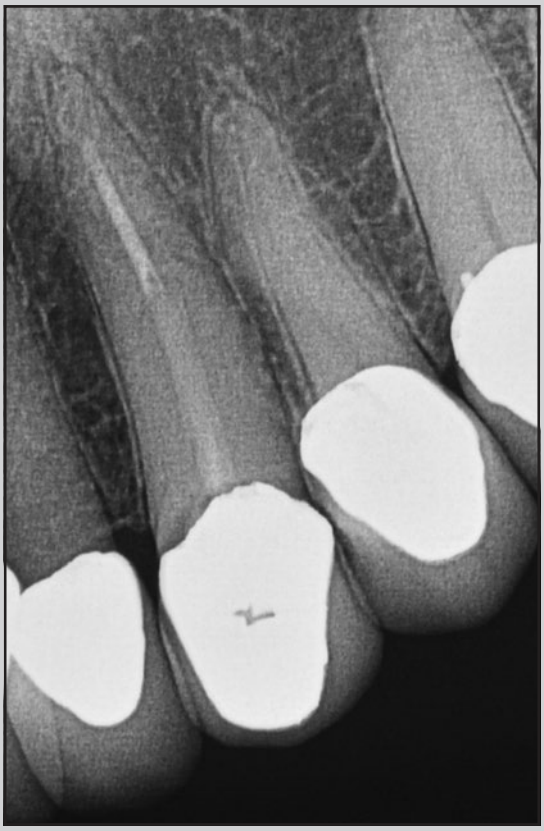

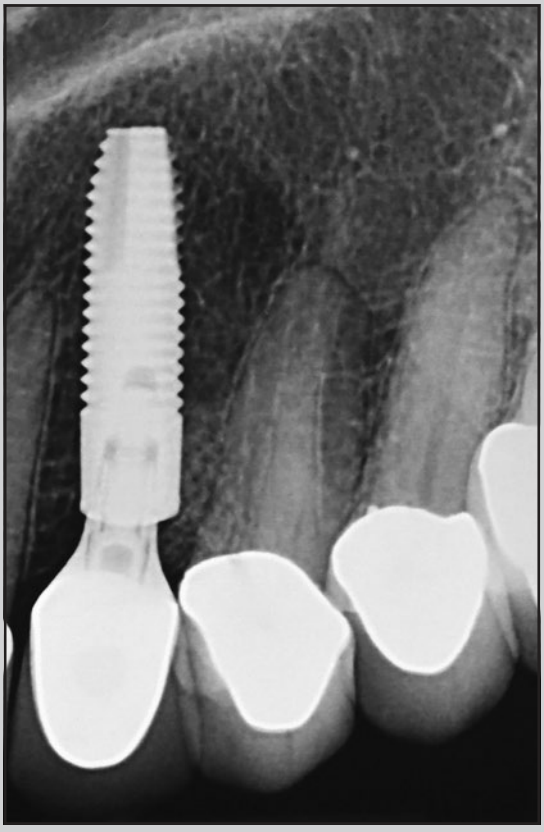

Changes in Peri-implant Soft Tissue Thickness with Bone Grafting and Dermis Allograft. Part II: A Comparative Retrospective Case Series Using a Subcrestal Angle Correction Implant Design

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Immediate tooth replacement therapy (ITRT) in the maxillary anterior sextant is an increasingly frequent treatment option sought by patients and performed by clinicians worldwide. Achieving long-term results that are predictable, stable, esthetic, and healthy is the ultimate goal. This trend also lends itself to minimally invasive surgery as well as defining the procedure to a singular surgical intervention. Preserving and augmenting hard and soft tissues at the time of immediate implant placement provides the best opportunity to achieve these goals. Incorporating an implant with a subcrestal angle correction [SAC] or biaxial feature facilitates screw retention of both provisional and definitive restorations through the cingulum portion of the crown. Compared to uniaxial implants, these implants also feature an extended or variable platform switch [VPS] facially. Measurements of the peri-implant soft tissue thickness 2.0 mm apical to the facial free gingival margin were compared between two groups of 15 consecutively treated patients with different implant designs to evaluate the effect of SAC/VPS for ITRT. The null hypothesis was that there is no difference between uniaxial and biaxial implants with bone grafting and dermis allograft. These authors contend that using a combined hard and soft tissue grafting approach along with SAC/VPS biaxial implants has a synergistic effect on increasing peri-implant soft tissue thickness compared to uniaxial implants.
Int J Periodontics Restorative Dent 2020;40:539–547. doi: 10.11607/prd.4583

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Submitted August 7, 2019; accepted October 27, 2019.

Immediate tooth replacement therapy (ITRT) is a common and predictable method of replacing maxillary anterior teeth.[1,2] Outcomes are comparable to those achieved with implants placed in healed edentulous sites.[3] Implants inclined facially result in less supracrestal soft tissue thickness compared to those with palatal inclinations.[4–6] Howes[7] reported that the offset between the root and crown of maxillary incisors ranges from 8 to 12 degrees. This often results in implants being placed with facial-incisal inclinations, requiring custom abutments and cement-retained restorations, increasing the incidence of peri-implant mucositis and bone loss.[8] Placing immediate implants with palatal access for screw retention increases the risk of perforating the facial bone in the apical region.[9] One solution is angle correction access screw channel (ASC) abutments. However, it was recently demonstrated that achieving and maintaining appropriate screw-tightening torque may not be possible.[10] With the abutment's angle-correction existing coronal to the facial crest of bone, especially in the presence of thin tissues, pressure may cause recession and esthetic failure.[11] Another solution to facilitate favorable implant positioning and screw retention without pressure on the supracrestal mucosa is an implant

with a subcrestal angle correction (SAC). Angled implants were originally used in severely atrophic maxillae to avoid violation of the maxillary sinus.[12,13] This design features a larger horizontal displacement of the implant-abutment junction, or "platform shift," compared to uniaxial implants. Platform-switching better preserves hard and soft tissues compared to implants with platform-matching connections.[14,15] Canullo et al[16] demonstrated that the greater the disparity between the diameter of the implant and abutment, the more favorable maintenance of marginal bone occurred. Placing a particulate bone graft between the walls of the extraction socket and the implant, combined with grafting the tissue zone or space between the abutment/provisional crown and supracrestal soft tissue results in greater soft tissue thickness compared to nongrafted and nontemporized controls.[17] The addition of a dermal allograft further increased supracrestal soft tissue thickness compared to nongrafted, historical controls.[18] Currently, the synergy between SAC implants and simultaneous augmentation has not been demonstrated.

The purpose of this consecutive case series is to demonstrate synergistic properties of a dermal allograft with an SAC implant design in ITRT on labial soft tissue thickness compared to the conventional uniaxial-designed (UA) implants, which were discussed in Part 1 of this study.[18]

Materials and Methods

Immediate implant placement of maxillary anterior teeth (canine to canine) along with immediate temporization was performed in a single private periodontal practice. All surgeries were performed by one of the authors (B.P.L.). Patients were referred by their general practitioners for extraction of hopeless teeth and immediate implant placement and temporization. Prior to surgery, patients were examined and considered periodontally stable. Periapical radiographs and cone beam computed tomography scans (Galileos, Dentsply Sirona) were performed to confirm that restoratively driven implant placement could be performed with primary stability utilizing palatal and apical bone. Preoperative impressions were made to fabricate vacuum-formed surgical guides and to fabricate screw-retained provisional crowns at the time of surgery. All temporary crowns were out of occlusal contact with antagonist mandibular teeth. All patients signed informed consent forms.

Sulcular incisions were made with a 15c scalpel (Miltex) to severe supracrestal periodontal fibers. Without elevating a mucoperiosteal flap, teeth were carefully extracted using periotomes, narrow elevators, and forceps. Caution was taken to avoid trauma to the facial bony walls of the sockets. Following extraction, sockets were thoroughly debrided with manual and ultrasonic instrumentation to remove all soft tissue and periodontal ligament remnants, then conditioned with a slurry of doxycycline and sterile saline on gauze squares for 3 minutes, followed by copious irrigation with sterile saline.

Osteotomies were performed with a palatal bias with the pilot twist drill emerging through the incisal edge of the surgical guide. Implants with a 12-degree SAC and variable platform-switching at the direct facial aspect were placed at a position 3.0 to 4.0 mm apical to the facial gingival margin. A titanium or polyetheretherketone (PEEK) temporary abutment was affixed to the implant, and a composite bone graft consisting of small-particle (250 to 800 microns) mineralized, cortical allograft (FDBA; Symbios, Dentsply Sirona) and porcine xenograft (0.25 to 1.00 mm; ZenGro, Southern Implants), in a 4:1 FDBA/xenograft ratio, was applied in both bone and soft tissue zones.[19] The vacuum-formed template was then placed over the abutment and bis-acryl resin was injected into the template to mechanically lock onto the roughened temporary abutment. It was then removed, and the remainder of the temporary crown was fabricated using a flowable, light-cured composite resin, extraorally. Adjustments were made to assure that proximal contacts with adjacent teeth were established, permitting the passage of floss, and no untoward pressure was placed against the facial and proximal soft tissue. The occlusion was also verified, to confirm that no contact with the opposing mandibular teeth existed. A thin dermal allograft (0.4 to 0.8 mm; PerioDerm, Dentsply Sirona) was trimmed, and a biopsy punch was used to perforate the allograft and allow it to be "draped" over the

abutment/crown portion of the one-piece temporary crown. The dermal allograft was oriented in a manner in which the basement membrane side was facing inward, towards the bone graft and crestal bone, and the connective tissue side was oriented facing the soft tissue. Then, a small, subperiosteal pouch was created between the soft tissue and labial bone, extending 3 to 5 mm apical to the facial, osseous crest, as described previously.[20] The provisional crown was hand-tightened, and a radiograph was taken to confirm the temporary restoration was completely seated onto the implant. Once this was confirmed, the abutment screw was tightened to 15 Ncm, and a 5-0 resorbable suture (Monocryl, Ethicon) was placed in a figure-eight manner to gently compress the tissues against the provisional crown and for hemostasis. Patients were prescribed amoxicillin (clindamycin for patients allergic to penicillin), a 6-day tapering course of methyl prednisolone and etodolac (400 mg) for anti-inflammatory and analgesic purposes, and chlorhexidine rinses. They were instructed to avoid using a toothbrush in the operated area until suture removal at approximately 10 days postoperative and to avoid mastication with anterior teeth for at least 6 weeks.

After a healing period of about 12 to 14 weeks, radiographic and clinical examinations confirmed osseointegration and to rule out infections and biologic and mechanical complications. Patients were then referred back to their restorative dentists to commence definitive restorative therapy. The surgical and follow-up methods for UA implants were previously described.[18]

Measurement of Facial Soft Tissue Thickness

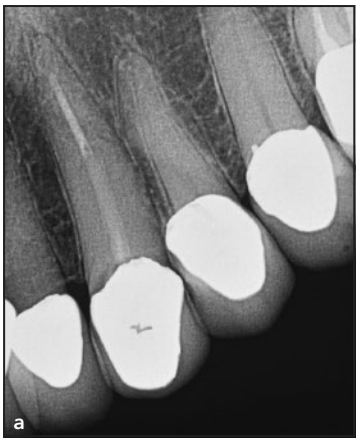
The midfacial soft tissue thickness (labial-palatally) was measured and analyzed using three-dimensional scanning of casts (CEREC inLab, Dentsply Sirona) and three-dimensional software analysis (CEREC SW 4.3, Dentsply Sirona). The buccal soft tissue thickness at 2.0 mm apical to the free gingival margin was selected based on the previous results from part one of this study,[18] and the patient was marked as having either a thick or thin phenotype, based on the gingival scallop and tooth form. The data were submitted to a nonparametric test (Mann-Whitney *U* test, $P \leq .05$).

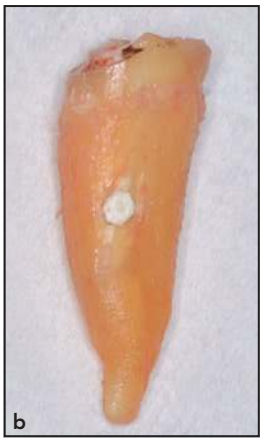
Experimental Case 1

A 72-year-old female patient presented for evaluation following endodontic perforation of the maxillary left canine. This was demonstrated radiographically (Fig 1a). Following supracrestal fiberotomy with a 15c scalpel, the tooth was carefully extracted with periotomes, narrow elevators, and forceps. The lateral root perforation was clearly visible extraorally (Fig 1b). A cylindrical implant (diameter: 4.0 mm; length: 13.0 mm) was placed with a palatal bias into the extraction socket. This implant featured a 12-degree SAC, where the insertion axis emerged through the incisal edge of the extracted tooth according to the surgical guide. This SAC resulted in an abutment screw-access emerging through the cingulum region of the anticipated restoration (Fig 1c). A PEEK temporary abutment was tightened to the implant, and dual-zone bone grafting, as described in Materials and Methods, was performed with a FDBA/xenograft particulate graft in a 4:1 ratio. After intraoral connection of the temporary abutment with tooth-colored bis-acryl resin and the vacuum-formed template used as a surgical guide, the provisional crown was finished extraorally with flowable composite resin, then contoured and highly polished. After, a dermal allograft (with a prehydrated thickness of 0.4 to 0.8 mm) was trimmed, then pierced with a biopsy punch to be adapted around the apical portion of the provisional crown. The orientation of the dermal allograft was such that the basement membrane side would be in direct contact with the underlying bone, and the connective tissue side in contact with the periosteum of the facial mucosa (Fig 1d).

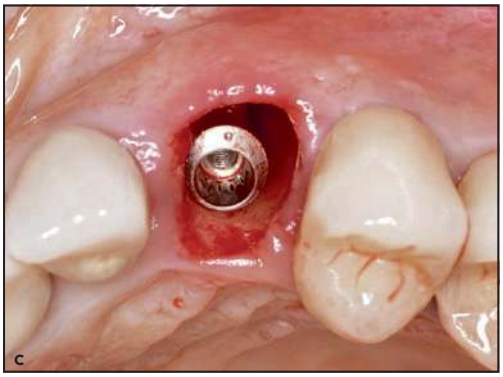
A narrow, subperiosteal pouch was created with a small periosteal elevator to provide space for the dermal allograft to be inserted. The provisional crown, with the dermal allograft positioned, was then hand-tightened, and a periapical radiograph confirmed complete seating onto the implant.

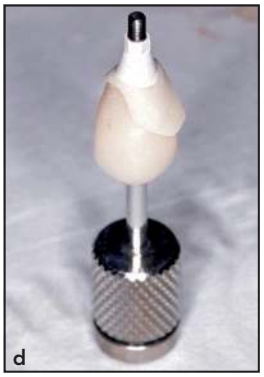
The abutment screw was tightened to 15 Ncm after adaptation of the dermal allograft into the subperiosteal pouch, and resorbable, monofilament sutures were used for gentle compression and hemostasis (Fig 1e).

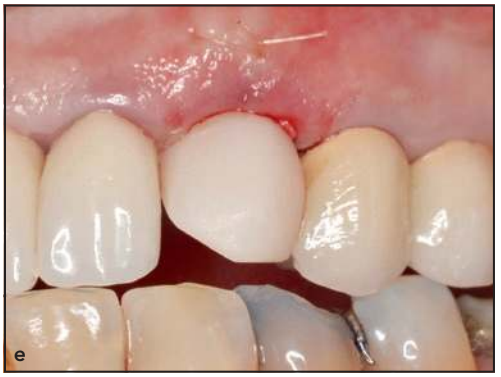


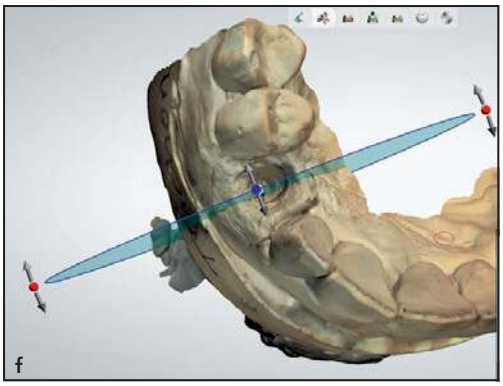


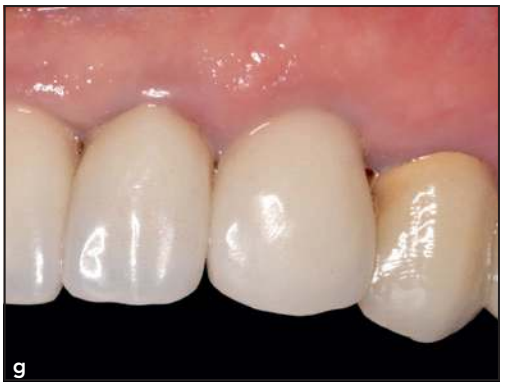
Figs 1a to 1e (a) *Preoperative condition of the maxillary left canine with a lateral, endodontic perforation.* (b) *The extracted root of the tooth. A lateral perforation caused by endodontic therapy is visible.* (c) *Implant with a 12-degree SAC. The implant was placed with a palatal bias to avoid proximity with the facial socket walls and to allow a space to be obturated with particulate bone graft to the level of the gingival margin.* (d) *The temporary crown, with the dermal allograft trimmed and adapted around the apical portion of the one-piece provisional crown/abutment.* (e) *The screw-retained provisional crown in place. The occlusion was designed to avoid contact with the mandibular anterior teeth in maximum intercuspation and excursions.*

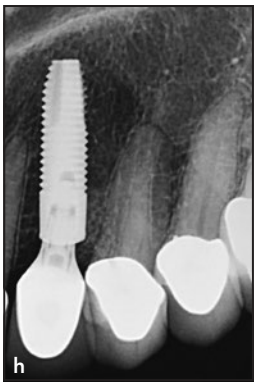












Figs 1f to 1h (f) *A 2.895-mm facial mucosa thickness was measured 2.0 mm apical to the free gingival margin.* (g) *The final screw-retained crown in place. Final crown by Dr D. Frank in Abington, Pennsylvania, USA.* (h) *Radiograph at the completion of therapy. Marginal bone levels are even with the implant platform.*

After an uneventful healing period of 12 weeks, the patient was referred back to her restorative dentist. The soft tissue model was digitally scanned (3Shape, Trios) and the thickness of the soft tissue 2.0 mm apical from the facial free gingival margin was recorded as 2.895 mm (Fig 1f).

The maxillary left canine was restored with a screw-retained crown, demonstrating excellent peri-implant health and satisfactory esthetics (Fig 1g). Radiographically, the marginal bone levels were present at the height of the implant platform (Fig 1h).

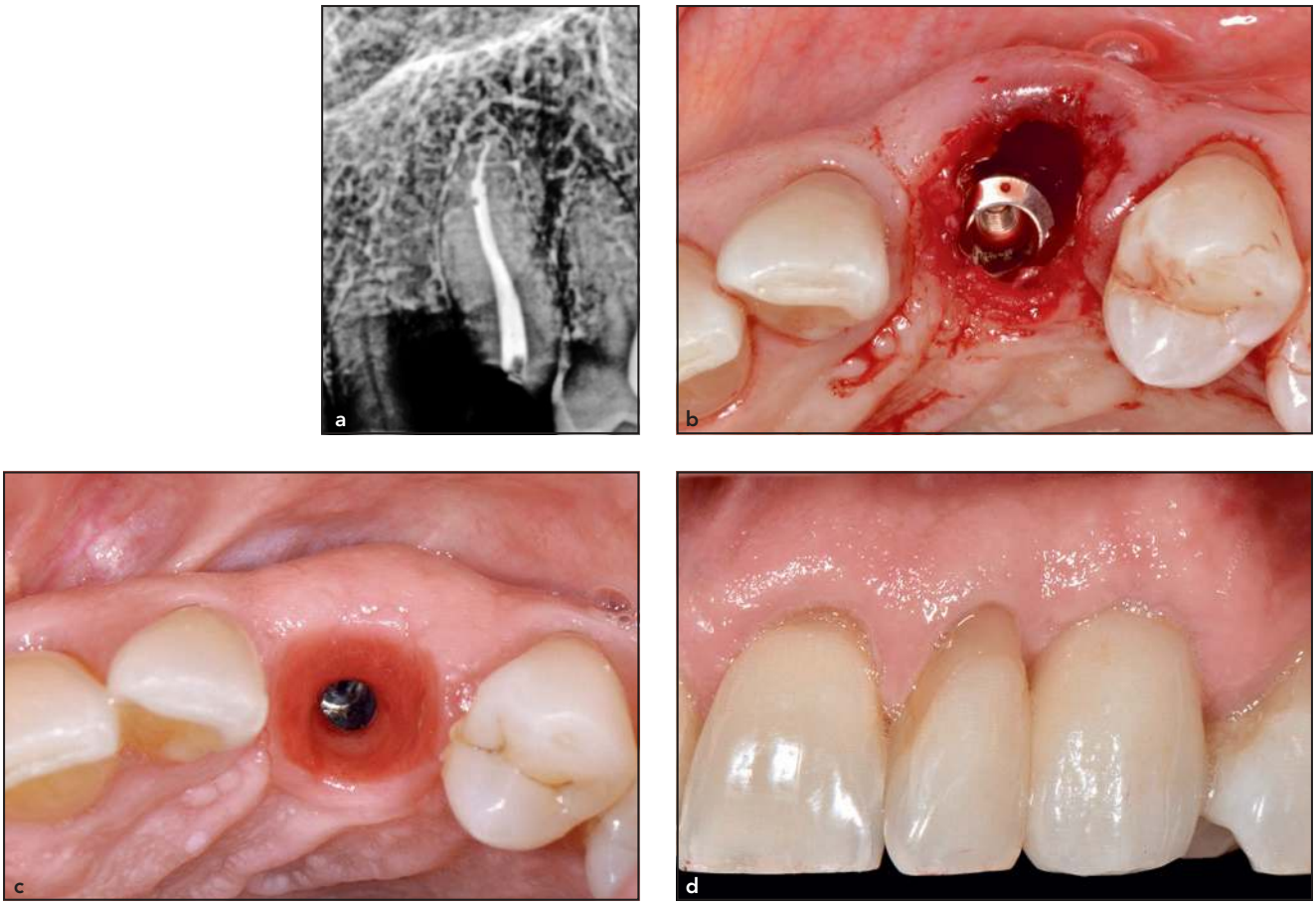


Fig 2 (a) *Radiograph of the carious root of the maxillary left canine. The crown is no longer in place due to caries and lost retention.* (b) *Occlusal view of palatal placement of the SAC implant within the immediate extraction socket.* (c) *Occlusal view of peri-implant soft tissues at time of final impressions (6 months after immediate tooth replacement surgery and provisionalization). The soft tissue thickness measured 5.29 mm at a level 2.0 mm apical to the gingival margin.* (d) *The final, screw-retained crown in place. Final crown by Dr M. Weiss in Jenkintown, Pennsylvania, USA.*

Experimental Case 2

A 65-year-old male patient presented for ITRT for his maxillary left canine. Due to caries rendering this tooth unrestorable, implant therapy was proposed and accepted by the patient (Fig 2a). Following flapless extraction, debridement, and conditioning identical to the previous case, palatal implant placement of a tapered 4.0-mm × 13.0-mm implant with a deep conical connection and 12-degree SAC was performed (Fig 2b). Dual-zone bone grafting was performed as previously described, and immediate temporization was performed using the dermal allograft technique simultaneously with provisionalizing the implant.

After 6 months of healing, during which time the patient lightened the shade of his natural teeth under the care of his restorative dentist, final impressions were taken. The soft tissue thickness at 2.0 mm apical to the facial gingival margin measured 5.89 mm (Fig 2c). The final restoration was delivered with screw retention (Fig 2d).

Results

A total of 30 patients (13 men and 17 women, age range 21 to 88 years old) underwent ITRT of a single maxillary anterior tooth utilizing the

Table 1 Restoration Characteristics of Each Case

Tooth no. (FDI system)	Platform diameter, mm	Post-treatment tissue thickness*	Pret-reatment gingival phenotype	S vs C
SAC implant cases				
23	4.0	2.895	Thin	S
11	4.0	3.712	Thin	S
13	4.0	3.148	Thick	S
23	4.0	2.63	Thin	S
12	3.5	3.24	Thin	S
11	4.0	2.35	Thin	C
12	3.5	3.219	Thin	C
11	4.0	3.856	Thick	S
22	3.5	3.131	Thick	C
13	4.0	3.026	Thin	S
23	4.0	5.81	Thick	S
23	4.0	5.289	Thin	S
23	4.0	4.98	Thick	S
21	4.0	5.002	Thick	S
23	3.5	3.835	Thick	S
UA implant cases				
12	4.2	2.96	Thick	C
12	3.0	3.01	Thick	C
21	4.2	2.69	Thick	S
22	3.0	2.58	Thick	S
12	3.0	3.26	Thick	C
11	4.2	2.70	Thick	C
12	4.2	3.57	Thin	C
13	4.8	1.79	Thin	C
12	3.6	3.36	Thin	S
11	4.2	2.19	Thin	C
21	4.2	1.92	Thin	C
12	3.6	2.48	Thin	C
22	3.6	3.25	Thick	C

S = screw-retained; C = cement-retained; SAC = subcrestal angle correction; UA = uniaxial. Phenotypes were assigned based on having a high or low degree of gingival scallop and the type of clinical crown form (square vs triangular).
*Tissue thickness measured at 2 mm apical to the facial gingival margin at the time of final impressions (at least 12 weeks following surgery).

identical surgical and provisionalization technique, with either a conventional UA implant (n = 15; Astra Tech EV, Dentsply Sirona) or an implant with a 12-degree SAC (n = 15; Co-Axis, Southern Implants). All implants were placed with bone grafting in the residual buccal gap and a dermal allograft. The survival rate of the implants and prosthesis were 100% at the 3-year follow-up for UA group and at the 1-year follow-up for SAC group. A minimum healing period of 3 months was observed prior to the impression making for the fabrication of the final restoration. Of the 15 patients receiving final crowns in the UA implant group, 12 received cement-retained crowns and 3 had their crowns screw-retained. In the SAC group, 3 patients received a cement-retained restoration and 12 received a screw-retained one; screw retention was used 80% of the time with an SAC implant compared to only 20% in UA cases. This decision was at the discretion of the restorative dentist. The advantages of retrievability and the elimination of cement (and the possible biologic complications associated with undetected cement) are significant and more predictable using an implant with an SAC design.

Soft tissue models from 15 consecutively treated patients were digitally scanned (3Shape), and soft tissue thickness was measured at 2.0 mm apical to the facial gingival margin (Tables 1 and 2). The difference in the buccal soft tissue thickness between thin and thick biotypes was clinically significant but not statistically significantly different (Fig 3).

When the comparison of buccal soft tissue thickness was made, SAC showed a statistically significantly greater increase compared to UA (3.74 ± 1.05 mm vs 2.85 ± 0.47 mm, respectively) (P = .05).

Discussion

Esthetic implant therapy should be expedient, minimally invasive, and stable over time. Hard and soft tissue stability has been shown to be unpredictable following immediate tooth replacement.[21] The additional step of augmenting the facial mucosa with a subepithelial connective tissue graft has been shown to reduce gingival recession compared to sites only receiving a xenograft particulate between the socket walls and immediate implant.[22] Though highly effective, morbidity associated with acquiring an autogenous soft tissue graft can be significant.[23] This step also increases treatment time and cost of treatment.

In addition to limiting recession, regenerative therapy—soft tissue augmentation in particular—can improve esthetic outcomes by reducing the appearance of shadows caused by abutments via increasing soft tissue thickness. In an in vitro animal study,[24] a minimum soft tissue thickness of 2.0 mm was necessary to prevent visible color changes over ceramic materials, and a 3.0-mm thickness was required to prevent perceptible changes over metallic materials. Ferrari et al[25] demonstrated that soft tissue thickness of at least 2.0 mm is capable of masking the color of titanium, gold, and zirconia abutments. The author demonstrated with uniaxial implants that a mucosal thickness 2.0 mm apical to the gingival margin at time of restoration was 2.79 mm with a range of 1.79 to 3.57 mm.[18] This compares favorably to a study where subepithelial connective grafts were placed after xenogeneic bone particulate was grafted into the gap between the socket wall and immediate implant.[26]

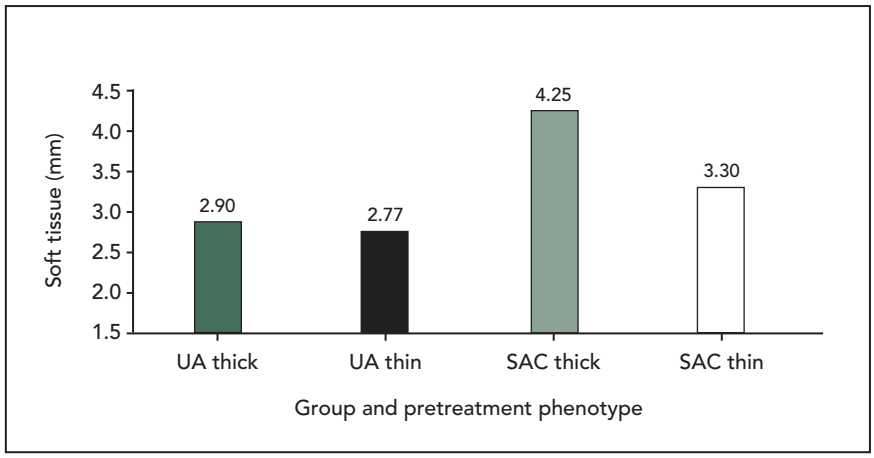


Fig 3 *Average facial soft tissue thickness per gingival phenotype in each implant group. UA = uniaxial; SAC = subcrestal angle correction.*

Table 2 Facial Soft Tissue Thickness Measured at Time of Final Restorations

	Implant	
	SAC	UA
Range	2.35–5.81	1.92–3.57
Average thickness	3.742	2.85
3.0-mm platform		2.92
3.5-mm platform	3.36	
3.6-mm platform		3.03
4.0-mm platform	3.882	
4.2-mm platform		2.77

SAC = subcrestal angle correction; UA = uniaxial.
Values given in millimeters.

Another aspect of ITRT is the role provisional restorations play in supporting the proximal and facial mucosae. Properly contoured temporary crowns or custom healing abutments support interproximal papillae.[27,28] Supporting the existing soft tissues, without exerting excessive pressure, which can cause apical displacement of the gingival margin, is critical for achieving acceptable gingival contours.[29] These contours can then be transferred via a custom impression to working models and fabrication of definitive restorations.[30,31] The utilization of SAC implants for ITRT is not new. Brown and Payne[32] and Vandeweghe et al[33] demonstrated an external hexagon version of an SAC implant for this purpose with satisfactory results regarding hard and soft tissue maintenance, which was recently shown[34] to remain stable 5 years after treatment.

The implants placed in the current case series all featured an SAC design. The implant diameter was either 3.5 or 4.0 mm, and the facial length of the horizontal offset or platform switch was 1.06 or 0.82 mm, respectively. From a three-dimensional perspective, this increased offset provides more space for palatal migration of soft tissue and for dual-zone bone grafting and placement of the dermal allograft within the tissue zone. Properly supporting the bone and dermal allograft with a properly contoured provisional crown seals the extraction socket and guides the healing process. The SAC/variable platform-switch implant affords clinicians the predictability of screw retention. This is most important at time of surgery, where extrusion of undetected cement can be catastrophic regarding early postoperative infections. This concept also allows provisional crowns to be tightened directly to the implant via the abutment screw, eliminating the element of cement altogether. This is a case series with a small number of subjects. Larger, randomized, controlled clinical studies are necessary to further validate this treatment concept.

Conclusions

The results of this comparative retrospective case series demonstrate the synergistic effects of SAC implants with a facial variable platform-switch and dual-zone bone grafting combined with a dermal allograft for ITRT. The increased soft tissue thickness may provide more three-dimensional stability of the site resistant to recession, along with better concealment of the underlying abutment, leading to esthetic success.

Acknowledgments

The authors declare no conflicts of interest.

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