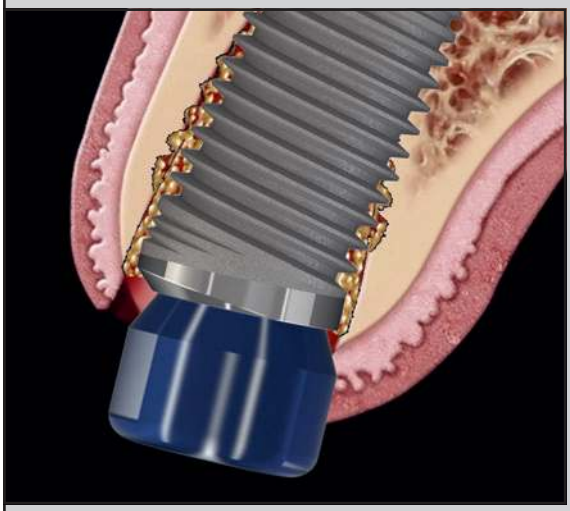

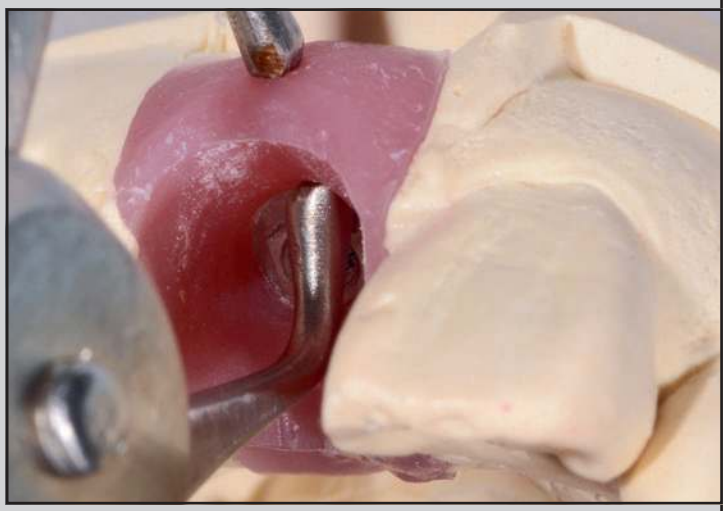

Immediate Tooth Replacement Therapy in Postextraction Sockets: A Comparative Prospective Study on the Effect of Variable Platform-Switched Subcrestal Angle Correction Implants

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Immediate tooth replacement therapy (ITRT), ie, immediate implant placement and provisional restoration in postextraction sockets, has been shown to achieve favorable outcomes in reference to soft tissue stability and esthetics. However, avoiding socket perforation with uniaxial implants in the anterior maxilla can be challenging due to the inherent anatomy. Dual or co-axis subcrestal angle correction (SAC) implants have been developed to change the restorative angle of the clinical crown restoration subcrestally at the implant-abutment interface to enhance the incidence of screw-retained definitive restorations. An additional benefit of this macrodesign implant feature is variable platform switching (VPS) that increases soft tissue gap distance above the implant platform. The purpose of this prospective study on ITRT in maxillary anterior postextraction sockets was to investigate the effect of SAC with VPS (SAC/VPS) compared to conventional platform-switch–design implants (PS) relative to ridge dimension stability and peri-implant soft tissue thickness. A total of 29 patients had undergone ITRT and received either a PS or SAC/VPS implant; previously described measurements were made compared to the contralateral natural tooth sites. When the comparison of buccal soft tissue thickness was made, SAC/VPS showed a greater increase compared to PS (3.12 mm vs 2.39 mm, respectively) with statistical significance (P = .05). The increase was independent from periodontal phenotype. Therefore, SAC/VPS may increase peri-implant soft tissue thickness and help minimize recession following ITRT.
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Immediate tooth replacement therapy (ITRT), ie, immediate implant placement and provisional restoration in postextraction sockets, has been shown to achieve favorable outcomes in reference to soft tissue stability and esthetics with proper case selection and meticulous treatment.[1–3] In addition, selection of specific treatment protocols, such as a flapless approach and hard tissue grafting the gap, can enhance clinical outcomes.[4–7] The three-dimensional (3D) position of the implant within the extraction socket seems to be a critical factor influencing not only osseointegration but also esthetics, specifically gingival recession.[8–10] Palatal implant placement and increasing the labial gap were important to maintain the labial crest of bone.[11] Several animal studies reported that increased bone crest and more coronal bone-to-implant contact are attained with subcrestal placement of implants without flap elevation.[12,13] Palatal placement of the implant is also advised in order to facilitate an adequate emergence profile and space for the prosthetic abutment, which are crucial to optimizing the maintenance of peri-implant soft tissue to achieve adequate thickness and minimize recession.[14] In addition, the use of implants with a platform-switch design has been shown to be associated with significantly greater midfacial soft tissue thickness with

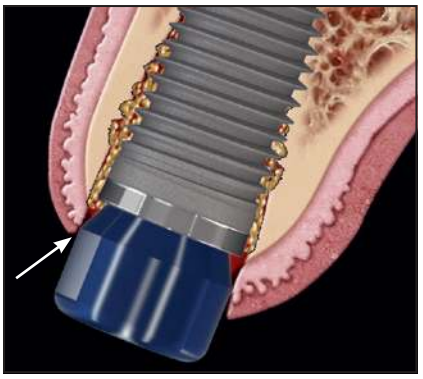


Fig 1 *Conventional straight implant designs have less distance between the implant-abutment interface and peri-implant soft tissues.*

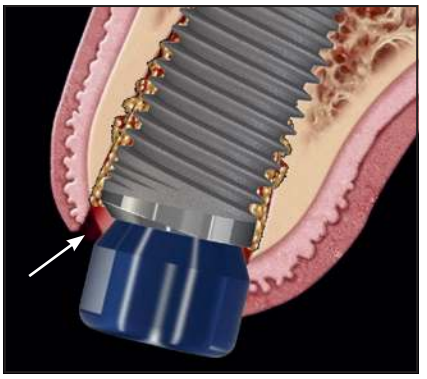
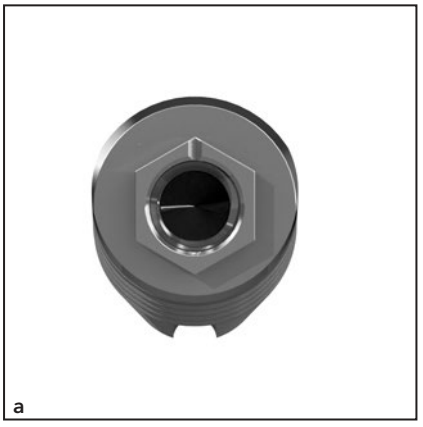


Fig 2 *Subcrestal angle correction (SAC) implants with variable platform switching (VPS) create a greater distance between the implant-abutment interface and peri-implant soft tissues, thereby allowing more graft material to be placed in this area, which results in a gain of tissue thickness.*

Fig 3 (a) *Occlusal and* (b) *lateral views of a 12-degree SAC implant design with VPS. Note the amount of VPS is greatest at the direct facial aspect of the implant.*



bone grafting (dual-zone therapeutic concept) compared to non–platform-switched implants when used in ITRT.[15]

A significant challenge in immediate implant placement is the anatomy of the anterior maxillary region, which slopes from anterior to posterior in a corono-apical direction. Consequently, the long axis of a conventional straight or uniaxial implant design (the body) does not coincide with the long axis of the clinical crown restoration. Therefore, customized abutments are frequently used in combination with cement-retained restorations or angulated screw channel (ASC) abutments to eliminate cementation; however, the soft tissue gap distance is diminished above the implant-abutment interface (Fig 1). Therefore, since the early 2000s, dual- or co-axis implants have been developed that change the restorative angle of the clinical crown restoration subcrestally at the implant-abutment interface to enhance the incidence of screw-retained definitive restorations (Fig 2).[16,17] Besides reducing the potential negative consequences of undetected cement in the peri-implant soft tissues and excessive labial contour with ASC and custom abutments, an additional benefit of SAC implants is increased soft tissue gap distance above the implant platform. This macrodesign implant feature includes variable platform switching (VPS), meaning that by design, a greater platform disparity is seen at the direct facial aspect of the implant. Consequently, this could allow for greater graft material—hard or soft—to be placed into this "chamber" above the abutment connection, as compared to conventional straight implant designs that may enhance augmentation of the peri-implant soft tissue complex (Fig 3).[16,17]

Therefore, the purpose of this ITRT prospective study in maxillary anterior postextraction sockets was to investigate the effect of using subcrestal angle correction implants with variable platform switching on *(1)* ridge dimension stability and *(2)* peri-implant soft tissue thickness.

Materials and Methods

Patients were recruited to the study based on previously described inclusion and exclusion criteria.[4,15,18] The study was approved by Western Institutional Review Board, and informed consent was obtained from all participants. Twenty-nine patients were identified who had undergone flapless extraction of a single anterior maxillary anterior tooth with immediate implant placement and provisional restoration between 2016 and 2018. During the first visit, an initial examination was performed, including assessment of periodontal phenotypes with a periodontal probe as per Kan et al (midfacial soft tissue thickness < 2.0 mm was classified as thin phenotype), as well as obtaining diagnostic impressions and selection of the shade (tooth color selection was made with conventional shade tabs and digitial photographs).[19] Extraction was performed without flap elevation under local anesthesia. An intact buccal plate (5.0 mm or less from the free gingival margin [FGM]) was confirmed with a periodontal probe (William Probe, Hu-Friedy). Using manufacturer recommendations, an osteotomy was made and patients received either conventional platform-switch–design implants (PS; Tapered Plus, BioHorizons), Certain T3 implants (Zimmer Biomet), or VPS-designed implants with subcrestal angle correction (SAC) (Co-Axis 12D, Southern Implants), all with bone grafting in the residual buccal gap. Small-particle mineralized cancellous allograft material was also placed into the peri-implant soft tissues (dual-zone grafting). Titanium sleeve screw-retained provisional abutments/restorations were fabricated chairside using autopolymerizing acrylic resin (Super T, American Consolidated Manufacturing) with non-occlusal loading. Antibiotic prophylaxis and pain medication as needed were prescribed postoperatively with standard postoperative instructions. Follow-up visits were scheduled 2, 4, and 8 weeks postoperatively. After a tissue maturation period of a minimum of 4 months, the provisional restoration was removed for the first time, and final implant-level impressions were made using a polyvinylsiloxane impression material. All definitive restorations made on SAC implants were screw-retained. In instances where custom abutments were required, UCLA-type was used, and porcelain-fused-to-gold crowns were fabricated and delivered with provisional cement (Tempbond NE, Kerr). This restorative phase was scheduled within a 4- to 8-week period after impression making. Subjects returned to the clinic for the study measurements 6 months after the delivery of the definitive restoration.

Measurement of Volumetric Ridge Change

Buccolingual ridge dimension and midfacial soft tissue thickness were measured and analyzed using 3D scanning of casts (CEREC InLab, Dentsply Sirona) and 3D software analysis (CEREC SW 4.3, Dentsply Sirona). The reference point (2 mm below the FGM) to evaluate the buccolingual ridge dimension compared to the contralateral natural tooth was selected based on previous results.[4,15,18,20] Digital models from scanned casts were superimposed, and computer subtraction analysis was performed to obtain the difference in buccolingual dimension.

Measurement of Labial-Palatal Soft Tissue Thickness

The midfacial peri-implant gingival thickness (labial-palatally) was measured coronal-apically from the FGM to the implant-abutment junction using a periodontal probe, and the peri-implant soft tissue dimensions were measured. The vertical distance from the FGM to the implant shoulder was divided into three labial-palatal points of reference designated as the middle zones, respectively measured in millimeters on the scanned cast. The data were submitted to a 2×2 analysis of variance ($P \leq .05$).

Results

A total of 29 patients (23 women; age range: 26 to 73 years old) who had undergone flapless extraction of a single maxillary anterior tooth with immediate implant placement and provisional restoration received either a conventional PS-design implant (n = 14: 8 Tapered Plus implants and 6 Certain T3 implants) or a VPS-design implant with SAC (n = 15). In the PS group, there were 9 patients with thin phenotype and 5 patients with thick phenotype; in

Fig 4 *Pretreatment periapical radiograph* (left) *and cone beam computed tomography* (right) *showed a thin labial plate at a maxillary right central incisor and bone palatal-apical to the root.*

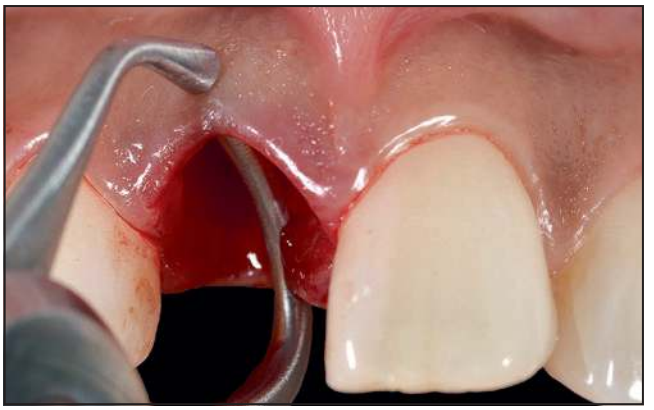


Fig 5 *The buccal soft tissue thickness 2.0 mm below the free gingival margin was measured with an Iwanson Spring Caliper without spring tension at the time of ITRT. The dimension for this patient was only 0.5 mm.*

Fig 6 *Implant driver showed an implant platform angle correction of 12 degrees, which enabled a screw access hole position at the cingulum area for a macrodesign implant alone.*

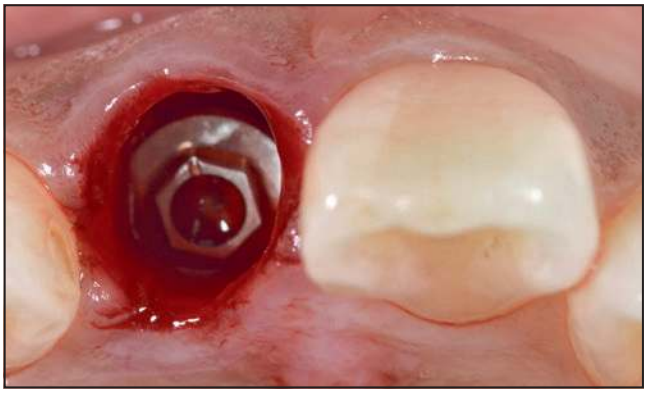


Fig 7 *Occlusal view of the implant position relative to the buccal plate. An SAC implant was placed approximately 3 to 4 mm below the buccal free gingival margin. Note that the external hex platform was positioned at the cingulum, and the angle of the implant-abutment interface is more palatally placed, allowing a greater amount of graft material to be placed.*

Fig 8 *Cone beam computed tomography scan, taken immediately after tooth replacement therapy, showing the restorative platform angle correction and avoiding apical perforation of the labial bone plate.*

the SAC group, there were 7 patients with thin phenotype and 8 patients with thick phenotype. The platform-switching distances (ie, the distance between the implant diameter and the abutment interface) ranged from 0.5 to 1.3 mm for the SAC group and 0.5 to 0.6 mm for the PS group. Twenty-eight implants were placed in central incisor locations, and one implant in the SAC group was placed in a lateral incisor location. All implants were placed with bone grafting in the residual buccal gap (Figs 4 to 9). The survival rate of the implants

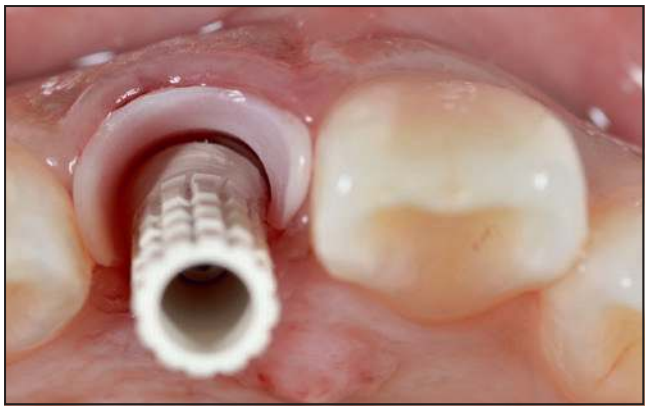


Fig 9 *A prefabricated, preformed polymethylmethacrylate provisional abutment sleeve was placed onto the polyetheretherketone implant cylinder. Note that the 12-degree platform angle correction enables optimal angulation of the prosthetic abutment with screw retention relative to the extraction socket and implant position.*

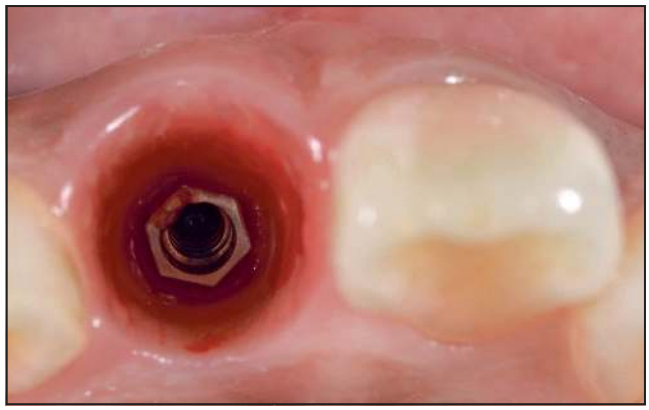


Fig 10 *After a healing period of 4 months, the provisional restoration was removed for the first time at final impression making. Residual graft particles (small particle mineralized cancellous allograft) are seen in the peri-implant sulcus; the stability of both the buccolingual ridge and soft tissue is noted.*

Fig 11 (a) *Buccal and* (b) *occlusal views of a definitive restoration at the time of delivery. Buccolingual dimensional stability was achieved in both hard and soft tissues with a screw-retained definitive implant crown.*

and prosthesis at 12 months after delivery of the definitive restoration was 100% for both groups. A 4-month–minimum healing period was given prior to the impression making for fabrication of the definitive restoration (Fig 10). Four patients received cement-retained restorations, and 25 received screw-retained restorations (Fig 11).

When the comparison of the buccolingual ridge width to the

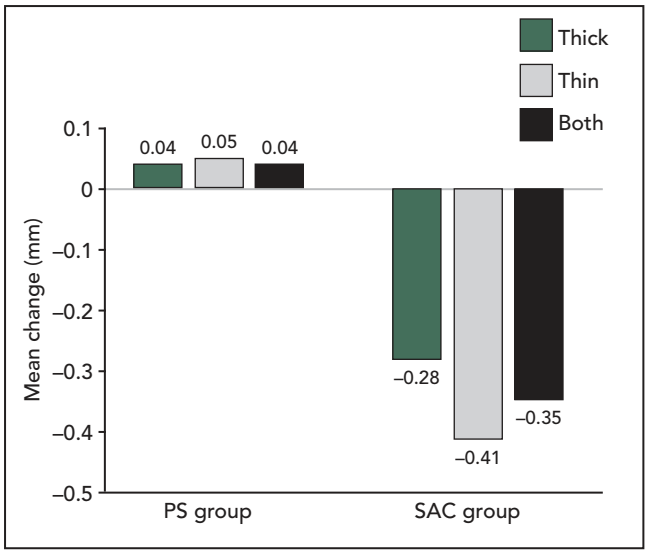


Fig 12 *Mean buccolingual ridge width change by treatment group and gingival phenotype. Measurements were taken 2 mm below the free gingival margin at the time of definitive restoration delivery. Analysis indicates that the SAC implant may have a positive effect on preservation of ridge dimension in both thick and thin phenotypes. PS group = patients who received implants with a platform-switch design; SAC group = patients who received implants with a variable platform-switch design and subcrestal angle correction; thick phenotype = equal to or greater than 2.0 mm thick; thin phenotype = less than 2.0 mm thick.*

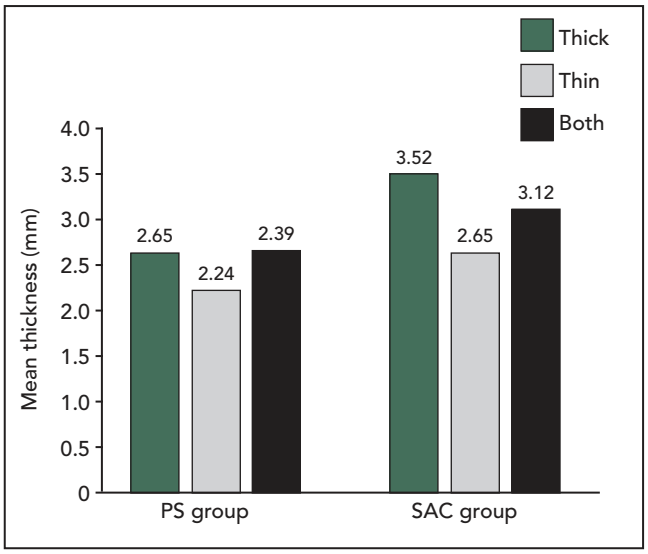


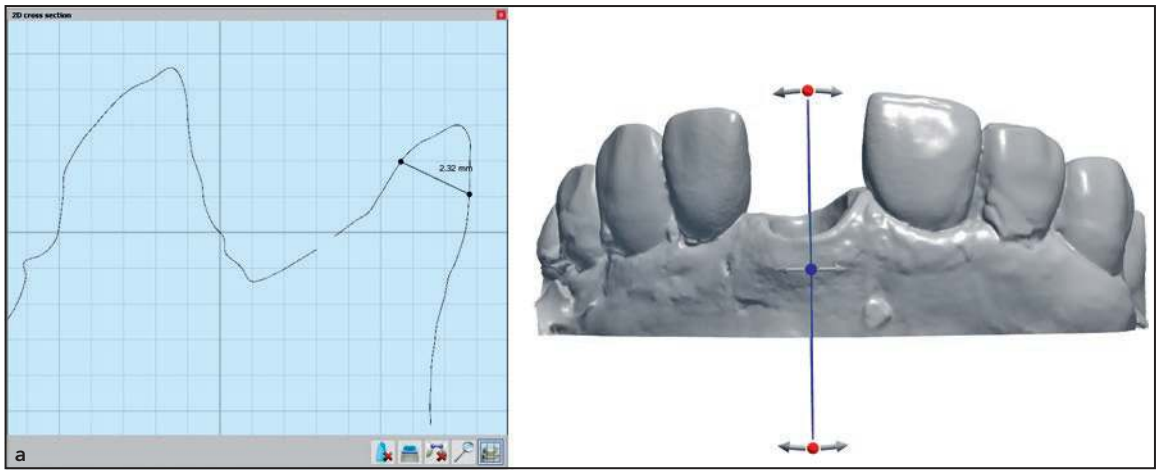
Fig 13 *Mean peri-implant buccal soft tissue thickness by treatment group and gingival phenotype. Measurements were taken 2 mm below the free gingival margin at the time of definitive restoration delivery. Analysis indicates that the SAC implant may have a positive effect on increasing peri-implant buccal soft tissue thickness in both thick and thin phenotypes. PS group = patients who received implants with a platform-switch design; SAC group = patients who received implants with a variable platform-switch design and subcrestal angle correction; thick phenotype = equal to or greater than 2.0 mm thick; thin phenotype = less than 2.0 mm thick.*

contralateral natural tooth sites was made between the PS and SAC groups, the SAC group showed a slight increase (–0.35 mm vs 0.04 mm, respectively), but it was not statistically significant. Figure 12 presents the breakdown of the buccolingual ridge width change in biotype.

When the comparison of buccal soft tissue thickness was made between the PS and SAC groups, SAC showed a greater increase compared to the PS group (3.12 mm vs 2.39 mm, respectively) with statistical significance ($P = .05$) (Fig 13). The increase was independent of phenotype (Fig 14).

Discussion

In the present study, the use of a dental implant with an SAC design in immediate implant placement and provisional restoration with bone grafting in the residual buccal gap was examined 6 months after the delivery of the definitive restoration. Since the SAC implant also has a configuration of a VPS design, conventional PS implants were used as a control. Previous studies have shown that using PS implants is associated with significantly greater midfacial soft tissue thickness than using bone grafting alone on non-PS implants in ITRT.[4,15,18] The result indicated that the use of an SAC implant was associated with an increase in peri-implant buccal soft tissue thickness regardless of the pretreatment phenotype. The pretreatment phenotype was measured using Kan's phenotype assessment in which less than 2.0 mm is categorized as thin, and posttreatment peri-implant soft tissue thickness was measured in millimeters.[19] When the data were adjusted to the pretreatment phenotype, the SAC group exhibited greater posttreatment buccal soft tissue thickness independent from phenotype. In other words, the SAC feature of the VPS implant contributes to an



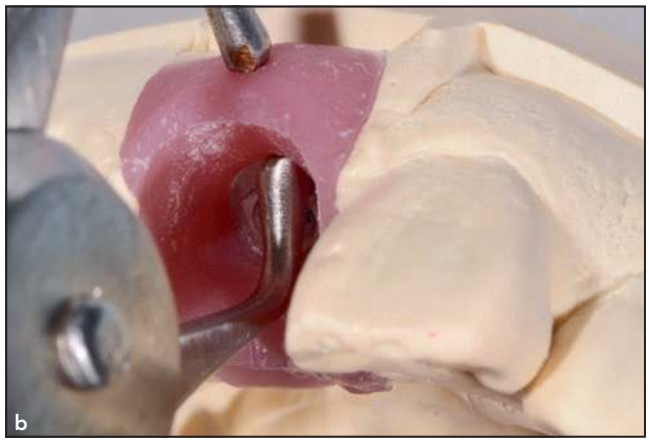


Fig 14 (a) *The buccal soft tissue thickness was measured on the cast 2.0 mm below the free gingival margin at 5 months after implant placement.* (b) *A 2.0-mm increase of the buccal soft tissue thickness was noted in the corresponding cast from the properative clinical condition shown in Fig 5.*

Figures 4–7, 9, 10, 11b, and 14b were reprinted with permission from Mieleszko AJ, Saito H, Chu SJ. The use of dual- or co-axis macro-designed implants to enhance screw-retained restorations in the esthetic zone. Quintessence Dent Technol 2019;42:222–232.

increase in the buccal soft tissue thickness in thin phenotypes. As previously reported, the PS implant design helps increase the buccal soft tissue thickness; however, the effect on thin phenotypes was inconclusive.[15] The subgroups of PS/thick and SAC/thin both exhibited a 2.65-mm buccal soft tissue thickness; this may indicate that the SAC feature further aids to thicken the soft tissues on thin-phenotype patients equivalent to PS in peri-implant soft tissue thickness.

When a sufficient amount of palatal bone is available to achieve primary stability during immediate implant placement, the implant should be placed 1.5 to 2.0 mm palatal to the incisal margin of the central maxillary incisors and should be inserted such that at least 2 mm of buccal bone remains.[21] Clinically, this VPS SAC design provides robust initial primary stability at the time of implant placement, as well as an ideal prosthetic interface for prosthetic placement that allows a better emergence profile to facilitate a space for peri-implant soft tissue buccal to the prosthetic abutment.[16,17] The thickness of the soft tissues influences the behavior of the crestal bone during tissue integration of implants.[10] Attempts to increase the buccal soft tissue thickness in order to prevent soft tissue recession have been made through different prosthetic abutment designs.[22,23] A significant correlation between soft tissue thickness and bone loss with more

loss at thin soft tissue sites has been reported.[24] It was confirmed in the present study that thin soft tissues led to increased marginal bone loss. Studies have shown that palatal placement of the dental implant into the postextraction socket results in more horizontal bone fill in the gap and less reduction in labial plate thickness after remodeling.[25–27]

As these authors have reported in the present study and another,[15] the use of *(1)* bone grafting in the residual buccal gap, *(2)* immediate provisional restoration, and *(3)* implants with a PS design may each contribute to the present results. Bone grafting in the residual buccal gap labial to the implant after placement seems effective in achieving stability of both the buccolingual ridge dimension and peri-implant soft tissue, clinically. Studies showed that placement of an immediate provisional restoration or custom healing abutment helps promote preservation of the native buccolingual ridge dimension and enhanced stability of the midfacial soft tissue form.[4,20,28–31] Moreover, PS implants significantly increased peri-implant soft tissue thickness in both thin- and thick-phenotype patients. Combining these factors may have an additive effect in the maintenance of buccolingual ridge dimension and stability of the peri-implant soft tissues.

There are certain limitations in this study. The sample size of each group was relatively small, preventing drawing definitive conclusions on the effect of SAC implants, especially when stratified by the pretreatment phenotype. Also, the follow-up period of only 6 to 12 months represents only the short-term results, and possible further remodeling of soft and hard tissues may occur after this time period. Further research is required to assess the long-term outcome.

Conclusions

A VPS implant with SAC may increase peri-implant soft tissue thickness and help minimize peri-implant soft tissue recession following immediate implant placement and provisional restoration with bone grafting. Further research is required to assess these outcomes long-term.

Acknowledgments

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