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CLINICAL ARTICLE

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Transmucosal abutments in the esthetic zone: Surgical and prosthetic considerations

Iñaki Gamborena DMD, MSD, FID[1,2] | Yoshihiro Sasaki CDT[2] | Markus B. Blatz DMD, PhD[1]

[1]Department of Preventive and Restorative Sciences, University of Pennsylvania School of Dental Medicine, Philadelphia, Pennsylvania, USA

[2]Private Practice, San Sebastian, Spain

Correspondence
Markus B. Blatz, DMD, PhD Robert Schattner Center, Department of Preventive and Restorative Sciences, University of Pennsylvania School of Dental Medicine, 240 South, 40th St., Philadelphia, PA 19104, USA.
Email: mblatz@upenn.edu

Abstract

Objective: This article describes an updated step-by-step protocol for transmucosal abutment selection and treatment sequencing after immediate implant placement in the esthetic zone.

Clinical Considerations: Current surgical and prosthetic concepts strive to preserve hard and soft-tissues to provide optimal esthetics at the implant-abutment interface. Consequently, restoring implants in the esthetic zone with transmucosal abutments presents a great challenge and must take into consideration implant depth, angulation, and bucco-lingual position as well as transmucosal height and space for an optimized emergence profile of the restoration and the dimensions of the anterior tooth to be restored. The proper selection of the type, shape, and dimensions of implant components and connections, determined by the product portfolio offered by the implant manufacturer, play a critical role in the ability to adequately address these challenges. This article provides an update on surgical and prosthetic workflows for single implant restorations in the esthetic zone.

Conclusions: Following esthetic, mechanical, and biologic principles, the long-term success of implant-supported restorations in the esthetic zone is directly correlated to proper execution and sequencing of surgical and prosthetic treatment steps, especially after immediate implant placement. These steps must be critically assessed based on the current scientific evidence to achieve the desired clinical outcomes on a predictable and consistent basis.

Clinical Significance: Selection of surgical and prosthetic treatment protocols to achieve ideal esthetic outcomes and emergence profiles in implant dentistry is often a great challenge, not only determined by technical and clinical skills of the provider but also by the type and dimensions of implant components and connections offered by the manufacturer. Following certain decision-making principles and workflows are key for clinical success with implant-supported restorations after immediate implant placement the esthetic zone.

KEYWORDS
emergence profile, implant abutment, soft tissue, transmucosal, zirconia

Management of the peri-implant restorative interface is the key to anterior implant esthetics.[1] All surgical and prosthetic concepts strive to preserve the hard and soft-tissues to provide optimal esthetics at this interface. Consequently, the restoration of implants in the esthetic zone presents a great challenge. To achieve long-term stable outcomes, implant depth, angulation, and bucco-lingual position as well as transmucosal height and space for an optimized emergence profile of the restoration and the dimensions of the anterior tooth to be restored must be taken into consideration. The proper selection of the type, shape, and dimensions of implant components and connections play a critical role in the ability to adequately address these challenges. Therefore, clinical success is not just determined by clinical and technical skills of the provider but also by the availability and degree of customization of these components, determined by the product portfolio offered by the implant manufacturer.

This article discusses updated clinical and technical steps for successful treatment with single implant-supported restorations in the esthetic zone. Guidance for treatment planning, selection, and execution of these steps to maximize clinical outcomes in a challenging esthetic situation is presented in a step-by-step manner. While component selection is demonstrated with an implant system and components offered by one manufacturer, the general concepts and strategies are not limited to one manufacturer and may also be applied to other systems.

FIGURE 1 Zirconia crown, universal base, transmucosal abutment, and implant (Nobel Biocare N1 system, Nobel Biocare).

FIGURE 2 Preoperative intraoral view of a failing left maxillary lateral incisor and insufficient crown on the left maxillary central incisor.

FIGURE 3 Preoperative radiographic views reveal root fracture and periapical granuloma on the left maxillary lateral incisor. The adjacent central incisor shows an insufficient crown and endodontic post.

1 | BONE REMODELING

All two-piece implants have a microgap between the implant and the supra structure, either an abutment or screw-retained restoration. The internal compartment of the implant is contaminated with microbes and histological evidence reveals an inflammatory cell infiltrate located 1–1.5 mm adjacent to the microgap.[2] Bone remodeling (1.5–2 mm) during the first year after loading and an annual bone resorption of less than 0.2 mm was generally accepted as success for two-piece implants.[3] This is a multifactorial reaction due to interproximal bone loss, including surgical trauma, microgap, biologic width, location of implant-abutment microgap or type and connection design characteristics.[4,5]

2 | IMPLANT-ABUTMENT MICROGAP

Position of the implant-abutment microgap at the level or below the bone crest results in a more intense bone remodeling, due to the displacement of the bone as a consequence of bacterial colonization.[6] To overcome this phenomenon, the concept of platform switching has been introduced[7]: abutments of smaller diameter are connected to the implant to create a horizontal offset to relocate microgap away from the bone.[8] All conical connections provide a horizontal off-set besides a degree of conicity (morse cone) with minimal tolerances to decrease the space and, consequently, amount of bacterial colonization. The length of the connection also plays a significant role in the sealing ability of the implant-abutment interface. A lower degree of conicity paired with a longer connection creates a press fit connection. By reducing the friction angle, the insertion torque of the prosthetic components can be lowered.

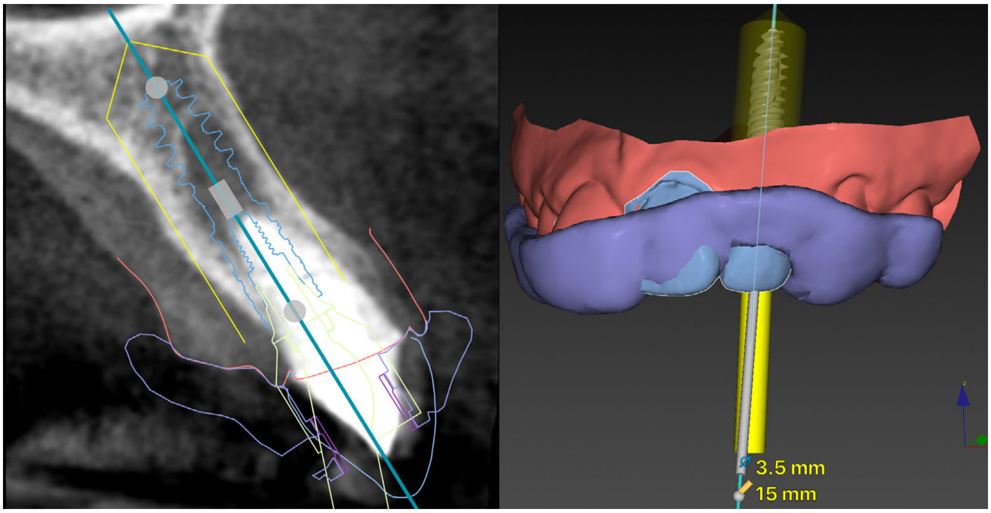

FIGURE 4 Digital implant planning and design of the surgical implant guide.

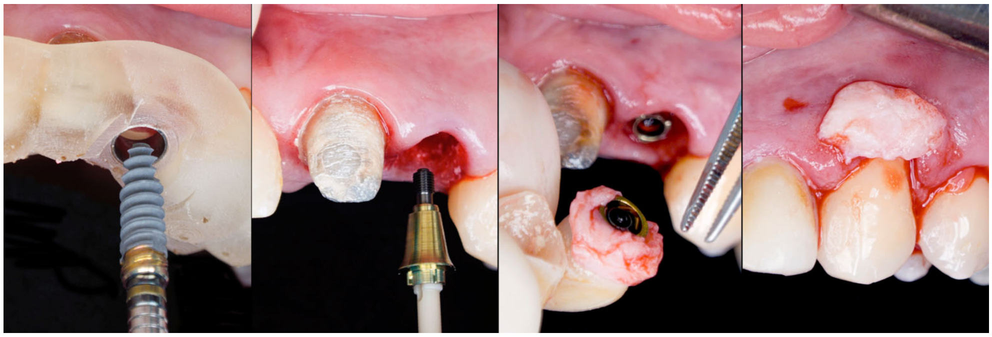

FIGURE 5 Surgical sequence of implant placement, circular connective tissue graft (CTG), abutment and provisional placement. Another CTG was placed to treat soft-tissue recession on the adjacent canine.

FIGURE 6 Postsurgical radiographic and clinical views.

3 | TRANSMUCOSAL ABUTMENT

A factor that has been largely neglected in scientific research is the influence of the shape of the emergence profile of the transmucosal abutment on clinical outcomes. Early studies already indicated that converging abutments have less soft tissue recession in immediate implant placement than convex abutments.[9] More recent research showed that flat and wide abutments induce a downshift of the biological width and crestal bone resorption than slim abutments in an animal experiment.[10,11] Therefore, current abutment designs intend to emerge slim or concave from the implant shoulder to avoid any pressure on the crestal bone and the supra-crestal connective tissue. Less peri-implant marginal bone loss was observed when a higher transmucosal abutment was used to allow the establishment of the biologic width and avoid disruption at the implant-bone level.[12] Similarly, some studies have demonstrated that abutment height may influence interproximal marginal bone levels.[13–16] They concluded that greater abutment height is related to lower marginal bone loss and greater stability of interproximal bone levels.

It can be hypothesized that the reason for this is the establishment of the biologic width at the abutment instead of the implant level, protecting the peri-implant bone. This would allow for soft tissue healing at abutment level while protecting the osseointegration of the implant.[17,18]

The material and surface microstructure of the abutment also play a significant role in the degree of soft tissue attachment. While milled

FIGURE 7 Clinical situation immediately after surgery.

FIGURE 8 Clinical situation 2 weeks after surgery.

FIGURE 9 Clinical situation 3 months after surgery.

titanium has preferred properties, an anodized and nanostructured surface of the abutment and collar of the implant provides even better soft tissue outcomes and a lower bleeding index at abutment removal at 2-year follow-up.[19]

FIGURE 10 Soft-tissue condition 3 months after implant placement, illustrating the integration of the circular CTG for adequate tissue volume.

FIGURE 11 Full contour wax up establishing proportions for ideal emergence profile.

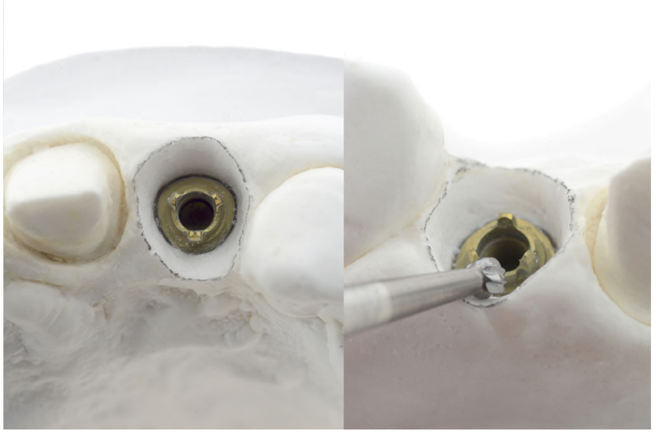

FIGURE 12 Creating ideal emergence profile on master cast.

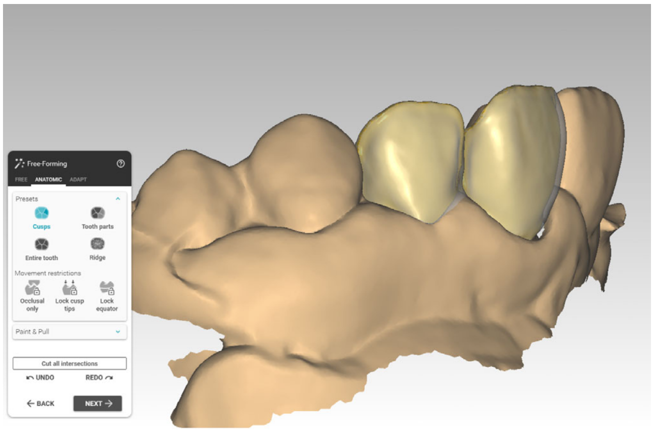

FIGURE 13 Digital design for zirconia crowns with cut back for porcelain veneer microlayer.

FIGURE 16 Intraoral bisque bake try in. Control of value is a challenge without opaque resin cement.

FIGURE 14 Porcelain layering of zirconia crown copings.

FIGURE 17 Shade communication with the dental laboratory with photos.

FIGURE 15 For bisque bake try in, the crown was attached to the titanium base with cyanoacrylate for fixation during try in and easy removal afterwards.

FIGURE 18 A customized master cast was fabricated, simulating the shade of adjacent teeth and underlying structures to optimize shade match and adapt chroma and value of the restorations.

The scientific evidence is fairly clear on the negative effects of frequent abutment connection and reconnection on the peri-implant soft and hard-tissues levels, with several studies and systematic literature reviews indicating significantly greater bone loss around implants with frequent abutment dis and reconnections.[20–24]

In terms of macro design, there two distinct zones at the implant-abutment-crown complex, the critical contour and the subcritical contour.[25] Gomez-Meda et al.[26] proposed a concept for the design of abutments in the esthetic zone and refer to it as "the esthetic biological contour concept". The abutment should be narrow at the implant-restorative interface and flaring to the desired scallop. Since the prosthetic design greatly impacts the peri-implant soft tissue architecture, precise communication with the laboratory technician is of fundamental importance to control the final outcome.

FIGURE 19 Definitive restorations on the master cast. The crown on the natural tooth was fabricated with a palatal retentive hole to facilitate a wire splint of the natural teeth and prevent their shifting due to continuous maxillary growth.

4 | CASE REPORT

A 48-year-old male patient presented with a failing left maxillary lateral incisor. The step-by-step clinical and laboratory protocols and implant component selection for the replacement of the lateral incisor are demonstrated (Figure 1). Preoperative clinical and radiographic views are shown in Figures 2 and 3. Periapical radiograph and CBCT evaluation revealed a granuloma and root fracture of the lateral incisor as well as a deficient crown and insufficient endodontic post on the adjacent central incisor. The treatment plan included immediate implant placement to replace the left maxillary lateral incisor and reconstruction of the central incisor after replacing the existing post with a fiber post, two all-ceramic zirconia-based crowns, and coverage of the soft-tissue recession on the left maxillary canine.

For this specific case, a novel implant system (N1, Nobel Biocare, Zurich, Switzerland), which was optimized for immediate implant placement, was selected. The system was developed based on new concepts and tools for the osteotomy to preserve bone viability.[27,28] It features a trioval conical connection with an 8° and 2.5 mm high contact surface, creating a very strong connection and tight seal with a reduced insertion torque of 20 Ncm,[29] allowing for slim prosthetic components. This connection reduces stress on the bone and has platform shift integrated by design. The slim and long concave transmucosal abutments provide an ideal emergence profile and support for the surrounding soft tissues, enhanced by the anodized and nanostructured surface on the abutment and implant collar (Xeal, Nobel Biocare).[19]

First, a provisional restoration was fabricated with ideal soft tissue support to transfer the shape, dimensions, and outline of the natural tooth to the immediate implant provisional restoration. An impression was made with a polyvinyl siloxane impression material and the master cast fabricated with an epoxy resin material to allowed complete seating of the 3D printed surgical guide onto the cast

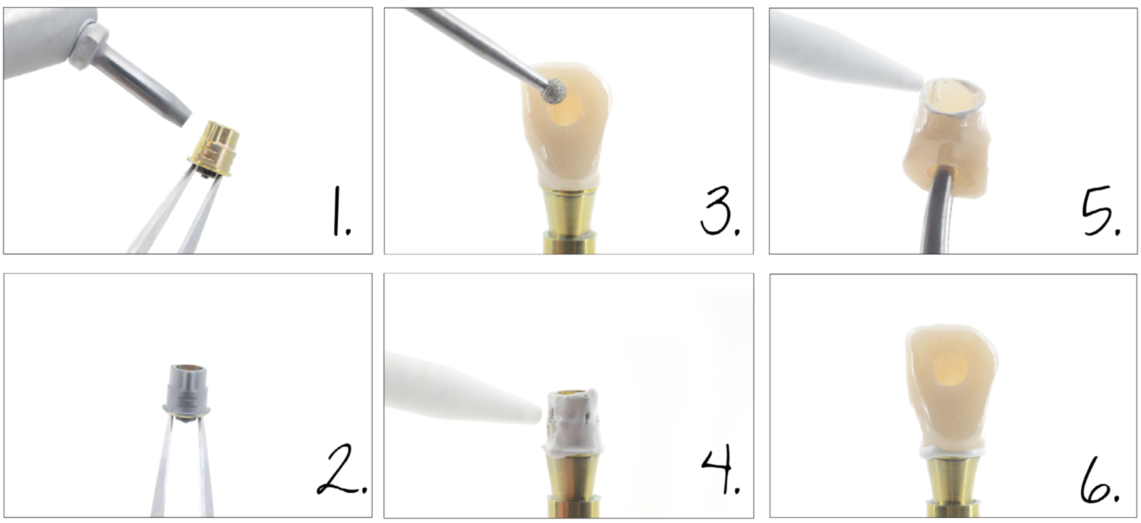

FIGURE 20 Bonding of the zirconia crown on the titanium base with opaque composite resin cement following "APC" technique": Air-particle abrasion with alumina, primer application, and composite resin cement on both materials.

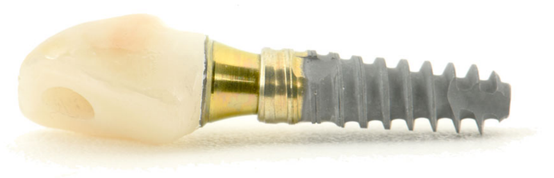

FIGURE 21 Definitive zirconia restoration cemented on titanium base with a 2.5 mm transmucosal abutment on N1 implant (Nobel Biocare).

FIGURE 22 Definitive crown on the natural central incisor with a palatal retentive hole for splining wire.

without damaging it. A full-contour wax up of the tooth to be extracted was made and both the master cast and the wax up were scanned. The digital scans of the reduced master cast, the preparation finish line, and the wax up were digitally "fused" together with the CBCT (Smart Fusion, Nobel Biocare), serving as a stable reference for optimal implant planning in the design software (DTX Studio, Nobel Biocare; Figure 4).

The preparation finish line is critical for determining the depth of the implant, and its angulation should be oriented along the long axis of the tooth. The precise length of the transmucosal abutment was determined with the software. An additional 1.5–2 mm was allocated to the emergence profile of the screw-retained definitive restoration. The transmucosal base includes a small screw (Omnigrip, Nobel Biocare), which facilitates an angulated screw channel for compensation of the implant angulation of up to 25°.

The surgical guide was designed and 3D printed. After atraumatic tooth extraction, the implant (N1 4 × 13 mm, Nobel Biocare) was inserted fully guided and a 2.5 mm transmucosal abutment was placed. In this restorative approach, the provisional restoration on the tooth becomes key to control the tissue interface below the peri-implant soft-tissue margin. The same provisional restoration is

FIGURE 23 Final try in to verify chroma and value of the restorations before cementation.

connected to the provisional abutment above the transmucosal one, leaving a concave or straight shape to provide space for a circular connective tissue graft (CTG) and 360° support of the soft tissues. The provisional crown had the same shape and diameter as the root of the failing tooth, providing a seal for the underlying tissues vertical support for the peripheral soft tissues. It supports the formation and stability of a blood clot and the circular CTG. In addition to the implant graft, the surgical tunnel technique was extended to the adjacent canine and a buccal CTG was sutured in place. The surgical steps are depicted in Figure 5. The postoperative clinical situation and healing were documented on the day of surgery (Figures 6 and 7), 2 weeks (Figure 8) and 3 months (Figures 9 and 10) after surgery.

A full-contour wax up was fabricated (Figure 11) and an ideal emergence profile designed on the master cast (Figure 12). The wax up was scanned, and zirconia crowns were designed digitally with a cut back for a porcelain veneer microlayer (Figure 13). The zirconia crowns copings were veneered with a thin labial layer of veneering porcelain for improved esthetics (Figure 14). Both restorations were internally lined with several layers of white opaque procelain to block out the dark color of the central incisor and the implant abutment. To facilitate bisque bake try in, the implant crown was glued to the titanium base with cyanoacrylate (Figure 15) to facilitate and simplify adjustment of contact points, occlusion, and color. Afterward, it can be easily removed without damage. Color control is rather challenging as the dark appearance of the abutment and the transparent glue distort the value of the implant restoration (Figure 16). Clinical photographs were made to transfer the correct value and chroma to the final restorations (Figure 17). A customized master cast was fabricated, simulating the shade of adjacent teeth and underlying structures to optimize shade match and adapt chroma and value of the restorations in the laboratory (Figure 18). The definitive restorations on the master cast are depicted in Figure 19. The crown on the natural tooth was fabricated with a palatal retentive hole to facilitate a wire splint of the natural teeth and prevent their shifting due to continuous maxillary growth.

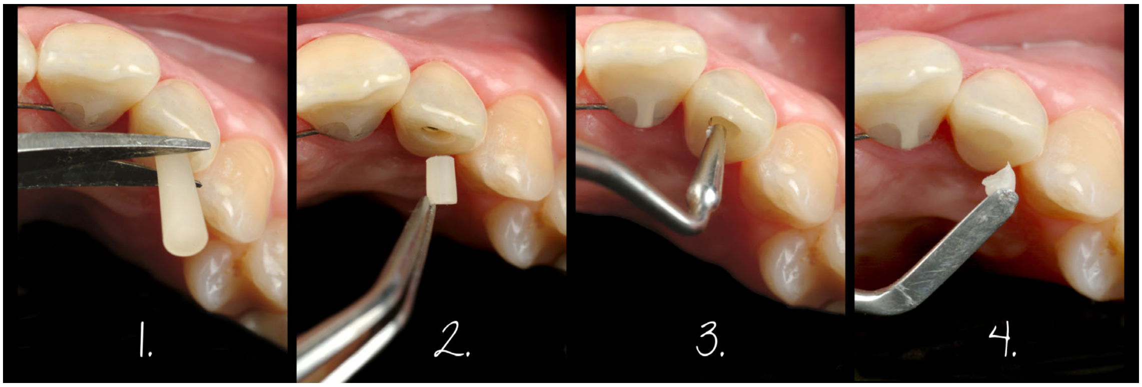

FIGURE 24 After splinting of the anterior teeth from the right maxillary canine to the crown on the left central incisor, the implant restoration was inserted. The screw access hole was filled with a silver plug and sealed with composite resin.

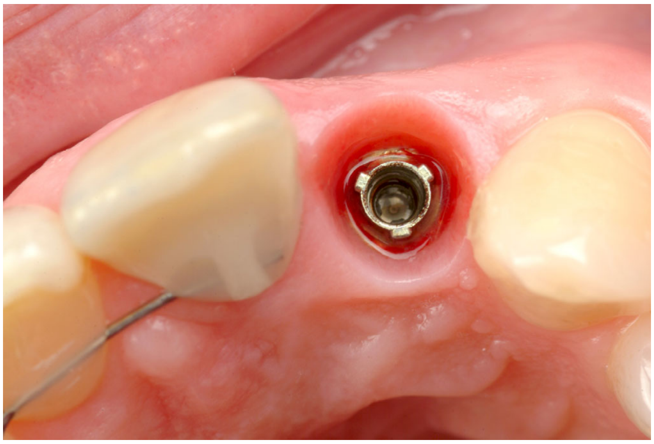

FIGURE 25 Occlusal view of the soft-tissue condition 6 months after restoration delivery.

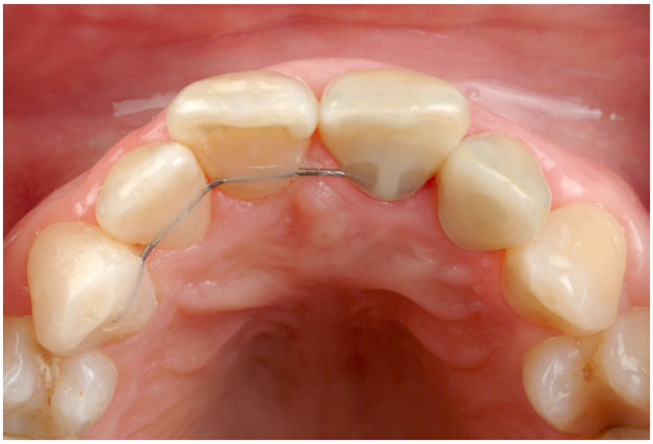

FIGURE 27 Postoperative intraoral occlusal view.

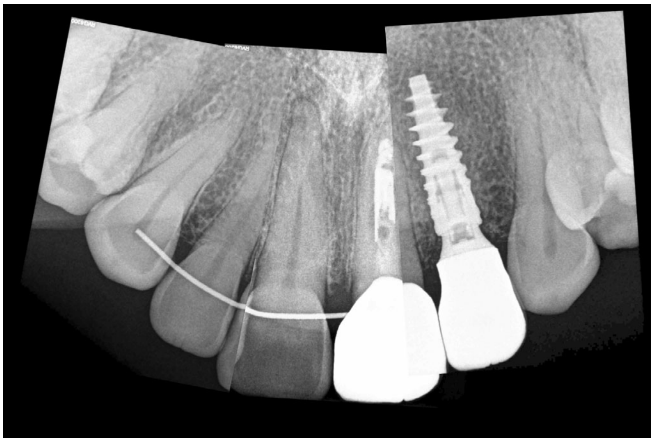

FIGURE 26 Postoperative radiographic view.

FIGURE 28 Postoperative intraoral anterior view: implant-supported crown on the left maxillary lateral and crown on central incisor.

The zirconia implant crown was bonded to the base with composite resin cement (Multilink hybrid abutment cement, Ivoclar Vivadent, Schaan, Liechtenstein) following the "APC" technique": Air-particle abrasion with alumina, primer application, and composite resin cement on both materials (Figures 20 and 21).[30] The central incisor crown was inserted with a try-in cement to evaluate its value and blending of both restorations (Figures 22 and 23). Then, it was adhesively bonded to the abutment with composite resin following common zirconia-bonding protocols.[30]

The implant the screw was torqued down to 20 Ncm after 10 min of glutaraldehyde disinfection. Then, a silver plug was adapted to the screw channel to avoid bacteria contamination and sealed with composite resin (Figure 24).

The natural teeth were splinted with a wire from the right maxillary canine to the left central incisor crown through the hole on the palatal aspect to avoid any future tooth movements due to continuous maxillary growth, which could impact the long-term esthetic outcome.

Soft-tissue condition and emergence profile 6 months after restoration insertion are shown in Figure 25. The peri-apical radiograph (Figure 26) reveals ideal bone response to the base-implant interface. Figures 27 and 28 demonstrate the clinical outcomes, soft tissue situation, and blending of the restorations with the adjacent teeth.

5 | DISCUSSION

The protocol for immediate implant placement using a transmucosal abutment and restoration in the esthetic zone described in this article serves as a clinical guide for the practitioner. Immediate implant placement and loading have demonstrated excellent long-term success rates and esthetic outcomes.[31] It was shown that, in general, oral well-being was significantly better after implant therapy, but that patient satisfaction was particularly greater when implants were loaded immediately.[32,33]

In the presented case, a novel and in some respects highly innovative implant system with a unique connection and abutment design was used to replace a lateral incisor. In this case, due to a Class 2 malocclusion, anterior tooth splinting was suggested to maintain the desired esthetic result in the long term as the patient refused any orthodontics that could compensate the effects of continuous maxillary growth. These effects include movements and further eruption of teeth next to the implant, causing asymmetries that are often difficult to correct, and, in some severe cases even require implant removal.

However, there are two important factors to consider before implementing new concepts into daily practice. First, the suggested protocols are techniques sensitive and there is evidence that implant success is directly correlated to the surgeon's technique, skill, and judgment.[34] It is, therefore, recommended to become well familiarized with any newly adapted techniques and implant systems. They should be practiced on a model before using them in a patient for the first time.

Second, a single technique should not be applied without being integrated in a complete, comprehensive concept and strict workflow. There are numerous alternative techniques to the ones described and illustrated in this article. However, the proposed concept incorporates a sequence of consecutive techniques, which build on one another. While adaptations to each individual patient situation are always necessary, major aberrations or changes in sequence may compromise the desired outcomes.

The suggested techniques and materials were discussed based on the existing scientific evidence. While the protocols were demonstrated with a specific implant system from one manufacturer, the fundamental clinical and laboratory treatment principles also apply to other systems. As technologies are constantly evolving and further clinical research becomes available, the proposed concepts are expected to be revised and updated in the future to best serve the needs and expectations of our patients.

6 | CONCLUSIONS

Following esthetic, mechanical, and biologic principles, the long-term success of implant-supported restorations in the esthetic zone is directly correlated to proper execution and sequencing of surgical and prosthetic treatment steps, especially after immediate implant placement. These steps must be critically assessed based on the current scientific evidence to achieve the desired clinical outcomes on a predictable and consistent basis.

DATA AVAILABILITY STATEMENT

Research data not shared.

DISCLOSURE

Drs. Gamborena and Blatz have received honoraria as scientific consultants and speakers for Nobel Biocare in the past.

ORCID

Markus B. Blatz https://orcid.org/0000-0001-6341-7047

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