The ABC Protocol in the Esthetic Zone: A Comprehensive Surgical and Prosthetic Approach

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The purpose of this article is to present a surgical and restorative protocol for the replacement of missing teeth in the esthetic zone. The ABC protocol consists of digitally guided implantation, autogenous bone graft (A), followed by bovine bone xenograft (B) and connective tissue graft (C). Autogenous bone is placed in contact with the implant surface to induce osseointegration; bovine bone xenograft is then applied to augment the ridge dimension and provide long-term stability. Connective tissue is used to provide additional volume. The ABC biomaterial sequence offers favorable hard and soft tissue dimensions and immediate provisional restoration predictably leads to an esthetically pleasing definitive prosthesis. (Int J Periodontics Restorative Dent 2015;35:561–569. doi: 10.11607/prd.2170)

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Dental agenesis of permanent teeth is a common condition with an incidence that ranges from 2% to 10%.[1] Excluding third molars, the teeth most commonly affected are lateral incisors, premolars, and canines.[2] The lack of permanent tooth dental follicle formation and absence of the eruption process is often associated with hard and soft tissue deficiencies and orthodontic space problems. The use of implants for restoration of congenitally missing teeth is associated with patients who have undergone orthodontic space opening and maintenance until growth is complete. Completion of growth is determined by a series of cephalometric radiographs taken at least 6 months apart. Patients are usually referred for delayed implant placement in early adulthood. Early or delayed implantation scenarios in the esthetic zone also present with similar challenges. Usually, resorption has occurred after extraction loss of anterior teeth.[3] The patients' esthetic expectations are commonly high, and an individualized risk assessment is required before undertaking implant therapy. This article presents a comprehensive periodontal and prosthetic protocol for replacing congenitally missing teeth with implant restorations. The key elements of this protocol are image-guided implantation surgery and the use of an onlay composite graft consisting

Fig 1a *Facial aspect of edentulous space. Notice the facial concavity as well as the abundance of keratinized tissue.*

Fig 1b *Occlusal aspect of edentulous space. Siebert Class I defect is evident.*

of autogenous bone graft (A), bovine bone xenograft (B), and a subepithelial connective tissue graft (C). In addition, immediate provisional restorations are used to create optimal peri-implant tissue architecture during the healing process.

Case 1

Clinical presentation

A 27-year-old man with a noncontributory medical history presented with a chief complaint of a missing right lateral incisor. The patient reported a history of orthodontic treatment and space maintenance with a removable retainer. Clinical examination revealed absence of periodontal disease or other pathology. A Siebert Class I defect[4] was present at the site of the congenitally missing right lateral incisor, combined with a narrow soft and hard tissue concavity extending to the mucogingival junction (Figs 1a and 1b). The occlusal examination revealed a stable maximum intercuspation with anterior disclusion at protrusion and bilateral canine guidance. No interferences were noted during excursive movements. The temporomandibular joint examination did not reveal signs and symptoms of pathology. Adequate prosthetic space was confirmed after impressions, records, and mounting on a semiadjustable articulator.

Case management

Presurgical evaluation

A wax-up was performed and a duplicate cast was fabricated with type 3 dental stone (Microstone, Whip Mix). An impression of the opposing arch was made and a cast was fabricated. Maximum intercuspation was chosen as the maxillomandibular relationship of treatment. A cement-retained single implant prosthesis was planned. A computed tomography (CT) scan appliance prescription was made and the casts were sent to Biohorizons for fabrication of the CT scan appliance. The appliance contained three fiduciary markers. A CT scan was taken of the patient with the appliance seated intraorally. The Digital Imaging and Communications in Medicine (DICOM) file was imported into Virtual Implant Placement software (VIP 3; Biohorizons). Radiographic analysis revealed 5.5 mm of space to accommodate a 3.0-mm implant with approximately 1 mm safety distance from the roots. In the coronoapical dimension, the platform was planned 3 mm from the facial free gingival margin of the central incisor.[5] In an orofacial dimension, placement ensured that the implant body is in native bone, though sagittal plane analysis revealed a narrow two-wall defect on the facial aspect, resulting in a facial dehiscence. At completion of virtual planning, the data were sent to Biohorizons for fabrication of a Pilot Compu-Guide surgical template. The template dictated the angulation, depth, and location of the initial 2-mm osteotomy.

Surgical and restorative procedure

One hour before the procedure, a loading dose of 2 g of amoxicillin

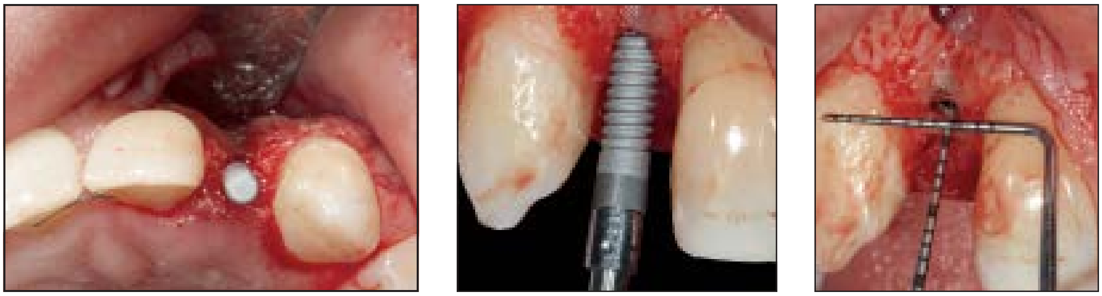

Fig 2a *Occlusal aspect of the ridge architecture. Notice two-wall facial defect of the initial 2.0-mm drill.*

Fig 2b *A 3.0-mm implant during placement. A 1.5-mm clearance from adjacent teeth was ensured.*

Fig 2c *Implant platform positioned 3 to 4 mm apical to the facial free gingival margin of adjacent teeth.*

and 600 mg of ibuprofen was administered. A 60-second, preprocedural rinse with chlorhexidine 0.12% was performed, and the lower face was scrubbed with a chlorhexidine 2% antibacterial soap for 60 seconds. A crestal incision was made, extending intrasulcularly on the facial aspect of the central incisor and canine teeth. The papilla between the canine and first premolar was preserved and a vertical beveled incision was made on the distal line angle of the canine. A full-thickness flap was elevated for visualization of the crest to the most apical extent of the defect. The Compu-Guide surgical template was seated and initial preparation was done using a 2.0-mm pilot drill to final depth of 12 mm (Fig 2a). During osteotomy, autogenous bone chips were collected and preserved in sterile saline. Without additional preparation of the implant bed, a 3.0 × 12-mm two-piece implant was placed (Laser-Lok, Biohorizons) (Figs 2b and 2c). Underpreparing the osteotomy allowed for final insertion torque of 35 Ncm. A narrow, vertical, deep concavity was noted on the facial aspect of the implant, confirming the radiographic findings. The harvested autogenous bone chips were placed as the first layer, followed by small granules (0.25–1 mm) of deproteinized bovine bone mineral (DBBM) (Bio-Oss, Geistlich Pharma) to restore the normal contour of the ridge. A radiograph was taken to evaluate final implant position. A polyetheretherketone temporary abutment was customized and connected to the implant and a provisional crown was fabricated using acrylic resin. During abutment preparation, care was taken to place the restorative margin 0.5 to 1 mm below the future free gingival margin. After crown fabrication, a free connective tissue graft was harvested from the palate, using a single-incision technique (Fig 3a). The connective tissue graft was positioned on the xenograft to protect the graft and to enhance soft tissue volume (Fig 3b). The provisional crown was cemented (Temp-Bond Clear, Kerr) before suturing, to enable removal of all excess cement. A sling suture was used to stabilize the CT graft just below the crown margin, using polyglactin 910 sutures (Vicryl, Ethicon). The flap was approximated with single vertical mattress sutures on the papillae, and the vertical incision was sutured with C3 5.0 chromic gut sutures (Perma Sharp, Hu-Friedy). An additional sling suture was placed through the facial flap and connective tissue graft to increase stability around the provisional crown. Occlusion was evaluated to ensure no contact on the temporary crown in maximum intercuspations or excursions. Postoperative instructions included soft diet, avoidance of anterior teeth use, as well as antibiotics (amoxicillin 500 mg three times a day for 7 days) and ibuprofen 600 mg every 6 hours as needed. In addition, chlorhexidine 0.12% wt/vol rinse was prescribed. The patient was evaluated at 1 week and then every month (Fig 4). At 4 months after surgery, the provisional crown was removed and an implant impression was made using a modified impression coping, which reproduced the provisional restoration emergence profile.[6]

Fig 3a (left) *Autogenous bone chips placed facial to implant, followed by an onlay of xenograft, and finally a subepithelial connective tissue graft, satisfying the ABC protocol. Note the temporary abutment used.*

Fig 3b (right) *Note soft tissue thickness.*

Fig 4 *Facial view showing 2-week healing.*

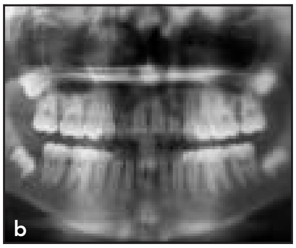

Fig 5a *Initial clinical presentation. Note discrepancy of the gingival margins between lateral incisors and canines.*

Fig 5b *Panoramic radiograph demonstrating advanced root resorption of maxillary anterior lateral incisors. Note adequate space between roots of adjacent teeth in areas of both teeth.*

Case 2

Clinical presentation

A 24-year-old woman presented with the following chief complaint: "Two of my front teeth are loose and my orthodontist referred me for implants." The medical history was noncontributory. The patient reported a history of orthodontic treatment at age 11 years, which included extraction of upper and lower first premolars. Clinical examination revealed degree 1 mobility of the maxillary lateral incisors and absence of periodontal disease or other oral pathology (Fig 5a). The radiographic examination revealed significant root resorption of both maxillary lateral incisors and lack of lamina dura (Fig 5b). The occlusal examination revealed stable maximum intercuspation with anterior disclusion at protrusion as well as bilateral canine guidance. No interferences were noted during excursive movements.

Case management

Presurgical evaluation

Impressions were made and diagnostic casts were fabricated. A radiographic template was fabricated from clear acrylic resin and connected to a templiX plate (Straumann). The templiX plate contained three reference pins that allowed for consistent orientation during digital surgical planning and surgical template fabrication. A cone beam tomography scan of the patient was taken with the radiographic template in place. The DICOM file was imported in CoDiacnostiX implant planning software (Straumann). Radiographic analysis revealed 7.5 mm between adjacent teeth to accommodate a 3.3-mm implant with approximately 2 mm safety distance from each root. Despite the noted concavity of the premaxilla, surgical planning indicated that implants would be

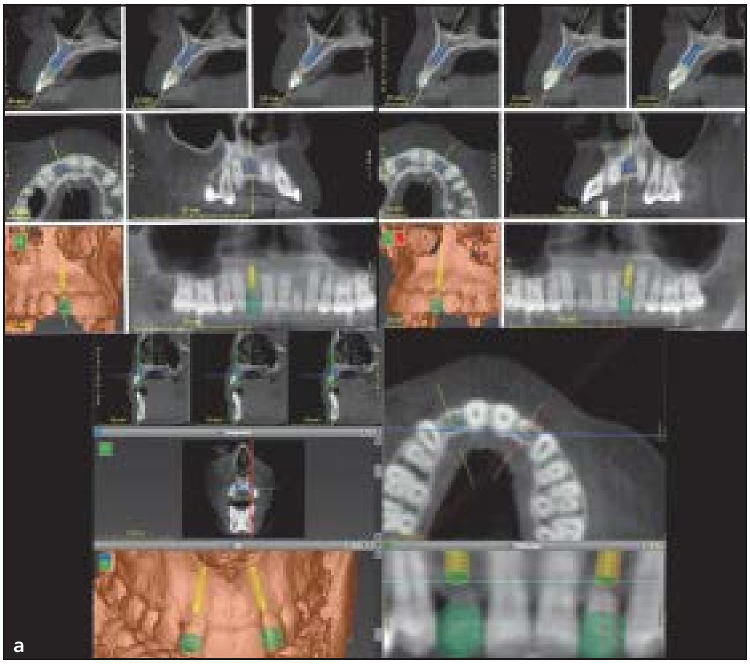

Fig 6a *Surgical planning and virtual implant positions took place in the Co-DiacnostiX Software (Straumann).*

Fig 6b *Surgical guide in place after extraction of teeth.*

entirely surrounded by native bone. Two cement-retained crowns were planned as the final prostheses (Fig 6a). Implant planning took place following the same principles as described for case 1. At completion of virtual planning, the data were used to fabricate a surgical template with the Straumann gonyX.

Surgical and restorative procedure

The patient was premedicated and prepared for surgery in the same fashion as case 1. The surgical template was tried, and after an accurate fit was ensured, local anesthesia was administered. The same incision designs were used as described previously, beginning with the right and then the left lateral incisor. The deciduous lateral incisors were removed with forceps. The right deciduous lateral incisor was ankylosed and bone formation was noted in the pulp chamber. Excess bone was removed and preserved in sterile saline. A round diamond bur was used on the crest of the ridge to accommodate a normal emergence profile. The surgical template was positioned and two 3.3 × 12-mm bone level implants (Straumann) were placed according to the aforementioned principles (Fig 6b). A final insertion torque of 35 Ncm was achieved. The harvested autogenous bone was placed first, followed by a layer of DBBM to restore the natural ridge contours (Fig 7a).

Two prefabricated abutments were connected to the implants. The abutments were selected after evaluating the dimensions of soft tissue in relation to the position of the prosthetic margin. Because cement-retained provisional restorations were used, care was taken to ensure that prosthetic margins were not positioned more than 0.5 to 1 mm apical to the gingival margin.[5] According to the ABC protocol, a 20 × 15 × 2-mm free connective tissue graft was harvested (Fig 7b)

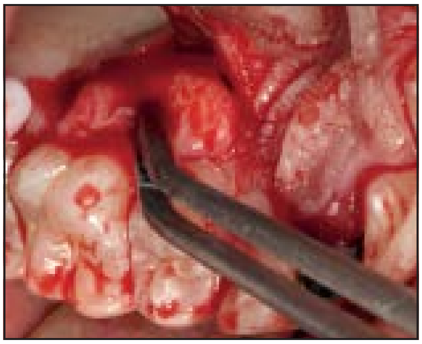

Fig 7a (left) *A prefabricated definitive abutment was used for provisionalization. Note the layer of xenograft placed as onlay.*

Fig 7b (right) *Single incision to harvest subepithelial connective tissue graft.*

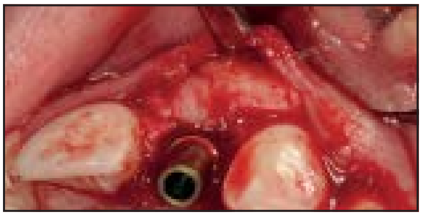

Fig 7c *Placement of subepithelial connective tissue graft over xenograft.*

Fig 7d *Facial view after suturing. Note peri-implant mucosa thickness and orientation of abutments.*

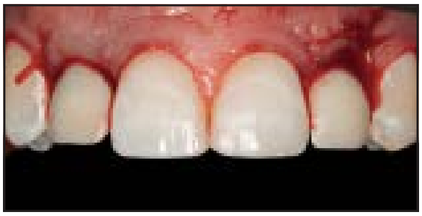

Fig 7e *Facial view after provisional crown fabrication.*

Fig 8a *Facial view of provisional crowns and mucogingival architecture, 1 month postoperatively.*

Fig 8b *Presentation at 1 week after crown delivery.*

Fig 8c *Occlusal view at 1 week after crown delivery.*

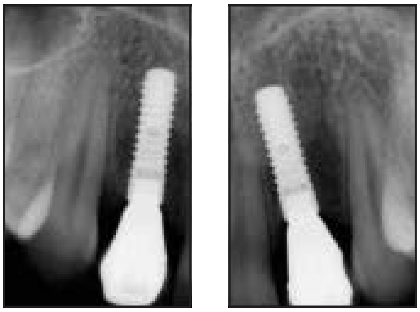

Fig 8d *Final periapical radiographs.*

and sectioned in two halves. The two pieces were positioned bilaterally to cover the augmented areas. Each CT graft was stabilized with a modified vertical mattress sling around the abutment, using polyglactin 910 sutures (Fig 7c). The flaps were repositioned and held with slight coronal tug to stretch elastic fibers back to their position before flap elevation. The vertical incision was closed first using interrupted chromic gut C3 5.0 sutures and papillae were approximated with internal vertical mattress polyglactin 910 sutures (Fig 7d).

The use of prefabricated abutments allowed for fabrication of cement-retained provisional restorations with a definitive margin that was easy to capture. A vacuform matrix was used to fabricate provisional crowns with acrylic resin. Temporary cement (TempBond Clear) was used (Fig 7e). Occlusion was verified using 0.8-mm shim stock to avoid any contacts in static and dynamic occlusion. Postoperative instructions and prescriptions were the same as described in case 1. The patient was evaluated at 1 and 2 weeks and then every month (Fig 8).

Outcomes

Both cases received 4 months of postsurgical follow-up before definitive restoration. The provisional restorations were used to register the emergence profile and maintain soft tissue architecture. In the first case, a UCLA abutment was used, while in the second case two zirconium dioxide abutments (Straumann) were selected and lithium disilicate crowns were fabricated. The crowns were delivered using resin-based radiopaque cement (Multilink, Ivoclar-Vivadent) (Figs 8 and 9).

Fig 9a *Facial view of provisional restoration and mucogingival complex at 4 months.*

Fig 9b *Occlusal view of provisional restoration and mucogingival complex at 4 months.*

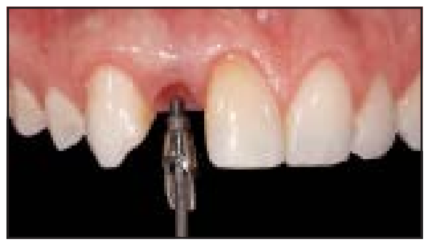

Fig 9c *Gold alloy UCLA abutment at delivery.*

Fig 9d *Final restoration the day of cementation.*

Fig 9e *Periapical radiograph on the day of delivery.*

Fig 9f *Final restoration 2 weeks after cementation.*

Discussion

The technique presented here is used for replacement of congenitally missing teeth in the esthetic zone. It is a combination of well-established treatment modalities, namely, guided surgery planning and placement; use of the ABC surgical protocol, consisting of autogenous bone particles, bovine bone particulate graft, and connective tissue as onlay grafts; and finally immediate provisional restoration.

Guided implant surgery allows for predictable accurate positioning of the implant in challenging cases like those presented herein. The absence of a permanent tooth follicle leads to alveolar atrophy, causing deficient implantation sites. Although the use of computer-guided implant placement has the same demands and challenges,[7] it offers great accuracy during implantation surgery. In the cases presented, guided surgery was used because of placement challenges such as adjacent root proximity, which require maximum accuracy.

In cases with dehiscence noted on the facial aspect, the autogenous bone layer is in proximity with the implant surface to induce osseointegration. Optimum esthetic results require long-term dimensional stability and minimum peri-implant tissue remodeling over time. With the present technique, a layer of bovine bone xenograft is applied to augment the ridge dimension and provide long-term stability. DBBM has low substitution rate and provides long-term dimensional stability in augmented sites.[8] Anorganic bovine bone mineral has high calcium content and has been shown to remain in augmented sites after a period of 10 years.[9]

This technique also offers excellent osteoconductivity and biocompatibility. Histologic studies have shown direct apposition of newly formed bone around bovine bone residual particles.[9,10] Bovine bone mineral has been successfully used as onlay graft in esthetic zone reconstruction.[11–13] Another property of bovine bone mineral is the high crystallinity and natural white color. These characteristics offer high opacity that can mask visible changes from restorative materials.[14]

Connective tissue is used to provide additional tissue volume. Grunder[8] showed reduced volume loss in a cohort of patients who received immediate implants when connective tissue grafts were placed on the facial aspect. In addition, Linkevicius et al[15] showed that initial soft tissue thickness is an important factor to prevent crestal bone remodeling around implants in a 1-year period. Less than 2 mm of soft tissue thickness may lead to up to 1.45 mm of crestal bone loss.[15]

Immediate provisionalization offers great potential in influencing peri-implant tissue architecture, because immediate connection takes advantage of the ongoing peri-implant tissue establishment.[6] In addition, it enhances the wound healing dynamic, providing stability at the interface between the soft tissue flap and the restorative materials. Significant hard and soft tissue changes take place at the interface during the first few months of healing, especially if grafting has occurred.[16] A properly contoured provisional restoration allows for development of interdental papillae as well as facial tissue volume at their maximum capacity for an optimal esthetic result.[17] In a cohort of 55 patients, Jemt[18] showed that using provisional crowns may restore soft tissue contour faster than healing abutments alone, and Su et al[17] introduced the concept of gradual modification of the critical and subcritical contour to achieve optimal soft tissue architecture with provisional restorations. The present technique maximizes this ability by increasing soft tissue volume with connective tissue graft. Attention needs to be paid in the provisionalization stage to avoid any occlusal contacts as well as any loosening of the retention screw or failure of the temporary cement. Such complications may lead to unfavorable loading and compromise osseointegration. In addition, care needs to be taken to avoid overcontouring of the provisional crown and violate soft tissue space.[17]

Similar grafting layering techniques have been used for guided bone regeneration around implants and have shown encouraging results. The sandwich bone augmentation technique uses layers of cancellous and cortical bone allograft in combination with bovine pericardium membrane. Results demonstrated significant hard tissue thickness gain as well as peri-implant tissue stability for the duration of the study.[19] Contour augmentation presented by Buser and coworkers[13] has been shown to provide stable long-term results. The present technique shares similar concepts with contour augmentation, such as use of locally harvested autogenous bone chips and DBBM as onlay grafting materials. Despite the similarities, significant differences should be noted. Unlike contour augmentation, this technique allows for transmucosal healing with the use of an immediate provisional restoration, instead of submerged healing. The ABC protocol uses connective tissue grafts to enhance soft tissue volume and complement immediate provisional restorations. At the 12-month follow-up, the two cases presented herein showed dimensional stability of the peri-implant tissues.

The proposed protocol is indicated for cases in which the osseous architecture allows for prosthetically driven implant placement within the contour of the alveolus but with resulting dehiscences on the facial aspect. Prospective clinical trials are required to evaluate the effectiveness of the ABC protocol for replacement of congenitally missing teeth. Such studies should focus on evaluating long-term dimensional stability as well as histologic results of the proposed biomaterial combination.

Conclusions

The ABC protocol for replacement of missing teeth in the esthetic zone uses computer guided implantation surgery, two bone fillers, as well as a connective tissue graft to enhance tissue volume and achieve optimal esthetics. Connection of an immediate provisional crown achieves esthetic rehabilitation and influences formation of the peri-implant mucosa, taking advantage of the ongoing wound healing dynamic.

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