Introduction: The replacement of congenitally missing maxillary lateral incisors can be a challenge from both a restorative and surgical perspective. The restorative dentist is limited in achieving esthetics by the surgical result not only by the implant position but by the surrounding periodontium of the site itself, as well as the adjacent teeth. The present case, replacing congenitally missing lateral incisors with an immediate provisional restoration, is important because it demonstrates the ideal team approach. By each clinician participating in stage I surgery, the restorative dentist and periodontist can work toward an optimal result. The combination of restorative expertise and regenerative enhancements simultaneously can result in a minimally invasive approach with fewer appointments and greater patient acceptance.

Case Presentation: This case report demonstrates the restorative and surgical considerations and techniques for prefabrication of screw-retained provisional restorations placed at the time of surgery. Surgical considerations and techniques to support the restoration position, size, and screw retention connection are also presented.

Conclusions: Close communication between treatment team members is critical to achieving predictable esthetics and function for congenitally missing maxillary lateral incisors. The participation of the restorative dentist at stage I surgery is critical in demanding esthetic cases such as this. Periodontal hard and soft tissues respond well to prefabricated screw-retained provisional restoration delivered at the time of surgery. Clin Adv Periodontics 2013;3:106-114.

Key Words: Clinical protocols; transplants.

Background

Although dental implants have arguably been considered the most significant advancement in dentistry, there is a lack of long-term controlled data regarding hard- and soft-tissue complications and poor esthetic outcomes. Kinzer and Kokich<sup>1,2</sup> explored the clinical considerations for choosing and achieving the most predictable esthetic and functional result for replacing congenitally missing maxillary lateral incisors from orthodontic, restorative, and implant perspectives.

Clearly there are several issues with regard to implant replacement involving adequate facial lingual bone volume, distance between implants and natural teeth, and implant position. Although the bone volume required to support implants may be arguable, the volume required to support esthetic outcomes is less controversial. The study by Becker et al.<sup>3</sup> was one of the first to question the need for bone grafting at the time of immediate placement of implants at extraction. They were able to demonstrate a cumulative success rate of 93.3% over 5 years. However, analysis of esthetic results was not done. Schwarz et al.<sup>4</sup> demonstrated that there was a greater likelihood of esthetic compromise as a result of marginal tissue recession around implants with incomplete bone formation. Keratinized tissue and soft-tissue thickness may be related to lower mean alveolar bone loss. In addition, soft-tissue thickness may relate to overall alveolar contour and may be influenced by connective tissue (CT) grafting, uncovering technique, or the contour of a provisional restoration. Grunder<sup>5</sup> demonstrated a significant increase in overall facial contour thickness in those cases grafted with CT grafts to enhance soft tissue around implants. Considerations with regard to the
interdental and interimplant papilla rely on both the periodontal condition of the adjacent teeth and the interimplant or implant–tooth distance. It is generally accepted that the height of the interproximal papilla is primarily dependent on the height of the papilla and bone of the adjacent natural tooth. Ideally, interimplant/implant–tooth distance should be 1.5 to 2 mm at a minimum. Although the implant–tooth horizontal distance reported as ideal is small, ranging from 1.5 to 2 mm, the significance to esthetic outcome may be large. If one considers that the smallest implant diameter used in this case report is 3.3 mm, that means that one should strive for a site that demonstrates 6.3 to 7.3 mm of space in the proposed lateral incisor space.

Immediate delivery of provisional restorations at the time of implant placement, although challenging, can have a predictable outcome on esthetics, integration, and patient satisfaction. The question of implant stability at insertion has been the subject of several papers. Radio frequency analyses expressed as implant stability quotient (ISQ) readings have been associated with implant stability and the predictability of osseointegration. Nedir et al. demonstrated that ISQ values ≥47 for implants at the time of insertion translated to predictable and maintainable osseointegration. The implant position in a facial palatal direction is determined presurgically to diagnose restoration design, cementable or screw retained. If a screw-retained restoration is selected, the position of the implant must allow for screw access without compromising facial contour and material strength. Once this position is determined by the restorative dentist, the periodontist must evaluate the proposed site with regard to adequate interradicular distance, facial bone contour, soft tissue, and alveolar bone height. Immediate provisionalization can be considered once implant stability is determined. The purpose of this report is to demonstrate how the periodontist–restorative dentist team can work together at stage I surgery to plan, fabricate, and insert screw-retained provisional restorations, while simultaneously managing the surgical and restorative complexities of replacing congenitally missing lateral incisors with implants.

Clinical Presentation

A 22-year-old female patient presented to the restorative office (KFH) in March 2009 with congenitally missing maxillary lateral incisors, Class I occlusion, and recent post-orthodontic treatment with an over-retained primary tooth present on the right side and missing primary tooth on the left. The patient’s chief complaint was “I want to have adult teeth that look good.” Review of her medical history was non-contributory, and the patient was classified as an American Society of Anesthesiologists Category I healthy patient. Her only previous dentistry apart from routine maintenance and minor restorative care was the recent completion of orthodontics. Clinical and radiographic evaluation revealed a normal periodontium with good intercuspation of teeth and acceptable alignment of the maxillary anterior segment. The mesial–distal spaces of the maxillary lateral incisors (#7 and #10) appeared equal, but site #10 demonstrated a significant facial contour deficiency. As a result, the implant sites were significantly different in both alveolar bone width and height (Fig. 1). Facial–lingual alveolar width for both sites were deemed adequate for implant placement as determined by cone-beam computerized tomography. The patient also expressed a desire to avoid the continuation of a removable temporary device during the healing phase after implant placement. Considerations with regard to treatment options were discussed in detail with the patient and her mother, and written and oral informed consent was provided regarding options for tooth replacement, timing, and provisionalization.

Case Management

Because of the demanding esthetic and functional requirements of this patient, the treatment team consisting of the periodontist (DSC) and restorative dentist (KFH) outlined a plan that could potentially result in high predictability of these requirements with low risk.

Restorative Preparation

Presurgical study cast planning and accurate surgical guide fabrication were essential to assist in the proper placement of implants and indirect provisional fabrication. Proper planning, spacing, and instructions to the laboratory technician were critical before fabrication of the surgical guide. The key elements for surgical guide design (Fig. 2) and indirect provisional fabrication are outlined below (Figs. 3 and 4).

Material. Rigid clear orthodontic acrylic resin supported by the occlusal surface of the adjacent teeth similar to an occlusal guard was used. A rigid design was beneficial presurgically for accurate placement of the implant replicas into the study cast, which was used for provisional fabrication prior to stage I surgery.

Designate access opening for implant site/sites. A 3-mm access opening was made on the surgical guide to locate the target location for each implant site. Ideal emergence for a cement-retained restoration is through the incisal edge and modified based on alveolar ridge contours.

Indirect provisional fabrication. Using the surgical guide, a 3-mm opening was drilled in the study casts (laboratory osteotomy was performed) completely through the stone. The temporary abutment was marked with a vertical line to designate the flat portion of the connector (represents facial position) and a horizontal line to mark the tissue depth of 3 mm at the midfacial position. The temporary abutment was connected to the implant replica and placed in the study cast to the designated depth and orientation. The replica was set into the cast from the underside with a fast-set, self-curing acrylic resin. A screw-retained provisional restoration was fabricated to estimated contours (Figs. 3 and 4).

‡ GC pattern resin, GC America, Alsip, IL.
§ NC Temporary Abutment, Straumann, Andover, MA.
At surgery, the patient was premedicated with 1.5 g amoxicillin given the day before surgery. She fasted at least 6 hours before surgery. She was positioned in a semisupine position, and an intravenous infusion was established in the left hand. One hundred milligrams pentobarbital and 3 mg midazolam were titrated to a level of moderate sedation. One hundred forty-four milligrams lidocaine with 0.072 mg epinephrine were given as local infiltrations. A full-thickness flap was established on the facial aspect of the maxillary anterior segment extending from the mesial aspect of the maxillary left bicuspid to the mesial aspect of the maxillary right bicuspid. Care was taken to only involve the facial aspect of the associated papillae and to avoid vertical incisions. Lingual flap reflection was accomplished in the lateral incisor areas to gain access to the lingual alveolus (Video 1). Next, a surgical guide was placed, and initial osteotomies were established with a 2-mm twist drill. An intraoperative radiograph was then taken to verify implant trajectory with respect to the adjacent teeth. In addition, the apical position of the implant was verified against the surgical guide in an effort to place the implant far enough apically to allow for ideal emergency profile of the implant restoration through the overlying soft tissue (Video 2).

Finally, the internal flat side of the implant profile was lined up against the facial plate in an effort to allow for seating of the prefabricated provisional crown with screw-retained retention and engaging the anti-rotational features of the implant.

**Implant site #10.** For this site, the implant position met all of the above requirements. In addition, the ISQ was 64 at the time of placement. However, when evaluating the facial contour, the shadow of the facial aspect of the implant was visible as a result of the lack of facial contour in the alveolus. This was grafted with mineralized freeze-dried bone allograft (FDBA)** and a long-term resorbable collagen membrane†† (Fig. 5). The provisional was placed, the position was verified, and the final contacts were added with light-cured composite. The provisional restoration was then hand tightened to place using ≈10 Ncm.

**Implant site #7.** Surgical placement of this implant mimicked the surgery for site #10 with one major difference. After initial seating of the provisional restoration, it was determined that the gingival emergence was not consistent with the rest of the anterior segment, demonstrating a position that was too far in the coronal direction (Video 3). This was because the alveolar ridge at site #7 was coronal to the adjacent natural teeth. This is a common condition of these sites. Alveoloplasty and osseous crown lengthening was performed to allow for adjustment of the apical position of the implant. This was dictated by the prefabricated provisional restoration. The ISQ reading for this fixture was 68. The facial and lingual flaps were then repositioned and sutured with individual, interrupted 6-0 polyglactin 910 sutures. Care was taken to ensure that the provisional restorations were kept out of occlusion in centric occlusion and all excursive movements. The patient was administered 60 mg ketorolac intravenously and given a non-steroidal anti-inflammatory drug for post-operative pain. She was dismissed in alert and stable condition to the care of her mother. She was told not to brush the areas and only to swab the sites with water until her next visit which was in 2 weeks (Video 4).

**FIGURE 1** Preoperative photographs (1a and 1b) and panoramic radiograph (1c) of a 22-year-old female patient presenting with congenitally missing maxillary lateral incisors with an over-retained primary tooth present on the right side and missing primary tooth on the left. As a result, the implant sites were significantly different in both vertical and horizontal dimensions.
After fixture placement, provisionals were placed one at a time starting with site #10 (Video 5). First, the surgeon (DSC) confirmed that the implant fixture flat portion of the internal connector was oriented to the facial aspect so that the provisional would fit as designed. The restorative team member (KFH) altered the contact points, incisal length, and lingual surface before bone augmentation and closure of the surgical site. The

**Immediate Provisionals**

After fixture placement, provisionals were placed one at a time starting with site #10 (Video 5). First, the surgeon (DSC) confirmed that the implant fixture flat portion of the internal connector was oriented to the facial aspect so that the provisional would fit as designed. The restorative team member (KFH) altered the contact points, incisal length, and lingual surface before bone augmentation and closure of the surgical site. The
mesial contact on both provisionals was closed with the addition of composite resin and repolished. Care was taken to ensure that the contact points were not too tight, which may cause micromovement on the implants and produce a negative effect on integration. Dental floss was used to ensure proper contact. Immediate provisionals are typically shorter than the definitive restoration to avoid contact in centric or any excursive movements (Fig. 6).

When planning for the use of immediate provisionals, the team must be prepared if placement is not possible because of the following challenges: 1) unfavorable implant stability (low ISQ readings); 2) unfavorable occlusion; 3) unfavorable site; 4) provisional not fitting; 5) abutment not seating; 6) implant position; or 7) implant appears loose. Alternatives include the following. 1) Make an implant transfer index to study cast, the restorative team makes minor modifications, and deliver the same day. 2) Reduce provisional to the gingival level to create a custom healing abutment and place a vacuum-formed retainer. In 2001, Garber et al.\textsuperscript{14} reported a custom healing abutment as an alternative to the full contoured provisional, which provided preservation of soft tissue and prevented any unfavorable occlusal trauma and micromovement. 3) Make an index impression for early loading, place a vacuum-formed retainer, and deliver the corrected provisional within 2 to 14 days. 4) Make an index impression for delayed loading, place a vacuum-formed retainer, and deliver the provisional in 6 to 24 weeks.

**Clinical Outcomes**

**Final Radiographs, Tissue Healing, and Clinical Photographs**

The 2-week postoperative visit demonstrated normal healing of the soft tissues with some edema in the tissues still present. Of note was site #10, which demonstrated thickened, bulky contours with soft-tissue cratering interproximally. No recontouring of either the provisional or soft tissue was done, and the areas were allowed to mature unaided. The patient was instructed in using a soft toothbrushing technique with light interproximal flossing.

At 4 months, the patient demonstrated excellent soft-tissue response to the provisional restorations and healthy, stable interproximal papilla. Periapical radiographs were taken to verify healing of the implant fixtures, and definitive impressions were initiated using the “custom
impression coping technique” reported by Hinds in 1997.\textsuperscript{15} Provisionals were removed one at a time, and pickup impression copings were modified with composite resin and connected to the implant fixture. The composite was contoured directly in the implant sites and light cured to harden the material. The impression copings were then removed and inspected, and composite resin was added to fill any voids and polished. As a result, the copings should accurately represent the healed soft tissue created by the provisional restoration (Fig. 7).

The custom impression copings were reconnected to the fixture level, and an open-tray polyether\textsuperscript{\textnumero} impression was made. Implant replicas were connected to the impression copings, and the impression was poured in die stone to create a master cast. All-ceramic, zirconia computer-aided design/computer-aided manufacturing (CAD/CAM)\textsuperscript{**} abutments and all-ceramic, zirconia restorations were fabricated (Fig. 8).

The definitive abutments were connected and torqued to 35 Ncm. A cotton pellet and elastic, single component light-cured resin\textsuperscript{\textdagger} was used to close the abutment access opening. The definitive prostheses were cemented with radiopaque glass ionomer luting cement\textsuperscript{***} (Fig. 9). To avoid complications with residual subgingival cement, the following protocol was followed.

Protocols for Anterior Cement-Retained Prosthesis

Provisional restorations. One-piece screw-retained provisional restoration was essential to develop proper soft-tissue contours, interdental papilla, and facial margin before the fabrication of the definitive prosthesis.

\textsuperscript{\textdagger} Impregum, 3M ESPE, St. Paul, MN.

\textsuperscript{\textdagger} NobelProcera CAD/CAM scanner, Optimet Metrology, North Andover, MA.

\textsuperscript{\textdagger} Telio CS Inlay Syringe Transparent, Ivoclar Vivadent Amherst, NY.

\textsuperscript{***} Ketac glass ionomer cement, 3M ESPE.
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6.3 mm; thus, 3.3-mm-diameter implants were used. The spaces between adjacent teeth were verified with the scan. In this case report, the space between teeth measured 1 mm coronal to the gingival crest. 3) The interproximal margin of the abutment was 5 mm below gingival crest. 3) The interproximal margin was even with the gingival crest. 4) The palatal margin was 1 mm coronal to the gingival crest.

Discussion

The term “team approach” has been used throughout the health care industry, and as technologies continue to advance, this term has evolved from simply referring a patient back and forth to detailed treatment planning and case selection. In this case report, the restorative dentist presence and participation at stage I surgery was a valuable asset to achieving the ideal esthetic and functional result for this patient.

Once adequate bone for implant placement was determined using cone-beam computerized tomography, distances between adjacent teeth were verified with the scan. In this case report, the space between teeth measured 6.3 mm; thus, 3.3-mm-diameter implants were used. The facial gingival-most apical aspect of the guide for the designated implant site must be fabricated accurately to represent desired final gingival margin of the definitive restoration. The surgeon will use the guide to measure 3 mm apical to set the proper implant depth. With this particular patient displaying uneven gingival heights from right to left, the guide provided a critical reference for fixture placement. When designing the surgical guide, the direction/angle of the access opening may be affected by prosthetic design. The restorative team member must determine whether the definitive restoration will be cement or screw retained. There is currently significant discussion about cement-retained restorations contributing to the causes of peri-implantitis. For this reason, some clinicians have abandoned cement-retained implant restorations. Screw-retained implant prosthesis may require an implant placement in a more palatal position. This could have a negative effect on the final esthetic result. Although a screw-retained restoration avoids the complication of excess cement, it adds an additional degree of difficulty because of the small margin of error for implant placement. Cement-retained restorations allow implant placement in an ideal position based on available bone, ability to augment ridge, proper depth to create ideal transitional profile, and proper mesial–distal spacing and not on prosthetic design. Any necessary correction in angle in a facial–palatal direction is made with the custom-contoured abutment. In 2012, Wadhwani et al. reported the most effective method to avoid excess cement with cementable restorations was to avoid subgingival margins. The authors recommended supragingival abutment–implant crown margins. In addition, it was recommended that the materials used on the abutment is the same shade of the prosthesis to avoid detection on recession on the facial aspect.

Replacement of maxillary incisors with implants requires a thorough understanding of the periodontal anatomy, regenerative potential of bone and soft tissue, and the biomaterial principals of the restorative techniques used. In this case report, positioning of implant analogs in the ideal positions on a diagnostic cast before surgery was key in fabricating a surgical guide to aid the periodontist in implant positioning. With the restorative dentist present, an additional skill set to complement the regenerative and surgical esthetic techniques used resulted in highly accurate, reproducible implant positions so that pre-fabrication of provisional crowns could be accomplished. These crowns engaged the anti-rotational features of the implants that were verified as “stable” based on ISQ values >60. Screw retention of the provisional restorations avoided the possibility of cement migration and allowed for guided bone regeneration (GBR) to be performed around implant #10 simultaneously. Long-term implant success using GBR has been documented by a number of authors, and bone allografts have also been shown to allow for up to 42% new bone formation at 6 months. Clearly, the amount of bone required for integration and implant stability is less than that needed for ideal implant position and soft-tissue contours. This bony support of soft-tissue contour can be an advantage as well as a disadvantage, as demonstrated by this case. For example,
because of the coronal position of the alveolar crest in site #7, periodontal surgical crown lengthening was required to reposition the implant more apically, dictated by the surgical guide. For site #10, although the implant was positioned accurately to allow for a cementable definitive restoration, the facial contour of bone was depressed and thin. GBR was used in an effort to prevent facial bone loss and to expand the soft-tissue contour over the implant restoration. Full-thickness flaps without vertical incisions in this case report had the advantage of avoiding any soft-tissue scaring from vertical incisions, allowing for manipulation of soft tissue by repositioning and coronal advancement over the idealized provisional, and of course, facilitating the regenerative and crown-lengthening surgery. This would not have been possible if a flapless technique were used, and there would be a strong likelihood that the final restorative results would be compromised although integration would have been successful. In addition, this case demonstrates that highly accurate restorative and surgical procedures can be accomplished without the use of computer-generated guides.

Ultimately, it is the team approach that accounts for the esthetic and functional success of this case, taking advantage of the synergy of working together to maximize each clinician’s skill in contributing to the best, most predictable, least invasive outcome for the patient. The authors’ experience shows that this approach has high predictability and high patient acceptance.

Summary

<table>
<thead>
<tr>
<th>Why is this case new information?</th>
<th>Prefabrication of provisional implant restorations can be done without the use of computer-generated surgical guides and allow for regenerative/esthetic surgery to support both implant stability and soft-tissue contour before the definitive restoration.</th>
</tr>
</thead>
</table>
| What are the keys to successful management of this case? | Close communication and planning between the periodontist and the restorative dentist before executing the surgical plan  
Periodontist and restorative dentist participating in stage I surgery for highly demanding esthetic cases  
Verified implant stability  
Extended healing time to allow for tissue maturation |
| What are the primary limitations to success in this case? | Adequate bone for proper implant position  
Accurate surgical guides to communicate implant position in four perspectives: axial, sagittal, apical, and rotational |

Acknowledgements

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indicates key references.