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Presentation of Two Cases of Immediate Restoration of Implants in the Esthetic Region, Using Facilitate Software and Guides with Stereolithographic Model Surgery Prior to Patient Surgery

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Abstract

Improvements in both implant microsurfaces and placement techniques have reduced healing time and increased survival rates. CAD/CAM technology and improved ceramic materials allow for achievement of improved esthetics at the implant restoration level. Two clinical procedures have the capacity to decrease patient postoperative discomfort and improve esthetics. Flapless surgery reduces surgical trauma and postoperative problems. Placement of the final prosthetic abutment at the time of implant placement stabilizes soft tissue adhesion and position to the implant. Both results require careful presurgical planning with precise implant and abutment placement. This is a clinical report of two cases that are part of a larger ongoing clinical trial of 20 patients. The inclusion criterion was that patients should be missing a single tooth in the esthetic zone. Facilitate™ software was used in conjunction with dicom files transferred from CT scans for diagnosis. Stereolithographic models and surgical guides were fabricated from the digital information. Surgical guides were used preoperatively so implant replicas could be placed in stereolithographic models as simulated surgery. A ZirDesign™ ceramic abutment was adapted on the model, and a provisional crown was fabricated. At the time of actual implant surgery, the same surgical guide was used with a flapless approach. The previously modified ceramic abutment was screw-retained and torqued to place into the implant. The provisional crown was then cemented after blocking out the screw access hole. A final restoration was fabricated from all-ceramic material after several months. Success requires careful patient selection and attention to each step of the technique. Preliminary outcomes from the ongoing clinical trial are promising.

Good dental esthetics have a very positive impact on patients' everyday lives. During the last decade, clinical implant dentistry has moved from simply placing and restoring integrated implants for missing teeth, to much more sophisticated planning for both functional and esthetic management.

This clinical report presents two cases that are part of a larger clinical trial that includes the University of Athens, Greece (University of Athens School of Dentistry's Ethics Committee for Clinical Trials approval number 82; May 27, 2008), Astra Tech Dental (Astra Tech AB, Molndal, Sweden), and Materialise Dental (Materialise Dental NV, Leuven, Belgium). The goal of the trial is evaluation of an approach that predetermines anterior implant esthetics. There are three key events for the optimal esthetic outcome: (1) flapless surgery, (2) immediate placement of final abutment, and (3) use of ceramic restorative materials. Description of the treatment of two patients follows a more detailed consideration of the aspects of the methodology.

Previously, when placing an implant, the first step for the surgeon was to use a scalpel to raise the appropriate flap and reveal the underlying bone. Immediately, optimal esthetics was already compromised.[1] Because surgery by raising a flap was a more invasive procedure than flapless surgery,[2] surgeons proposed flaps, modified flaps, mini flaps, and micro flaps to minimize the impact of the violation of the mucosal tissues

Table 1 Modified flowchart for the restorative procedure

1.	Diagnosis and treatment planning
2.	CT scan and processing of dicom files
3.	Implant position planning through computer software
4.	Development of Facilitate™ surgical guide
5.	"Surgery" on stereolithographic model
6.	Modification of the final ceramic abutment
7.	Development of interim crown
8.	Flapless surgical procedure on patient
9.	Placement of final abutment and interim prosthesis

and attachment to underlying bone, which triggered increased host defense reactions (i.e., inflammation).[2] Surgery with a flap was time consuming.[2] For a single-tooth implant, raising and suturing the flap doubled the surgical time without even considering suturing techniques for demanding esthetic areas. Flapless surgery significantly reduced patient discomfort.[3,4] Healing time was shorter, fewer medications were needed, and no sutures were placed, so there was usually no swelling, and thus, the patient was back to normal life more quickly. Even more important, with flapless procedures much less crestal bone was lost, leading to better esthetic results.[5] Tarnow et al[6] showed that crestal bone position was the major variable influencing anterior implant esthetics and was what the patient valued the most, once surgery and discomfort were forgotten.

In addition to adequate bone to support the implant and soft tissues, adequate soft tissue[7,8] must also be present to "frame" the crown with papillae and be attached to underlying bone[9] to prevent recession. Despite potential advantages, flapless surgery is not ideal for every patient. It is contraindicated when vital structures (i.e., nerves) could be injured or underlying bone is not optimal. Then it may first require soft or hard tissue augmentation prior to flapless surgery. Careful patient selection[10] and presurgical planning are always required for optimal and permanent results.

There are also critical steps in the restorative phase for success. Removing the healing abutment could compromise esthetics, even if flapless surgery had been performed. Moon et al[11] found that the "fibroblast rich barrier tissue next to the titanium surface plays a key role in the maintenance of a proper seal between the oral environment and the peri-implant bone." This soft tissue seal was violated[12] during restorative procedures. The healing abutment was removed to make the final impression for the framework try-in, for the esthetic try-in, and for the definitive restoration placement. The soft tissue seal was violated four times. Occasionally additional try-ins were necessary. Abrahamson et al[13] suggested that disconnection and reconnection of restorative components made the connective tissue zone move apically. When this happened, the body tried to reestablish a "biologic width."[14,15] During this procedure bone was lost around the neck of the

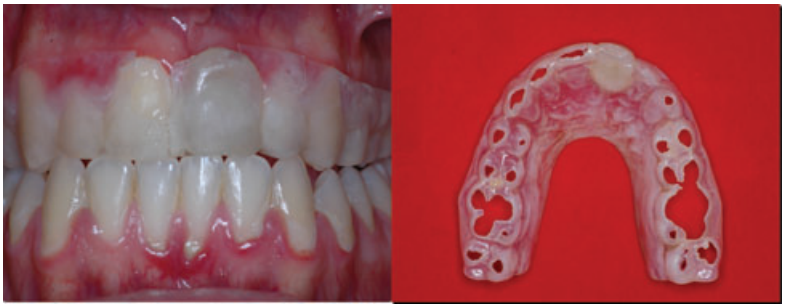

Figure 1 The patient's initial clinical status with the mouth guard acting as an interim prosthesis.

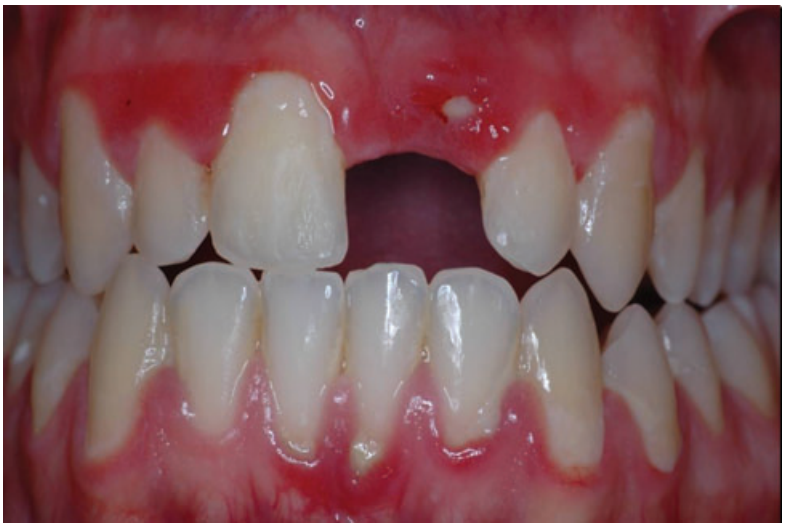

Figure 2 The guard was removed to allow for soft-tissue healing.

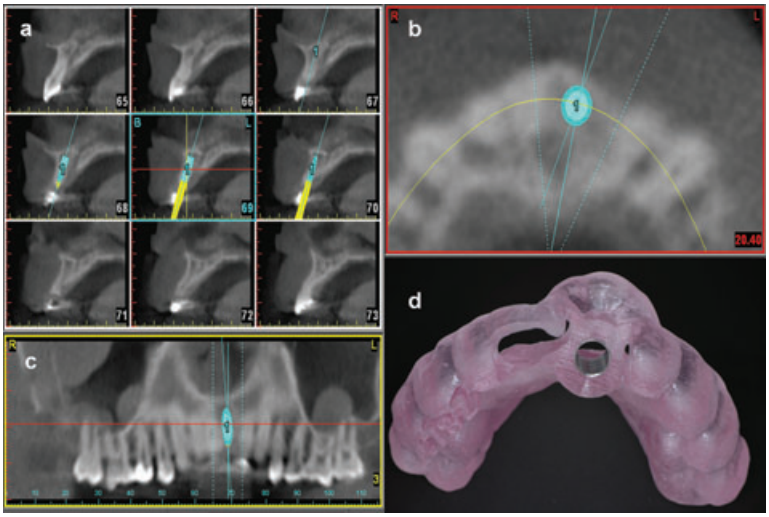

Figure 3 The implant position is planned in three dimensions. The surgical guide is fabricated accordingly.

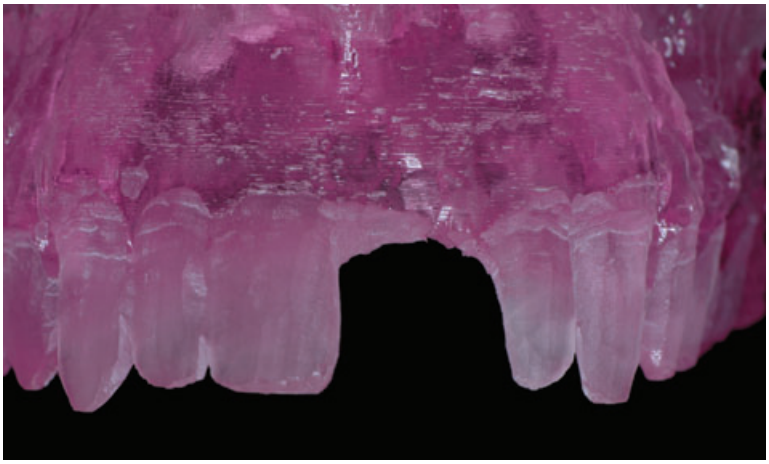

Figure 4 Stereolithographic model before surgery.

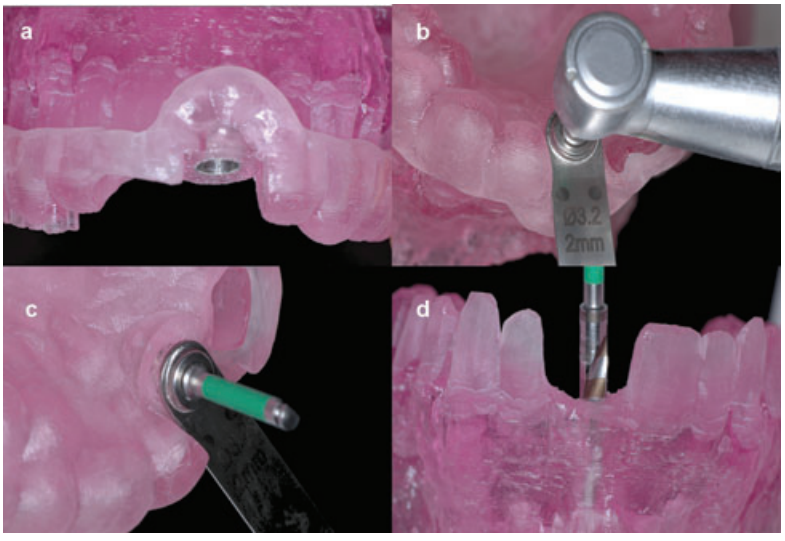

Figure 5 Surgical steps are performed on the stereolithographic model through the guide as in a real clinical situation.

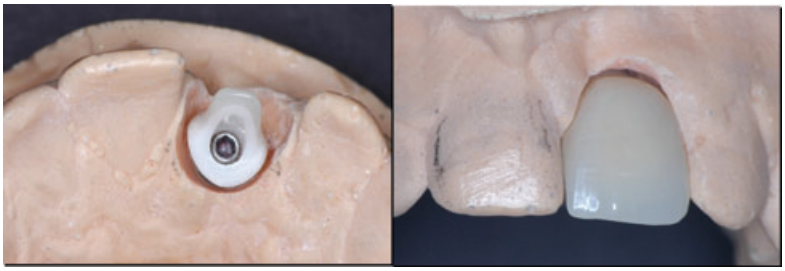

Figure 6 A ceramic abutment is selected and modified. A provisional crown is made to fit the abutment.

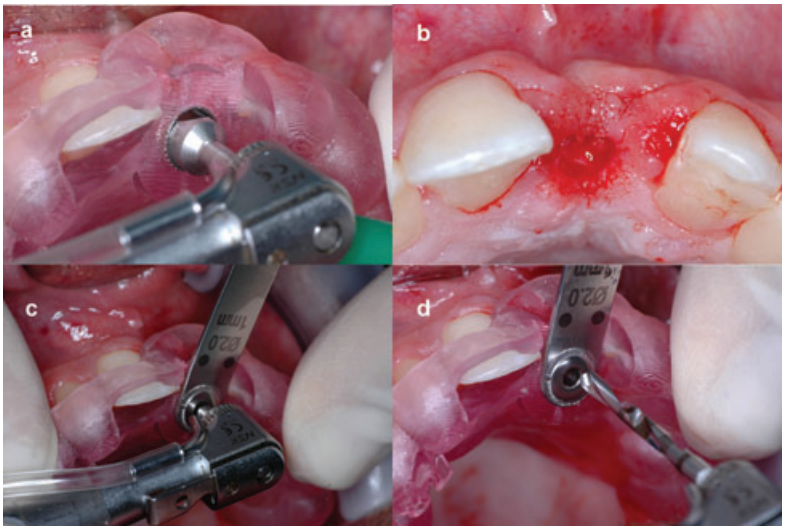

Figure 7 Surgery is flapless and starts with the mucosal punch. Every step is performed with the surgical guide, through special Facilitate™ keys.

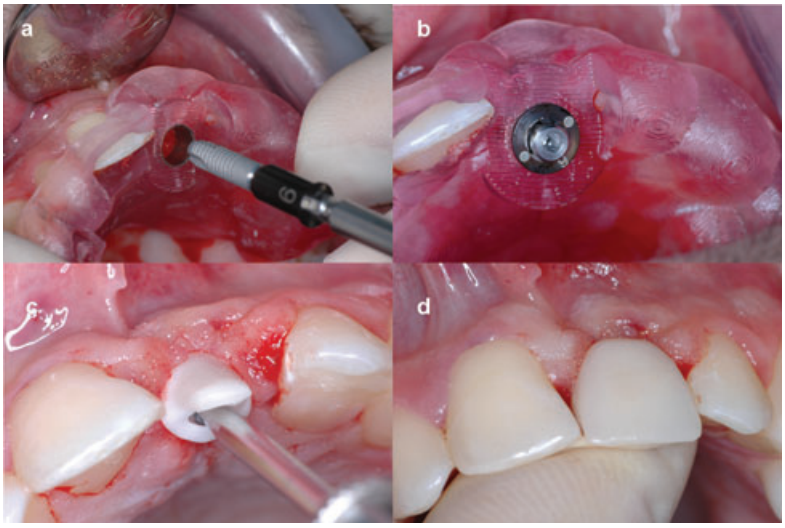

Figure 8 The implant is placed through the surgical guide on a Facilitate™ carrier. The dots help to orient the implant. The final ceramic abutment is placed, and the provisional crown is seated on the abutment and adjusted.

implant. These problems were avoided if a healing abutment was not used, because "a final abutment was placed at the time of surgery."[16,17] This also permitted an immediate loading situation requiring special care. The implant must be initially stable, torqued to at least 35 Ncm, and restored with a provisional crown.[11,18] Augmentation procedures must be done prior to surgery. The implant must be protected from even light, direct occlusal loads that could compromise its survival.

Ceramic use for abutments and crowns is the third determinant for an optimal outcome. Formation of mucosal attachment[19] is favored by high-strength ceramic surfaces in contrast to gold alloys or feldspathic porcelain ones. While Ti is biologically as good, it is not esthetic.

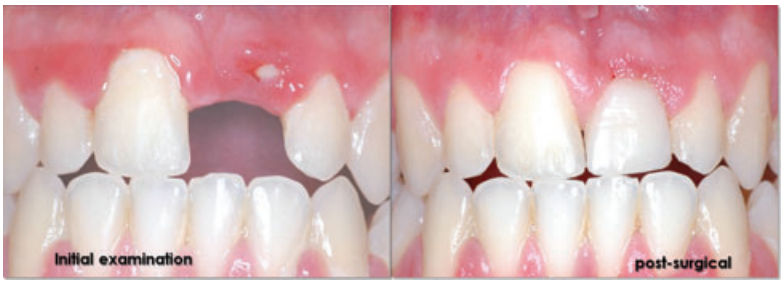

Figure 9 The result at 1 week compared to the initial situation.

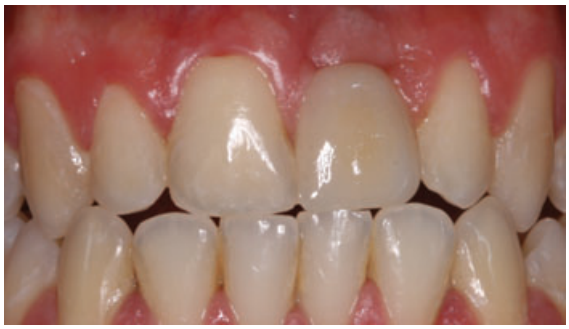

Figure 10 The final ceramic crown.

Good surgical and prosthetic planning requires sound surgical techniques of site development and implant placement, placement of the final abutment at the time of surgery, use of ceramic abutments, and immediate temporization. A tool to guarantee complete accuracy is needed to manage all of these. Recently, two excellent options have become available. Both are based on recent digital imaging[20] techniques and involve the use of CAD/CAM technology.[21] One is computer-guided implant treatment software (Facilitate™, Astra Tech AB), which was created by a collaboration between Astra Tech Dental and Materialise Dental. The second is the use of stereolithographic models and surgical guides. Stereolithographic models have been used in medicine to simulate complicated surgical procedures and allow the surgical team to be trained before the actual procedure. They have also allowed surgeons to view different tissues deep in the patient's body or skull. These tissues could be represented with different colors, and as the model is transparent, these tissues become visible. In dentistry, tissues like the mandibular nerve, the sinuses, or impacted teeth, could be represented.

Description of the technique

Facilitate software uses CT scans (which are dicom files) to create a 3D image of the patient's jaw. Table 1 provides a flow chart for the procedures involved. Interactive software allowed simulated implants to be planned and positioned within the 3D image. From this information it is possible to create an actual surgical guide using stereolithographic fabrication technology for installing the actual implants.[22,23] It is also possible to simulate the entire surgical site with a stereolithographically fabricated model to allow a real ceramic implant abutment to be placed in position using the surgical guide. A ceramic abutment can be modified to the correct contours and fitted with an

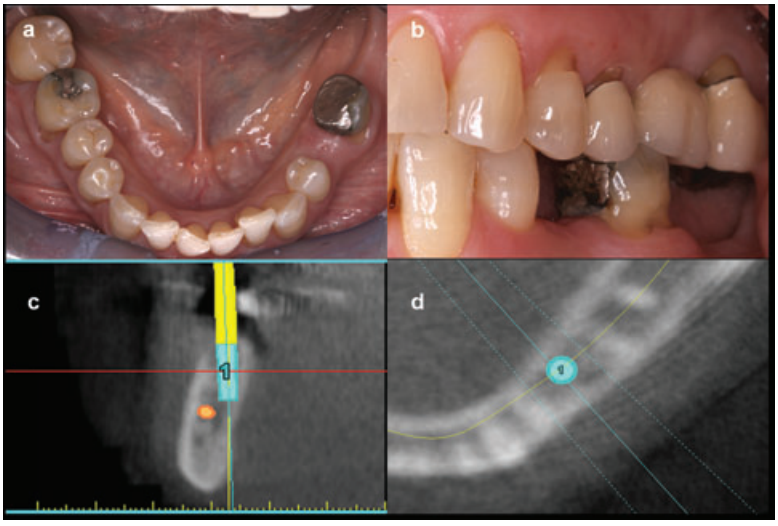

Figure 11 The patient is missing the second mandibular premolar. The implant position is planed through Facilitate™ software.

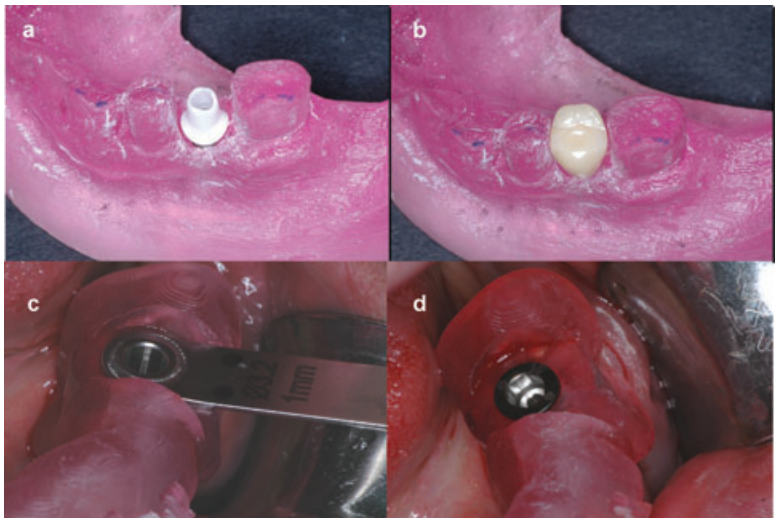

Figure 12 Surgery on the stereolithographic model results in the selection of the final ceramic abutment and the construction of an interim prosthesis. Surgery is performed on the patient through the surgical guide.

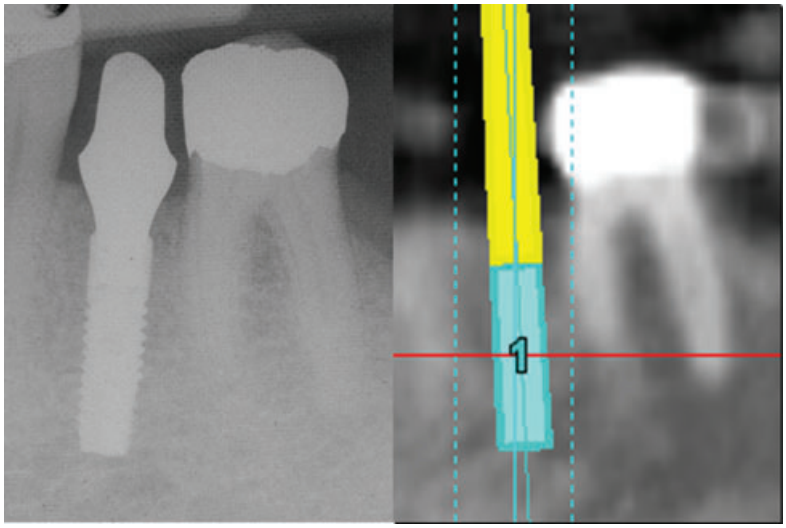

Figure 13 The postoperative X-ray shows that the implant was placed at the planned position.

interim prosthesis before the actual surgery takes place. Two patient cases are described.

Restoration of patient A

Patient A was the first patient treated with the proposed technique. For years he had worn what seemed like an orthodontic retainer (Fig 1) in an effort to replace one central incisor lost in a basketball-related accident. The apical part of the root had not being removed (Fig 2) and was showing through the tissues. Wearing of the retainer, along with inadequate oral hygiene, as could be seen by the food debris left on the mandibular teeth, resulted in severe mucogingival inflammation. The patient was classified as class I according to the Prosthodontic Diagnostic Index, as he was missing only one central incisor.[24] To improve the soft tissue condition, the original guard was replaced by a "Rochette" type interim FPD. The patient was given oral hygiene instructions and was placed on a recall schedule. His tissues were left to heal. Four months later the patient's periodontal condition was significantly improved, allowing for the surgery to be planned using the software. Computerized tomography (CT) was performed, and digital images were reconstructed through Facilitate™. Facio-lingual slices (Fig 3A) were collected at positions that allowed determination of the inclination and length of the selected implant type (Osseospeed™, Astra Tech AB). The panoramic view (Fig 3C) ensured the roots of adjacent teeth were not compromised. The crestal view (Fig 3B) allowed evaluation of the overall position of the implant in the jaw. A stereolithographic surgical guide was fabricated at a remote station (Fig 3D). A stereolithographic model of the patient's jaw was also fabricated (Fig 4).

For both the simulated and actual surgery, the Facilitate™ instrument kit (Astra Tech AB) that included special drill keys, implant holders, and implant holder drivers was used. During simulated surgery, the surgical guide was secured on the stereolithographic model, and all surgical steps were performed

through the placement of the implant in the selected and prepared position (Fig 5). At this point there was a model with the implant in its actual position in relation to adjacent teeth and the cementoenamel junction. Then the appropriate ceramic abutment (Fig 6) was adjusted to correct contours and modified with special porcelain facially to achieve adequate support of the crown. An interim prosthesis was also fabricated on the abutment.

For this first attempt, a problem arose at this point because the stereolithographic model fabricated directly from CT scans did not provide sufficient accuracy of adjacent tooth structures to adjust the interim crown's contours. This problem was resolved by increasing the sensitivity of the digital images from which stereolithographic models were constructed.

Actual surgery followed the same protocol (called "navigated implant placement"), starting with a mucosal punch (Fig 7A, B), site development through the surgical guide (Fig 7C, D), and implant placement using the special implant holder and driver (Fig 8A, B) with the unit's torque value set at 35 Ncm. The ceramic abutment was tried in. As long as the simulated surgery was performed accurately, the abutment did not require adjustment (Fig 8C). The provisional crown try-in that followed provided time for adjacent soft tissues to adjust (Fig 8D), as there was no flap present. The provisional crown's occlusion was adjusted to prevent direct loading at maximum intercuspation and eccentric movements. A radiograph was taken to check implant and abutment positions and create a baseline for future comparisons. The patient was released following postsurgery instructions (i.e., follow a soft diet, avoid applying direct pressure on the restoration) and recall scheduling (1 week, 30 days, and once/month until final restoration insertion). At each recall, implant stability, abutment and restoration performance, soft tissue health, and soft tissue adaptation were assessed. At 1 week, tissue healing was exceptional, and the patient reported no discomfort (Fig 9). The esthetic outcome was good, considering the patient's initial limitations (bone height preservation, papilla formation, and a medium lip line). At 4 months there was no mobility, and tissue health was optimal, so the final all-ceramic restoration was fabricated and placed (Fig 10).

Restoration of patient B

Patient B was the first patient involved in the clinical trial who was missing the lower second premolar (Fig 11A, B) at the edge of the esthetic zone as defined in the present study. The patient was classified as class I according to the Prosthodontic Diagnostic Index, as she was missing only one premolar and one molar.[24] The same procedures were followed (Fig 11C, D). The simulated surgery was performed on the stereolithographic model, the implant was placed, the abutment (Fig 12A, B) was selected and modified, and the provisional crown was fabricated. The surgical procedure was performed on the patient (Fig 12C, D) with care to achieve the appropriate torque for the implant and to adjust the occlusion, as this was a posterior tooth. The immediate postsurgical radiograph (Fig 13) demonstrated a good immediate outcome from the presurgical planning.[25,26] The same recall protocol was followed as for patient A. At 1 week, the tissue healing was excellent, and patient discomfort was minimal. The definitive restoration was placed after a period of 2 months.

Discussion

For patients A and B, no problems were encountered. Tissue reaction remained very good. There were no signs of implant mobility. No further occlusal adjustment was necessary. A 20-patient clinical trial is currently ongoing at the University of Athens, Greece (University of Athens School of Dentistry's Ethics Committee for Clinical Trials approval number 82, May 27, 2008), in cooperation with Astra Tech Dental and Materialise Dental. This will provide more substantial documentation about the advantages and long-term outcomes for this procedure.

From these two cases presented (and experiences with seven others in the ongoing clinical trial), there were several lessons. Patients to be treated with this technique should be carefully selected to have adequate hard and soft tissues for flapless implant placement. Planning for implant positioning with Facilitate™ requires some experience with the software and careful clinical design. Stereolithographic models made from CTs do not appear quite as accurate as stone models made from traditional impressions. Implant placement accuracy using Facilitate™ Surgical Guides is acceptable in *x*–*y* axes of three dimensions but not along the *z*-axis. For this reason, the provisionals required minor occlusal adjustment.

Summary

This implant management procedure [(1) flapless surgery, (2) immediate final abutment placement, and (3) use of all-ceramic restorative materials] has the potential to avoid a significant number of events that traditionally compromise final implant esthetics; however, patients must be carefully selected for this option, as adequate bone and soft tissue are of paramount importance. Very accurate procedures are possible with the stereolithographic approaches to fabrication of surgical guides, creation of ceramic abutments, and fabrication of interim prostheses. The only current limitation at present is some decreased accuracy in the z direction for 3D software reconstruction of the images, leading to some occlusal adjustments of provisionals at the end.

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