AI Virtual Tooth Extraction for immediate replacement of a failing central upper incisor

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Implant placement in the esthetic zone requires a comprehensive understanding of surgical and prosthetic aspects, including the correct choice of placement modalities and components.

Introduction

Immediate placement in fresh extraction sockets has recently gained significant consideration for this indication[1]. Besides reducing treatment time and surgical sessions and providing the possibility for immediate fixed temporization, immediate placement may also promote esthetic outcomes by supporting the preservation of the contours of soft tissues and interdental papillae[2–4]. These aspects render this treatment modality especially attractive for treatments in the esthetic area[4].

The immediate placement of implants in fresh extraction sockets represents a predictable and successful treatment modality, provided cases are carefully selected, and surgical protocols are respected[1,5–7]. Specific case selection criteria have been proposed to ensure functional and esthetic success[1,7]. These criteria include the sagittal root position, the gingival margin level, the gingival biotype, the extraction socket anatomy, the presence and quality of buccal bone, the shape of the edentulous ridge, and the presence of adequate bone volume and quality to achieve primary stability of the implant[8–10].

An often applied classification to estimate the probable success of an immediate placement is based on the presence and condition of the buccal bone and facial soft tissues[11]. According to this classification, type I sockets are ideal for immediate placement. These sockets display nominal and post-extraction unchanged facial soft tissue and buccal crestal bone levels relative to the cementoenamel junction of the hopeless tooth. Any deviation from this ideal situation, e.g. as with type II sockets that lack the buccal wall, has been associated with a higher onset of, for example, post-treatment soft tissue recessions and less-than-ideal esthetic results[11]. In these cases, detailed planning of the restorative design and surgical approach based on the patient's conditions is critical[11]. Advanced, state-of-the-art virtual planning tools may help to facilitate this process and render such treatments more efficient and predictable.

The following case report describes immediate implant placement and restoration in a patient with high esthetic expectations who experienced a root fracture of the central incisor. The partial absence of the buccal wall complicated the treatment of the case. To facilitate a more predictable outcome, we have tested/used the novel "Virtual Tooth Extraction" feature of coDiagnostiX®. Besides implant positional planning, this novel software module can be used for delivering a prefabricated final zirconia abutment in a one-time-one-abutment approach. Precise adaptation of the abutment to the socket's bone and soft tissue architecture before surgery and precise implant placement helped deliver a superior and long-term stable esthetic outcome.

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Figure 1: Pre-treatment clinical evaluation comprising frontal overview (LEFT) and intraoral frontal (MIDDLE) and buccal (RIGHT) views of the maxilla with compromised tooth #21 showing coronal displacement.

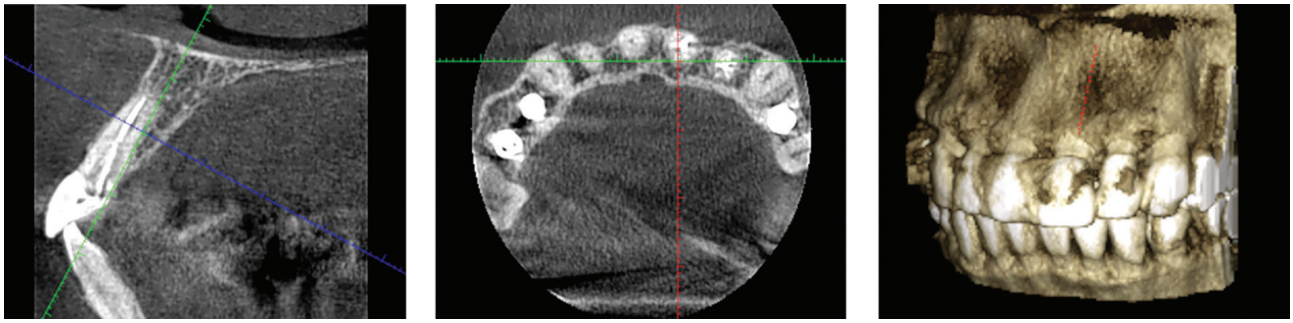

Figure 2: Pre-treatment diagnostic CBCT evaluation comprising buccopalatal sagittal (LEFT) and transversal (MIDDLE) sections and 3D reconstructive views (RIGHT) illustrating the tooth root anatomy, sagittal root position, and the morphology of the bone anatomy around the central incisor #21.

Initial situation

A 58-year-old woman presented in our clinic with a chief complaint of pain and mobility at her upper left incisor. Clinical examination confirmed extended mobility of tooth #21 associated with a coronal displacement of the tooth crown (Figure 1). Diagnostic cone beam computed tomography (CBCT) evidenced the presence of a horizontal crown root fracture of the previously endodontically treated tooth. No signs of inflammation or infection were detected. Since the prognosis of the affected tooth was unfavorable, extraction was recommended. Her general anamnesis confirmed that the patient, a non-smoker with good oral hygiene, was in good health.

No systemic or local risk factors or contraindications for implant treatment were identified. No vestibular lamina (buccal bone plate) could be identified from the CBCT (Figure 2). Extraction was assumed to likely result in a type II extraction socket with intact soft tissues, but with the buccal plate most likely to be missing after extraction[11]. Abundant amounts of bone for implant placement apical and palatal to the tooth root (class I sagittal root position, according to Kan) were present[12]. The anatomic conditions were evaluated as adequate to attain primary stability as part of immediate implant placement, with an elevated risk for soft tissue dehiscences due to the lack of buccal tissues.

Following the anamnesis, the patient was informed about the different treatment options, including immediate or delayed protocols and associated potential risks and advantages. The patient strongly preferred an immediate restoration due to her concern about a temporary esthetic compromise.

Treatment planning

Based on the clinical and radiographic evaluation, the treatment strategy comprised atraumatic tooth extraction followed by immediate implant placement and restoration. Implant planning was based on models combined from CBCT and intraoral scans using coDiagnostiX® surgical planning software and 3shape smile composer. As evidenced in Figure 3, the implant restoration was planned based on a Straumann® BLT Roxolid®, SLActive® Ø3.3 x12 mm combined with an immediate temporary restoration with a prefabricated final Variobase® zirconia abutment. The latter was planned and designed, taking into account the anticipated post-extraction local soft tissue contours, using 3Shape Smile Composer® (Figure 4). Figure 5 illustrates the capabilities of the new coDiagnostiX® Virtual Tooth Extraction module to visualize and finely adjust the planned implant-prosthetic restoration in the context of the patient's local soft and hard tissue anatomy. The implant position was

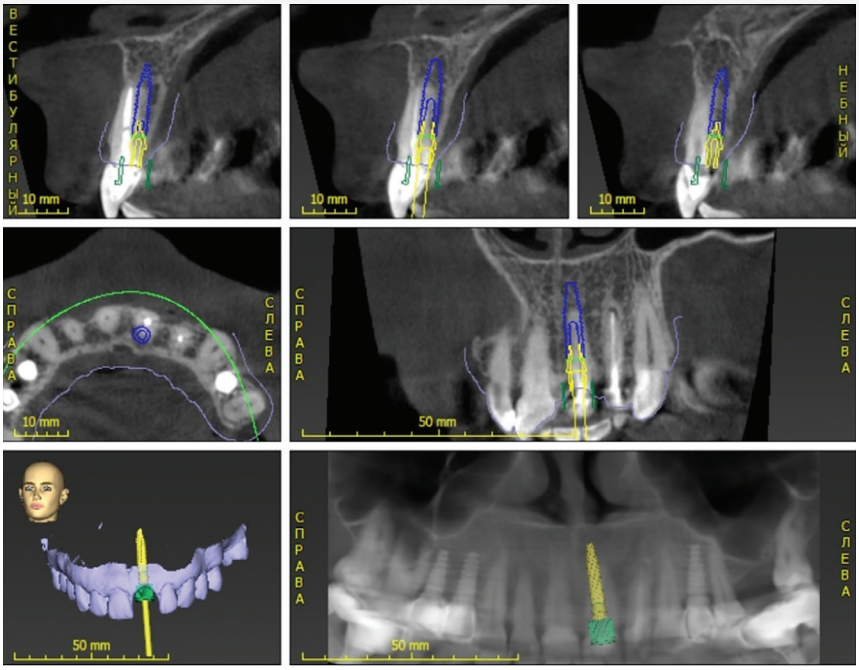

Figure 3: Surgical planning of implant type and implant position in coDiagnostiX®, taking into account the sagittal root length and position and correspondingly available bone and soft tissue architecture after tooth extraction.

planned buccally with regard to the existing tooth's position to attain adequate primary stability, maximizing the buccal and coronal engagement of the implant, with an adequate emergence profile to support the future restorative crown.

The abutment was prefabricated to allow optimal and immediate post-extraction soft tissue adaptation, while

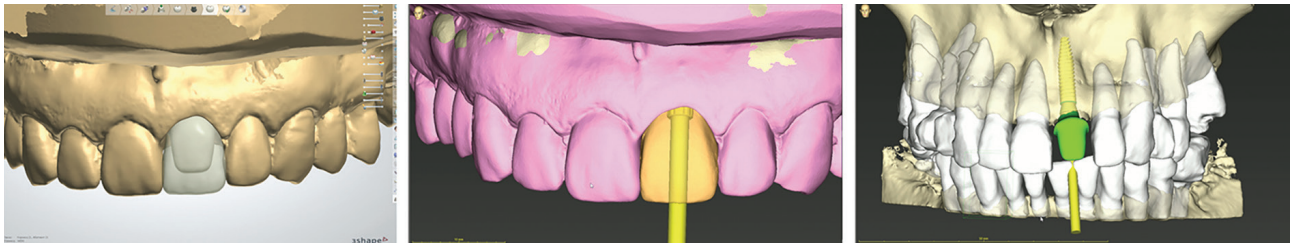

Figure 4: Surface contour visualizations of the planned restoration in frontal view, illustrating the crown and abutment in 3Shape Smile Composer® (LEFT), the crown in relation to the dental and soft tissue contours (MIDDLE), and the implant and abutment position and designs in relation to the patient's bone anatomy.

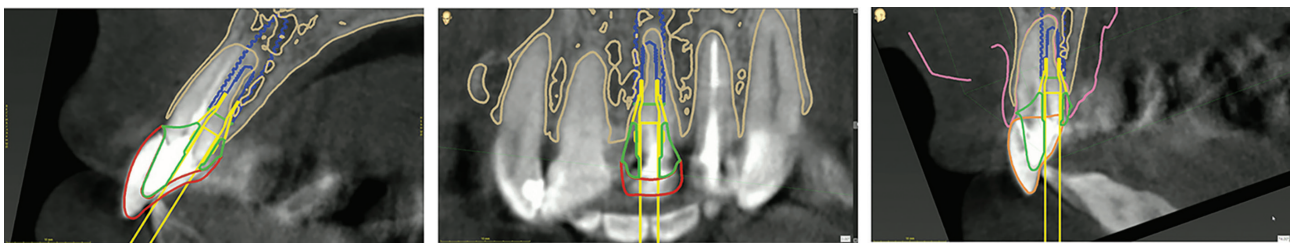

Figure 5: Cross-sectional visualizations of the planned implant and prosthetic restoration in relation to the patient's dental, bone and soft-tissue anatomy. LEFT and MIDDLE: Sagittal and frontal cross-sections of the implant (blue), Variobase® (yellow), the ceramic abutment (green) and crown (red) in relation to the alveolar crestal anatomy (light brown). RIGHT: Sagittal view illustrating the implant (blue) and abutment (yellow and green) in relation to the residual dental structures (orange), alveolar crestal anatomy (light brown) and soft tissue contours (pink).

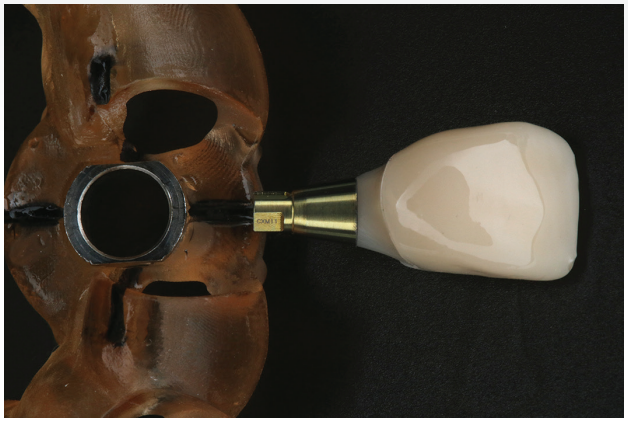

Figure 6: Surgical template and prefabricated crown comprised of the final Variobase®-built zirconia abutment combined with a provisional crown obtained using coDiagnostiX®.

minimizing the number of prosthetic restorative events at the surrounding peri-implant mucosal interface post healing[13]. The surgical template was also designed using coDiagnostiX® software and printed on a 3D printer (Figure 6).

Surgical procedure

Surgery was carried out under local infiltration anesthesia (lidocaine 2% with epinephrine 1:100,000) and started with the atraumatic extraction of tooth #21, preserving a maximum amount of the hard and soft tissues around the tooth (Figure 7).

After extraction, the tooth-retained surgical guide was placed, and proper placement and fit were verified before proceeding to the osteotomy preparation and implant placement (Figure 8).

A fully guided flapless surgical protocol for placing a Straumann® Bone Level Tapered Implant, ∅ 3.3mm x 12 mm, was adopted. The procedure started with pilot drilling using a ∅ 2.2 mm milling cutter to provide a horizontal base within the extraction socket, followed by ∅ 2.2 mm pilot and ∅ 2.8 mm final drilling. The osteotomy was finalized by adapting the crestal bone contour using a bone profiler (Figure 9). Guided placement of the implant using a motor-driven handpiece was followed by manual insertion and final verification of the appropriate insertion torque of > 35 Ncm.

The surgical procedure was directly followed by immediate provisionalization. Figure 10 illustrates the delivery of the prefabricated permanent zirconia abutment, followed by a try-in of the temporary crown. The soft tissue contours around the newly positioned crown were evaluated as ideal and in excellent harmony with the adjacent teeth.

The absence of the buccal wall and thin soft tissue biotype of the patient resulted in an unsatisfactory esthetic result, with the implant becoming visible through the soft tissues, calling for additional augmentative corrective procedures.

Figure 11 shows the soft tissue thickening of the vestibular tissues covering the apical implant aspect. The procedure was performed in the same session using a subepithelial connective tissue graft from the palate. Next, a temporary crown was cemented on the abutment.

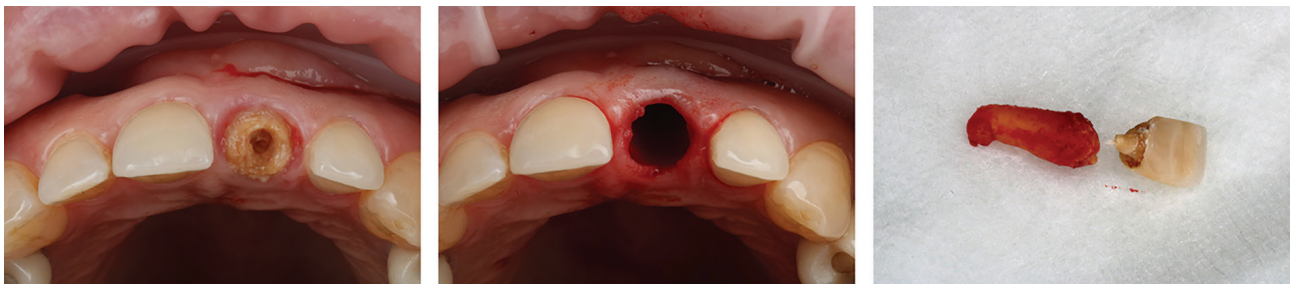

Figure 7: Atraumatic extraction of tooth #21. Occlusal views after removal of the crown (LEFT) and following atraumatic extraction of the tooth root (MIDDLE). RIGHT: Crown and tooth root fragments after extraction.

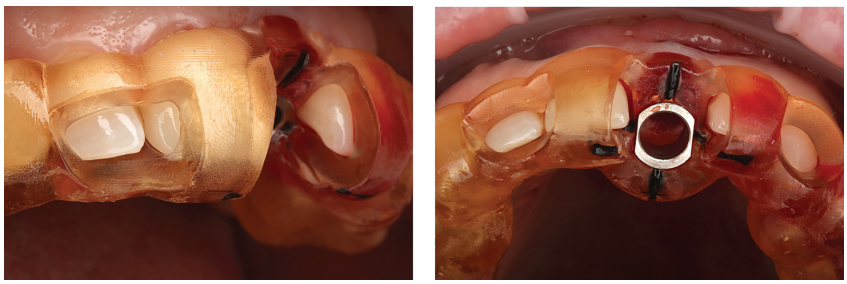

Figure 8: Lateral and occlusal views on the surgical template designed in CoDiagnostiX®.

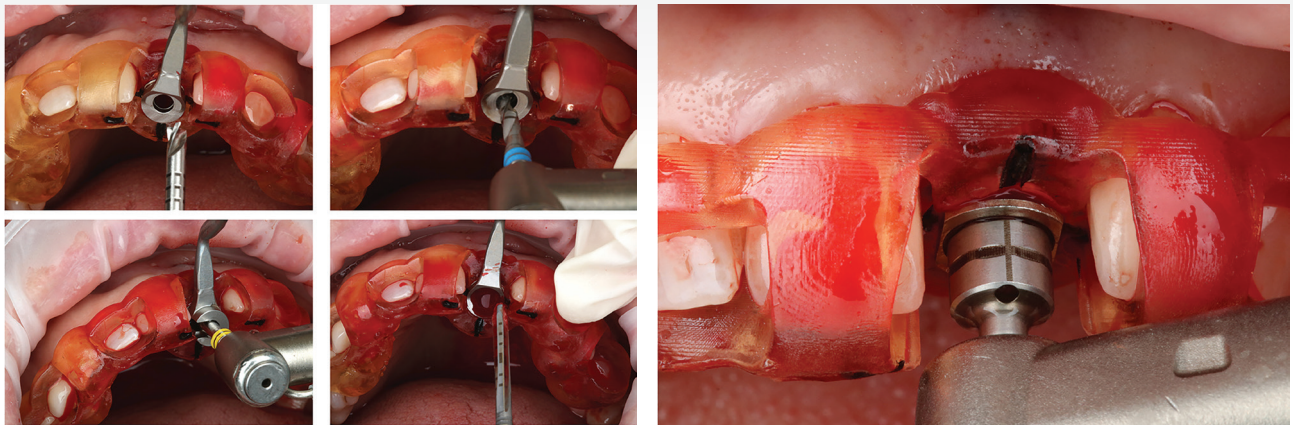

Figure 9: Illustration of the guided osteotomy preparation following the standard guided surgery protocols for regular bone quality, comprising preparation of the alveolar wall with a milling cutter (Ø 2.2 mm) (UPPER LEFT), followed by Ø 2.2 mm pilot drilling (UPPER RIGHT), widening of the osteotomy to Ø 2.8 mm (MIDDLE) and finalization of the implant bed using a profile drill (BOTTOM).

Prosthetic procedure

The patient was recalled three days post surgery, and the crown was removed for cement control and to evaluate the crestal soft tissue conditions. As evidenced in Figure 12, the soft tissue healing and conditioning to the contours around the abutment and new crown were optimal. Radiographic controls at two months post surgery indicated adequate osseointegration and stable peri-implant bone conditions. Impressions for the final restoration were taken two months post surgery.

Treatment outcomes

The frontal esthetic outcome after delivery of the final restoration is illustrated in Figure 13 and demonstrates the ideal esthetic outcome of the delivered restoration and surrounding soft tissue conditions. Similarly, it highlights the efficacy of the applied soft tissue graft and immediate insertion of the final zirconia abutment. Both promoted an increased soft tissue volume supporting the regeneration of the anterior vestibular bone for an esthetically pleasing and stable outcome. We would like to thank Albert Latypov of the Werk dental laboratory (Yekaterinburg, Russia) for manufacturing the restoration.

Discussion

The presented case illustrates the adoption of an immediate implant placement and restoration protocol to replace a failing upper central incisor within the intricate context of a noticeable deficiency in vestibular bone volume. The fully guided treatment approach used the new coDiagnostiX® "Virtual Tooth Extraction" module. Based on virtual models, this module allowed us to precisely plan the procedure and restoration taking into account the predicted anatomic hard and soft tissue architecture of the extraction socket. It helped specifically in deriving the ideal implant position for adequate immediate stability, but was also used to presurgically design and manufacture the permanent zirconia abutment considering the bony anatomy and emergence profile of the extraction socket. The immediate delivery of the as-designed abutment supported the pre-existing soft tissue contours,

Figure 10: Temporary immediate restoration. LEFT: Mounting of a prefabricated Variobase® zirconia abutment. Temporary crown before (MIDDLE) and during (RIGHT) temporary try-in illustrating the immediate esthetic overall result.

Figure 11: Buccal soft tissue thickening using a palatal subepithelial connective tissue graft. Palatal subepithelial connective tissue graft after harvesting (LEFT) and at the recipient site before (MIDDLE) and after (RIGHT) grafting.

Figure 12: Evaluation of the soft-tissue healing and cement control after removal of the temporary crown at three days post surgery.

Figure 13: Frontal esthetic outcome after delivery of the final restoration at two months post-surgery. The patient was highly satisfied with the achieved result. The gingival tissues around the delivered crown appeared healthy and natural and harmonized perfectly with the residual dentition.

comprising the gingival edge and mesial and distal papillae, resulting in optimal esthetic soft tissue parameters and improved esthetics in terms of the patient's smile. The case likewise illustrates the advantages of immediate placement and temporization, not only reducing the treatment sessions and time but also allowing the immediate delivery of the final abutment of the ideal design, allowing a "one-time-one-abutment" approach for ideal and stable esthetic outcomes. Other aspects, including prosthetic designs to allow adequate personal and professional prophylaxis, may be considered as important as the selection of the delivered components' optimal material and surface properties. Ceramic has, for example, proved ideal in anterior areas or situations with thin gingival mucosa. Customized CAD/CAM abutments (e.g. Straumann® CARES®) may further support the soft tissue quality and esthetics in anatomically and physiologically challenging situations.

Finally, the case illustrates the importance of a carefully designed and digitally visualized surgical prosthetic protocol in delivering implants and prostheses of ideal dimensions and design in the optimal three-dimensional position and at the right time to ensure an adequate blood supply to the surrounding bone and mucosa, supporting their regeneration and long-term stability.

Conclusion

Achieving highly esthetic and long-term stable outcomes as part of immediate placement and restorative treatments in the esthetic area can be a challenging task, requiring multifactorial approaches, meticulous planning and prudent handling. Next to material and procedural considerations, tailored state-of-the-art digital planning tools can significantly improve the predictability and efficiency of delivered treatments and ultimately help guarantee full patient satisfaction.

References 1-13 are available on request from:
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