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Early Implant Placement with Simultaneous Bone Augmentation and Digital Planning in the Aesthetic Zone: A Clinical Case Report

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ABSTRACT

Anterior implant rehabilitation presents challenges in terms of soft and hard tissue preservation, aesthetics, and long-term function. Early implant placement with guided bone regeneration (GBR) and digital planning is a predictable approach to manage compromised anterior sites. This case report aims to highlight a multidisciplinary approach involving prosthetically driven planning, bone augmentation, and soft tissue management in a compromised central incisor case. A 33-year-old male patient presented with persistent pain in a previously root canal treated maxillary left central incisor. Clinical and radiographic evaluation revealed reinfection, periapical pathology, and insufficient ferrule, rendering the tooth unrestorable. Cone beam CT showed a narrow width? alveolar ridge measuring approximately 5.63. mm. Tooth 21 was atraumatic extracted, and a fixed provisional restoration was delivered for aesthetic maintenance. After 12 weeks, early implant placement (AnyRidge® Megagen Ø 4.0 x 10 mm) was performed using a 3D-printed surgical guide, along with simultaneous GBR using autogenous bone from the mandibular ramus and xenograft (Bio-Oss®), covered with a collagen membrane (Biomend®). Six months later, an apically positioned flap was used to enhance buccal keratinized tissue, and a provisional crown was placed to contour the emergence profile. Final prosthetic rehabilitation was completed with a monolithic zirconia crown supported by a prefabricated titanium abutment. This case demonstrates the benefit of combining digital planning with early implant placement and GBR in the aesthetic zone. This approach enhances aesthetic outcomes and implant stability. It reinforces the significance of prosthetically guided implant placement and supports future research comparing timing strategies in anterior implant therapy.

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1. INTRODUCTION

Implant placement in the anterior maxilla poses a unique set of challenges due to high aesthetic demands and anatomical considerations (Gamborena & Blatz., 2014). Achieving optimal outcomes requires careful management of both hard and soft tissues, particularly when replacing a failing tooth in a prominent aesthetic zone (Tan et al., 2012). Following tooth extraction, the alveolar ridge undergoes significant dimensional changes, with studies reporting up to 50% reduction in ridge width and vertical height loss within the first year, most notably within the initial three months (Schropp et al., 2003). These changes are especially critical in the anterior maxilla, where buccal bone is often thin and susceptible to resorption (Heimes et al., 2021). Immediate implant placement, while convenient, is associated with risks of soft tissue recession and compromised aesthetics due to ongoing bone remodelling (Chappuis et al., 2017). In contrast, early implant placement, typically performed from 4 to 16 weeks post-extraction, allows partial bone healing and soft tissue stabilization (Buser et al., 2017). This approach provides a balance between preserving hard and soft tissues and achieving favourable aesthetic outcomes (Chen & Buser., 2014). Digital dentistry has further advanced implant therapy by enabling prosthetically driven treatment planning and precision-guided surgery (Wang et al., 2024). Digital dentistry also reduced operator-related errors in this highly visible aesthetic zone (Wang et al., 2024). Using cone-beam computed tomography (CBCT) imaging, digital wax-ups, and 3D-printed surgical guides, clinicians can enhance the accuracy of implant positioning, critical for achieving an ideal emergence profile and long-term success (Saini et al., 2024). This case report describes the management of a compromised maxillary central incisor with inadequate alveolar ridge width, utilizing a digitally guided surgical approach and simultaneous bone augmentation to facilitate early implant placement and optimal prosthetic rehabilitation.

2. CASE DESCRIPTION

A 33-year-old Dusun male was referred to the restorative specialist unit with the chief complaint of persistent pain in the upper front tooth. The patient reported that his upper front tooth (21) had undergone treatment approximately five years prior, with recurring discomfort over the last two months.

2.1 Clinical and radiographic findings

Patient has an average smile line and straight smile arch with rotated mesiopalatal of 11. Clinical examination revealed that tooth 21 was heavily restored with composite, with only approximately 30% of coronal tooth structure remaining. Secondary caries was noted on the distal wall. The tooth was tender to percussion and palpation. Intraoral periapical radiography revealed the presence of a periapical radiolucency and widening of the dura associated with a previously treated root canal (Figure 1). CBCT imaging showed inadequate labiopalatal alveolar ridge width at the site, measuring approximately 5.63 mm (Figure 2). Based on these findings, the tooth was diagnosed as Previously Treated with Symptomatic Apical Periodontitis complicated with inadequate alveolar ridge. The prognosis was deemed questionable (Class C) (Samet & Jotkowitz, 2009).

Fig. 1. An IOPA radiograph of endodontically treated 21showed presence of periapical radiolucency at the apical region.

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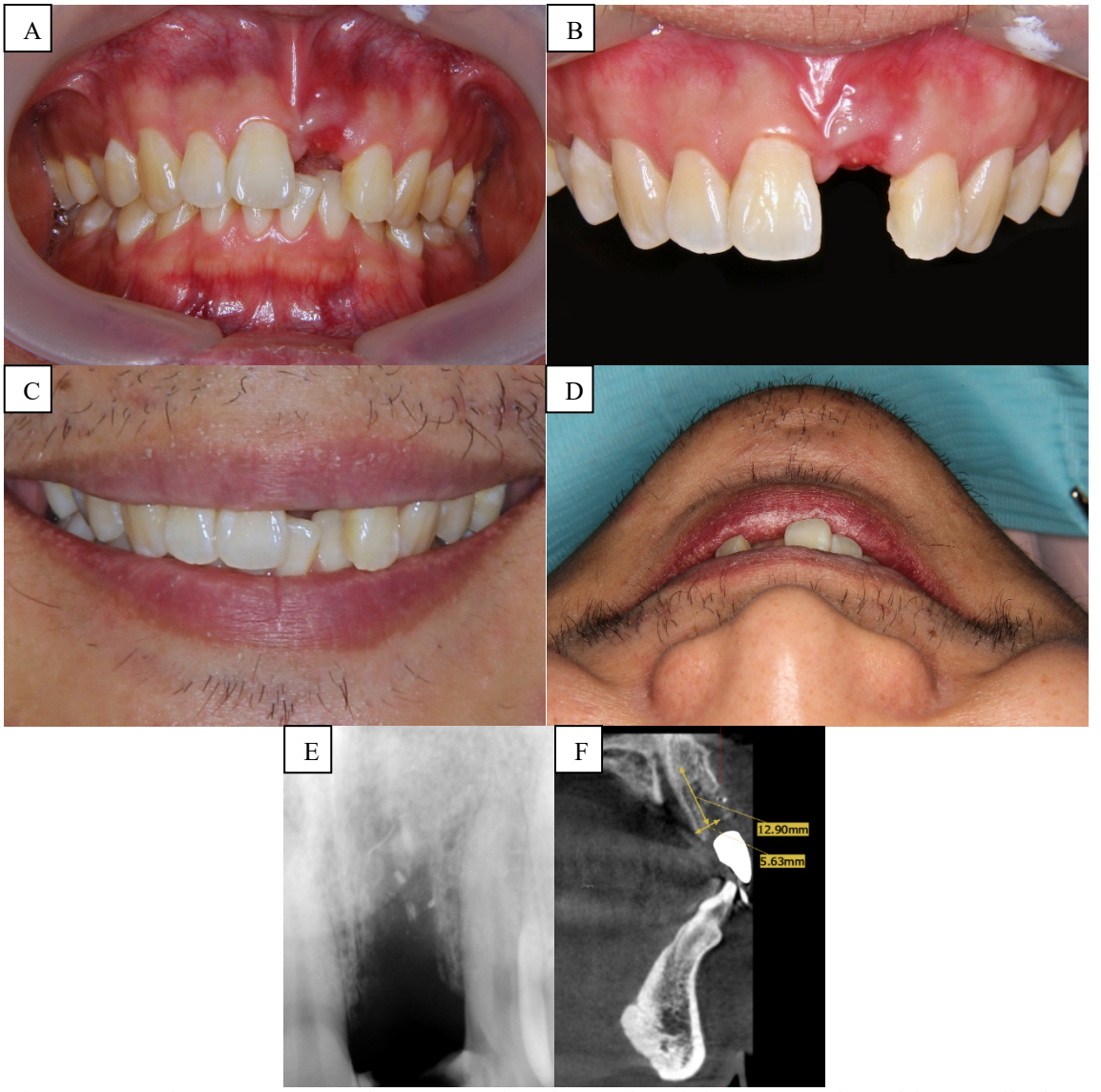

Fig. 2. Pre-operative assessment 4-weeks post-extraction of 21. A) frontal view B) Area of complaint C) Smile view D) 12 O'clock smile view E) An IOPA radiograph showed the healing socket area of extracted tooth 21 F) CBCT analysis with radiographic guide measuring the bone quality and quantity.

2.2 Treatment planning and surgical phase

Given the questionable prognosis, the treatment plan included extraction of tooth 21, followed by early implant placement with simultaneous bone augmentation and eventual prosthetic rehabilitation. A temporary fibre-reinforce bridge (FRB) was fabricated after atraumatic extraction of 21 to maintain aesthetics and allow soft tissue healing. The extraction site was reviewed after 4-week post-extraction. The proposed implant site demonstrates satisfactory soft-tissue healing, with healthy peri-implant mucosa characterized by adequate keratinized tissue, normal color and contour, and absence of signs of inflammation. The interdental papillae and mucogingival architecture appear well preserved, indicating favorable soft-tissue conditions for subsequent implant placement. (Figure 2). A CBCT scan was obtained to assess alveolar bone volume, bone quality, and the relationship to adjacent anatomical structures at the

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planned implant site of tooth 21, and the data were imported into implant planning software (Implant Studio®, 3Shape, Copenhagen, Denmark). A digital intraoral scan of the patient and a diagnostic wax-up of the planned restoration were superimposed onto the CBCT dataset to facilitate prosthodontically driven implant planning. Virtual implant placement was performed along the long axis of the planned crown to optimize implant depth, angulation, and buccopalatal positioning (Figure 3). Digital evaluation revealed insufficient labial alveolar bone volume to support the planned implant position; therefore, the implant diameter and length were selected in conjunction with a planned guided bone regeneration (GBR) procedure to achieve adequate peri-implant bone support and long-term biomechanical stability. Following virtual planning, a tooth-supported stereolithographic surgical guide with metal sleeves was fabricated using autoclavable resin to ensure accurate transfer of the digital plan to the clinical setting. At four weeks post-atraumatic extraction, first-stage implant surgery was performed (Figure 4). A midcrestal and sulcular flap was raised to access the surgical site, followed by thorough removal of granulation tissue. An implant fixture (AnyRidge® Megagen, Ø 4.0 × 10 mm) was placed using the surgical guide to ensure proper positioning. Bone augmentation was carried out at buccal side using a mixture of autogenous bone harvested from the mandibular ramus and a bovine-derived xenograft (Geistlich Bio-Oss®), covered with a resorbable collagen membrane (Biomend®). The surgical site was closed with sutures, and the patient was monitored for immediate post-operative bleeding. At the one-week review, suture removal was performed. FRB was then fabricated using composite resin and glass fibre to temporarily replace the 21 area. The temporary restoration featured a hygienic pontic design to prevent pressure on the surgical site and to facilitate effective plaque control during the healing period.

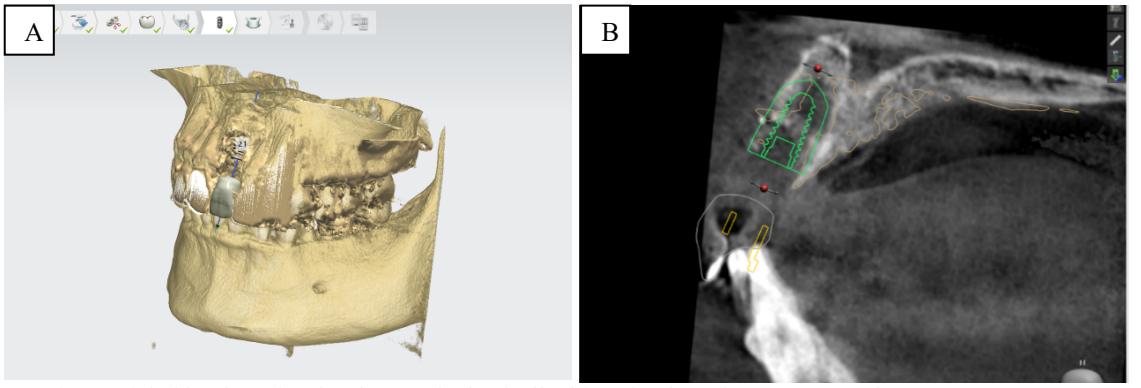
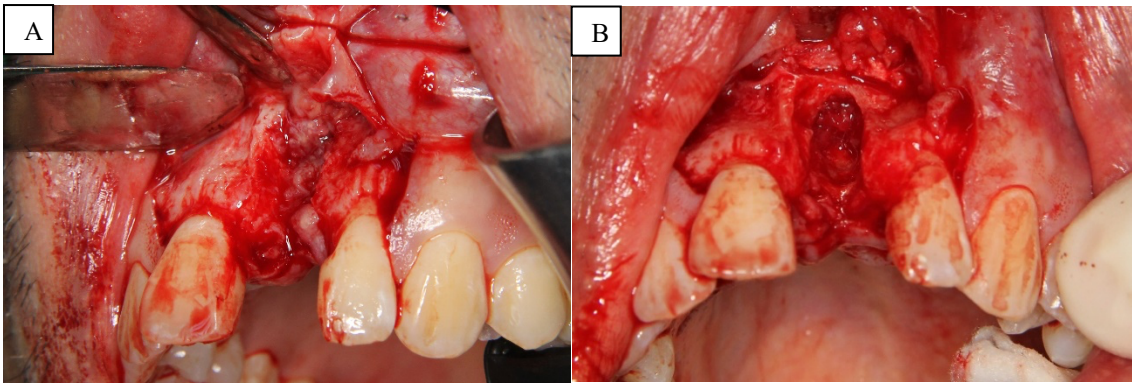


Fig. 3. Digital implant planning for prosthodontically driven implant placement at tooth 21. (A) CBCT cross-sectional view of the planned implant site at tooth 21 demonstrating alveolar bone morphology and labial bone deficiency. (B) Superimposition of CBCT and intraoral scan data showing virtual implant positioning based on the planned prosthetic restoration.



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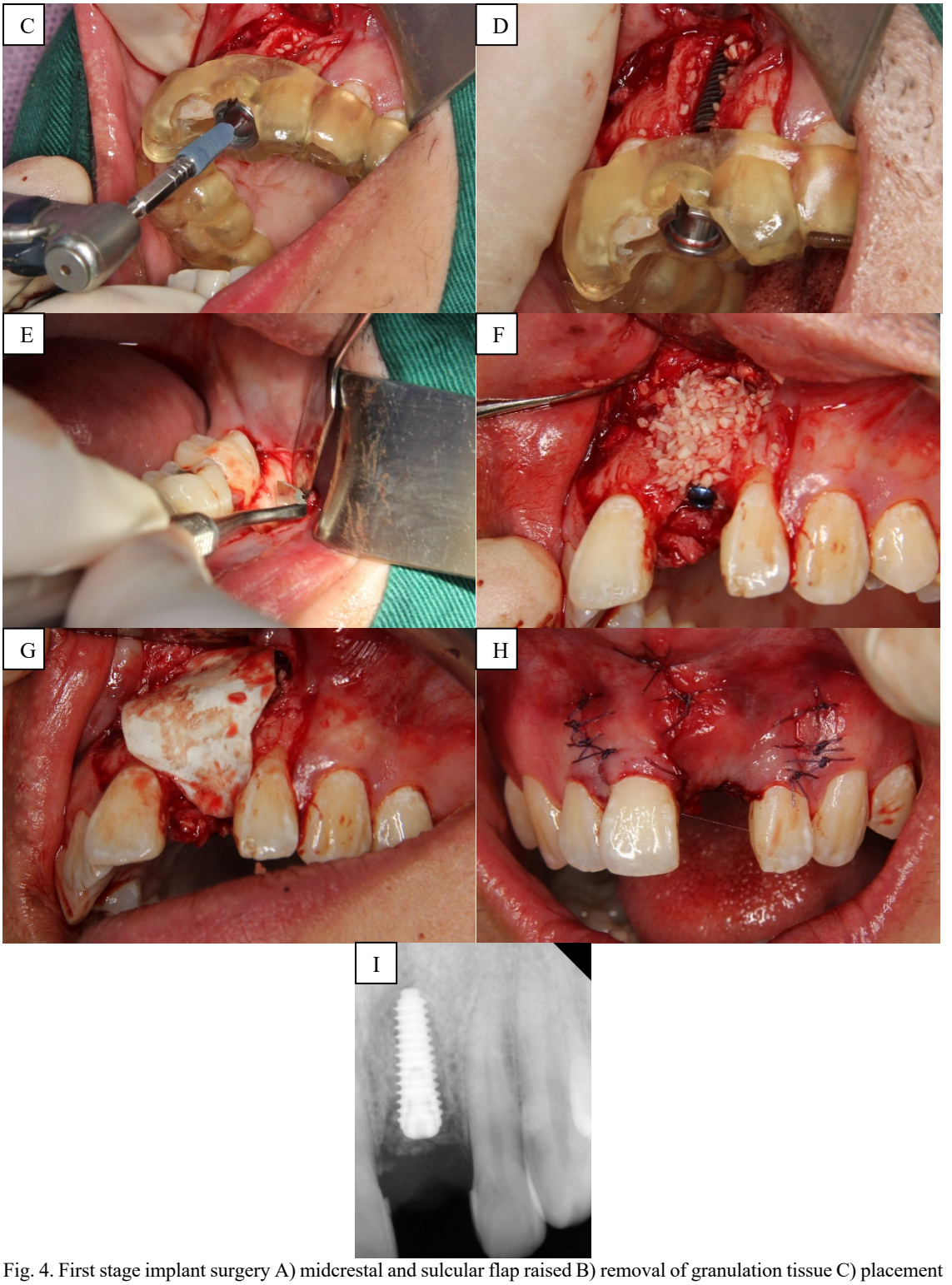

Fig. 4. First stage implant surgery A) midcrestal and sulcular flap raised B) removal of granulation tissue C) placement of implant fixture using the surgical guided D) Buccal bone defect E) autogenous bone harvested from the mandibular

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ramus F) placement of bone graft at defect site G) placement of resorbable collagen membrane H) suture closure I) An IOPA radiograph showed the position of the implant placement at 21 region.

2.3 Prosthetic Phase

Six months following implant placement, a second-stage surgery was performed to prepare the soft tissue for prosthetic restoration (Figure 5). An apically positioned flap was carried out to increase the width of keratinized tissue on the buccal aspect of site 21. During this procedure, the cover screw was replaced with a temporary abutment. A provisional crown was fabricated chairside using bis-acryl composite resin. This provisional restoration was carefully contoured to shape the peri-implant soft tissue and guide the development of a natural-looking emergence profile. The patient was reviewed monthly to assess soft tissue maturation (Figure 6). After two visits of adjusting provisional crown, an ideal emergence profile was achieved. Digital intraoral impression was captured using a scan body and a Shining 3D intraoral scanner. The implant-supported crown was designed using a computer-aided design (CAD) workflow in exocad DentalCAD 3.3 (Chemnitz, Germany). The digital design incorporated the definitive emergence profile, occlusal morphology, and proximal contacts based on the approved virtual wax-up (Figure 7). Upon completion, the design was reviewed and validated by the clinician to ensure optimal functional and aesthetic parameters. Milling was carried out using a DWX-53DC 5-axis milling unit (DGSHAPE, Japan), following the manufacturer's recommended milling strategies. After pre-sintered milling, the restoration underwent post-processing, including sprue removal, surface finishing, and characterization prior to clinical try-in. The definitive restoration was fabricated as a monolithic zirconia crown supported by a prefabricated titanium abutment. The final prosthesis demonstrated satisfactory aesthetic integration and functional stability, with healthy and well-contoured peri-implant soft tissues. However, there is a slight discrepancy in the gingival zeniths of the maxillary central incisors. While complete symmetry was not fully achievable, the outcome represents the best possible result given the pre-existing tissue anatomy and healing limitations. The patient expressed satisfaction with the aesthetic outcome, and the presence of an average smile line helped to mask minor gingival asymmetry during function and smiling, preserving overall harmony in the anterior aesthetic zone (Figure 8). The summary of treatment phase was illustrated in Table 1.

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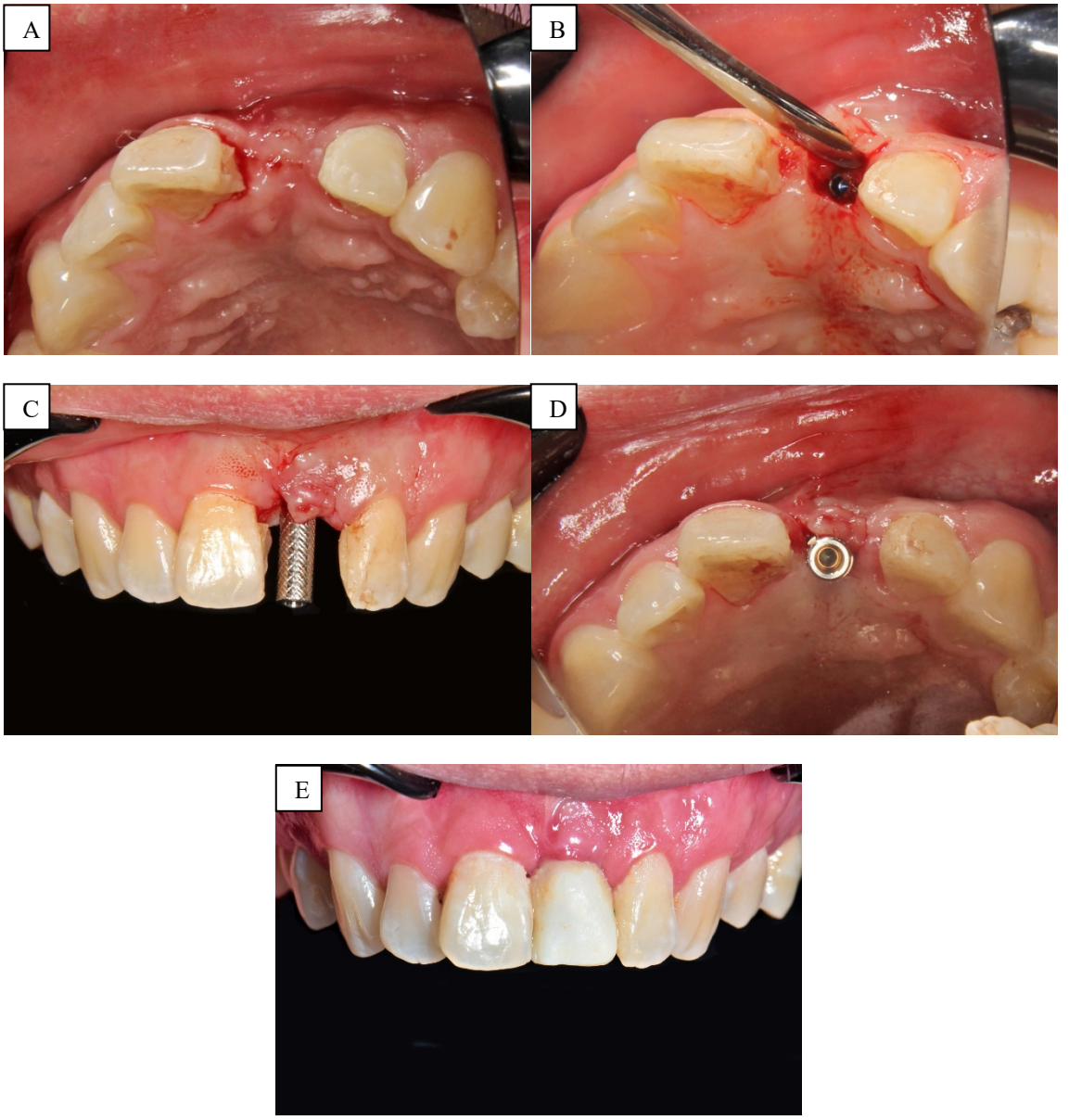

Fig. 5. Second stage surgery A) pre-operative B) apically positional flap C) placement of temporary abutment (frontal view) D) placement of temporary abutment (occlusal view) E) provisional restoration.

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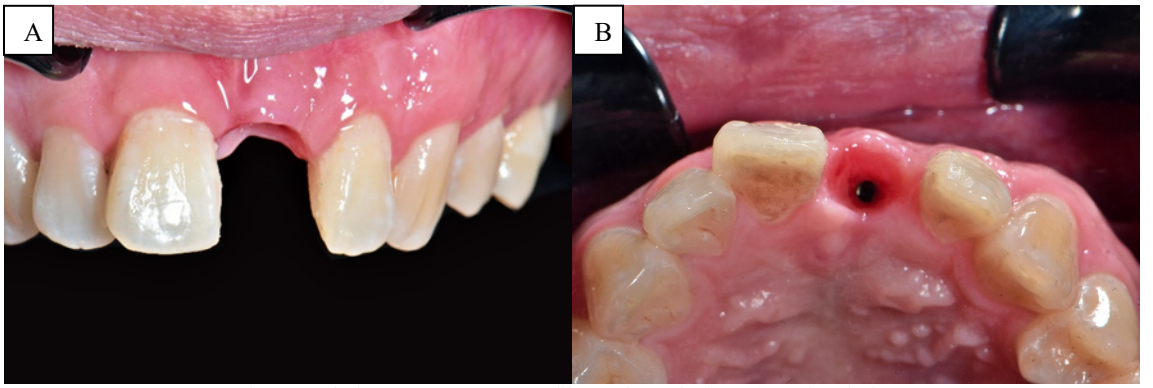

Fig. 6. Soft tissue emergence profile A) frontal view B) occlusal view.

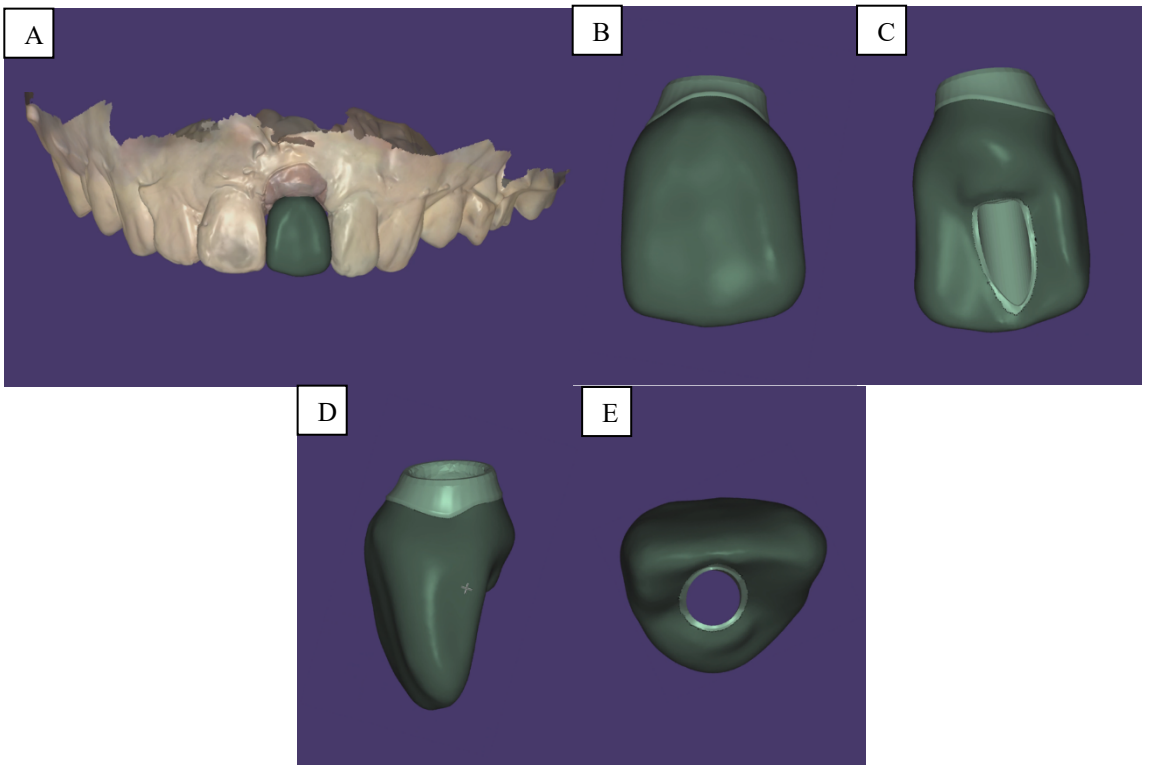

Fig. 7. Digital design of implant supported crown: A) Frontal view B) Facial side C) Palatal side D) Proximal side E) Occlusal side.

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Fig. 8. Post-operative assessment. A) frontal view B) Area of complaint C) Smile view D) 12 O'clock smile view E) An IOPA radiograph showed the Monolithic Zirconia Implant Crown is well seated to the implant.

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Table 1. Summary of treatment phase

Clinical Phase	Procedure
Diagnostic Phase	Clinical exam, IOPA, CBCT, digital planning, diagnostic wax-up
Extraction & Ridge Healing	Atraumatic extraction of 21, temporarization with fibre-reinforce bridge
Surgical Phase	Open flap surgery, implant placement (Ø 4.0 × 10 mm), bone grafting, sutures
Healing Phase	Six-month osseointegration and soft tissue healing with fibre-reinforce bridge as temporary restoration
Second-Stage Surgery	Apically positioned flap, replacement of cover screw with temporary abutment
Provisionalization	Chairside fabrication of bis-acryl temporary crown to contour soft tissue
Final Prosthesis	Digital impression, computer-aided design (CAD) and computer-aided manufacturing (CAM), zirconia crown delivery on prefabricated abutment

3. DISCUSSION

Management of anterior maxillary tooth loss is particularly challenging due to the critical importance of aesthetics, soft tissue harmony, and underlying bone architecture (Gamborena & Blatz, 2014; Ioannou et al., 2015). In this case, tooth 21 exhibited reinfection following previous endodontic treatment and was deemed unrestorable due to extensive loss of coronal structure and the absence of a ferrule (Jotkowitz & Samet, 2010). In this context, it is important to consider how reinfection may affect the architecture of both bone and soft tissue. Such alterations can have a significant impact on the aesthetic outcome of the prosthesis and may explain why the final soft tissue result was only satisfactory. Changes in peri-implant hard and soft tissue contours are known to compromise aesthetic predictability, particularly in the anterior region (Buser et al., 2004; Belser et al., 2009). CBCT confirmed insufficient alveolar ridge width, highlighting the need for bone augmentation to support future implant placement (Zhang et al., 2015). To avoid the potential aesthetic and biological compromises of immediate implant placement, an early implant placement approach was chosen. This strategy typically performed 4–16 weeks after extraction, allows partial socket healing and soft tissue maturation while minimizing further ridge resorption (Buser et al., 2017). Studies have shown that early placement strikes a balance between the benefits of immediate intervention and the stability of delayed protocols, providing improved predictability in the aesthetic zone (Bassir et al., 2019).

The use of a 3D-printed surgical guide, designed through digital planning and wax-up, ensured prosthetically driven implant placement (Abad-Coronel et al., 2024). This approach enhances the accuracy of implant positioning, particularly in terms of depth, angulation, and mesiodistal spacing parameters essential to achieving an ideal emergence profile and preserving interproximal papillae (Gervyte et al., 2023). Proper implant positioning also plays a crucial role in facilitating primary stability, a key factor in successful osseointegration and long-term survival (Javed et al., 2013). Simultaneous bone augmentation using autogenous bone combined with a xenograft and a resorbable membrane addressed the horizontal ridge deficiency effectively (Nagaraj et al., 2024). This technique not only allowed for optimal implant placement within available bone but also promoted favourable soft tissue outcomes and reduced the need for staged grafting procedures (Nagaraj et al., 2024; Mittal et al., 2016). The use of an apically positioned flap during second-stage surgery further improved the width of keratinized tissue, contributing to long-term peri-implant health (Reddy et al., 2013).

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Temporarization following tooth extraction and early implant placement in the aesthetic zone presents a significant clinical challenge, as the temporary restoration must satisfy aesthetic demands while avoiding mechanical or biological interference with soft and hard tissue healing. In the present case, immediate placement of a conventional provisional crown was contraindicated due to the need for simultaneous bone augmentation and the risk of pressure on the grafted site, which could compromise wound stability and osseointegration (Buser et al., 2008). Therefore, a fibre-reinforced composite resin bridge (FRB) was selected as an interim prosthesis, as it provides a fixed, minimally invasive, and tissue-passive solution without transmitting occlusal forces to the surgical site. The FRB incorporated a hygienic pontic design, which was critical in preventing contact with the healing mucosa and facilitating plaque control during the early healing phase. Compared with removable partial dentures or flipper prostheses, which are associated with mucosal loading, patient discomfort, and increased risk of graft disturbance, the FRB offers superior stability, patient acceptance, and protection of the surgical site. Adhesive retention to adjacent teeth further eliminates the need for additional preparation and allows easy modification or removal as soft tissue maturation progresses (Goguta et al., 2019). Following implant placement, the FRB was maintained throughout the osseointegration period until second-stage surgery at 6 months. During this time, no implant-supported provisional crown was provided to avoid micromovement and mechanical stress at the implant–bone interface. This staged approach allowed undisturbed healing, predictable graft maturation, and preservation of peri-implant soft tissue architecture (Venet et al., 2017). Subsequently, soft tissue contouring was further refined through provisionalization with a bis-acryl temporary crown after implant uncovering, enabling controlled emergence profile development prior to definitive restoration.

The fabrication of a provisional prosthesis is especially critical in the aesthetic zone, where peri-implant soft tissues are highly scalloped and responsive to prosthetic guidance. Provisional restorations serve not only to replace missing teeth temporarily but also to shape the emergence profile, guiding the contour of the mucosal margin and interproximal papillae (Kouveliotis et al., 2024). The transition zone, spanning from the implant platform to the mucosal margin, is particularly sensitive to pressure and shape exerted by the provisional prosthesis. By carefully designing the provisional's contours, clinicians can apply controlled tissue support that promotes optimal soft tissue adaptation, preserves interdental papillae, and facilitates hygienic maintenance (Sun & Chang, 2024). This approach enables the laboratory to fabricate the definitive restoration with an emergence profile that maintains both function and aesthetics while minimizing the risk of tissue recession.

The screw-retained monolithic zirconia implant restoration achieved functional stability and satisfactory aesthetic integration. However, a slight greyish hue was observed on the implant crown, reflecting a common limitation of all-ceramic prostheses over metallic abutments. The inherent translucency of ceramic materials can allow the underlying metal to show through, potentially compromising aesthetics, particularly in the anterior region (Peng et al., 2017). Several strategies can mitigate this effect, such as the use of an opaque porcelain layer between the abutment and veneering ceramic, selection of an opaquer zirconia core, or application of veneering glass ceramics with color-modifying dentin or enamel layers. Each approach aims to mask the metallic abutment while maintaining a lifelike translucency and shade match with adjacent teeth (Parushev et al., 2023). Careful shade selection, core design, and layering techniques are therefore critical when restoring implants with metal abutments in the aesthetic zone to achieve optimal aesthetic outcomes.

Beyond the clinical and radiographic outcomes, the patient's perspective played an important role in evaluating treatment success. The patient reported high satisfaction with the final prosthesis and expressed positive feelings regarding the improved appearance and confidence gained following treatment. Such patient-reported outcomes reinforce clinical findings and highlight the overall progress achieved through a comprehensive, digitally guided, and patient-centred approach to implant rehabilitation. This case illustrates how a multidisciplinary approach, including digital planning, guided surgery, simultaneous augmentation, and careful soft tissue management can lead to successful implant rehabilitation even in anatomically and aesthetically demanding scenarios.

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4. CONCLUSION

This case highlights the successful rehabilitation of a compromised anterior maxillary tooth using a digitally guided, prosthetically driven treatment approach. Early implant placement, combined with simultaneous bone augmentation and soft tissue management, provided a predictable solution in the aesthetic zone. The integration of digital planning, surgical precision, and thoughtful provisionalization facilitated ideal implant positioning, emergence profile development, and optimal aesthetic outcomes. This multidisciplinary protocol demonstrates that even in cases of inadequate ridge dimensions and complex soft tissue considerations, a digitally assisted workflow can support long-term functional success and high patient satisfaction.

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CONFLICT OF INTEREST

The author declares no conflict of interest in the publication of this case report.

AUTHORS' CONTRIBUTIONS

Mohd Khairul Firdaus Mazlan (main and corresponding author) conceived the work, acquired and curated the clinical data, drafted the manuscript, and led all subsequent revisions and submission processes.

Evelyn Able Padtong contributed to critical revision of the manuscript, supervised the guided bone regeneration procedure, and provided expert clinical input related to the surgical aspect of the case.

Muhammad Amal Abd Wahab and **Ammar Yaseer Abdul Hakim @ Abdul Khakin** contributed to manuscript revision, provided substantive intellectual input, and were responsible for the digital design and fabrication of the prosthesis using CAD/CAM technology.

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5. APPENDIX

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