International Journal of Dental Research and Allied Sciences
2025, Volume 5, Issue 1, Page No: 13-20

Available online at: www.tsdp.net

ISSN: 3062-3502

Original Article

Prompt Implant Placement Using a Fully Digital Approach for Central Incisor Replacement

Clement G Yedjou[1], Iokasti Papathanasiou[2], Constantine J. Oulis[2], Eugenia Grivakou[2*]

[1] Department of Restorative Dental Sciences, College of Dentistry, University of Florida, Gainesville, FL 32610, USA.
[2] Independent Researcher, 11527 Athens, Greece.

***E-mail** ✉ Eugenia.grivakou@hotmail.com

Received: 04 November 2024; **Revised:** 24 January 2025; **Accepted:** 27 January 2025

ABSTRACT

Replacing a maxillary central incisor with immediate implant placement can be a challenging clinical task. This case report outlines a comprehensive digital approach used for a 35-year-old male patient who sustained a horizontal root fracture following a sports injury. The treatment plan incorporated digital implant planning, a minimally invasive tooth extraction, computer-assisted implant placement, soft tissue enhancement, and provisional restoration to shape the gingiva. The process started with a CBCT scan and a treatment consultation, where the patient opted for an implant. A 3D-printed surgical guide ensured precise implant placement, followed by a soft tissue graft to improve the gum contour. A provisional restoration was used to support and shape the peri-implant tissues. After healing, a final digital impression was taken, and a screw-retained all-ceramic crown was fabricated. This digital workflow allowed for precise planning and seamless execution of the implant procedure, leading to a functional and aesthetic result while minimizing treatment time. The case demonstrates that successful immediate implant placement in the aesthetic zone demands careful planning and execution, with advanced digital tools playing a crucial role in achieving favorable results.

Keywords: Immediate implant placement, Digital workflow, CAD/CAM, Scanners

How to Cite This Article: Yedjou CG, Papathanasiou I, Oulis CJ, Grivakou E. Prompt Implant Placement Using a Fully Digital Approach for Central Incisor Replacement. Int J Dent Res Allied Sci. 2025;5(1):13-20. https://doi.org/10.51847/crAWBLAKpP

Introduction

Dental injuries can occur in individuals of all ages and genders, making them a significant global concern. Studies suggest that approximately 900 million people worldwide have experienced trauma to their permanent teeth [1]. Annual rates of dental injuries are around 4.5%, with a significant proportion of children and adults affected [2]. Maxillary central incisors are particularly vulnerable, as they are located at the front of the mouth and account for more than half of all dental trauma cases [3, 4].

Restoring maxillary anterior teeth is particularly challenging since even small defects are highly noticeable. Factors such as the smile line, gingival exposure, tooth spacing, and symmetry must be carefully assessed to ensure aesthetic results [5-7]. When a tooth is deemed irreparable, more complex treatment options, such as implants combined with fixed or removable prosthetics, may be necessary [8, 9].

Dental implants are an excellent solution for replacing damaged teeth in the aesthetic zone. They can be placed immediately after extraction, following an early placement protocol (within 1 to 2 months), or through a delayed placement approach (after 2 months). The timing of loading the implant also follows these classifications [10]. Several factors, including the

patient's health, habits, site management, bone quality, healing rates, and implant positioning, influence the timing of implant placement [11, 12]. Immediate implant placement has shown excellent success rates—96% after five years in posterior regions and 95.5% in anterior areas [13, 14].

Digital workflows have revolutionized implant planning, allowing for faster and more consistent restorations [15]. Many patients also prefer these modern methods over traditional ones [16]. Current technology, such as CBCT and intraoral scanners, aids in three-dimensional planning and the creation of precise surgical guides. Studies have demonstrated that digital guides are more accurate than traditional thermoplastic ones [17].

Replacing a single tooth in the aesthetic zone with an immediate implant poses challenges, as numerous factors must be considered to ensure predictable results. This case report details all the steps involved in the planning and execution of an immediate implant replacement for a compromised maxillary central incisor using a fully digital workflow to achieve optimal results for both the clinician and patient.

Materials and Methods

A 34-year-old male patient presented with a complaint of "loose front crown" following recent trauma during a soccer game. The patient did not report any pain, and his medical history was unremarkable, classifying him as ASA type I. On clinical examination, the patient had a ceramic crown on tooth #21 with Miller's mobility class II and incisal wear on tooth #11. The alignment of the upper anterior teeth was slightly asymmetrical. Periodontal assessment indicated healthy gums with a thick biotype, and the patient maintained good oral hygiene with bi-annual dental cleanings.

A CBCT scan revealed a metal post in the maxillary right central incisor with a horizontal root fracture just below the crown margins, making the tooth non-restorable **(Figure 1)**.

Figure 1. Initial presentation: Intraoral scans (A) frontal, (B) right and (C) left views, (D) periapical radiograph, (E) interproximal CBCT view showing the fractured root, (F) frontal view

The patient was provided with a variety of potential treatment options, including implant placement, a fixed dental restoration supported by adjacent teeth, or a removable partial denture. Other possibilities, such as crown lengthening to modify the gum contours, veneers across the upper canines, or a direct resin composite restoration for the right central incisor to address wear, were also discussed. The patient chose to proceed with direct resin composite for the right central incisor and opted for an implant to replace the left central incisor. A digital impression was taken using an intraoral scanner (Medit i600, Seoul, South Korea) and merged with the previous CBCT data to create a precise surgical plan (MSOFT, MIS Dental Implants, Misgav, Israel). A 3D-printed surgical guide and provisional restoration guide were designed and printed using biocompatible resin (Keyguide Keyprint, Keystone Industries, Gibbstown, NJ, USA) **(Figure 2 and 3)**.

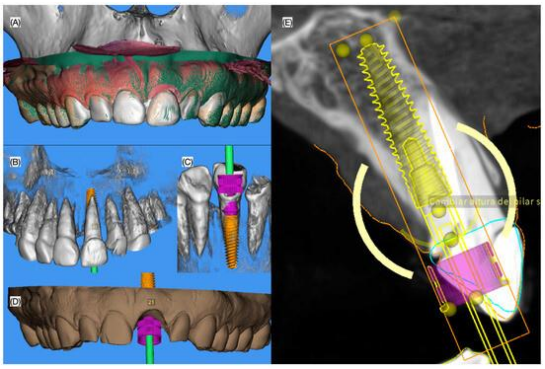

Figure 2. Implant surgical planning in 3D. (A) Overlay of intraoral scan on CBCT image, (B) frontal and (C) lingual views of the proposed implant position, (D) frontal view without the existing tooth, (E) interproximal view for planning

Figure 3. Design of surgical and provisional guides. (A) Frontal and (B) incisal view of surgical guide, (C) and (D) seating guide for provisional restoration with and without the maxillary arch, (E) incisal, (F) frontal, and (G) lingual views of the provisional restoration design

A provisional restoration was 3D printed (NextDent C&B Micro Filled Hybrid, NextDent, Soesterberg, Netherlands), and a 3D model of the maxilla was also created. The tooth extraction was performed with minimal trauma, using forceps to ensure the preservation of the cortical plates. After cleaning and irrigating the extraction site, an implant (MIS C1 3.75 × 16 mm, MIS Dental Implants, Misgav, Israel) was placed using the 3D-printed guide **(Figure 4)**.

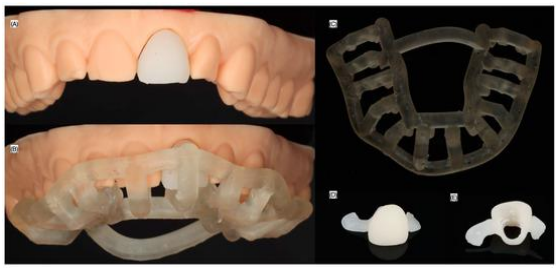

Figure 4. Interim restoration and seating guide. (A) Interim restoration applied to a 3D-printed model, (B) guide placed on model, (C) occlusal view of guide and interim restoration, (D) and (E) frontal and lingual views of interim restoration

After achieving primary stability, the 3D-printed provisional restoration was secured to the implant with flowable composite and a polyetheretherketone (PEEK) abutment (Direct Temporary Abutment, MIS Implants, Misgav, Israel), keeping the restoration free of occlusal contact to prevent overload **(Figure 5)**. A connective tissue graft was harvested from the palate and placed on the facial aspect to enhance the gingival contour. Additionally, xenograft material (Geistlich, Bio-Oss, Wolhusen, Switzerland) was used to fill the gap between the implant and buccal bone.

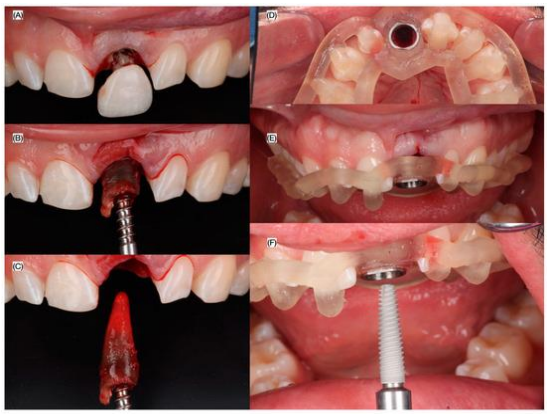

Figure 5. Tooth extraction and implant placement procedure. (A) Removal of fractured crown, (B) initial and (C) final root removal, (D) occlusal view of 3D-printed guide, (E) frontal view during implant placement

Follow-up visits were scheduled at 24 hours, 1, 2, and 4 weeks, and again at 2 and 3 months after surgery. At the 3-month visit, a new provisional restoration was placed to finalize the gingival contour. A final digital impression (Medit i600, Seoul, South Korea) was taken during the 4-month visit, along with intraoral photos (Nikon D7500, Nikon, Tokyo, Japan) for shade matching (Figure 6, Figure 7, and Figure 8).

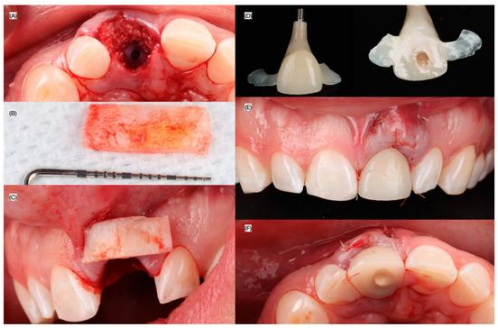

Figure 6. Grafting and interim restoration. (A) Incisal view post-bone grafting, (B) size of connective tissue, (C) intraoral assessment of connective tissue for placement, (D) facial and lingual views of screw-retained interim restoration, (E) frontal view, (F) incisal view

Figure 7. Follow-up evaluation. (A) Periapical radiograph at 4 months, (B) frontal view with and (C) without provisional restoration, (D) incisal view without provisional restoration

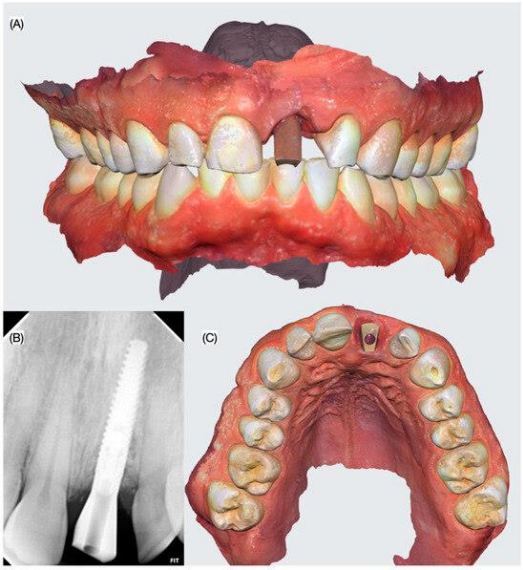

Figure 8. Final digital impression. (A) Frontal view, (B) periapical radiograph, (C) incisal view of scan body used for impression

A layered zirconia crown (Prettau 5 Anterior Disperse, Zirkonzahn GmbH, Gais, Italy) was fabricated and attached with cement (Panavia V5 LC, Kuraray Noritake, Tokyo, Japan) to a titanium-based abutment (Ti-Base, MIS Implants, Misgav, Israel). After placing the restoration, nano resin composite (Clearfill AP-X-ES-2, Kuraray, Tokyo, Japan) was applied to the incisal edge to match the length of the implant restoration. The patient was pleased with the final result, which included the shape, contour, and shade of both the crown and the resin composite restorations **(Figure 9)**.

Figure 9. Intraoral photos for shade-matching. (A) White calibration card and (B) shade tabs, along with cross-polarized images (C) white calibration card and (D) shade tabs

Upon delivery of the final restorations, the patient was given an occlusal guard for nighttime use to protect the work **(Figure 10)**.

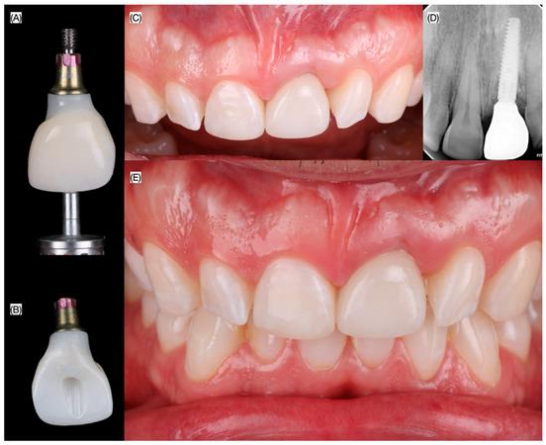

Figure 10. Final restorations. (A) Screw-retained provisional implant, (B) lingual view before placement, (C) intraoral frontal view, (D) radiograph, (E) frontal intraoral photograph of occlusion

At the 3-year follow-up, both the implant and resin composite restorations were stable, and the patient was very satisfied with the aesthetic outcomes **(Figure 11)**.

Figure 11. Follow-up evaluation of the restorations

Results

Selecting an immediate implant to replace a failed tooth in the aesthetic zone requires thorough clinical evaluation. The first step involves using a CBCT scan to examine the bone quantity on both the buccal and lingual sides of the socket. This helps in determining the appropriate size of the implant, including its width and length, to ensure the best fit for the clinical situation. After the digital planning stage, a surgical guide is created to assist with the accurate placement of the implant according to the plan. To prevent gum recession and preserve tissue volume around the implant, soft tissue grafting is performed at the time of placement. Additionally, a provisional restoration is applied, which facilitates the development of the surrounding gingival architecture and establishes an emergence profile that integrates well with the adjacent teeth.

In this case, the digital workflow allowed for the precise creation of the implant restoration, ensuring that the width and length matched the neighboring teeth—this is particularly crucial when restoring a single central incisor. The patient was satisfied with the final result, and during the follow-up after three years, both the restoration and surrounding tissues continued to meet the patient's functional and aesthetic expectations. The workflow steps involved in this digital process are summarized in **Figure 12**.

Figure 12. Overview of the steps in the treatment workflow

Discussion

The implant approach used in this case successfully replaced the fractured, irreparable maxillary right central incisor. Using 3D imaging, we were able to assess the available bone and plan the implant placement with high precision. The tooth extraction was performed with minimal trauma to preserve the surrounding bone structure, thus providing a favorable prognosis for implant placement. The use of soft tissue grafting along with the implant procedure helped prevent gum recession, maintaining the ideal tissue contours. Recommendations for clinical conditions that lead to successful outcomes are summarized in **Table 1** [18-20].

Table 1. Summary of systematic reviews on the outcomes of immediate implant placement and loading protocols [18-20]

Investigators and Year	Research Method	Primary Results
Lang *et al.* (2012) [18]	Independent researchers conducted a literature search across academic repositories, focusing on English-language studies from 1991–2010. Included were human trials with endosteal implants and follow-up periods exceeding 12 months, assessing implant durability, complications, and tissue changes.	Immediate implants had an annual failure rate of 0.82%, yielding a 2-year survival rate of 98.4%. Groups receiving antibiotics post-surgery showed lower failure rates. Tissue alterations were most evident in the first 3 months post-restoration, stabilizing by year's end. Bone resorption around implants occurred mainly in the first year, typically under 1 mm.
Gallucci *et al.* (2018) [19]	A detailed search of major scholarly databases examined outcomes of various implant insertion and loading approaches. Studies included human trials with endosteal implants (3–6 mm diameter), at least 10 cases, and a minimum 12-month observation period. Survival rates were weighted by follow-up duration and implant quantity.	Protocol 1A (immediate insertion with immediate restoration/loading) achieved a 98% survival rate (median 100, range 87–100%), a well-established method. Protocol 1B (immediate insertion with early loading) also had a 98% survival rate (median 100, range 93–100%), clinically validated. Protocol 1C (immediate insertion with standard loading) recorded a 96% survival rate (median 99, range 91–100%), supported by scientific and clinical evidence.
Chen *et al.* (2024) [20]	Two independent reviewers searched academic databases from January 2000 to March 2022. A meta-analysis using statistical tools evaluated implant survival,	Implant survival reached 98.1%. Bone resorption measured 1.03 mm at 6 months, 1.15 mm at 12 months, and 1.15 mm at ≥24 months. Gum recession was 0.25

bone resorption, and aesthetic outcomes for implants in the cosmetic zone.	mm at 12 months. Aesthetic scores (PES) were 12.34 at 12 months and 12.58 at ≥24 months.

The literature supports the efficacy of immediate implants, with a systematic review of single immediate implants showing a survival rate ranging from 83.7% to 100%, based on studies with at least a 12-month follow-up. Common causes of failure included infection, implant mobility post-loading, and procedural complications [21]. A recent in vivo trial placed 20 immediate implants in the aesthetic zone, following up at one, three, and six months. The study found a high success rate at one and three months, but three implants showed mobility at six months. Most patients reported high satisfaction, leading the researchers to conclude that immediate implants in the aesthetic zone have a high success rate and good patient acceptance [22]. This evidence guided the decision to proceed with immediate implant therapy in this case.

Additionally, soft tissue grafting has been shown to enhance outcomes when used in conjunction with immediate implants. A recent systematic review and meta-analysis, which included 9 randomized controlled trials, concluded that using bone and soft tissue grafting techniques alongside immediate implant placement prevents excessive tissue loss, improves bone stability, and achieves better aesthetic results [23]. Furthermore, a 5-year study comparing immediate implants with and without connective tissue grafting showed that implants with grafting experienced fewer tissue changes (−0.4 to 0.5 mm) than those without grafting (−1.1 to −0.1 mm). The study confirmed that soft tissue grafting helps maintain stable peri-implant tissues and improves the aesthetic outcome over time [24]. Based on these findings, soft tissue grafting was incorporated into the treatment plan in this case study to optimize both functional and cosmetic results.

The entire digital workflow presented in this clinical report involved obtaining a final impression in the front region using an intra-oral scanner. A recent systematic review explored the precision of digital implant impressions in clinical research. Initially, 6255 studies were identified, from which 974 were screened. Out of these, 54 studies were considered eligible, but ultimately only 8 were included. The review concluded that the precision of modern intra-oral scanners for capturing digital implant impressions in patients is clinically acceptable [25]. Impressions taken from the anterior area were also found to have superior accuracy compared to other regions, regardless of the clinician's expertise. Another study investigated how both the scanning site and the operator influenced the precision of dentate arch scans with a single implant. The study involved scanning a dentate model with an anterior implant, using a laboratory scanner as the benchmark, with three different operators performing both complete and partial arch scans. The results revealed that the precision and accuracy were higher in the anterior region compared to the posterior. It was concluded that accuracy was greater in the anterior region, irrespective of whether the scan was partial or complete, and that the operator's impact on scan precision was minimal [26].

In this case study, a platform-switching implant was used, known to offer favorable biological outcomes such as reduced bone and tissue loss when compared to conventional platform designs. A randomized clinical trial assessed soft tissue healing around single implants, comparing platform-switching implants with traditional platform-matching implants. The study involved eighteen participants and included follow-up evaluations of healing at one, two, four, six weeks, and eight months. The results highlighted that platform-switching implants provided benefits over traditional ones, notably with lower bleeding upon probing [27]. A comprehensive review and meta-analysis also examined platform-switching implants and their effect on bone preservation. The analysis, which included randomized clinical trials and prospective studies, found that platform-switching implants were associated with less bone loss than regular implants [28]. Based on these documented advantages, the implant used in this clinical report was a platform-switching type.

The temporary restoration was made using polyetheretherketone (PEEK), a material that has shown favorable results in various areas of dentistry. PEEK is recognized for its biocompatibility and for its mechanical properties, which resemble those of bone, enamel, and dentin [29-31], making it an ideal choice for restorations. Studies on PEEK implant abutments have indicated that there is no significant difference in terms of bone resorption or soft tissue inflammation when compared to titanium implant abutments [32]. Additionally, the adhesion of oral bacteria to PEEK abutments has been found to be similar to that observed with titanium, zirconia, and polymethylmethacrylate abutments [33]. Based on these advantages, PEEK was chosen for creating the implant abutment.

This case study has some limitations. A key drawback is its low level of evidence, as it relies on a single case report. Additional clinical studies are necessary to compare the results of immediate implants with and without soft tissue grafting. Moreover, upcoming

research should involve a broader range of intraoral scanner brands for capturing final implant impressions. Future studies should also aim to gather quantitative data on the outcomes of implant therapy, including monitoring bone loss over time, evaluating changes in peri-implant tissue related to the materials used, and assessing any modifications in ceramic restorations. Longer-term follow-up studies would provide more robust and reliable data on the treatment's long-term success.

Conclusions

Replacing a maxillary central incisor with an immediate implant and restoration is a proven and dependable method. However, to ensure a successful outcome, it is crucial to conduct a thorough evaluation, which should include reviewing the patient's medical and dental history, performing a 3D assessment, utilizing digital planning, placing the implant with the aid of a surgical guide, and providing a provisional restoration to shape the surrounding gum tissues appropriately.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

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