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A case report of full-mouth implant placement utilizing 3D-guided surgery

Sultan Alanazi

Department of Preventive Dental Sciences, Faculty of Dentistry, Najran University, Najran, Saudi Arabia

ABSTRACT

Dental implants are widely recognized as a dependable and cost-effective solution for replacing missing teeth. Achieving successful outcomes in modern implantology and prosthetics depends on rigorous diagnostic methods and diligent planning that meet the expectations of patients and dentists and leverage advancements in materials and digital technologies. The predictability and success rates of implant dentistry have significantly improved following the development of computed tomography, implant planning software, guided implant surgery techniques, and advanced materials. This report presents the case of a 54 year-old healthy male with partial tooth loss who received seven implants in the upper jaw and six in the lower jaw. Based on comprehensive Cone Beam Computed Tomography imaging, the treatment plan was devised to support a fixed prosthesis. Precise implant placement, guided by the treatment plan, addressed the optimal prosthodontic requirements while minimizing invasiveness through a flapless surgery approach. The landscape of rehabilitation practices is evolving due to the incorporation of computer-aided design in treatment planning and the increased application of computer-assisted manufacturing. Guided implant techniques have emerged as a means to mitigate the limitations associated with traditional methods. Compared to conventional approaches, guided implant surgery significantly improves implant placement precision by reducing chairside time, involves minimally invasive procedures, and augments predictability.

Keywords: dental implant; 3D CBCT; guided implant

INTRODUCTION

The introduction of computer-aided design and computer-assisted manufacturing (CAD/CAM) technologies has considerably impacted clinical dentistry, particularly in oral implantology. One recent in-novation is the implementation of three-dimensional (3D)-guided implant surgery [1,2]. Practitioners can strategically arrange implant placements within a virtual 3D representation generated from computed tomography (CT) data using specialized software that combines CAD/CAM technology and 3D CT scan images. This method enables medical professionals to design treatment plans considering prosthetic and anatomical factors. According to Lin et al. (2020), the innovative technique of integrating photographs, made possible by the development of digital technology and equipment, has expedited and cost-effectively streamlined the planning process. A computer program can perform direct intergation between dental surface images from a cone beam CT (CBCT) scan and those obtained from an optical scan of the dental model for patients with missing teeth. This technique also facilitates the creation of computerized images of missing teeth, simplifying implant planning using the same software. This technique aids in achieving high levels of precision in laboratory settings while avoiding errors in the creation and scanning of radiographic prostheses. While traditional impression techniques and plaster models remain available, they require extra time and cost.

The computer-guided stereolithographic procedure generates a surgical template based on implant lo-cation information. This template enables physicians to place implants in preset positions without the need for flap elevation [3,4]. The benefits include minimal invasiveness, precise implant positioning,

Corresponding author:
Sultan Alanazi
E-mail: sul6an1055@gmail.com

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predictability, and reduced post-operative discomfort, which are inherent in 3D-guided implant surgical protocols. Furthermore, this protocol requires less recovery time than conventional implant placement techniques. In this procedure, healthcare professionals can carefully evaluate and leverage the available bone to achieve optimal clinical outcomes. This approach eliminates the need for bone grafts and the careful planning of their application. The presented case study demonstrates the use of computer-assisted diagnostics through 3D CBCT, virtual implant planning, stereolithographic surgical template creation, and dental implant placement using a surgical guide.

MATERIALS AND METHODS

A 54-year-old male patient, concerned about his missing upper and lower teeth, was referred to the periodontics clinic. The patient indicated a preference for fixed restorations and a desire to avoid using removable prosthetics while undergoing treatment. Vital signs were within normal ranges, and the patient's medical history indicated no significant factors that could impact dental procedures. A thorough clinical assessment (Figure 1) and radiographic examination (Figure 2) showed that the patient had partial tooth loss, compromised restorations, an inadequate occlusal plane, and a bilateral posterior support deficit. The remaining teeth showed unfavorable to extremely poor prognoses, presenting with widespread periodontitis classified as Stage IV Grade B, coupled with instances of caries and Miller's Class III mobility (Figures 1 and 2). Collectively, these indicated severe periodontal disease. The patient provided informed consent for the publication of his case particulars along with accompanying images.

Following an extensive discussion outlining the benefits, potential drawbacks, and alternative treatment options, the patient consented to proceed with fixed implant-supported restorations for both his upper and lower jaws. The researchers selected seven implants for the upper arch and six for the lower arch while considering the patient's unique anatomical characteristics, the planned design of the prosthesis, and the fundamental principles of biomechanical prosthodontics. The primary treatment goals were to reestablish adequate structure, functional capabilities, and aesthetic appeal while ensuring the patient's continued use of fixed prosthetic devices throughout treatment duration. Before the surgical treatment, the researchers obtained verbal and written consent from the patient.

FIGURE 1. Initial examination. Clinical presentation

Treatment Plan

The researchers extracted all teeth during the initial treatment phase and fabricated upper and lower full dentures. Radiographic guidance was employed during tooth extraction (Figures 3 and 4). Subsequently, a hybrid approach combining traditional and digital techniques was used to ensure precise implantation during surgery (Figure 5). Approximately eight weeks post-extraction, two CBCT images were imported into the Shape Implant Studio Software using the Digital Imaging and Communications in Medicine (DICOM) format. The first scan showed the patient's prosthesis in isolation, while the second showed the patient wearing the prosthesis. The software combined the scans to produce the final proposed treatment plan. This plan was relayed to a Formlabs 3D SLA printer, which generated a stereolithography file that acted

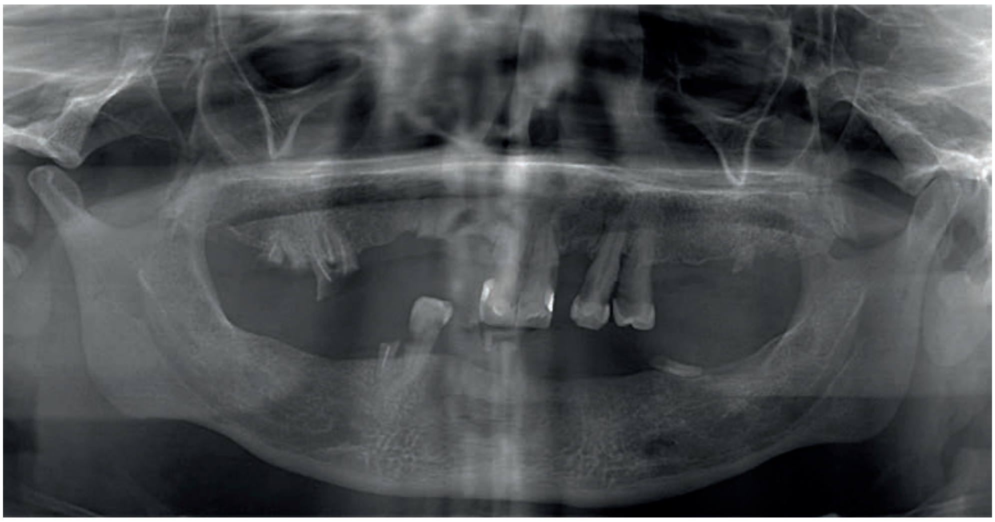

FIGURE 2. Initial examination. Radiographic presentation

FIGURE 3. Clinical presentation after full mouth extraction

as a surgical template (Figure 6). For the maxilla, a plan was formulated to place seven implants in positions corresponding to the central incisor, canines, first premolars, and first molars. The mandible was set to receive six implants, aligning with the canines, first premolars, and first molars.

Surgical Procedures

Once the accurate fitting of the surgical template within the oral cavity was confirmed, the implant procedure commenced per the specified protocol, leveraging the toolsets provided in the Straumann® Guided Surgery Cassette (Figure 7). The surgical

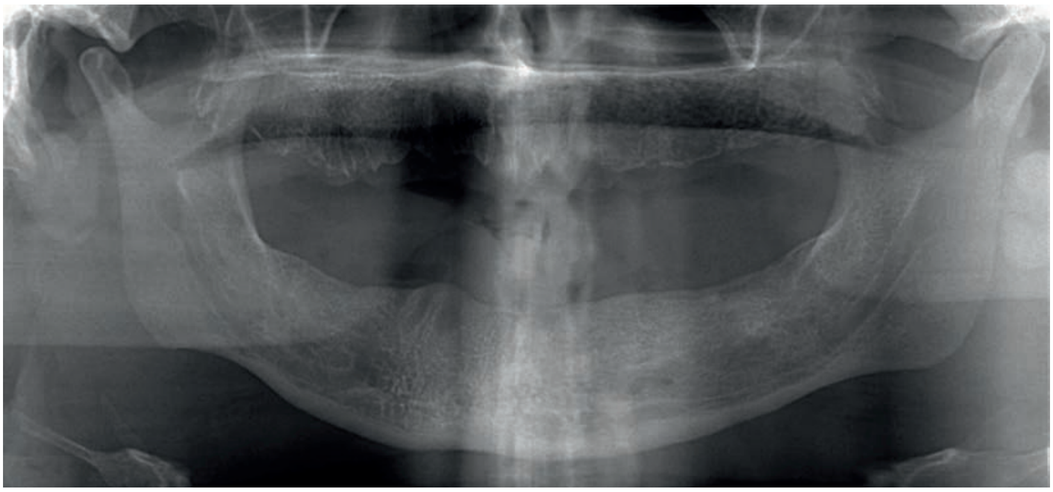

FIGURE 4. Radiographic presentation after full mouth extraction

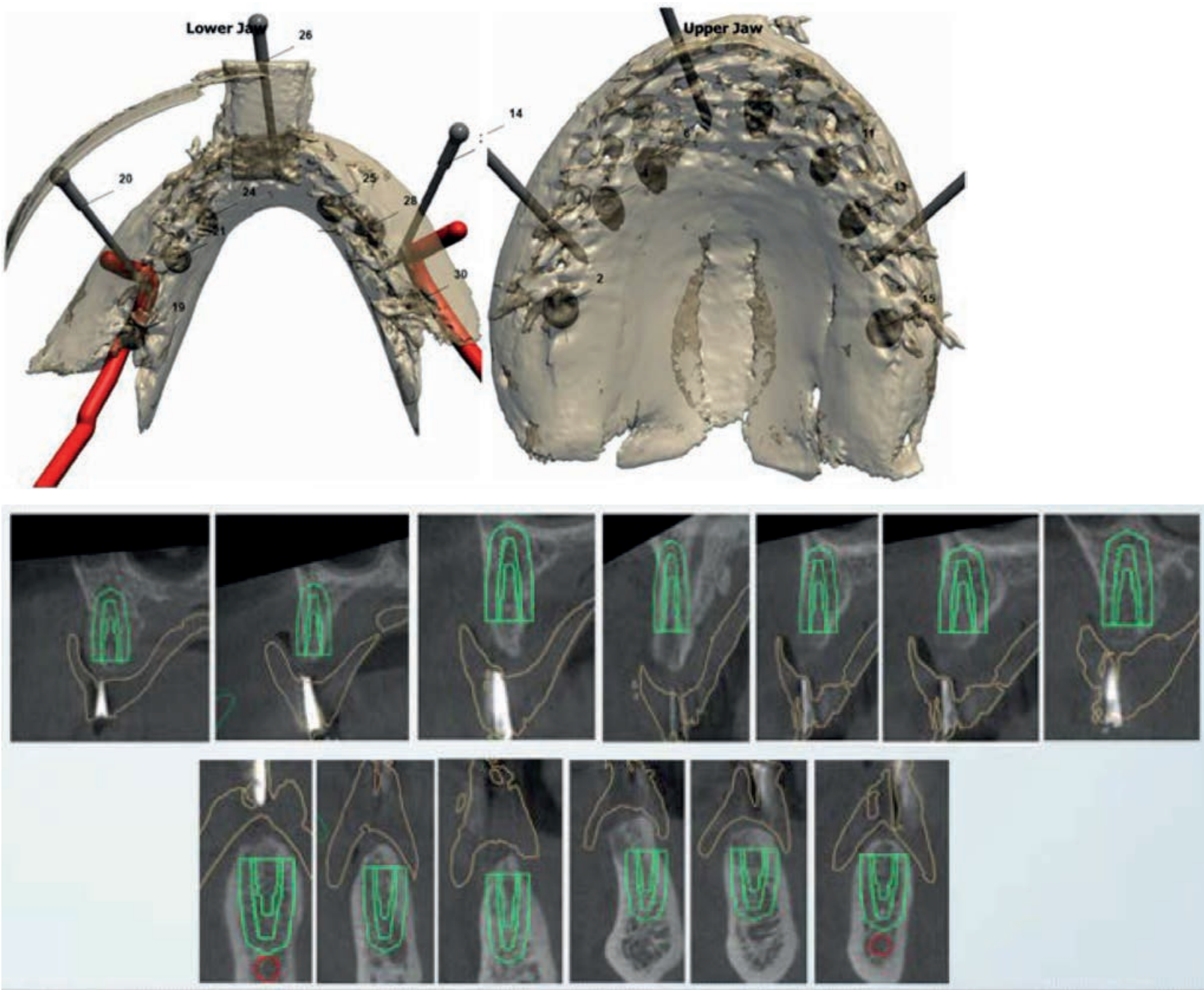

FIGURE 5. Integrated digital workflow for the guided implantation surgical intervention

FIGURE 6. Fabrication of the surgical template

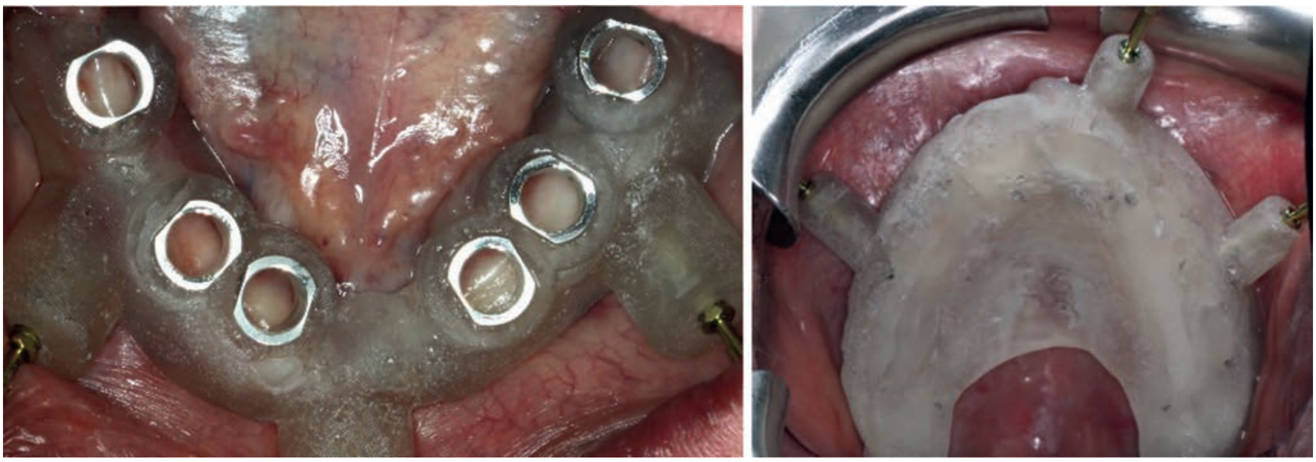

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FIGURE 7. (A) Intraoral confirmation of the lower surgical template fit. (B) Intraoral confirmation of the upper surgical template fit

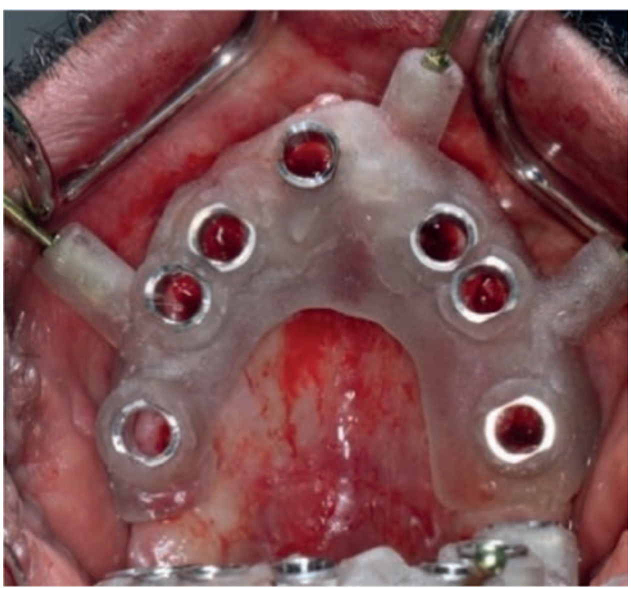

FIGURE 8. The surgery was initiated with a mucosa punch

protocol included the surgical template and specified the exact sequence of instruments required for preparing each implant site. The surgical procedure began with using a mucosa punch under local anesthesia, enabling blade-free incision and minimizing trauma (Figure 8). The foundational preparation of the implant bed proceeded in line with the recommended sequence laid out in the surgical protocol (Figure 9).

The surgical protocol ensured the accurate preparation of the osteotomy sites per the predetermined plan. Thirteen Straumann bone-level tapered Roxolid® SLA implants were successfully inserted following flapless implant bed preparation. The sequence began with the maxillary arch, where a range of implant sizes were employed: 3.3 mm NC, SLA 10 mm, Roxolid, Loxim for the central incisor, canines, and first premolars region, and 4.1 mm RC, SLA 10 mm, Roxolid, Loxim for the first molars region (Figure 10). The treatment then transitioned to the mandibular arch, where a similar approach using implants of different dimensions: 3.3 mm NC, SLA 10 mm, Roxolid, Loxim for the canines and first premolars region, and 4.1 mm RC, SLA 10 mm, Roxolid, Loxim for the first molars region. Healing abutments were affixed post-implantation, eliminating the need for sutures to close the soft tissues overlying the implant sites. A radiograph was captured post-surgery to confirm precise adherence to the intended implant positioning (Figure 11). The following day, the patient returned for a follow-up appointment. No indications of pain, edema, or any post-surgical complications were noted.

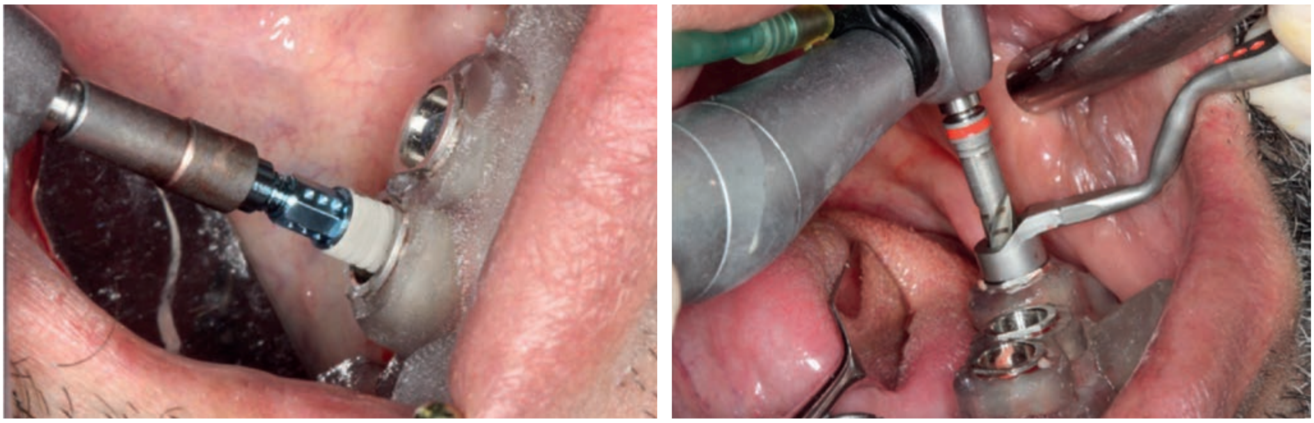

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FIGURE 9. (A) Basic implant bed preparation was performed in the recommended sequence. (B) Implant placement

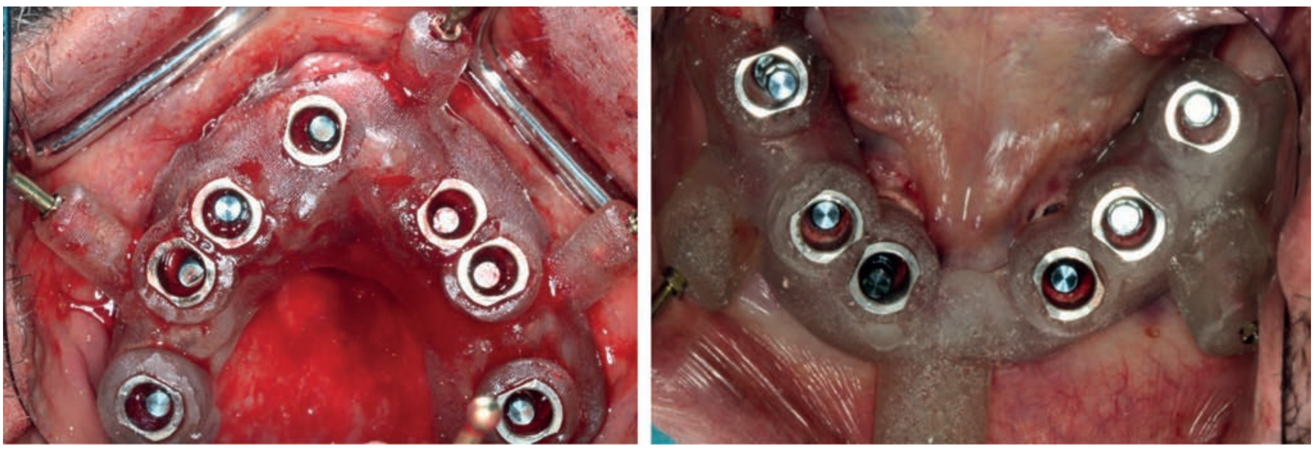

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FIGURE 10. (A) Placement of seven implants in the maxillary arch. (B) Placement of six implants in the mandibular arch

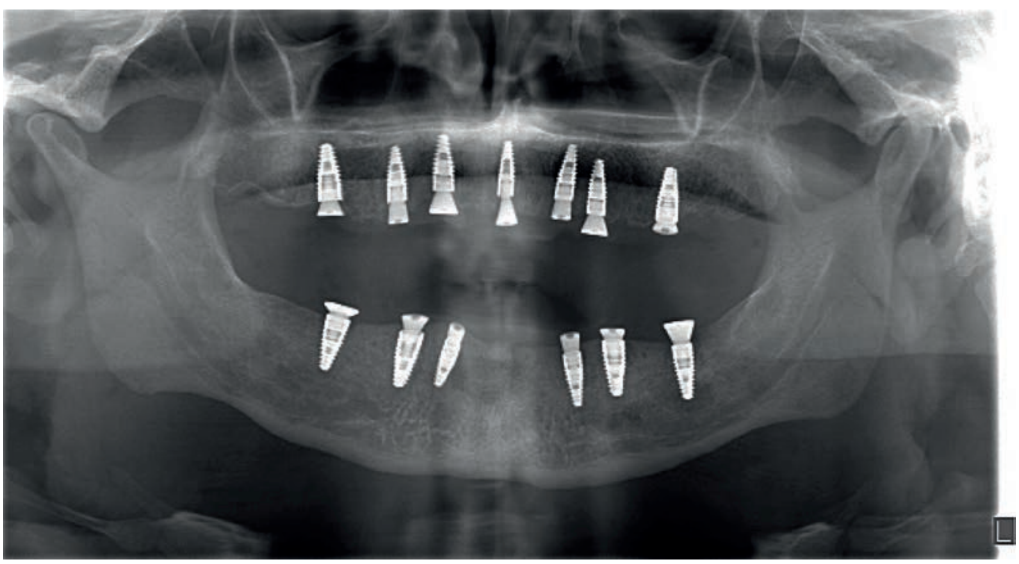

FIGURE 11. Post-surgical panoramic radiograph after the placement of all implants

A post-operative evaluation was conducted three months after the initial surgery. This marked the onset of the next phase, which involved the second stage procedures. After one month in this phase, the cover screw was replaced by healing abutment. A prosthodontist was engaged to fabricate a variety of implant-supported, screw-retained dental prostheses. These included a full denture supported by implants spanning from #16 to #26, a partial denture supported by implants from #36 to #34, a second partial denture supported by implants spanning from #33 to #43, and a concluding partial denture sup-ported by implants from #44 to #46 (Figures 12–16).

DISCUSSION

In this case, a comprehensive approach encompassing extensive extractions, virtual implant planning, and computer-assisted surgery was employed to facilitate the placement of full-mouth implants. Guided implant surgery, an innovative technique designed to expedite dental implant insertion,

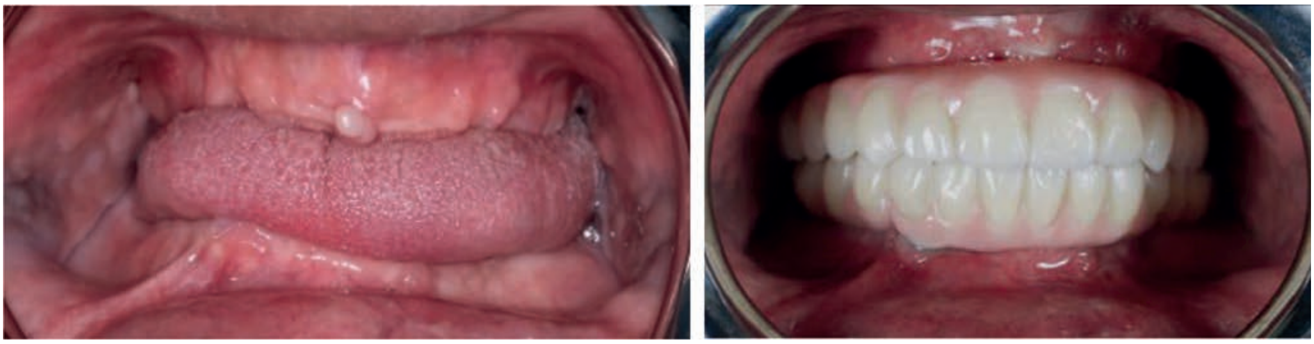

FIGURE 12. Pre- and post-frontal view of the patient

FIGURE 13. Pre- and post-maxillary occlusal view of the patient

FIGURE 14. Pre- and post-mandibular occlusal view of the patient

FIGURE 15. Post-operative left and right lateral views of the patient

FIGURE 16. Pre- and post-operative photographs of the patient

played a pivotal role. This method employs 3D CBCT and stereolithographic surgical templates, enabling the establishment of final implant positions before both the surgical and prosthetic phases. Given its novelty, enhancing the comprehension of this technology and the advantages associated with surgical templates is paramount. While flapless guided surgery may offer expedited procedural times compared to conventional techniques, the rigorous preoperative planning required demands significant time investment [5].

The use of CAD/CAM surgical templates requires a deep understanding of the potential variances that might arise and necessitate the resolution of anatomical challenges to ensure the successful implementation of prosthetic reconstructions. Numerous studies have demonstrated comparable or superior results when assessing the clinical outcomes of implants positioned using CAD/CAM surgical templates versus traditional procedures. Harnessing virtually generated and printed templates and superimposing surface scans onto CBCT data improves surgical template accuracy and effectively translates virtual plans into real-world scenarios. Incorporating intraoral and surface scans of cast models post-impression generation may increase accuracy further.

A direct correlation was established between CBCT alignment and intraoral and laboratory scans, demonstrating their accuracy in laboratory settings. Both desktop and intraoral scanners yield highly accurate digital impressions regarding precision and correctness. By merging the dental surface registration algorithm with the intraoral scanning technique, a fully digital workflow for guided implant surgery planning can be synthesized. This approach could eliminate human error and enhance time efficiency through optimized methodologies.

Sebastian et al. (2015) elaborate that guided implant surgery using printed templates can yield extremely accurate results [6]. Numerous techniques provide options for computer-guided implantation for procedures with or without flap exposure and immediate loading. While many methods have been described in the literature, there are no discernible distinctions between conventional and guided implant treatments regarding implant survival rates. Susanne et al. (2011) used simulated guided implant placement for pre-operative casts to demonstrate the precision achievable when replicating implant locations [7,8]. Computer-based implant planning has demonstrated remarkable effectiveness and reliability. The 3D interface associated with specialist software allows for the most accurate evaluation of implant placement, refinement of axes, and the selection of the optimal surgical and prosthetic approaches for each patient [9].

A promising alternative to conventional surgical techniques has been developed, combining computer-guided approaches with traditional surgical methods. Methodologies involving the placement of flapless guided implants minimize surgical stress on the bone and surrounding soft tissues. In a study by Barter et al. (2010), patients underwent flapless-guided surgery to prevent further exposure of previously grafted locations [4]. The prostheses continued to function well after four years, and the implants survived with a 98% success rate. The flapless technique offers several benefits, including enhanced blood flow to the surgical site, reduced risk of resorption, and the preservation of both hard tissue volume and soft tissue structure. Furthermore, this approach shortens procedure duration and healing time [10-12].

CONCLUSIONS

This case study demonstrates complete oral restoration through the integration of dental implants and supportive prosthetics. Leveraging 3D CBCT scans and virtual models, a sophisticated implant planning software was used to design the placement of dental implants. Subsequently, a precise plan was executed using a stereolithographic surgical template and flapless technique, which resulted in accurately implanted prosthetics. In contrast to conventional procedures, our strategy resulted in successful implant insertion while minimizing patient discomfort and streamlining the overall process. Guided implant treatments mitigate the errors associated with conventional techniques.

Guided implant surgery significantly improves the accuracy of implant placement while minimizing procedure time. It is also less invasive compared to traditional methods. Complex cases of full-mouth implant restoration can significantly benefit from the heightened precision, efficiency, and predictability of phased computer-guided implant surgical strategies that integrate CAD/CAM technology, meticulous planning, and precise execution. A comprehensive grasp of the limitations inherent in conventional and digital dentistry allows practitioners to amalgamate procedures from both domains, ultimately elevating the management of challenging conditions through sophisticated treatment.

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Conflicts of Interest: The author declares no conflict of interest.

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