Journal of Clinical and Translational Research 2024; 10(5): 283-290

Journal of Clinical and Translational Research

Journal homepage: http://www.jctres.com/en/home

CASE REPORT

Computer-guided implant surgery and tooth-mirroring digital workflow to treat an esthetically compromised clinical case

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ARTICLE INFO

Article history:
Received: July 1, 2024
Accepted: October 8, 2024
Published Online: October 24, 2024

Keywords:
Computer-guided implantology
Surgical diagnosis and design software
Surgical guide
Artificial intelligence
Lithium disilicate veneers

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ABSTRACT

Background: In multidisciplinary dentistry, it is common to observe clinical cases that present multiple complications at the end of orthodontic therapy, such as differences in gingival height, alterations in size and shape of the teeth, and reduced residual spaces for implant therapies.
Aim: The aim of the study was to solve an esthetic case with the help of digitally assisted prosthetic and surgical design.
Methods: A young patient had been treated orthodontically for the agenesis of tooth 12 and the conoid shape of tooth 22. Previous therapy consisted of opening the space for tooth 12 by positioning a Maryland-type composite bridge, followed by reconstruction with a composite of tooth 22. Various composite reconstructions on teeth 11 and 21 were no longer adequate. Furthermore, both elements had discordant coronal axes, the diastema was observed at the incisal level, and tooth 21 was approximately 1 mm longer than tooth 11. Radiographic analysis revealed that the roots of teeth 11 and 13 converge, providing sufficient space for the insertion of a small-diameter implant. An intraoral scan and cone-beam computed tomography (CBCT) were performed; both data files were merged using surgical design software. A surgical guide was developed for the insertion of an implant in site 12. After insertion, the composite bridge, which was no longer suitable, was removed and a new temporary metal-composite Maryland bridge was positioned. Using an artificial intelligence tool of the design software, tooth 22 was isolated, mirrored, inserted in site 12 to reproduce the gingival profile, and subtracted from the digital impression. A technician then copied this emergence profile to build a zirconia prosthetic crown to be screwed on the implant. Teeth 22, 11, and 21 were restored with a lithium disilicate crown and two veneers, respectively.
Results: The initial digital design and the use of a guided surgery procedure allowed for the insertion of a small diameter implant without damaging the roots of the adjacent teeth. The prosthetic design procedure, using the digital tools of the design program, made it possible to standardize and create symmetrical gingival profiles of teeth 12 and 22. The overall composition was completed by the use of minimally invasive adhesive prosthetic techniques on teeth 11, 21, and 22.
Conclusion: Digital resources have become essential tools for dental professionals. The knowledge and use of technologies like intraoral scanning and CBCT, combined with various innovations such as artificial intelligence in prosthetic and implant design software, enable dentists to manage even the most complex interdisciplinary clinical cases with greater confidence.
Relevance for Patients: Digital techniques are now widely used across all fields of dentistry. This has led to the need for operators of all ages to adjust their decision-making process compared to traditional techniques. These new techniques have also improved communication with patients, allowing the dental team to have a clearer understanding of the clinical path to follow and consequently offer their patients precise dentistry solutions.

1. Introduction

In the 21st century, having a radiant smile has become increasingly important. A smile characterized by white, perfectly aligned teeth that are proportionate in size

DOI: https://doi.org/10.36922/jctr.24.00035

and symmetrically pleasing boosts confidence in social interactions and enhances attractiveness [1]. Dentistry has adapted and improved its techniques to meet these new requirements, strengthening the relationship between various dental disciplines, such as prosthetics, orthodontics, and implantology. This interdisciplinary connection has been facilitated by the impressive development of digital techniques in recent years. This includes the ability to easily manipulate patient impressions obtained with intraoral scanners, such as standard tessellation language (STL) files, and to combine them with 3D visualization of the bone from digital imaging and communications in medicine (DICOM) files generated by cone-beam computed tomography (CBCT) [2]. Therefore, dentists now have the opportunity to create a "virtual patient" on their computers, allowing them to establish adequate diagnostic criteria to obtain excellent results [3]. This strategy becomes particularly important when operators are faced with a reduced buccal bone wall, which can compromise the final long-term esthetic results in immediate [4] and late [5] implant placement. In contrast, adopting this strategy requires operators to improve their skills to become familiar with all the tools necessary to achieve the desired results [6]. Designing esthetically pleasing prosthetic work requires absolute synergy among all dental team members. In the past, this workflow required collaboration between the various operators, which could be complex due to difficulties in visualizing the final result. Conversely, the digital process has greatly simplified communication between dentists, thanks in part to the ability to visualize various steps in 3D, especially in clinical cases where esthetics is critical [7]. The aim of this work was to present an implant-prosthetic clinical case resulting from a previous orthodontic treatment, successfully treated using new digital technologies. This article was prepared following the strengthening the reporting of observational studies in epidemiology guidelines.

2. Methods

This retrospective clinical case was conducted according to the 1964 Helsinki Declaration principles for biomedical research involving human subjects. The patient was informed of the nature of the study, its benefits, risks, and possible alternative treatments, and written consent was also obtained for the use of clinical images. The patient was a 22-year-old man who complained of esthetic problems that arose after a previous orthodontic treatment. The orthodontic therapy involved reopening the space for tooth 12 to resolve agenesis of the related permanent element, along with a temporary composite reconstruction of the conoid tooth 22. The intraoral examination displayed a composite Maryland bridge replacing tooth 22 (Figures 1 and 2), temporarily positioned by the orthodontist, probably in view of the implant therapy. Teeth 11 and 21 featured some old composite reconstructions, discordant coronal axes, and the presence of a diastema at the incisal level; tooth 21 also appeared to be about 1 mm longer than tooth 11 (Figures 3 and 4). In tooth 12, the CBCT (Promax 3D Max; Planmeca, Finland) displayed an adequate vestibulo-palatal bone diameter for the insertion of a small-sized implant (Figures 5-7),

Figure 1. Maryland-type temporary composite bridge in site 12

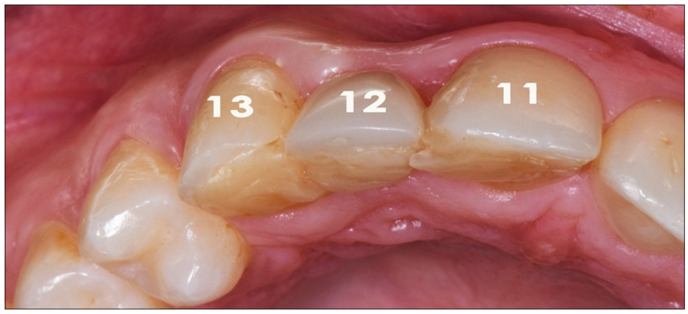

Figure 2. Palatal view detail of the bridge attached to teeth 11 and 13

Figure 3. Frontal view of the smile before treatment

but the root axes of teeth 13 and 11 converged toward the apices, making traditional implant surgery difficult (Figures 8-10). The anteroposterior view of the conoid dental element 22 displayed composite reconstruction with a large horizontal over-contour, most likely to compensate for the vestibulo-palatal inclination of the root axis (Figure 11). The gingival parabolas of the upper anterior group appeared unlevelled. Furthermore, the patient had moderate gingival exposure. Hence, the proposed treatment plan included the insertion of a small diameter implant in site 12 through computer-guided implant surgery, a zirconia crown

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Figure 4. Frontal view with retractor: the interincisive diastema and the different lengths of teeth 11 and 21 can be observed

Figure 5. Frontal view of the large mesial-distal space in site 12

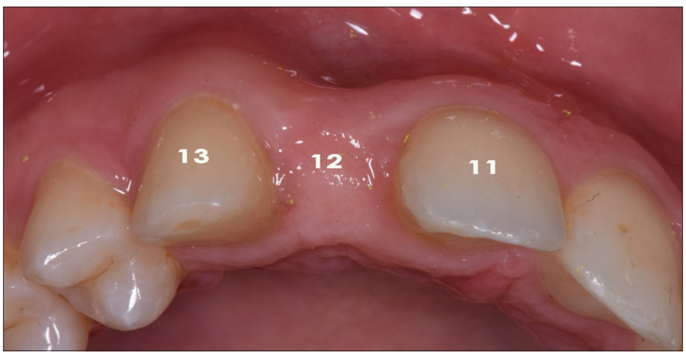

Figure 6. Occlusal view in site 12, which displays an adequate vestibule-palatal space

in site 12, two veneers in sites 11 and 21, and a crown in site 22, all made from lithium disilicate. A first intraoral scan was performed (Medit i500, Medit; MEDIT Co., Korea). The corresponding STL files were merged with the DICOM data derived from the CBCT using surgical diagnosis and planning software (coDiagnostiX; Dental Wings version 10.8, United States of America [USA]). At site 12, a small-diameter dental implant was virtually inserted (3.3 Bone Level Tapered; Straumann, Switzerland), and a surgical guide was designed (Figures 12 and 13). CoDiagnostiX is equipped with an artificial intelligence assistant that can be consulted remotely, making it possible to isolate individual teeth from the jaw bone and obtain individual 3D files. The 3D file of tooth 22 was loaded onto open-source software Meshmixer (Autodesk, USA), mirrored (Figure 14), and inserted where tooth 12 was missing; both were

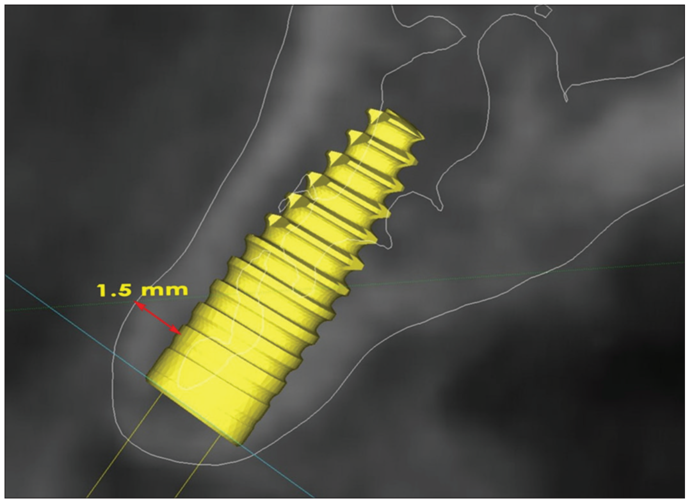

Figure 7. Sagittal view of cone-beam computed tomography with a virtual representation of the implant in site 12, which displays an adequate vestibular bone thickness of 1.5 mm

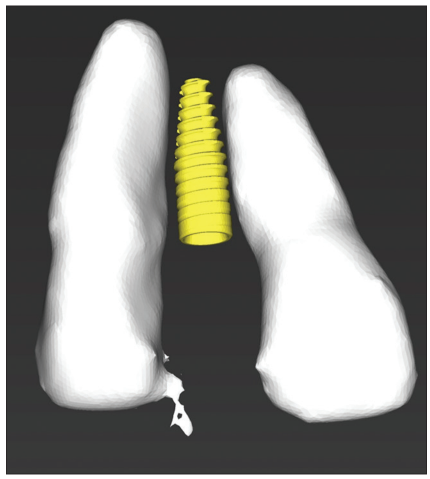

Figure 8. Frontal view of teeth 13 and 11, featuring a convergence of the root apices that reduce the space for the insertion of a standard implant

aligned with the virtual dental implant and gingival level of the contralateral (Figure 15). In Meshmixer, a Boolean procedure was performed on the mirrored tooth 22 by subtracting it from the 3D STL file of the upper jaw and leaving the space corresponding to the emergence profile (Figure 16). The project was then sent to a technician who, using the data related to the virtual emergency profile, created a temporary composite crown to be screwed onto the implant at the time of implant exposure. Using the surgical guide, the implant was inserted at site 12, leaving it submerged (Figures 17 and 18); a metal-composite Maryland bridge was then applied (Figure 19). The decision not to perform an immediate loading procedure was derived from the desire to manage the maturation of the soft tissues at the end of osteointegration. After 3 months of healing, the temporary Maryland in site 12 was removed; the implant was exposed; the previously made composite provisional crown was screwed in. After nearly 60 days of gingival healing, a

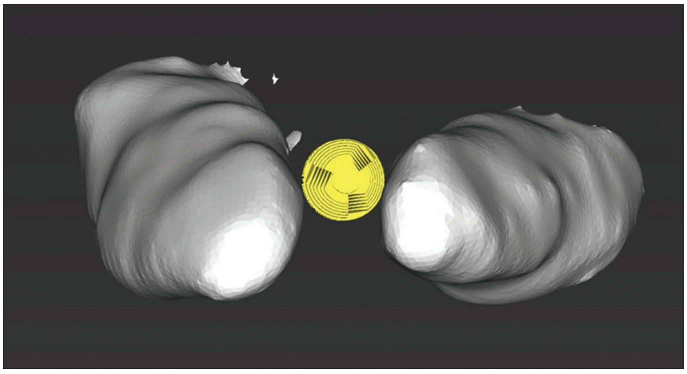

Figure 9. Apical view of teeth 13 and 11 (from Figure 8)

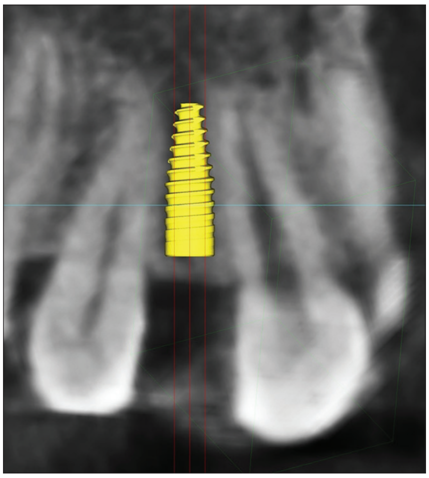

Figure 10. Sagittal cone-beam computed tomography view of the space available for the insertion of the implant in site 12

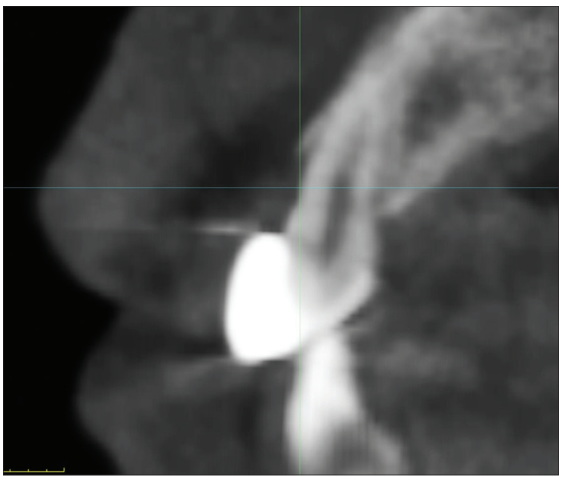

Figure 11. A sagittal view of the cone-beam computed tomography at site 22, displaying the wide horizontal overcontour of the composite reconstruction

digital impression was taken of both the temporary restoration adequately integrated into the soft tissues and the implant, as well as teeth 11, 21, and 22. The final work was then delivered. Both the crown on tooth 22 and the veneers on teeth 11 and 21 were made of pressed lithium disilicate (MT; Ivoclar-Vivadent

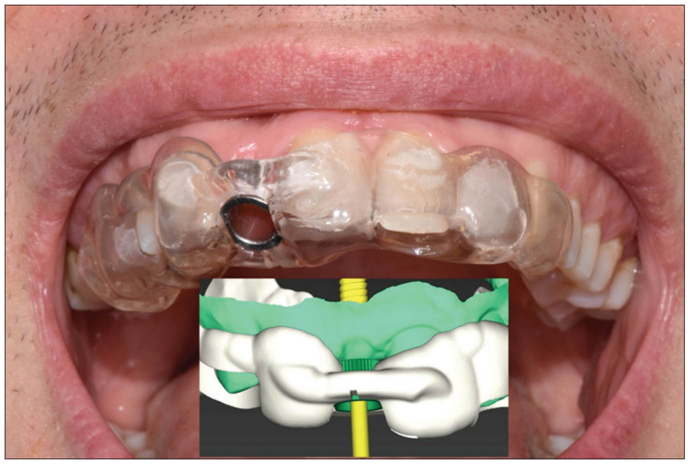

Figure 12. Frontal view of the surgical guide try-in

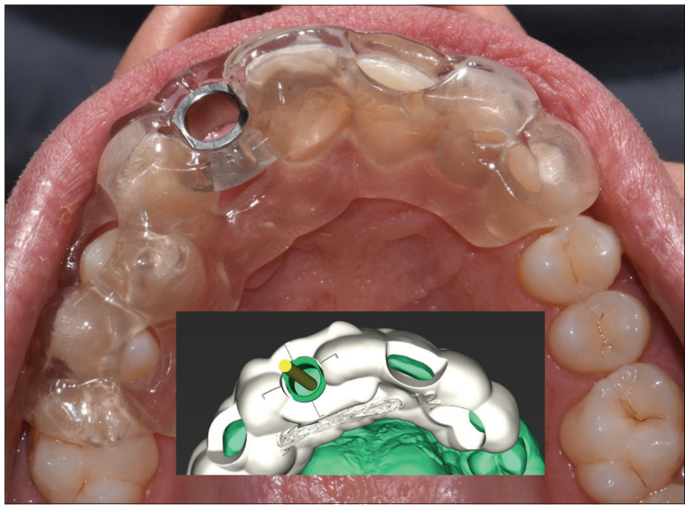

Figure 13. Occlusal view of the surgical guide try-in (from Figure 12)

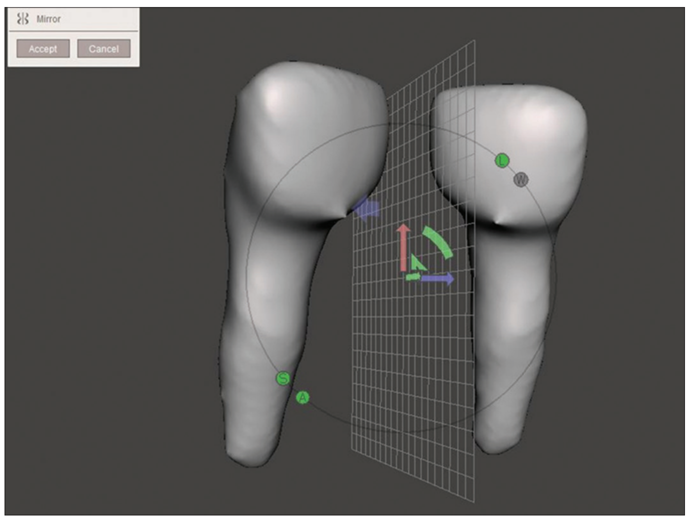

Figure 14. Tooth 22 was extracted from coDiagnostix, imported to Meshmixer (figure above), mirrored, and re-imported into coDiagnostix

AG, Liechtenstein), micro-layered with ceramic (Creation LS, Austria) and colored (Ivocolor; Ivoclar-Vivadent AG,

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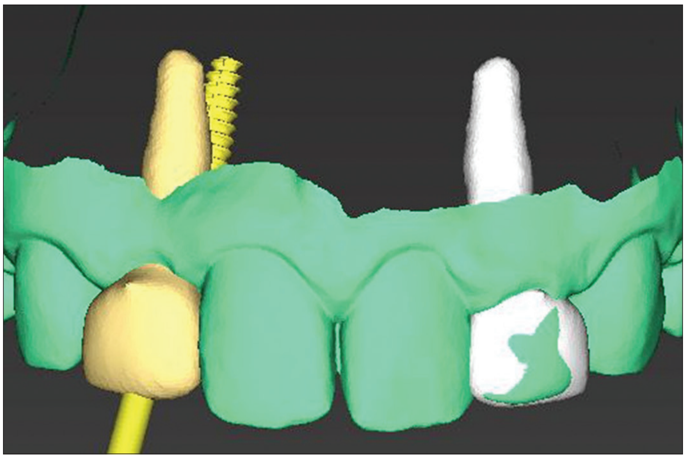

Figure 15. The mirrored tooth 22 was inserted in site 12 and aligned both with the axis of the implant and the gingival margin of tooth 22

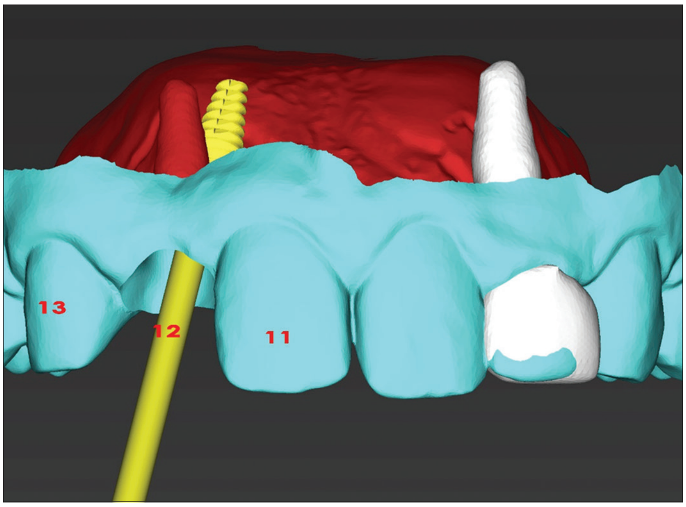

Figure 16. The mirrored tooth 22 was re-imported into Meshmixer along with the digital impression of the upper arch; it was then removed from the zone of tooth 12 using a subtractive Boolean procedure, leaving space for the copy of the emergence profile. Subsequently, it was re-imported into coDiagnostix and sent to the technician through the virtual planning export function.

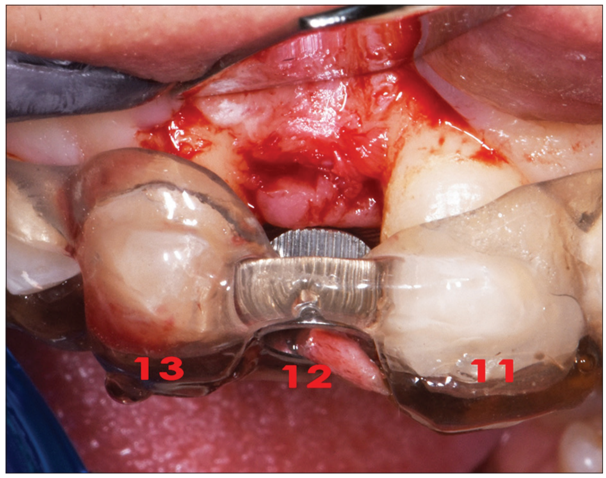

Figure 17. Frontal view of the implant insertion with the guide

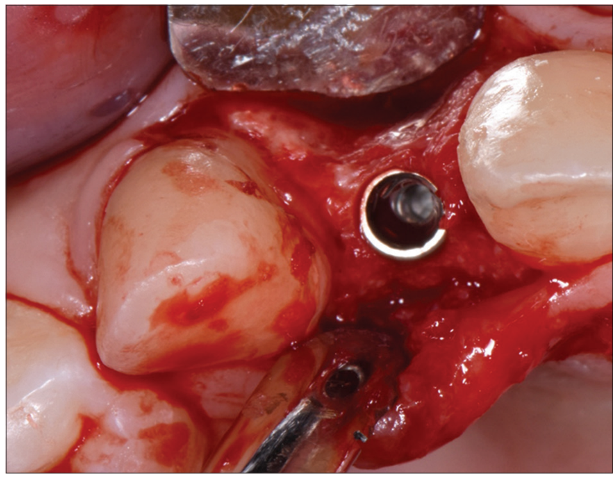

Figure 18. Occlusal view of the implant insertion with the guide (from Figure 17)

Liechtenstein). The prosthetic element on the implant in site 12 was made of multilayered Zirconia (Explore Esthetic; Shenzhen Upcera Dental Technology Co. Ltd., China), micro-layered and colored (Figures 20-22).

3. Results

The shaping of the gingival area of tooth 12 with a temporary composite crown screwed on the implant generated an emergence profile identical to tooth 22, ensuring the formation of an optimal gingival profile. In addition to the virtually performed modifications, the provisional crown did not require any further adjustments. This approach minimized the need for its removal and reinsertion, thereby reducing potential damage to the delicate peri-implant epithelium. Likewise, the computer-guided surgery enabled the implant to be inserted in an adequate position to avoid any damage to the roots of the neighboring teeth. The lithium disilicate veneers in teeth 11 and 21 also improved the length and shape differences of the elements. In general, the ceramic micro-layering technique, while quite sophisticated, has enabled the creation of restorations with optimal esthetics. The use of two modeling and prosthetic design software allowed the workflow to be optimized. In particular, Meshmixer has proven to be an intuitive computer-aided design software, with extremely simplified controls even for prosthetic purposes. To increase the mesiodistal dimensions of tooth 13, a mesial composite reconstruction was also performed.

4. Discussion

This clinical case demonstrates how a precise digital workflow enables efficient treatment of an esthetically compromised clinical case. Mirroring a contralateral tooth has been particularly helpful in developing an adequate emergence profile. Joda *et al.* [8] used the DICOM data of the CBCT to mirror the contralateral tooth. This enabled the creation of a personalized healing abutment, followed by a provisional crown with the same emergency profile. In this clinical case, only the

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Figure 19. Insertion of the temporary metal-composite Maryland bridge

Figure 20. Frontal view of the smile on delivery of the final prosthesis

Figure 21. Right lateral view of the smile on delivery of the final prosthesis

Figure 22. Left lateral view of the smile on delivery of the final prosthesis

provisional crown was realized to save time. Similarly, Zeng *et al*. [9] reproduced the emergence profile of a contralateral posterior tooth in an individualized healing abutment, which was then replaced with the provisional crown. Pozza *et al*. [10] proposed a technique to realize a personalized healing abutment based on a failing posterior tooth to be replaced with a dental implant. However, this technique works only if a tooth with an adequately intact emergence profile is present. Both Noharet and Van Dooren [11] and Passos *et al*. [12] proposed an analogical-digital technique, where a fractured anterior tooth was replaced with an implant-supported crown replicating its emergence profile. However, this technique requires the presence of a tooth. From a broader point of view, the aim of all of these digital techniques is to reduce time wastage while improving the clinical performance of the prosthetic workflow [13]. Besides reducing surgical time, digital techniques allow for obtaining a more precise implant insertion, particularly in cases of reduced alveolar spaces. Younes *et al*. [14] reported that guided implant surgery achieves better accuracy compared with free-hand technique in partially edentulous patients. Moreover, a flapless surgical approach appeared to yield better results when combined with guided surgery [15]. However, open-flap surgery is necessary in cases of poor CBCT residual facial bone visualization [16]. To achieve an esthetically pleasant final result, adequate prosthetic materials must be used, as well as the right dental technique. 3D printing allows for the realization of highly esthetic restoration [17], particularly when combined with modern dental materials [18].

5. Conclusion

Digital resources have become indispensable tools for dental professionals. The knowledge and use of technologies such as intraoral scanning and CBCT, combined with various innovations such as artificial intelligence offered in prosthetic and implant design software, enable dentists to manage particularly challenging interdisciplinary clinical cases with greater confidence. Computer-guided implant surgery, combined with digital tooth mirroring and appropriate ceramic dental techniques, allowed for the efficient resolution of this clinical case.

DOI: https://doi.org/10.36922/jctr.24.00035

Acknowledgments

The author would like to thank Mr. Alessandro Certini of the Nuova Arte Odontotecnica Laboratory of Florence for providing the prosthetic products and surgical guide.

Funding

None.

Conflicts of Interest

The author declares no competing interests.

Ethics Approval and Consent to Participate

This retrospective clinical case was conducted according to the principles of the Helsinki Declaration of 1964 for biomedical research involving human subjects. The patient was informed of the nature of the study, benefits, risks, and possible alternative treatments, and the patient provided written consent for using the clinical images.

Consent for Publication

The patient was informed of the nature of the study, benefits, risks, and possible alternative treatments, and the patient also provided written consent for using the clinical images.

Availability of Data

Data are available from the corresponding author on reasonable request.

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