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Digital Planning and Guided Surgery for Immediate Implants in Anterior Esthetic Area: Case Report

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Abstract

Background: Despite the high rates of guided-surgery success in the aesthetic region, only a few studies describe both the planning protocol and the clinical-tomographic-surgical performance to reach short-term satisfactory outcomes. **Aim**: The aim of the present study was to describe the planning applied to a guided surgery in the aesthetic region, and its clinical outcomes, by taking into consideration the periimplant tissue profile and the implant-supported prosthesis. **Method**: This report describes the case of a female patient, at the age of 48 years, who presented herself seeking rehabilitation treatment based on osseointegrated implant and prosthesis, and to replenish the upper lateral incisor region which showed fracture under examination. **Result**: The success of treatments based on implants in the aesthetic region depends on several factors, with emphasis on diagnostics and planning. The aforementioned stages are entangled in many benefits from guided surgery planning to conduction, such as surgery duration and acts' reduction, lower discomfort, and iatrogenic injuries to soft and hard tissues. **Conclusion**: The outcome in the rehabilitated aesthetic region was predictable, as well as functionally and aesthetically stable.

Keywords

Dental Implants, Bone regeneration, Computer-Guided Surgery, Aesthetic Region, Case Report

1. Introduction

Mouth rehabilitation has been following technological innovations aimed at improving and decision-making in dental procedures. Panoramic X-ray has limitations in implants' surgical planning; moreover, freehand surgery also has limitations that lead to different outcomes due to professional skills and decisions made during surgery, without real previous planning [1]. Cone-beam computed tomography is recommended to start the surgical planning applied to osseointegratade implants. Since 2002, implant dentistry has assessed and innovated with special software for guided surgeries and prosthesis installation on implants. Guided surgeries are recommended for a whole range of implant rehabilitation cases, including partial or total edentulous, as well as aesthetical nature areas [2]. These concepts have led to changes in surgical perspectives given the possibility to plan implant installations along with temporary or permanent prostheses. Computed tomography and the development of new software enable almost realistic-like virtual planning aimed at accurately guiding to a specific target in rehabilitating plans [3].

Accurate pre-operative planning applied to aesthetic regions, either for implant installation or for the manufacture of prosthetic restorations, as well as for gingival contour predictability, is a fundamental requirement for a successful rehabilitation, based on osseointegratade implants [4]. Cone-beam computed tomography, intraoral scanning and the availability of 3D printers made the practice of virtually planning implants and of using a surgical guide to point out the accurate and correct locations for milling and implant installation accessible, and it leads to aesthetic and biomechanical predictability [5].

The virtual planning of surgery in aesthetic regions became an excellent tool for treatments based on osseointegratade implants, because periimplant tissue stability, absorption of loads along the long axis, easy cleaning and satisfactory outcomes are the elements accounting for proper tridimensional implant positioning [6]-[8]. Aspects, such as the ideal distance between implants, between implants and dental elements, and implant depth, can also be controlled through this technique. There is a close association between a high success rate and shorter surgery duration due to previous virtual surgical planning [9].

The development and widespread use of different software for planning and prosthetic design allowed combining waxing purposes, which can now be virtually performed based on surgical planning [6]-[8]. These software types are diagnostic tools to previously analyze implant installation areas and to propose different alternatives to each case, a fact that helps reduce iatrogenic cases [10] [11].

Nowadays, guides' manufacturing is based on CT image overlay (DICOM) of data resulting from digital images of dental arches by using standard tessellation language (STL) intraoral scanning. Stereolithographic guides are made through *Computer-Aided Design /Computer-Aided Manufacturing* (CAD/CAM) by printing or milling devices [6]-[8].

Digital techniques are not only crucial for precision in implant placement but also represent a significant leap in enhancing overall patient care and outcomes in dentistry. According to recent findings, these methods facilitate minimally invasive procedures, reduce recovery time, and improve the predictability of aesthetic and functional results, thereby transforming traditional approaches to mouth rehabilitation [3]. Understanding these benefits within the wider medical field highlights the importance of these innovations in advancing patient-centered care.

Despite the high rates of guided-surgery success in the aesthetic region, only a few studies describe both the planning protocol and the clinical-tomographic-surgical performance to reach short-term satisfactory outcomes. The aim of the present study was to describe the planning applied to a guided surgery in the aesthetic region, and its clinical outcomes, by taking into consideration the periimplant tissue profile and the implant-supported prosthesis.

2. Clinical Case Report

Female patient, herein identified as FFF, at the age of 48 years, presented herself to the dentistry clinic of the Brazilian Navy seeking rehabilitation treatment based on osseointegratade implant and prosthesis, and to replenish the upper lateral incisor region (**Figure 1** and **Figure 2**). Under radiographic examination it was evident the presence of tooth fracture. The patient presented full dentition in the lower dental arch with the absence of the maxillary lateral incisor crown. The medical and familiar history showed no systemic disease, no medication use or any genetic disease. Patient had no history of previous intervention. In addition to the clinical and radiographic examinations, blood tests, such as complete blood count, coagulogram and glycated hemoglobin, were requested to confirm no systemic contraindication to the surgical procedure.

Figure 1. Initial aspect showing root fracture of superior lateral incisor with gingival tissue invasion and aesthetic contour loss.

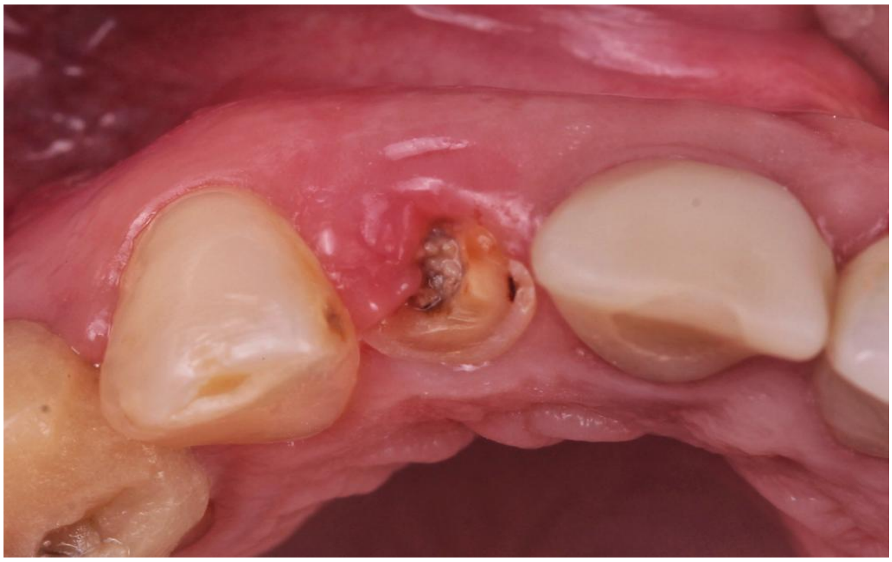

Figure 2. Initial aspect clinically showing root fracture of superior lateral incisor, gingival tissue invasion and aesthetic contour loss (occlusal view).

Guided surgery was the therapy of choice to operate on the upper dental arch due to recommendation for tridimensional implant accuracy in this region. It was done to favor aesthetic aspects and bone availability to implant performance based on the remaining root of the superior lateral incisor, as a spatial reference for guided surgical planning (**Figure 3**).

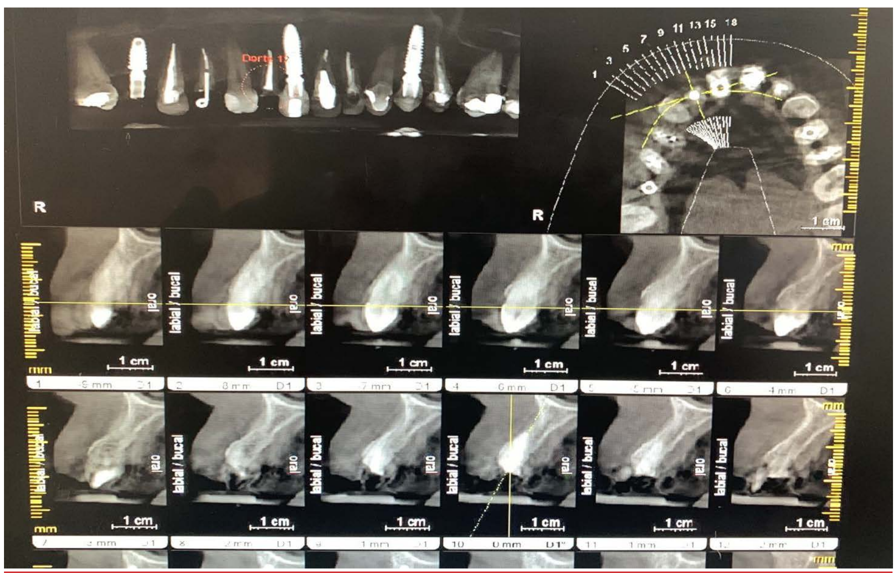

Figure 3. Tomographic aspect showing bone availability at dental element 12 region: 16 mm in height and 5 mm in thickness.

2.1. Guided Planning

Surgical planning was sent to the laboratory in video format along with DICOM images and their printed pictures (**Figure 3**). *Epikut* (by S.I.N., São Paulo, Brasil) was the guided surgery system of choice and *Cone Morse* (CM) 3.5 × 13 mm (reference ILCM3513) was the selected implant type. Virtual planning was carried out in Exoplan software (Smart Dent-Germany), which was used to manufacture the surgical guide based on imported STL files resulting from digital scanning (Cerec AC Omnicam 4.6, Dentisply Sirona, SP, Brazil) by using H6.5 washers (**Figure 4** and **Figure 5**). The guide was printed in Anycubic Photon S device and Smartdent Clear resin (Smart Dent-Germany) was the base material of choice.

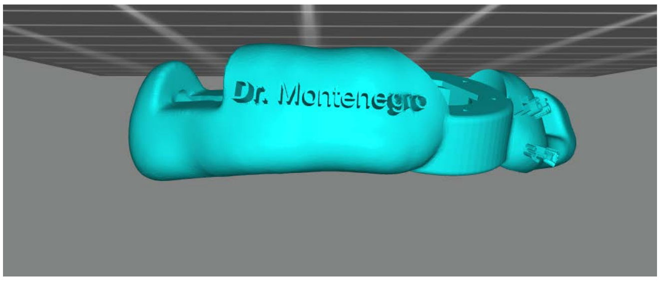

Figure 4. Surgical guide planned in Exoplan software (Smart Dent-Germany) and manufactured with STL exports.

Figure 5. Surgical guide manufactured in Smartdent clear resin (Smart Dent-Germany), in 3D type Anycubic Photon S printer.

2.2. Minimally Traumatic Tooth Extraction

Initially, based on diagnostic examinations, the patient was subjected to local anesthesia for anterior superior alveolar plexus block because the prognostic for immediate installation of post-extraction implant was classified as good. This procedure was performed with 4% Articaine added with epinephrine (at ratio of 1:100,000). Minimally traumatic tooth extraction was carried out starting from periotomy of the palatal, distal and mesial surfaces to make the extraction of the dental element easier and to make this procedure the least traumatic possible, as well as to preserve the vestibular bone plate and to support the soft tissue around element 12 (**Figure 6**).

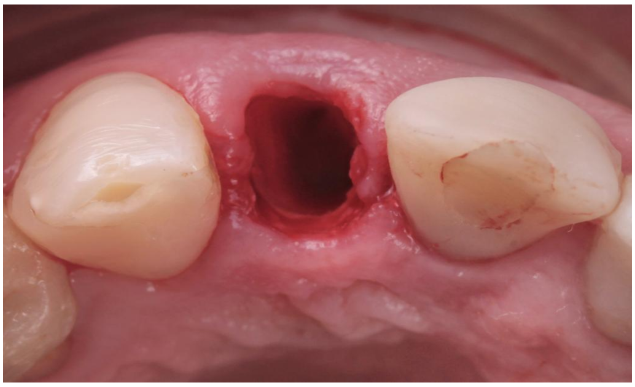

Figure 6. Clinical aspect right after tooth extraction showing the favorable mucosa contour and papillae and bone plates preservation.

The surgical guide received the windows to assess their stabilization, because it provides greater procedural safety. It is projected in areas presenting good-quality and sufficient bone tissue selected during digital planning (Figure 7).

Figure 7. Positioned surgical guide.

The implant was installed based on following the sequence of Epikut Guided Surgery System Surgical Kit Drills by SIN Implants (BKCSEG 0201, S.I.N., São Paulo, Brazil), according to manufacturer's recommendations.

Implant positioning followed the tridimensional positioning principles by keeping the minimum distance of 12 mm from implant platform and from adjacent teeth, and 3 - 4 mm distance between gingival margin and implant platform. The installed implant recorded 45N torque (Figure 8 and Figure 9).

Figure 8. Installation of CM Epikut 3.5 × 13 mm type implant (S.I.N., São Paulo, Brazil).

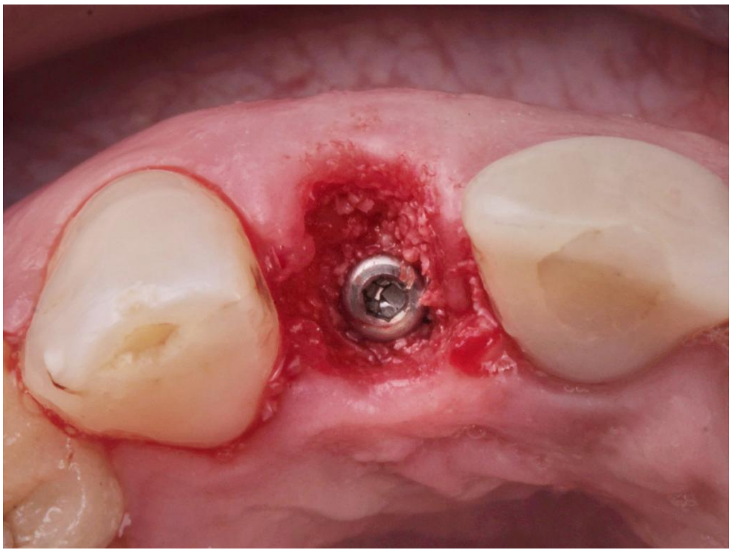

Figure 9. Placement of CM Epikut 3.5 × 13 mm type implant (occlusal view).

The surgical guide was removed and bone replenishing was carried out with biomaterial in the space between the installed implant and the vestibular bone plate, after implant installation. Replenishing was performed through Alobone® allograft (Osseocon, Rio de Janeiro, RJ, Brazil) (Figure 10). Chlorhexidine 0.12% was indicated twice daily for 14 days postoperatively.

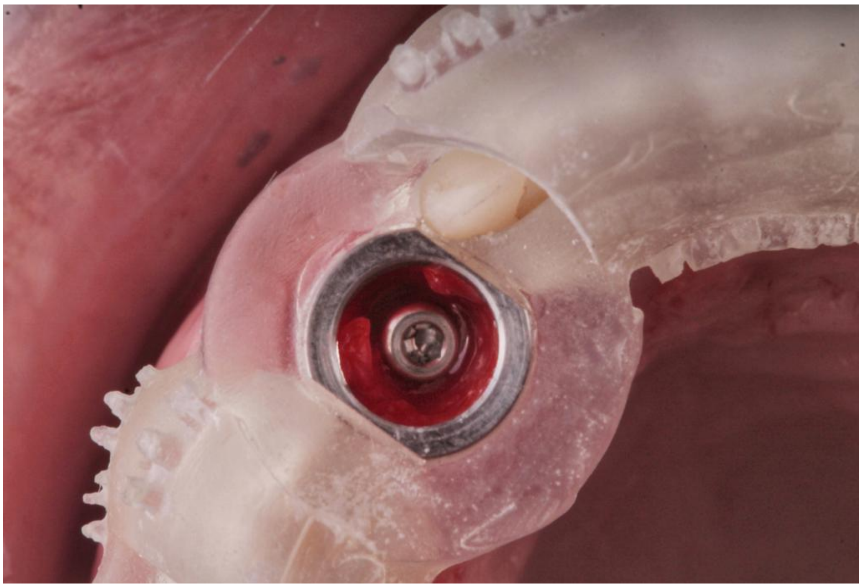

Figure 10. Immediate clinical aspect showing the favorable position of the installed implant and the integrity of the remaining soft vestibular tissues (occlusal view).

The choice of the Epikut system may be attributed to its high clinical success rate in implant dentistry, which underscores its reliability and effectiveness. Similarly, Exoplan software is favored for its specificity and ease of use, which facilitates precise planning and execution, enhancing the overall efficiency of the procedure.

2.3. Provisional Tooth Creation

The provisional tooth was created in B1 resin and made up by El Lab Externo, with emergency profile captured in A1 flow resin, based on using the connection in titanium provisional cylinder (CPTMU 3502-H, S.I.N., São Paulo Brazil), right after implant installation (**Figure 11** and **Figure 12**).

Figure 11. Immediate provisional tooth over the CM Epikut 3.5 × 13 mm implant printed in B1 resin and made up by El Lab Externo.

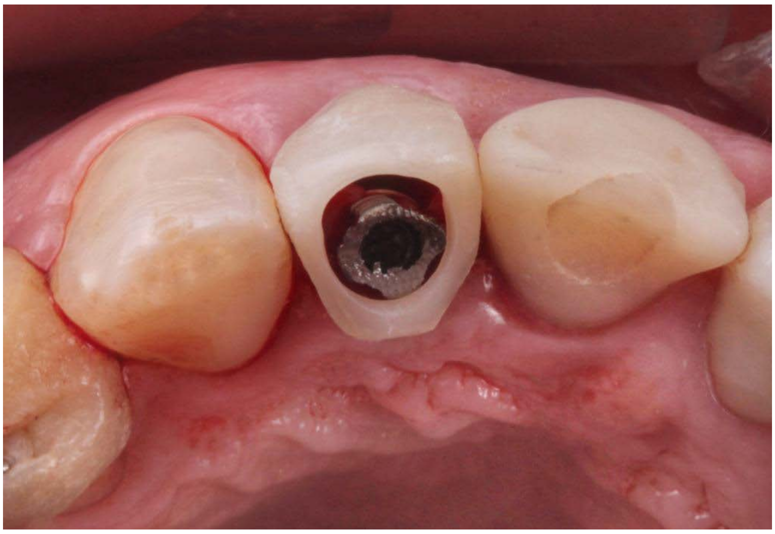

Figure 12. Immediate provisional tooth over the CM Epikut 3.5 × 13 mm made up by El Lab Externo with emergency profile captured in A1 flow resin, based on using titanium provisional cylinder connection (occlusal view).

The concavity in the sub-gingival portion of the prosthetic pillar was stressed with the aid of diamond drills under refrigeration. It was done to get thicker periimplant tissue, which accounts for long-term stability in gingival margin positioning. It was possible observing immediate aesthetics outcomes due to the use of provisional tooth, based on the virtual planning and on rehabilitating procedure accuracy (**Figure 13**).

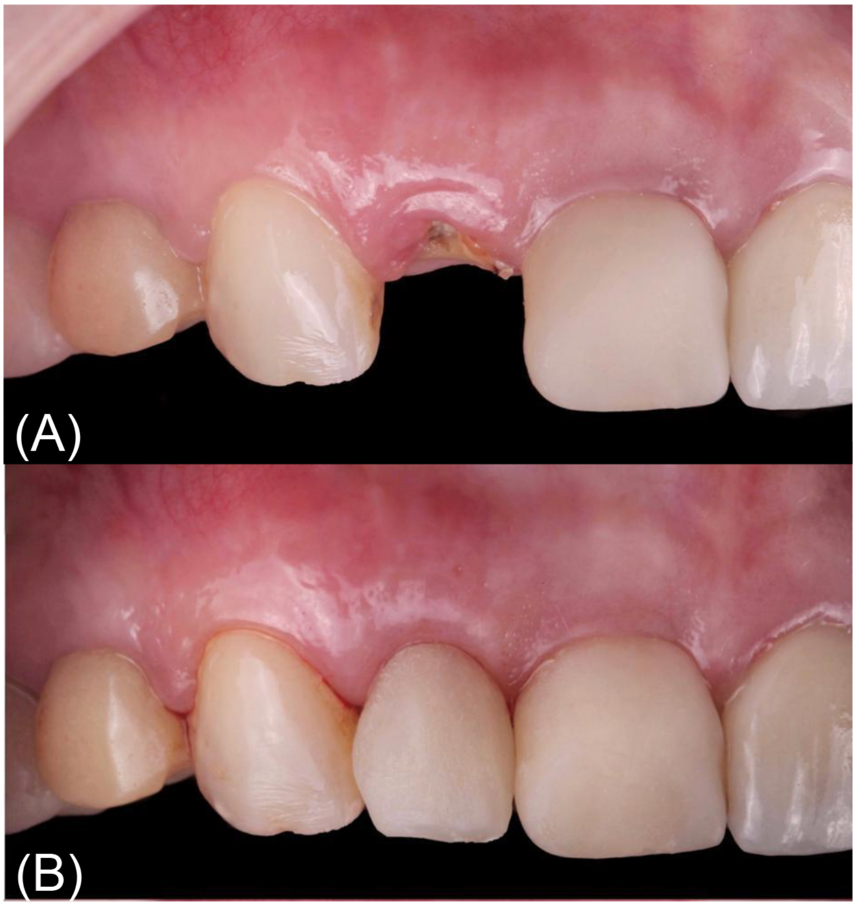

Figure 13. Initial aspect showing the root remains of dental element 12 (A). Immediate provisional tooth over CM Epikut 3.5 × 13 mm implant (SIN, São Paulo, Brazil), printed in B1 resin and made up by El Lab Externo, with emergency profile captured in A1 flow resin, by using titanium provisional cylinder connection (B).

Provisional restoration can be cemented and the hole to access the pin can be closed after 20N torque is applied to the prosthetic pillar. The patient appeared extremely happy with the immediate clinical aspect.

Six months later, the definitive porcelain prosthesis EUCLA type abutment (EUCLAMU 3502-H, S.I.N., São Paulo, Brazil) was placed (**Figure 14**). One year after prostheses placement patients showed aesthetic satisfactory result, according to herself report and clinical evaluation.

It's important to affirm that the patient was satisfied with the clinical result. In addition, the patient agreed with the proposed method from the beginning of the treatment, showing a positive reaction to the results achieved. No adverse events were observed.

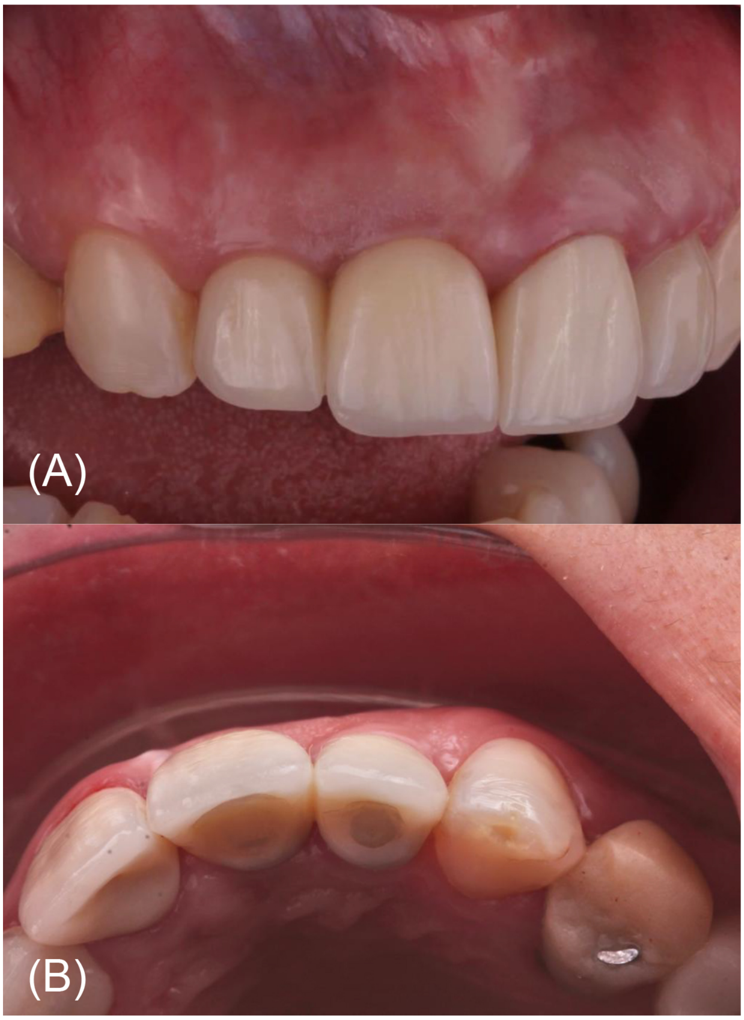

Figure 14. Final clinical aspect with the definitive porcelain prosthesis in frontal (A) and occlusal view (B). Note the aesthetics, the periimplant mucosa contour. This case was carried out based on virtual guided surgery planning.

3. Discussion

Implant dentistry has been having great impact on how we deal with edentulism. Rehabilitation based on dental implant has become the standard procedure to replace the lost teeth. Some parameters must be observed in aesthetic rehabilitation in order to reach long-term success. Gingiva biotype, smile line, dental elements' color, periimplant mucosa contour, papillae preservation, and the thickness and height of the underlying bone ridge, are among the main aspects observed in the maxilla anterior region [12]-[14]. The aim of all these factors does not only lie on reaching the expected aesthetics, but also on having treatment predictability when it comes to dental implants. The present case report opens room for discussions about some relevant points from the surgical and prosthesis aspect viewpoint, as well as about the emergence of digital planning as excellent tool to implant dentistry. Outcomes have clearly pointed out the functionality and aesthetics acquisition within a short period-of-time due to guided surgery employment.

Scientific evidence shows that early digital planning and 3D guided surgery duration were marked by concepts established in 2005, which have outspread guided surgery employment. The technology of choice at digital planning scope is called CAD (Computer Aided Design), which is an integration system substantiated by computer sciences. Digital planning is carried out in DTX software, which can import files in STL format. These files result from intra-oral scanning or from tomographic images. This tool allows previously planning surgery conduction by determining the ideal location for implant installation based on bone amount and quality. It also allows visualizing important accidents and anatomic structures that are often identified in other analogous tools, as well as takes into account the prosthetic needs at high positioning accuracy, reproducibility, color and shape [15].

The guided planning uses tomographic images associated with up-to-date 3D software capable of accurately and faithfully reproducing the anatomic structures of periimplants, as well as of their intermediate prosthetics and prosthesis, before the surgical procedure. It makes the production of surgical guides in high-accuracy acrylic resin feasible. These guides orient the implant insertion axis and optimize surgery duration, besides benefitting trans-surgical and post-surgical time [16]-[20].

Al Yafi F. *et al.* (2019) stated that the guided implant surgery is more accurate and reliable than freehanded implant surgeries. It is so, because the digital workflow for guided surgery follows a protocol to generate a tridimensional digital plan to be transferred to the patients' mouth through the surgical guide and protocol in order to reduce deviation and error risks [21]. All herein reported case stages, from tomography performance to tomography coupling to STL scanning, led to surgical accuracy and to high post-operative success predictability.

The guided surgery represents a less invasive, conservative and more accurate surgical modality [22]. According to Balem *et al.* (2010), the guided surgery and prototyping represent a new wave in dentistry, according to which, procedures become safer, predictable and less complex [23]. In addition, the adopted surgical kits and the implant of choice, based on manufacturers' recommendations, are essential for implants' primary stability and for trans-surgical handling. It is also important highlighting that surgical guide manufacture must follow the manufacturer's requirements, because they lead to accurate surgical conduction based on selected implant size.

The choice made for guided surgeries enables performing implant installations based on flap reflection, or not. The case presented by each patient is what differentiates the choice for a given surgical access, and one must take into account the need of bone and/or conjunctive graft followed by implant installation, a fact that demands opening the flap. Whenever there is no need of graft, one can choose the closed surgery, because it is possible building a tomographic guide after the tomography to virtually plan the best implant anchorage area [24]. The best positioning predictability is observed when the virtual planning is carried out by accurately respecting the 2mm distance between the implant and the vestibular bone plate, and the 3 - 4 mm distance between the gingival margin and the implant platform. It must be done to reach the best tridimensional implant control and, consequently, to allow adjacent tissue recovery [25]-[27]. This fact is clearly identified during immediate post-operative outcomes and it is mediated by guided rehabilitation, as shown in the current report.

Studies have evidenced that a surgical approach without flap can have additional advantages when it comes to traditional protocols with mucoperiosteal flap that, in its turn, can be related to higher reabsorption rates for the alveolar bone crest and of bone-implant contact (IOC) loss in implant's cervical region [28]. According to studies of remarkable scientific relevance, one can expect approximately 1mm of vestibular gingival retraction 1 year after implant installation [29]. We believe that adjacent tissues in the present report were preserved due to the adoption of the guided surgery without flap, no periimplant gingival retraction was identified.

Guided surgery predictability is only possible in specific software available in the market that generate linear and angle coordinates for washers' positioning. All tomographic images were generated in DICOM format and converted by the adopted software into the proper format required by each one of them [30]. Other studies have pointed out the advantages of the guided surgery, such as safe, simple, reliable and accurate technique; positive receptivity by patients; shorter surgical time; minimum post-operative discount; faster prosthesis installation [31]. Reverse planning stands out in the literature, and it is substantiated by several studies that state the proper use of this resource, which significantly reduces fail rates at the initial rehabilitation stage [32]. Reserve planning was an excellent resource for satisfactory clinical outcomes in this study. The 3D diagnostics and digital planning allowed determining the ideal location for dental implant installation with the aid of a guide, since it reduced the chances of having significant anatomic accidents.

This technique presents some limitations, such as higher costs due to the need of having a customized surgical guide and the necessary minimum amount of bones [6]-[8]. The main variation in comparison to the conventional technique is linked to milling sizes, which present longer upper length in the guided surgery system. Patient's mouth opening in the implant region must match the use of millings and installation keys of the system of choice. Limited mouth opening can interfere with implant instruments and installation, and cause surgery interruption.

As for the moment to extract the dental element and to install the dental implant, it is possible taking into consideration some facts evidenced in scientific studies according to which, one can expect horizontal loss close to 30% of the bone volume three months after tooth extraction [33]. Accordingly, immediate implant installation associated with bone graft avoids the need of further regeneration procedures and emerges as excellent option for patients recommended for this technique [34]. Besides, the use of surgical techniques that avoid incision acts, as well as gingival papillae displacement, is associated with lower bone loss standards [35]. We herein opted for preserving the adjacent tissues.

With respect to the immediate prosthetic and rehabilitating scope, it is important highlighting the need of installing the prosthetic pillar at the time to install the implant. It is known that the repetition of prosthetic pillar's connections and disconnections leads to marginal recession and to bone absorption in animal models [36]. Disruption of the junctional epithelium of the periimplant biological space was removed and the installation of new pillars can lead to new apical biological space at implant level, with consequent bone resorption. Humans show traces that more than two connections affect the periimplant mucosa sealing. Screwed provisional restoration installation at surgery time can be a quite feasible alternative; it must be disconnected three months later for the modeling stage and for the installation of the pillar associated with the definitive restoration [34]. As for the current case report, definitive prosthesis manufacture happened 6 months after implant installation, and it showed full periimplant mucosa stabilization and satisfactory aesthetic profile.

Based on relevant scientific studies, when the problem is the vestibular gingival retraction, one can expect approximately 1mm retraction 1 year after implant installation. The use of customized prosthetic pillars minimizes such a loss, since it keeps soft tissue architecture [37]-[39]. Data in scientific studies show either vertical increase or lack of tissue recession at the casuistic margin higher than 80% after 2-year follow-up. It sets the biological space in the prosthetic pillar structure and, consequently, preserves the bone crest of the periimplant region [36] [38].

Levine *et al.* (2017) considered 10 stages to reach a successful surgery to install immediate implants in the aesthetic region, namely: two planning stages, five surgical stages and three prosthetic stages. Altogether, these stages aim at minimizing soft and hard tissue complications to achieve the ideal implant aesthetic restoration [40]. We can consider that the herein introduced clinical case followed these ten stages, because we have employed two planning stages (tomographic and reverse planning), five surgical stages (non-traumatic tooth extraction, tissue manipulation, biomaterial installation, guided surgery and proper implant positioning) and thee prosthetic stages (manufacture of the milled provisional material, porcelain prosthesis design and digital prosthesis planning).

With respect to treatment based on dental implants in the aesthetic region, the multi-factorial dependence on clinical success is known, with emphasis on diagnostics and planning. These stages influence the reduction in intervention numbers, and it also reduces the risk of sequelae in soft and hard tissue structures, without affecting rehabilitation functional and aesthetic profiles. The guided surgery is an excellent alternative when the amount of bone in the patient is enough to receive dental implants without the need for a long surgical cut [41]. This technique leads to surgical predictability, which enables much more safety for surgeons and comfort to patients [42]-[45]. The present case report allows observing that the guided surgery was an excellent alternative, because the patient's clinical response was extremely satisfactory, and it allowed making an aesthetically ideal porcelain prosthesis in the shortest period-of-time.

However, it's essential to emphasize that while the current case report underscores the successful use of guided surgery, patient-specific factors must be considered as they can influence outcomes. For instance, differences in bone density can greatly affect implant stability and osseointegration. Furthermore, the patient's overall health, including immune response and healing capacity, plays a critical role in recovery time and success rates. In this particular case, the absence of systemic health issues facilitated a straightforward procedure. Future studies should focus on how personalized assessments and adaptations can enhance results, ensuring the full benefits of guided surgery are achieved for each individual patient.

While guided surgery techniques offer precision and predictability, they are not without complications or limitations. Potential issues include inaccuracies in the placement of surgical guides caused by deviations during imaging, guide fabrication, or placement errors during surgery. Additionally, the reliance on digital planning and technology requires significant training and familiarity, which can be a barrier for some practitioners [46]. Costs associated with the technology and the potential for increased surgical time due to guide placement are also considerations. Despite these challenges, advancements in technology continue to mitigate many limitations, improving outcomes progressively.

Virtual diagnostic and planning based on current scientific evidence, careful procedural planning and using high-quality materials are the essential requirements for a successful procedure. Guided surgery can accurately transfer virtual planning to the surgical act; besides, it is one more tool that helps dental surgeons in the dental implant field reach the best outcomes. As for the herein introduced clinical case, we have combined the following factors: (a) proper dental implant planning; (b) accurate soft tissue handling; (c) effective choice for the biomaterial; and (d) using new technologies associated with planning, and surgical and prosthetic performance. Based on these guidelines, it was possible ensuring a predictable aesthetic and functional outcome.

4. Conclusion

The success of treatments based on implants in the aesthetic region depends on several factors, with emphasis on diagnostics and planning. The aforementioned stages are entangled in many benefits from guided surgery planning to conduction, such as surgery duration and acts' reduction, lower discomfort, and iatrogenic injuries to soft and hard tissues. The outcome in the rehabilitated aesthetic region was predictable, as well as functionally and aesthetically stable.

Patients Perspective

From the patient's point of view, tooth fracture already indicated disability, and the patient was willing to perform the surgical procedure, with guided surgery, as discussed with the team. The patient was satisfied with the immediate and long-term aesthetic and functional results, with no complications to report.

Patient Consent

Written informed consent was obtained from the patient for publication of this case report and any accompanying images including clinical pictures and investigations. A copy of the written consent and approval by ethics committee from our institution are available for review by the Editor of this journal.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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