

Digital planning and static guided surgery in a limited prosthetic space: a clinical case report

Planejamento digital e cirurgia guiada estática em espaço protético limitado: relato de caso clínico

Beatriz Cristina de PAULO¹ , Leandro César da Silva SIMÕES¹ , Tatiana Pereira CURSINO¹ , Diana Pereira CUNHA¹ ,
Guilherme de Siqueira Ferreira Anzaloni SAAVEDRA¹ 

1 - Universidade Estadual Paulista "Júlio de Mesquita Filho". São José dos Campos, SP, Brazil.

How to cite: Paulo BC, Simões LCS, Cursino TP, Cunha DP, Saavedra GSFA. Digital planning and static guided surgery in a limited prosthetic space: a clinical case report. *Braz. Dent. Sci.* 2026;29:e5086. <https://doi.org/10.4322/bds.2026.e5086>

ABSTRACT

Dimensional reduction of the alveolar ridge after tooth extraction in the posterior mandible may limit available bone volume and prosthetic space, increasing the risk of improper implant positioning. Digital technologies (CBCT, intraoral scanning, virtual planning, and guided surgery) have enhanced three-dimensional control of the procedure and reduced clinical subjectivity. **Objective:** To report a clinical case in which digital planning and static guided surgery improved the predictability of a single-tooth rehabilitation in a posterior region with limited bone availability. **Case report:** A 51-year-old female patient with a root fracture and mobility of tooth 36 underwent extraction. After 12 months, a new CBCT scan and intraoral scan were obtained and superimposed for reverse planning and fabrication of a 3D-printed surgical guide. A 3.75 × 8.5 mm implant was placed using a guided protocol, with an insertion torque of 60 Ncm and an initial ISQ of 75. After five months, the ISQ increased to 80; an intraoral scan with a scan body was performed, and a zirconia crown cemented on a TiBase was fabricated and delivered without the need for occlusal adjustment. **Results:** Progressive implant stability was observed throughout clinical follow-up, with a functional definitive restoration and no reported complications. **Conclusions:** This case suggests that integrating digital planning with static guided surgery may support accurate three-dimensional implant positioning and increase the predictability of single-tooth rehabilitations in posterior regions with limited bone availability.

KEYWORDS

Digital planning; Guided surgery; Implant stability; Intraoral scanning; Posterior mandible.

RESUMO

A redução dimensional do rebordo alveolar após exodontias na mandíbula posterior pode limitar o volume ósseo e o espaço protético, aumentando o risco de posicionamento inadequado do implante. Tecnologias digitais como, TCFC, escaneamento intraoral, planejamento virtual e cirurgia guiada têm trazido maior previsibilidade clínica, ampliando o controle tridimensional do procedimento, reduzido a subjetividade. **Objetivo:** Relatar um caso clínico em que o planejamento digital e a cirurgia guiada estática favoreceram a previsibilidade de uma reabilitação unitária em região posterior com disponibilidade óssea limitada. **Relato de caso:** Paciente feminina, 51 anos, com fratura radicular e mobilidade no dente 36, foi submetida à exodontia. Após 12 meses, realizou-se nova TCFC e escaneamento intraoral, com sobreposição de imagens para planejamento reverso e confecção de guia cirúrgico impresso em 3D. Foi instalado um implante de 3,75 × 8,5 mm por protocolo guiado, com torque de inserção de 60 Ncm e ISQ inicial de 75. Após cinco meses, o ISQ foi de 80; realizou-se escaneamento com scan body e confeccionou-se uma coroa em zircônia cimentada sobre TiBase, instalada sem necessidade de ajuste oclusal. **Resultados:** Observou-se estabilidade progressiva do implante ao longo do acompanhamento clínico, com restauração definitiva funcional e sem intercorrências relatadas. **Conclusões:** Este caso sugere que a integração do planejamento digital com a cirurgia guiada estática pode favorecer o posicionamento tridimensional adequado e aumentar a previsibilidade de reabilitações unitárias em regiões posteriores com limitação óssea.

PALAVRAS-CHAVE

Planejamento digital; Cirurgia guiada; Estabilidade do implante; Escaneamento intraoral; Mandíbula posterior.

INTRODUCTION

Implant dentistry has experienced substantial progress in recent years, primarily due to the incorporation of digital technologies in the planning and execution of surgical procedures. With the assistance of computed tomography, particularly cone-beam computed tomography, and intraoral scanning, it is possible to evaluate the patient's anatomy in advance, simulate the three-dimensional positioning of the implant, and anticipate potential limitations. These resources have improved clinical decision-making by enabling more predictable and individualized treatments, even in complex clinical situations [1-4].

One of the most frequent challenges in implant placement is the dimensional loss of the alveolar ridge after tooth extraction. This reduction can compromise the ideal three-dimensional implant position and lead to functional and aesthetic limitations, especially when associated with limited prosthetic space or proximity to critical anatomical structures [5,6]. In such cases, even small millimetric variations during implant positioning may render the treatment unfeasible or compromise future rehabilitation [7].

Digital planning and guided surgery are predictable tools for managing many of these limitations. These protocols allow for a detailed analysis of the case, supporting accurate implant placement, respect for biological boundaries, and reduced risk of intraoperative deviations [8,9]. The use of guided surgery is particularly relevant in situations where the available bone or prosthetic space is limited, as it assists in maintaining three-dimensional control of the procedure. Furthermore, prosthodontically driven implant planning allows the ideal three-dimensional positioning of the crown to be defined first, and from this, the optimal placement of the implant can be determined, thereby improving prosthetic rehabilitation and the overall outcome [10].

The use of surgical guides supports a more conservative approach, requiring minimal tissue reflection and providing greater precision during the surgical procedure. In addition, this strategy may reduce the risk of angular deviations and improper implant positioning, thereby increasing the predictability of the treatment. In cases where the margin of error is minimal, digital technology becomes a decisive factor for the treatment's success [3,11,12].

The present study reports a clinical case of a patient who underwent extraction of tooth 36 and subsequent implant placement using static guided surgery. The case illustrates how digital planning can be a viable and decisive tool in posterior regions with limited bone volume, reinforcing the role of digital technologies in contemporary implant dentistry.

CASE REPORT

A 51-year-old female patient sought care at the Institute of Science and Technology of São Paulo State University (ICT Unesp) in São José dos Campos for evaluation of the posterior mandibular region. Tooth 36 demonstrated signs of a previous root fracture as well as clinical mobility (Figure 1). After radiographic and clinical assessment, extraction of the tooth was indicated.

Following the extraction, a titanium barrier (Surgitime Seal, Bionnovation) was placed with the aim of preserving the ridge contour and promoting tissue healing.

After 12 months, the patient returned to begin rehabilitation with a single implant in the region of tooth 36 (Figure 2).

A treatment plan was done using mandibular cone-beam computed tomography and intraoral scanning (CS 3600, Carestream). The files were imported into the Exoplan software (Exocad GmbH), allowing image superimposition and prosthodontically driven implant planning to ensure the ideal prosthetic position prior to determining the implant placement (Figures 3, 4 and 5).

A 3.75 × 8.5 mm implant (Flash, Conexão Sistemas de Prótese) was selected, and the surgical guide was designed in the same software (Figure 6).



Figure 1 - Clinical aspect of tooth 36 presenting extensive crown fracture and indication for extraction, buccal view.

The guide was printed using the dima® Print Surgical Guide & Tray polymer (Kulzer GmbH,



Figure 2 - Clinical appearance of the healed alveolar ridge in the region of tooth 36 twelve months after extraction, occlusal view.

Hanau) on a 3D printer (Cara Print 4.0 pro, Kulzer) through the DLP method (Figure 7). For the implant placement surgery, the EXPERTGUIDE® drilling kit (Conexão Sistemas de Prótese) was used.

The drilling sequence used was:

- Punch Flat Regular – to remove soft tissue and expose the bone;
- Plane Regular – to level the bone surface;
- Center Regular Ø2.8 – 5 mm – to penetrate the cortical bone;
- Hand Free Regular Ø2.8/3.2 – 8.5 mm drill – for implant site preparation.

After implant placement, an insertion torque of 60 Ncm was achieved, and the Implant Stability Quotient (ISQ) was measured using the Osstell Beacon device (Osstell AB), yielding an initial value of 75 (Figure 8).

Five months after implant placement, the patient went for a follow-up and a second-stage procedure. A new ISQ measurement was taken, yielding a value of 80, indicating improved implant stability. Subsequently, a new intraoral scan was obtained with a scan body (Conexão Sistemas de Prótese) in position. With the digital files acquired, the definitive crown was designed using the Exocad software (Exocad GmbH).

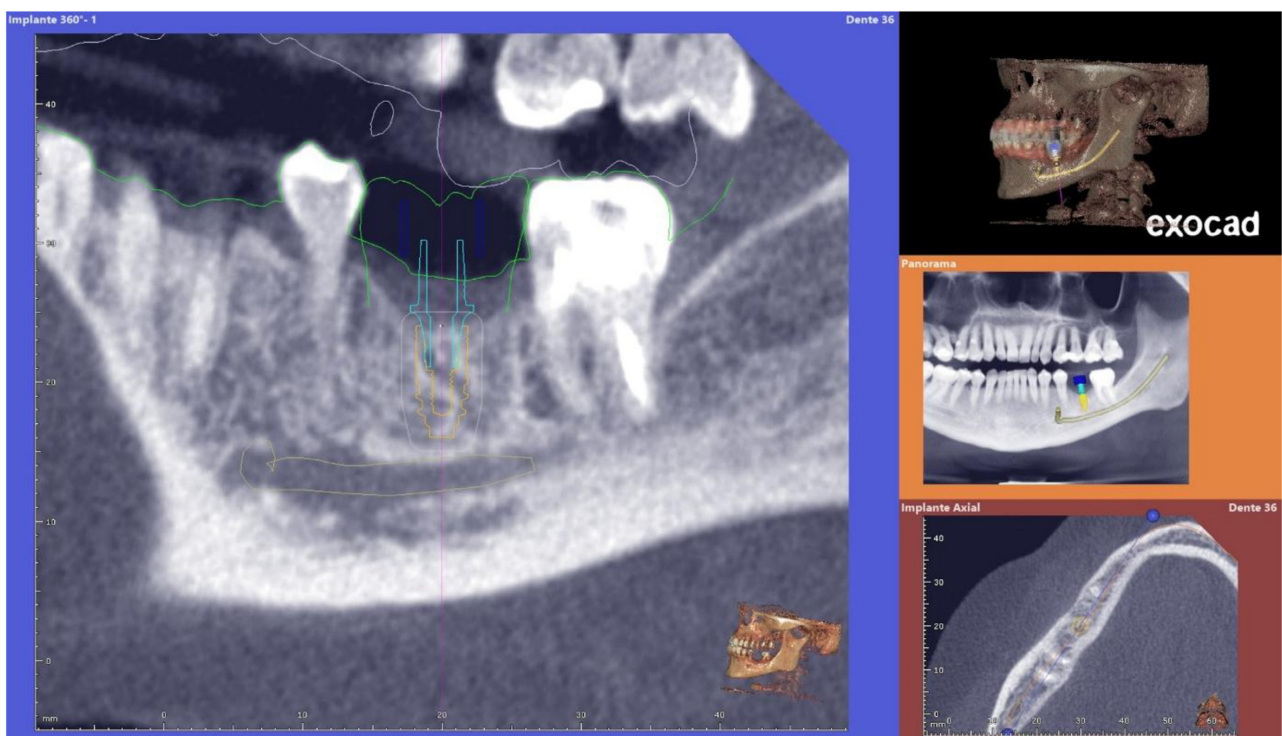


Figure 3 - Sagittal CBCT view of the virtual implant planning in the region of tooth 36 using Exoplan software (Exocad GmbH).

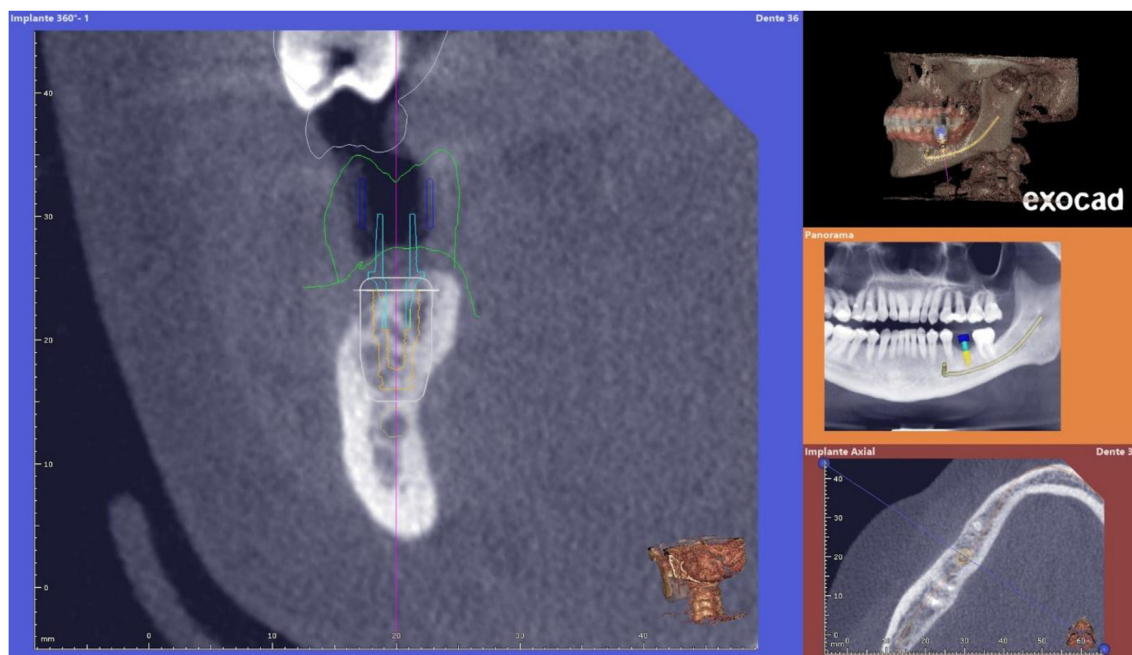


Figure 4 - Cross-sectional CBCT view of the virtual implant planning demonstrating the proposed implant position in the region of the tooth using Exoplan software (Exocad GmbH).

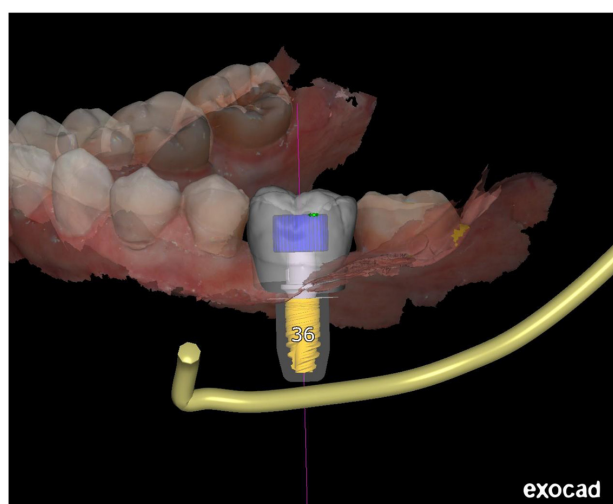


Figure 5 - Prosthetically driven virtual planning showing the relationship between implant position and definitive crown restoration, lateral view, using Exoplan software (Exocad GmbH).

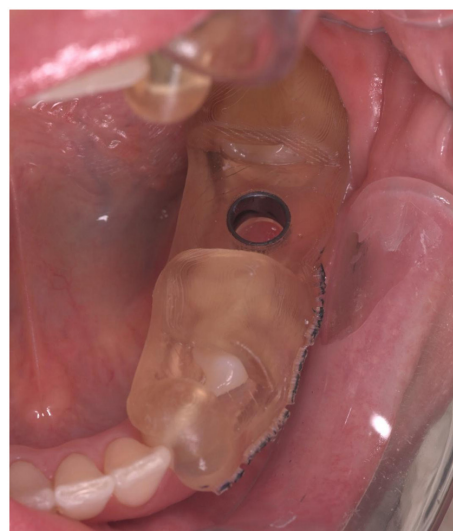


Figure 7 - Intraoral view of the surgical guide seated in position before implant osteotomy, occlusal view.

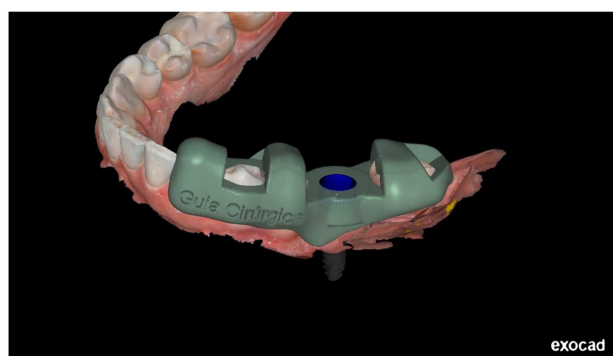


Figure 6 - Computer-designed surgical guide for implant placement in the region of tooth 36, lateral view, using Exoplan software (Exocad GmbH).



Figure 8 - Measurement of implant stability quotient (ISQ) using the Osstell Beacon device immediately after implant placement, lateral view (Osstell AB).



Figure 9 - Prosthetic crown after 6 months of crown installation, occlusal view.

The crown was then milled in zirconia (IPS e.max ZirCAD Prime Esthetic, Ivoclar) and cemented onto a TiBase (Small NP, Conexão Sistemas de Prótese). It was installed at the following appointment, and no occlusal adjustments were required.

After 6 months of crown installation, the patient returned for a follow-up appointment (Figure 9). Radiographic evaluation revealed no evidence of marginal bone loss (Figures 10A, 10B and 10C). The peri-implant tissues showed no signs of inflammation. Additionally, the patient reported satisfaction with both the esthetic and functional outcomes of the prosthetic rehabilitation.

DISCUSSION

Advances in digital technologies and surgical protocols have directly influenced the accuracy and clinical reliability of implant-supported rehabilitations [13].



Figure 10 - Periapical radiographs of the implant site at different treatment stages. (A) Preoperative radiograph; (B) Immediate postoperative radiograph after implant placement; (C) Periapical radiograph obtained at the 6-month follow-up.

Historically, implant placement in posterior mandibular regions has represented a clinical challenge, especially in situations where the ridge exhibits significant dimensional reduction following tooth extraction. Under these circumstances, the risk of improper positioning increases substantially and may compromise the functional and aesthetic outcomes of the treatment [14].

The incorporation of software planning and guided surgery techniques allows both anatomical and prosthetic parameters to be anticipated, reducing clinical subjectivity and enabling proper three-dimensional implant positioning [15,16].

Prosthetically driven implant planning has been proven as a key factor contributing to the clinical success of implant treatments, as it allows the ideal crown position to be defined first and subsequently transferred to the surgical phase. This concept eliminates the need to adapt the prosthesis to the implant position and instead determines the implant position based on functional, structural, and prosthetic requirements [17,18]. In areas where prosthetic or bone space is limited, as observed in this clinical case, the digital approach provides greater control, assisting in the distribution of masticatory loads and in the preservation of peri-implant tissues. Prosthetic planning is performed before surgery according to the principles of prosthodontically driven implant planning. This process involves the evaluation of interocclusal space, occlusal relationships, load distribution, esthetic demands, available bone volume, soft tissue characteristics, emergence profile, implant angulation, and restorative material selection to define the optimal prosthetic position and guide three-dimensional implant placement [19].

In addition, recent quantitative studies have demonstrated that computer-guided surgery provides greater accuracy when compared to the conventional freehand technique for dental implant placement [20]. Systematic reviews and meta-analyses have reported that freehand surgery presents average deviations of approximately 7.46° in the insertion angle, 1.56 mm in the coronal entry point, and 2.22 mm in the implant apex, while fully guided surgical protocols reduce these values to approximately 2.57°, 0.72 mm, and 0.88 mm, respectively [21]. Furthermore, comparative analyses have shown that computer-assisted implant protocols increase the accuracy of implant positioning, reducing angular and linear deviations, especially when fully guided static surgical guides are used [22].

Another relevant aspect, regarding the surgical phase, concerns the primary stability of the implant, which is considered an indicator of early success. This stability can be assessed using two methods: a torque wrench, which measures mechanical resistance during implant insertion, and resonance frequency analysis (RFA), which provides the Implant Stability Quotient (ISQ) value, measuring the bone-implant contact immediately after implant insertion and after the osseointegration period [23,24].

Torque primarily reflects local bone quality and the macrogeometry of the implant, whereas the ISQ provides a noninvasive assessment of the stiffness of the implant–bone complex throughout the healing period. Current literature indicates that torque values above 35–45 Ncm and ISQ values greater than 65–70 are generally associated with successful osseointegration [25–27]. In the present case, a progressive increase in ISQ values was achieved throughout the follow-up period, indicating maintenance and improvement of biological stability and contributing to a favorable prognosis after crown placement.

The literature also extensively discusses the use of short implants in posterior regions. Although limitations exist and long-term studies are still relatively scarce, it is well established that greater implant length and diameter result in a larger bone–implant contact area and, consequently, more effective dissipation of masticatory forces [28,29].

However, in cases where anatomical conditions impose restrictions and bone reconstruction procedures would entail greater biological and surgical costs, short implants—when combined with digital planning and guided surgery—represent a viable clinical alternative. Moreover, the design and macrogeometry of modern implants have enabled improved bone anchorage even in reduced vertical dimensions [30,31].

In this study, load distribution is particularly important due to the use of short implants, whose reduced length limits the area available for stress dissipation, necessitating better occlusal adjustment. Therefore, biomechanical control through proper prosthetic design and occlusal adjustment is essential to maintain peri-implant bone stability and ensure long-term rehabilitation success. Studies have shown that oblique loads and excessive occlusal contacts can increase stress concentration in the crestal bone around short implants [32,33].

In addition, digital planning can incorporate biomechanical considerations to optimize treatment performance and long-term stability. The prosthetic design should be developed to achieve an optimal emergence profile, favorable crown contours, and an appropriate occlusal scheme, promoting efficient load distribution along the implant axis while minimizing lateral stresses on the peri-implant tissues and prosthetic components [34]. Occlusal adjustment prioritized axial contacts in maximum intercuspation and a mutually protected occlusal scheme, with reduced excursive interferences. Furthermore, a simplified occlusal anatomy, characterized by a narrower occlusal table, flatter cusp inclinations, and reduced occlusal contacts, was adopted to decrease bending moments and enhance the biomechanical performance and longevity of the implant-supported restoration [35].

Another relevant aspect concerns the crown-to-implant ratio, which is often increased in rehabilitations involving short implants. Although this relationship has historically been associated with a higher risk of biomechanical complications, more recent evidence suggests that the crown-to-implant ratio alone should not be considered a determining factor for clinical failure, provided that adequate osseointegration, prosthetic stability, and favorable distribution of occlusal loads are achieved [36,37]. In this context, digital planning plays a fundamental role by allowing these factors to be comprehensively evaluated prior to treatment, thereby facilitating optimal implant positioning and occlusal scheme design to promote improved load distribution and long-term prosthetic stability [19].

Static guided surgery helps minimize the risk of intraoperative deviations, reduce surgical time, and promote a minimally invasive approach. These factors are directly associated with lower morbidity rates and greater postoperative comfort for the patient. Likewise, intraoral scanning and the integration of three-dimensional imaging contribute to procedural accuracy, allowing the planned positioning to be more accurately transferred during the surgical phase [38,39].

Regarding the design and extension of the surgical guide, the present case employed a half-jaw surgical guide rather than a conventional full-arch guide. Previous studies have demonstrated that shortened tooth-supported surgical guides can achieve accuracy comparable to conventional full-arch guides when adequate dental support and guide stability are present. Furthermore,

reduced guide extension may improve surgical access, visibility, and irrigation during osteotomy preparation. However, full-arch guides provide a larger support area and may offer greater resistance to displacement during surgery [40,41]. Therefore, the choice between a half-jaw and a full-arch guide should be based on the clinical situation, available support, and surgical requirements.

Guided surgery is not free from limitations, the technique requires additional costs related to imaging exams, planning software, surgical guide fabrication, and specific surgical kits. Moreover, its clinical success depends on an adequate learning curve, careful digital planning, proper guide adaptation, and stable intraoperative positioning [42]. Even when fully guided protocols are used, deviations may still occur due to errors in image acquisition, segmentation, guide manufacturing, or guide seating during surgery. Therefore, guided surgery should be considered a tool to improve surgical control rather than a method capable of completely eliminating clinical deviations [31].

Finally, the absence of complications during follow-up and the clinical stability observed after crown placement confirm the effectiveness and predictability of the protocol used in this clinical case. The adoption of an approach based on digital planning, guided surgery, and objective assessment of implant stability demonstrates that, even under conditions of limited bone availability, favorable clinical outcomes can be achieved, and masticatory function can be safely restored.

CONCLUSION

This case demonstrates that the integration of digital planning and guided surgery can enhance the predictability of single-tooth rehabilitations, even in posterior regions with limited bone availability. The approach adopted enabled proper three-dimensional positioning, maintenance of stability throughout follow-up, and satisfactory functional restoration after placement of the definitive crown. These findings reinforce the importance of digital resources as allies in clinical decision-making and in the execution of minimally invasive treatments. Although the results observed in this case cannot be generalized, this report contributes to a better understanding of the potential of these technologies and highlights the need for further studies to assess their benefits in diverse clinical scenarios.

Acknowledgements

The authors would like to thank the professionals and faculty of the São Paulo State University (UNESP), São José dos Campos campus, for their clinical and technical support throughout the patient's treatment and for providing the infrastructure necessary for the digital planning and surgical procedures.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author's Contributions

BCP, LCSS: Conceptualization, Methodology, Writing – Original Draft Preparation. DPC: Writing – Original Draft Preparation. TPC, GSFAS: Data Curation, Writing – Review & Editing, Formal Analysis. GSFAS: Resources, Project Administration, Funding Acquisition.

Conflict of Interest

No conflicts of interest declared concerning the publication of this article.

Funding

The authors acknowledge Conexão Sistemas de Prótese for providing the surgical kits used in this clinical case.

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of Comitê de Ética em Pesquisa of the Faculdade de Odontologia de São José dos Campos – UNESP and the patient signed the free and informed consent form.

REFERENCES

1. Haghaniifar S, Shafaroudi AM, Nasiri P, Amin MM, Sabet JM. Evaluation of bone density by cone-beam computed tomography and its relationship with primary stability of dental implants. *Dent Res J*. 2022;19(1):22. <https://doi.org/10.4103/1735-3327.340107>. PMID:35432788.
2. Dioguardi M, Spirito F, Quarta C, Sovereto D, Basile E, Ballini A, et al. Guided dental implant surgery: systematic review. *J Clin*

- Med. 2023;12(4):1490. <https://doi.org/10.3390/jcm12041490>. PMID:36836025.
3. Subramani K. Is computer-guided implant placement with a flapless approach more accurate than with a flapped surgical approach? *Evid Based Dent*. 2022;23(3):110-1. <https://doi.org/10.1038/s41432-022-0813-2>. PMID:36151285.
4. Shi Y, Wang J, Ma C, Shen J, Dong X, Lin D. A systematic review of the accuracy of digital surgical guides for dental implantation. *Int J Implant Dent*. 2023;9(1):38. <https://doi.org/10.1186/s40729-023-00507-w>. PMID:37875645.
5. Misch CE, Perel ML, Wang HL, Sammartino G, Galindo-Moreno P, Trisi P, et al. Implant success, survival, and failure: The International Congress of Oral Implantologists (ICOI) pisa consensus conference. *Implant Dent*. 2008;17(1):5-15. <https://doi.org/10.1097/ID.0b013e3181676059>. PMID:18332753.
6. Papaspyridakos P, Chen CJ, Singh M, Weber HP, Gallucci GO. Success criteria in implant dentistry: a systematic review. *J Dent Res*. 2012;91(3):242-8. <https://doi.org/10.1177/0022034511431252>. PMID:22157097.
7. Putra RH, Yoda N, Astuti ER, Sasaki K. The accuracy of implant placement with computer-guided surgery in partially edentulous patients and possible influencing factors: a systematic review and meta-analysis. *J Prosthodont Res*. 2022;66(1):29-39. https://doi.org/10.2186/jpr.JPR_D_20_00184. PMID:33504723.
8. Romandini M, Ruales-Carrera E, Sadilina S, Hämmerle CHF, Sanz M. Minimal invasiveness at dental implant placement: a systematic review with meta-analyses on flapless fully guided surgery. *Periodontol 2000*. 2023;91(1):89-112. <https://doi.org/10.1111/prd.12440>. PMID:35906928.
9. Pereira GM, De Paulo BC, Franca CG, Conceição SP, Pereira TC, Saavedra GSFA. Knoop microhardness test in polymers used for surgical guide manufacturing after the disinfection process. *Braz Dent Sci*. 2025;28(3):e4643. <https://doi.org/10.4322/bds.2025.e4643>.
10. Reiff FS, Bischoff C, Woelfler H, Roehling S. Influence of clinical expertise and practical experience on transfer accuracy in guided dental implant placement - an in vitro study. *Oral Maxillofac Surg*. 2024;28(4):1491-500. <https://doi.org/10.1007/s10006-024-01269-4>. PMID:38914846.
11. Chackartchi T, Romanos GE, Parkanyi L, Schwarz F, Sculean A. Reducing errors in guided implant surgery to optimize treatment outcomes. *Periodontol 2000*. 2022;88(1):64-72. <https://doi.org/10.1111/prd.12411>. PMID:35103317.
12. Singthong W, Serichetaphongse P, Chengprapakorn W. A randomized clinical trial on the accuracy of guided implant surgery between two implant-planning programs used by inexperienced operators. *J Prosthet Dent*. 2024;131(3):436-42. <https://doi.org/10.1016/j.prosdent.2022.01.038>. PMID:35314068.
13. Bayrakdar SK, Orhan K, Bayrakdar IS, Bilgir E, Ezhov M, Gusarev M, et al. A deep learning approach for dental implant planning in cone-beam computed tomography images. *BMC Med Imaging*. 2021;21(1):86. <https://doi.org/10.1186/s12880-021-00618-z>. PMID:34011314.
14. Chatzopoulos GS, Wolff LF. Dental implant failure and bone augmentation: a retrospective study. *J Clin Exp Dent*. 2023;15(3):e195-204. <https://doi.org/10.4317/jced.60171>. PMID:37008243.
15. Kernen F, Kramer J, Wanner L, Wismeijer D, Nelson K, Flügge T. A review of virtual planning software for guided implant surgery: data import and visualization, drill guide design and manufacturing. *BMC Oral Health*. 2020;20(1):251. <https://doi.org/10.1186/s12903-020-01208-1>. PMID:32912273.
16. Pereira TC, Godoy F, Cunha D, Viegas DC, Saavedra GSFA. How reverse planning and the use of digital devices revolutionize implantology? Case report. *Braz Dent Sci*. 2024;27(2):1-9. <https://doi.org/10.4322/bds.2024.e4327>.
17. Vasoglou G, Stefanidaki I, Apostolopoulos K, Fotakidou E, Vasoglou M. Accuracy of mini-implant placement using a computer-aided

- designed surgical guide, with information of intraoral scan and the use of a cone-beam CT. *Dent J.* 2022;10(6):104. <https://doi.org/10.3390/dj10060104>. PMID:35735647.
18. Mahmoud NR, Kamal Eldin MH, Diab MH, Mahmoud OS, Fekry YES. Computer guided versus freehand dental implant surgery: randomized controlled clinical trial. *Saudi Dent J.* 2024;36(11):1472-6. <https://doi.org/10.1016/j.sdentj.2024.09.006>. PMID:39619712.
 19. Flügge T, Kramer J, Nelson K, Nahles S, Kernen F. Digital implantology-a review of virtual planning software for guided implant surgery. Part II: prosthetic set-up and virtual implant planning. *BMC Oral Health.* 2022;22(1):23. <https://doi.org/10.1186/s12903-022-02057-w>. PMID:35094677.
 20. Reiff FS, Kroeger A, Roehling S, Reiff C, Kebschull M. Accuracy of freehand, static, and dynamic computer-assisted implant placement: a systematic review and meta-analysis. *J Periodontol Res.* 2026;61(2):111-37. <https://doi.org/10.1111/jre.70047>. PMID:41307329.
 21. Werny JG, Frank K, Fan S, Sagheb K, Al-Nawas B, Narh CT, et al. Freehand vs. computer-aided implant surgery: a systematic review and meta-analysis. Part 1: accuracy of planned and placed implant position. *Int J Implant Dent.* 2025;11(1):35. <https://doi.org/10.1186/s40729-025-00622-w>. PMID:40314873.
 22. Khaohoen A, Powcharoen W, Yoda N, Rungsiyakull C, Rungsiyakull P. Accuracy in dental implant placement: a systematic review and meta-analysis comparing computer-assisted (static, dynamic, robotics) and noncomputer-assisted (freehand, conventional guide) approaches. *J Prosthet Dent.* 2025;134(1):91.e1-25. <https://doi.org/10.1016/j.prosdent.2025.03.038>. PMID:40221370.
 23. Palaskar J, Joshi N, Shah P, Gullapalli P, Vinay V. Influence of different implant placement techniques to improve primary implant stability in low-density bone: a systematic review. *J Indian Prosthodont Soc.* 2020;20(1):11-6. https://doi.org/10.4103/jips.jips_244_18. PMID:32089594.
 24. Al-Juboori H, Petronis Z, Razukevicius D. The interrelation between cortical bone thickness and primary and secondary dental implant stability: a systematic review. *J Oral Maxillofac Res.* 2024;15(4):e2. <https://doi.org/10.5037/jomr.2024.15402>. PMID:40017687.
 25. Abdalla KL, Ali Mahmood TM. The effect of different orthodontic mini-implant brands and geometry on primary stability (an in vitro study). *Heliyon.* 2023;9(9):e19858. <https://doi.org/10.1016/j.heliyon.2023.e19858>. PMID:37809894.
 26. Khan MW, Inayat N, Zafar MS, Zaigham AM. A resonance frequency analysis to investigate the impact of implant size on primary and secondary stability. *Pak J Med Sci.* 2024;40(6):1261-6. <https://doi.org/10.12669/pjms.40.6.8213>. PMID:38952523.
 27. Annibali S, Bignozzi I, La Monaca G, Cristalli MP. Usefulness of the aesthetic result as a success criterion for implant therapy: a review. *Clin Implant Dent Relat Res.* 2012;14(1):3-40. <https://doi.org/10.1111/j.1708-8208.2009.00234.x>. PMID:19673953.
 28. Abdel-Halim M, Issa D, Chrcanovic BR. The impact of dental implant length on failure rates: a systematic review and meta-analysis. *Materials.* 2021;14(14):3972. <https://doi.org/10.3390/ma14143972>. PMID:34300891.
 29. Papaspyridakos P, De Souza A, Vazouras K, Gholami H, Pagni S, Weber HP. Survival rates of short dental implants (≤ 6 mm) compared with implants longer than 6 mm in posterior jaw areas: a meta-analysis. *Clin Oral Implants Res.* 2018;29(Suppl 16):8-20. <https://doi.org/10.1111/clr.13289>. PMID:30328206.
 30. Ku JK, Lee J, Lee HJ, Yun PY, Kim YK. Accuracy of dental implant placement with computer-guided surgery: a retrospective cohort study. *BMC Oral Health.* 2022;22(1):8. <https://doi.org/10.1186/s12903-022-02046-z>. PMID:35034613.
 31. Khaohoen A, Powcharoen W, Sornsuan T, Chaijareenont P, Rungsiyakull C, Rungsiyakull P. Accuracy of implant placement with computer-aided static, dynamic, and robot-assisted surgery: a systematic review and meta-analysis of clinical trials. *BMC Oral Health.* 2024;24(1):359. <https://doi.org/10.1186/s12903-024-04033-y>. PMID:38509530.
 32. Emfietzoglou R, Dereka X. Survival rates of short dental implants (≤ 6 mm) used as an alternative to longer (> 6 mm) implants for the rehabilitation of posterior partial edentulism: a systematic review of RCTs. *Dent J.* 2024;12(6):185. <https://doi.org/10.3390/dj12060185>. PMID:38920886.
 33. Yuan X, Liu Y, Yang Y, Ren M, Luo L, Zheng L, et al. Effect of short implant crown-to-implant ratio on stress distribution in anisotropic bone with different osseointegration rates. *BMC Oral Health.* 2023;23(1):683. <https://doi.org/10.1186/s12903-023-03379-z>. PMID:37730562.
 34. Schubert O, Schweiger J, Stimmelmayer M, Nold E, Güth JF. Digital implant planning and guided implant surgery: workflow and reliability. *Br Dent J.* 2019;226(2):101-8. <https://doi.org/10.1038/sj.bdj.2019.44>. PMID:30679852.
 35. Kaukinen JA, Edge MJ, Lang BR. The influence of occlusal design on simulated masticatory forces transferred to implant-retained prostheses and supporting bone. *J Prosthet Dent.* 1996;76(1):50-5. [https://doi.org/10.1016/S0022-3913\(96\)90346-7](https://doi.org/10.1016/S0022-3913(96)90346-7). PMID:8814635.
 36. Meijer HJA, Boven C, Delli K, Raghoobar GM. Is there an effect of crown-to-implant ratio on implant treatment outcomes? A systematic review. *Clin Oral Implants Res.* 2018;29(Suppl 18):243-52. <https://doi.org/10.1111/clr.13338>. PMID:30306696.
 37. Li R, Wu Z, Chen S, Li X, Wan Q, Xie G, et al. Biomechanical behavior analysis of four types of short implants with different placement depths using the finite element method. *J Prosthet Dent.* 2023;129(3):447.e1-10. <https://doi.org/10.1016/j.prosdent.2023.01.005>. PMID:36737356.
 38. Török G, Gombocz P, Bognár E, Nagy P, Dinya E, Kispélyi B, et al. Effects of disinfection and sterilization on the dimensional changes and mechanical properties of 3D printed surgical guides for implant therapy: pilot study. *BMC Oral Health.* 2020;20(1):19. <https://doi.org/10.1186/s12903-020-1005-0>. PMID:31973705.
 39. Pop SI, Dudesu M, Mihali SG, Păcurar M, Bratu DC. Effects of disinfection and steam sterilization on the mechanical properties of 3D SLA- and DLP-printed surgical guides for orthodontic implant placement. *Polymers.* 2022;14(10):2107. <https://doi.org/10.3390/polym14102107>. PMID:35631989.
 40. Kasradze D, Kubilius R. Influence of guide support on the accuracy of static Computer-Assisted Implant Surgery (sCAIS) in partially edentulous cases using a keyless guiding system: an in vitro study. *BMC Oral Health.* 2025;25(1):563. <https://doi.org/10.1186/s12903-025-05955-x>. PMID:40223057.
 41. Wu YT, Papaspyridakos P, Kang K, Finkelman M, Kudara Y, De Souza AB. Accuracy of different surgical guide designs for static computer-assisted implant surgery: an in vitro study. *J Oral Implantol.* 2022;48(5):351-7. <https://doi.org/10.1563/aaid-joi-D-21-00055>. PMID:34937081.
 42. Pimkhakham A, Chow J, Pozzi A, Arunjarosuk S, Subbalehka K, Mattheos N. Computer-assisted and robotic implant surgery: assessing the outcome measures of accuracy and educational implications. *Clin Oral Implants Res.* 2024;35(8):939-53. <https://doi.org/10.1111/clr.14213>. PMID:37994685.

Beatriz Cristina de Paulo
(Corresponding address)

Universidade Estadual Paulista “Júlio de Mesquita Filho”, São José dos Campos, SP, Brazil.

Email: beatriz.paulo@unesp.br

Editor-in-chief: Sergio Eduardo de Paiva Gonçalves

Editor: João Paulo Mendes Tribst

Date submitted: 2026 Feb 27

Accept submission: 2026 June 23