BRAZILIAN JOURNAL OF IMPLANTOLOGY AND HEALTH SCIENCES

ISSN 2674-8169

GUIDED SURGERY IN IMPLANTOLOGY: A HISTORICAL RETROSPECTIVE

Marvin Gonçalves Duarte[1], Diogo Acioli Filizola Germano[1], Lucas de Jesus Santana do Amaral[1], Gracielle Radja Rodrigues de Lima[1], Brunno Stephany Lima de Paula[2], Juliana Perez Leyva Ataíde[3], Rodolfo Scavuzzi Carneiro da Cunha[1], Ailton Coelho de Ataíde Filho[1], Luciano Barreto Silva[1] and Eudoro de Queiroz Marques Filho[1]

https://doi.org/10.36557/2674–8169.2025v7n2p2666-2678

Artigo publicado em 26 de Fevereiro de 2025

LITERATURE REVIEW

ABSTRACT

Objective: This study aimed to explore the technological advancements in modern implant dentistry, with a focus on guided surgery techniques. Specifically, it evaluated the benefits, limitations, and impact of software and digital tools in comparison to traditional implantology methods. **Materials and methods:** To construct this narrative review, a methodological strategy was developed to ensure the inclusion of the most current, relevant, and scientifically validated information on the topic, providing robust and well-supported content. Comprehensive searches were conducted across multiple databases, including DeCs, BVS/BIREME, PROSPERO, SciELO, PubMed Central, ScienceDirect, Web of Science, and The Cochrane Library, complemented by Google Scholar. **Results:** The findings revealed that guided surgery significantly enhances the precision of implant placement, reduces surgical errors, and improves the distribution of masticatory forces, resulting in higher implant longevity. Techniques like flapless surgery were associated with lower postoperative morbidity, reduced healing time, and improved patient comfort. Digital planning tools, including NobelClinician and CoDiagnostiX, enabled three-dimensional visualization and precise execution of surgical procedures. However, challenges such as high costs, technical learning curves, and dependency on advanced equipment were identified as barriers to widespread adoption. **Conclusion:** The integration of digital technologies into implantology has transformed clinical practice, offering superior outcomes compared to traditional methods. Guided surgery minimizes invasiveness, enhances procedural predictability, and improves patient recovery. Despite its advantages, the adoption of these technologies requires addressing economic and technical constraints to ensure broader accessibility and application.

Keywords: Dental Implants; Surgery, Oral; Mouth Rehabilitation.

CIRURGIA GUIADA NA IMPLANTODONTIA: UMA RETROSPECTIVA HISTÓRICA

RESUMO

Objetivo: Este estudo teve como objetivo investigar os avanços tecnológicos na implantodontia moderna, com ênfase nas técnicas de cirurgia guiada. A pesquisa focou em avaliar os benefícios, limitações e impacto das ferramentas digitais e softwares em comparação com os métodos tradicionais de implantodontia. **Metodologia:** Foi utilizada uma metodologia de revisão narrativa para reunir as informações mais atuais, relevantes e cientificamente validadas. Foram realizadas buscas extensivas em bases de dados como DeCs, BVS/BIREME, PROSPERO, SciELO, PubMed Central, ScienceDirect, Web of Science e The Cochrane Library, complementadas pelo Google Scholar. **Resultados:** A revisão destacou que a cirurgia guiada melhora significativamente a precisão no posicionamento dos implantes, reduz erros cirúrgicos e otimiza a distribuição das forças mastigatórias, aumentando a longevidade dos implantes. Técnicas como a cirurgia sem retalho demonstraram menor morbidade pós-operatória, tempo de cicatrização reduzido e maior conforto para o paciente. Ferramentas de planejamento digital, como NobelClinician e CoDiagnostiX, facilitaram a visualização tridimensional e a execução precisa dos procedimentos cirúrgicos. No entanto, barreiras como altos custos, curvas de aprendizado acentuadas e dependência de equipamentos avançados foram identificadas, limitando a adoção generalizada. **Conclusão:** A integração de tecnologias digitais na implantodontia revolucionou as práticas clínicas, oferecendo resultados superiores aos métodos tradicionais. A cirurgia guiada melhora a previsibilidade dos procedimentos, minimiza a invasividade e acelera a recuperação do paciente. Superar os desafios econômicos e técnicos é essencial para ampliar o acesso e maximizar o potencial desses avanços na prática odontológica rotineira.

Palavras-chave: Implantes Dentários; Cirurgia Bucal; Reabilitação Bucal.

Instituição afiliada – [1]Faculdade de Odontologia do Recife - FOR; [2]Universidade Maurício de Nassau - UNINASSAU, [3]Universidade de Pernambuco.
Autor correspondente: *Marvin Gonçalves Duarte - marvingduartee@gmail.com*

INTRODUCTION

The pursuit of rehabilitating lost teeth has been a constant throughout human history, dating back to ancient times when civilizations such as the Egyptians and Mayans experimented with replacing natural teeth using materials like shells and metals. Although rudimentary and with limited effectiveness, these early attempts underscore the functional and aesthetic importance of dentition in human life (ZARB; ALBREKTSSON; BAKER, 1998). However, it was only in the 20th century, with advancements in biotechnology and medicine, that modern implant dentistry began to take shape, particularly following the revolutionary discovery of osseointegration by Swedish professor Per-Ingvar Brånemark in the 1960s.

Osseointegration, a phenomenon in which titanium fuses stably with bone, enabled the development of dental implants that integrate durably and effectively into the body. Brånemark and his team demonstrated, through pioneering studies, that titanium could be used to rehabilitate edentulous patients with fixed prostheses supported by implants, forever transforming the field of restorative dentistry (BRÅNEMARK et al., 1977). This technique's introduction marked the onset of modern implant dentistry, which rapidly expanded over the following decades, becoming one of the most dynamic and innovative areas of dentistry.

However, the placement of osseointegrated implants initially relied almost exclusively on the surgeon's technical skill and clinical judgment based on two-dimensional radiographs. Although many cases were successful, traditional techniques were often associated with challenges such as improper implant positioning, damage to adjacent anatomical structures, and prolonged postoperative recovery periods (ADELL et al., 1981). These factors, combined with the anatomical variability among patients, highlighted the need for more precise and predictable methods for dental implant placement.

It was in this context that digital technology emerged as a transformative tool in implant dentistry over the past two decades. The development of computed tomography (CT) and its integration with three-dimensional surgical planning software enabled detailed visualization of the patient's anatomical structures and precise surgical planning before the intervention. From these innovations, guided surgery emerged as one of the most advanced techniques in dental implant placement, offering a level of precision and control previously unattainable with conventional methods (MISCH, 2008).

Guided surgery, utilizing customized surgical guides, allows implants to be positioned precisely according to the virtual plan, reducing the risk of errors and complications. The literature has demonstrated that this technique not only improves procedural accuracy but also provides significant benefits such as reduced invasiveness, shorter surgical times, and faster recovery for patients (VERCRUYSSEN; JACOBS, 2014). Furthermore, the predictability offered by guided surgery positively impacts implant longevity, as optimal positioning ensures better distribution of masticatory forces, reducing the risk of failure (TAHMASEB et al., 2014).

Among the leading software used for guided surgery planning are NobelClinician, SimPlant, and CoDiagnostiX. These programs offer sophisticated tools for analyzing and manipulating computed tomography images, allowing surgeons to plan implant placement with millimeter-level precision. The use of such software not only optimizes the aesthetic and functional outcomes of rehabilitations but also facilitates communication between the surgical team and the prosthetic laboratory, ensuring a more faithful execution of the planned procedure (ROCCI; MARTIGNONI; GOTTLOW, 2012).

Nevertheless, the adoption of guided surgery is not without challenges. The high cost of software and customized surgical guides, as well as the need for a significant learning curve, can pose barriers to widespread implementation. Additionally, reliance on advanced technologies requires clinics to be equipped with the necessary resources to perform procedures safely and effectively (BLOCK; EMERY, 2016).

Given this scenario, this study aims to delve deeply into the technological innovations driving the evolution of implant dentistry, with a particular emphasis on guided surgery. A comprehensive literature review will be conducted to discuss the advantages and disadvantages of this technique compared to traditional methods, as well as analyze the impact of the leading software used in the planning and execution of these procedures.

MATERIALS AND METHODS

During the development of this narrative review article, it was essential to establish a methodological strategy to ensure the inclusion of the most current, relevant, and scientifically validated information on the topic, providing robust and well-supported content. Searches were conducted across multiple databases, including DeCs, BVS/BIREME, PROSPERO, SciELO, PubMed Central, ScienceDirect, Web of Science, and The Cochrane Library, in conjunction with Google Scholar. Additionally, gray literature was utilized to provide supplementary and relevant insights, which proved crucial for a comprehensive exploration of the subject matter. To refine the scope and relevance of the searches, the following descriptors were employed: Dental Implants, Surgery, Oral and Mouth Rehabilitation. Given the narrative review format, it was necessary to adopt a framework that defines the structure, essential elements, and exclusions pertinent to this type of study. Consequently, Rother's (2007) work served as a methodological guide throughout the preparation of this article, ensuring consistency and adherence to the standards of narrative literature reviews.

RESULTS AND DISCUSSION

Traditional implantology techniques heavily relied on the clinical skills and judgment of the surgeon, which were honed through years of practice, hands-on experience, and mentorship under seasoned professionals. This reliance often necessitated extensive training periods where practitioners developed tactile proficiency and an intuitive understanding of patient-specific anatomical variations. Conventional surgery involved opening the gingival tissue to fully expose the bone, followed by manual drilling using burs. The placement of implants was primarily guided by two-dimensional radiographs and manual measurements performed by the surgeon during the procedure (Misch, 2008). While these methods yielded successful outcomes in numerous cases, they were inherently limited by the absence of three-dimensional precision. Consequently, inadequate implant positioning sometimes occurred, leading to aesthetic or functional compromises and, in severe cases, damage to adjacent structures such as nerves or the maxillary sinus. A study by Esposito et al. (1998) revealed that approximately 10-15% of traditional implant placements were associated with suboptimal positioning, underscoring the need for enhanced precision to prevent complications and improve long-term outcomes. Over time, these issues could negatively impact implant longevity and patient satisfaction (Esposito et al., 1998).

Unlike traditional techniques, the flapless approach eliminates the need for surgical flaps to confirm the site visually during drilling and implant placement. This technique ensures improved postoperative comfort for the patient by reducing inflammation in soft tissues, as nociceptive sensations in the postoperative period are directly proportional to the trauma caused in the region.

The flapless technique has gained prominence in implantology due to its minimally invasive nature and postoperative advantages, although it is not without limitations. Potential risks include insufficient visualization of the surgical site, which can lead to complications such as inaccurate implant positioning or damage to surrounding structures. Additionally, the technique may not be suitable for patients with complex anatomical conditions or insufficient bone volume, as these scenarios often require more invasive interventions to ensure stability and success. It is particularly recommended in cases where sufficient bone volume exists to place the implant without requiring grafts or other complex interventions. The technique is widely applied in immediate load cases, where the implant is placed, and a temporary prosthesis is fixed during the same surgical session. Patients with adequate bone density and gingival conditions benefit significantly from this approach, as it shortens healing time and achieves rapid functional and aesthetic rehabilitation (Rocci, Martignoni, & Gottlow, 2012). This technique allows patients to leave the clinic with a functional provisional prosthesis, enhancing comfort and satisfaction.

However, specific gingival conditions are necessary to maximize postoperative benefits. Harmful habits such as smoking directly impact the feasibility of applying the flapless technique. Smoking-induced heat causes hyperkeratinization of epithelial tissue and reduced vascularization in the region, adversely affecting gingival tissue (Badge et al., 2014).

The advent of computed tomography (CT) has revolutionized all medical fields, including implantology. CT enables more effective planning by integrating obtained data into software that assists in surgical planning, such as NobelClinician and BlueSkyPlan. These programs provide detailed visualizations and enhance precision, making them integral to preoperative assessments and execution. A prominent technique for guided procedures is the double-scan method. However, the mold-based tomography technique is gaining attention. This method involves performing a CT scan of the patient and a subsequent scan of the mold created for them. These images are then superimposed using specific software, enabling a more accurate study and minimizing distortions during the fabrication of the surgical guide.

Once the mold is prepared, surgery can be performed more safely. The mold is positioned in the patient’s mouth, and implants are placed in the pre-marked areas corresponding to the virtual model. This approach significantly reduces procedural risks.

With advancements in radiographic imaging, digital dentistry has become increasingly relevant in modern implantology, providing essential tools for procedures with minimal error margins and maximum tissue preservation during and after surgery. The precision offered by 3D planning software is critical for techniques involving surgical guides. This assistance can be categorized into static and dynamic approaches.

Static computer-assisted implant placement (sCAIP) involves using a prosthetic guide based on radiographic and scanning data. This guide is supported on adjacent teeth or exclusively on mucosa, enabling the procedure without surgical flaps. However, its static nature restricts adaptability during implant placement, confining adjustments to the preoperative stage (Romandini et al., 2014).

Conversely, dynamic computer-assisted implant placement (dCAIP) leverages comprehensive technological support during both planning and implant placement. Its navigation system provides real-time feedback on implant positioning derived from tomographic data, allowing intraoperative modifications.

Guided surgery has emerged as one of the most promising innovations in modern implantology, offering unparalleled precision and control in surgical planning. As demonstrated in the literature, the shift from manual techniques to technologically advanced approaches, such as surgical guides and dynamic navigation, has significantly improved procedural success (Tahmaseb et al., 2014).

The primary advantage of guided surgery lies in its predictable outcomes, reducing errors associated with improper implant positioning (Vercruyssen et al., 2014). Software like NobelClinician enables surgeons to visualize anatomical structures three-dimensionally before surgery, which is particularly beneficial for patients with complex anatomies or limited bone volume (Rocci, Martignoni, & Gottlow, 2012).

Another critical benefit highlighted in the literature is reduced surgical morbidity.

Minimally invasive approaches, such as the flapless technique, result in less tissue trauma, shorter recovery times, and lower postoperative complication rates (Bagde et al., 2023). The absence of surgical flaps accelerates healing, directly improving patient experience and reducing postoperative pain (Block & Emery, 2016).

Nevertheless, the widespread adoption of guided surgery faces challenges and limitations. High costs associated with technology, including planning software and surgical guides, can be significant barriers, especially in resource-constrained clinical settings (Block & Emery, 2016). Additionally, the learning curve required to master these tools may discourage professionals less familiar with digital technologies. Advanced equipment also necessitates specialized clinical infrastructure, which may not be universally accessible (D'Haese et al., 2012).

Static and dynamic approaches present distinct advantages and drawbacks. While static guided surgery offers high precision during planning, its lack of intraoperative adaptability is a disadvantage in unexpected situations (Romandini et al., 2023). Dynamic navigation, on the other hand, allows real-time adjustments but entails higher costs and greater complexity, limiting its accessibility and widespread use (Block & Emery, 2016).

CONCLUSION

In conclusion, guided surgery, particularly when combined with the flapless technique, offers significant advantages in terms of precision, predictability, and reduction of postoperative complications. The ability to achieve optimal implant positioning with minimal variability and reduced surgical trauma contributes to shorter recovery times and lower morbidity for patients. However, challenges such as high equipment costs and the learning curve associated with these advanced techniques continue to limit their widespread adoption, particularly in settings with limited access to technology. The evolution of dynamic navigation holds promise for further improving control during procedures, although its implementation is currently constrained by its cost and technical complexity. Despite these limitations, the ongoing development and refinement of these technologies are likely to play a crucial role in enhancing the outcomes of implant surgeries in the future.

REFERENCES

ADELL, R. et al. Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. **The International Journal of Oral & Maxillofacial Implants**, v. 5, n. 4, p. 347–359, 1990.

ALBREKTSSON, T.; WENNERBERG, A. On osseointegration in relation to implant surfaces. **Clinical Implant Dentistry and Related Research**, v. 21, n. S1, p. 4–7, 28 fev. 2019.

BAGDE, H. et al. Healing of Peri-Implant Tissue following Flapless Implant Surgery. **Journal of Pharmacy and Bioallied Sciences**, v. 15, n. Suppl 2, p. S1139–S1141, jul. 2023.

BLOCK, M. et al. Implant Placement Accuracy Using Dynamic Navigation. **The International Journal of Oral & Maxillofacial Implants**, v. 32, n. 1, p. 92–99, jan. 2017.

BRÅNEMARK, P. I. et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. **Scandinavian Journal of Plastic and Reconstructive Surgery. Supplementum**, v. 16, p. 1–132, 1977.

BRANEMARK, P.-I. Osseointegration and its experimental background. **The Journal of Prosthetic Dentistry**, v. 50, n. 3, p. 399–410, set. 1983.

BRODALA, N. Flapless surgery and its effect on dental implant outcomes. **The International Journal of Oral & Maxillofacial Implants**, v. 24 Suppl, p. 118–125, 2009.

D'HAESE, J. et al. Accuracy and Complications Using Computer-Designed Stereolithographic Surgical Guides for Oral Rehabilitation by Means of Dental Implants: A Review of the Literature. **Clinical Implant Dentistry and Related Research**, v. 14, n. 3, p. 321–335, 11 maio 2010.

D'HAESE, J. et al. Current state of the art of computer-guided implant surgery. **Periodontology 2000**, v. 73, n. 1, p. 121–133, 21 dez. 2016.

ESPOSITO, M. et al. Biological factors contributing to failures of osseointegrated oral implants, (II). Etiopathogenesis. **European Journal of Oral Sciences**, v. 106, n. 3, p. 721–764, jun. 1998.

FORTIN, T. et al. Effect of flapless surgery on pain experienced in implant placement using an image-guided system. **The International Journal of Oral & Maxillofacial Implants**, v. 21, n. 2, p. 298–304, 1 mar. 2006.

JODA, T.; BRÄGGER, U. Time-efficiency analysis of the treatment with monolithic implant crowns in a digital workflow: a randomized controlled trial. **Clinical Oral Implants Research**, v. 27, n. 11, p. 1401–1406, 6 jan. 2016.

LE GUÉHENNEC, L. et al. Surface treatments of titanium dental implants for rapid osseointegration. **Dental Materials**, v. 23, n. 7, p. 844–854, jul. 2007.

NAEINI, E. N. et al. Narrative review regarding the applicability, accuracy, and clinical outcome of flapless implant surgery with or without computer guidance. **Clinical Implant Dentistry and Related Research**, v. 22, n. 4, p. 454–467, 13 maio 2020.

PAGE, M. J. et al. The PRISMA 2020 statement: an Updated Guideline for Reporting Systematic Reviews. **British Medical Journal**, v. 372, n. 71, 29 mar. 2021a.

PAGE, M. J. et al. PRISMA 2020 explanation and elaboration: Updated guidance and exemplars for reporting systematic reviews. **BMJ**, v. 372, n. 160, 29 mar. 2021b.

PAPASPYRIDAKOS, P. et al. Success criteria in implant dentistry: a systematic review. **Journal of dental research**, v. 91, n. 3, p. 242–8, 2012.

RESNIK, R. **Contemporary Implant Dentistry.** S.L.: Mosby, 2017.

ROCCI, A.; MARTIGNONI, M.; GOTTLOW, J. Immediate Loading in the Maxilla Using Flapless Surgery, Implants Placed in Predetermined Positions, and Prefabricated Provisional Restorations: A Retrospective 3-Year Clinical Study. **Clinical Implant Dentistry and Related Research**, v. 5, n. s1, p. 29–36, mar. 2003.

ROMANDINI, M. et al. Prevalence and risk/protective indicators of peri-implant diseases:

A university-representative cross-sectional study. **Clinical Oral Implants Research**, v. 32, n. 1, p. 112–122, 29 dez. 2020.

ROMANDINI, M. et al. Prevalence and risk/protective indicators of buccal soft tissue dehiscence around dental implants. **Journal of Clinical Periodontology**, v. 48, n. 3, p. 455–463, 21 jan. 2021.

ROMANDINI, M. et al. Minimal invasiveness at dental implant placement: A systematic review with meta-analyses on flapless fully guided surgery. **Periodontology 2000**, v. 91, n. 1, 30 jul. 2022.

SCHNEIDER, D. et al. A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. **Clinical Oral Implants Research**, v. 20, n. 4, p. 73–86, set. 2009.

TAHMASEB, A. et al. Computer Technology Applications in Surgical Implant Dentistry: A Systematic Review. **The International Journal of Oral & Maxillofacial Implants**, v. 29, n. Supplement, p. 25–42, jan. 2014.

TATTAN, M. et al. Static computer-aided, partially guided, and free-handed implant placement: A systematic review and meta-analysis of randomized controlled trials. **Clinical Oral Implants Research**, v. 31, n. 10, p. 889–916, 26 jul. 2020.

TAVELLI, L. et al. Prevalence and risk indicators of midfacial peri-implant soft tissue dehiscence at single site in the esthetic zone: A cross-sectional clinical and ultrasonographic study. **Journal of Periodontology**, v. 93, n. 6, p. 857–866, 1 jun. 2022.

VERCRUYSSEN, M. et al. Depth and lateral deviations in guided implant surgery: an RCT comparing guided surgery with mental navigation or the use of a pilot-drill template. **Clinical Oral Implants Research**, v. 26, n. 11, p. 1315–1320, 2 set. 2014.

VERMEULEN, J. The Accuracy of Implant Placement by Experienced Surgeons: Guided vs Freehand Approach in a Simulated Plastic Model. **The International Journal of Oral & Maxillofacial Implants**, v. 32, n. 3, p. 617–624, maio 2017.

ZARB, G. A.; AL, E. **Osseointegration : on continuing synergies in surgery,**

prosthodontics, biomaterials. Chicago: Quintessence Pub. Co, 2008.

ZUCCHELLI, G. et al. Classification of facial peri-implant soft tissue dehiscence/deficiencies at single implant sites in the esthetic zone. **Journal of Periodontology**, v. 90, n. 10, p. 1116–1124, 3 jun. 2019.