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INNOVATIVE CONCEPTS OF THE USE OF THE SURGICAL GUIDE IN ORAL REHABILITATION

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Abstract

Surgical guides in oral rehabilitation are an essential innovation, offering significant advantages in the precision and efficiency of dental procedures. These customized devices, created based on three-dimensional imaging and advanced technologies such as CAD/CAM and 3D printing, enable detailed planning and accurate execution of interventions. Using polymers, light-curing resins, and biocompatible and bioactive materials ensures optimal integration with the patient's tissues, reducing the risk of complications and accelerating healing. 3D printing and bioprinting allow the creation of complex surgical guides, adapted to each patient's anatomy, contributing to the reduction of operative time and postoperative discomfort. However, high upfront costs and the need for specialized training pose significant challenges for large-scale deployment. In conclusion, although surgical guidelines bring considerable benefits, their effective integration into dental practice requires continuous investment and adaptations, thus improving clinical outcomes and patient experience.

Keywords*:* oral rehabilitation; surgical guide; 3D printing; CAD/CAM systems; laser technologies.

Introduction

Surgical guidelines in dentistry are an essential element in performing precise and effective dental procedures. They are used to improve the accuracy of interventions, reducing risks and ensuring optimal patient outcomes. In recent decades, dentistry has undergone a significant evolution due to technological advances and innovative materials, which have transformed traditional practices into minimally invasive and more predictable procedures [1-3].

Surgical guides are personalized devices designed to help place dental implants correctly and perform other surgical procedures with increased precision. They are designed using advanced imaging, such as computed tomography (CT) and 3D printing technology, which allow accurate models of the patient's anatomy to be made. Thus, surgical guidelines ensure that implants are placed in the exact position, avoiding vital anatomical structures and optimizing bone integration [1-4].

The use of surgical guides brings multiple benefits for both patients and dental professionals such as: surgical guides allow for detailed planning and precise execution of procedures, reducing errors and improving the predictability of results, by using surgical guides, the risks associated with surgeries are reduced, as they help to avoid critical structures such as nerves and sinuses, Guided procedures are usually less invasive, leading to faster healing and

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reduced postoperative discomfort for patients, surgical guides contribute to achieving superior aesthetic and functional outcomes, which improves overall patient satisfaction [2-5].

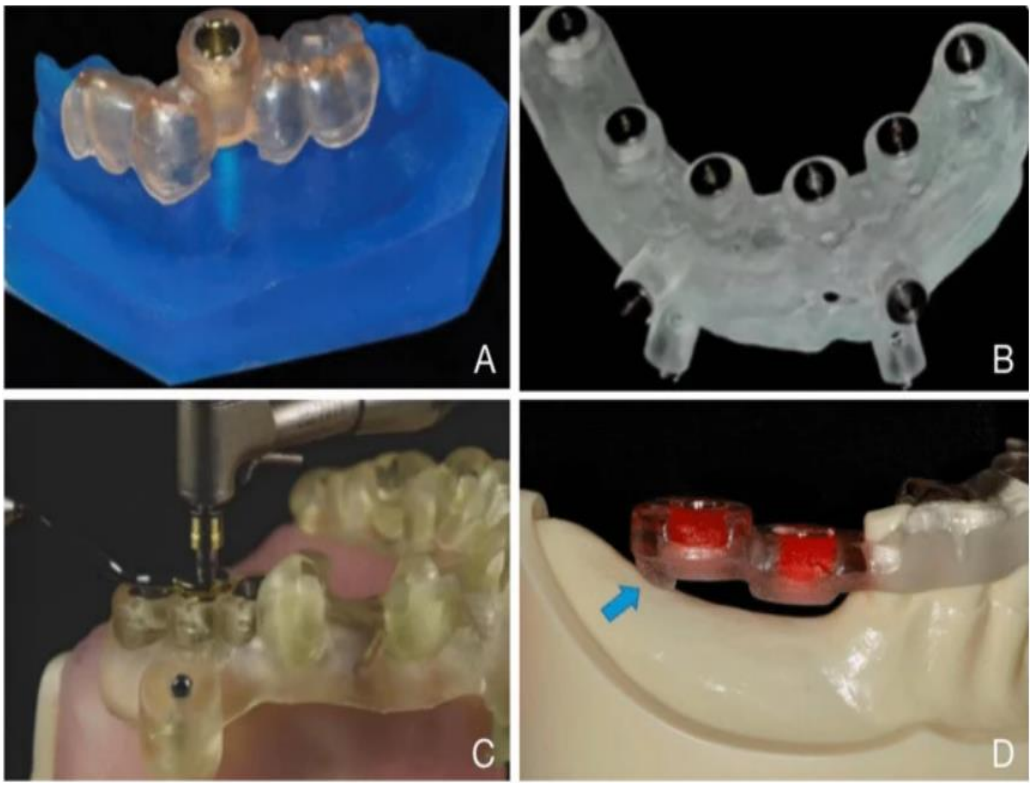

Fig 1. Support types for implanting guides, A) Guide with bilateral dental support; B) Guide with mucous support; C) Mixed guide with dental and mucosal support; and D) Mixed guide with dental and bone support [5].

The use of surgical guides optimizes the operative time and resources used, allowing more procedures to be performed in a shorter time frame [4-7].

This study aims to explore recent innovations in the field of surgical guides used in dentistry, with a particular focus on the modern materials used to make them. The objectives include evaluating the benefits and limitations of these materials, investigating the advanced technologies applied in the development of surgical guidelines, and identifying the impact of these innovations on clinical outcomes and patient satisfaction. It also aims to highlight future directions of research and development in this field [5-7].

Surgical guidelines in oral rehabilitation

Surgical guides are personalized medical devices designed to precisely target surgical instruments during dental procedures, especially in dental implantology. They are created based on three-dimensional radiological images of the patient, using CAD/CAM technology and 3D printing, to perfectly match the specific anatomy of each patient [5-8].

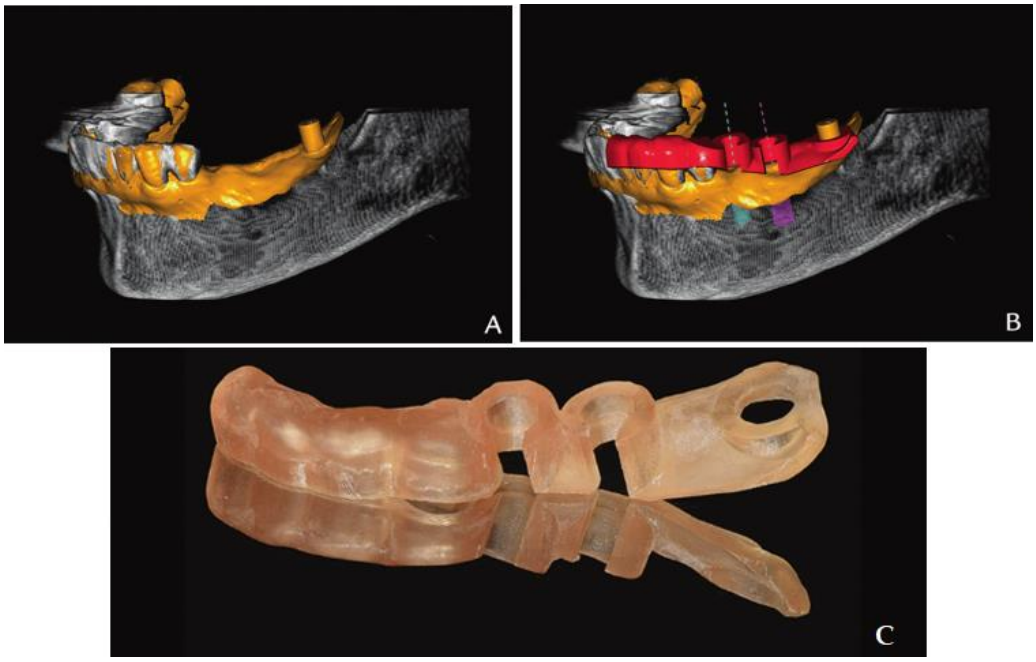

Fig 2. The process of designing and fabricating a surgical guide template includes A) Superimposing surface scans with cone beam computed tomography images using a scan cap and the remaining teeth; B) Designing the guide with a fully limiting concept; C) 3D printing the surgical guide template [8].

Surgical guides allow for detailed planning of procedures, ensuring the exact placement of dental implants and other surgeries. This reduces the risk of errors and improves the predictability of results. By using surgical guides, surgeons can avoid critical anatomical structures such as nerves and sinuses, minimizing the risks of intraoperative complications [8-10].

Surgical guides simplify and speed up surgical procedures, reducing operative time and allowing for better management of resources within the dental clinic. Guided procedures are usually less invasive, which translates into shorter recovery time and reduced postoperative discomfort. This contributes to a more enjoyable overall experience for patients [8-11].

Surgical guides ensure that implants are placed in ideal positions to maximize bone integration and the long-term stability of dental implants. The use of surgical guides contributes to the standardization of surgical procedures, ensuring high reproducibility of results, regardless of the surgeon's experience. The guidelines are created to perfectly fit each patient's anatomy, ensuring a personalized approach to each intervention, which increases the chances of success and patient satisfaction [9-12].

Modern materials used to make surgical guides

Light-curing polymers and resins

Polymers are versatile materials and are widely used in the manufacture of surgical guides due to their adaptable mechanical and chemical properties. Thermoplastic polymers such

as poly(methyl methacrylate) (PMMA) and polycarbonate (PC) are preferred for the manufacture of slides due to their strength and ability to be precisely shaped by 3D printing technology. These materials are biocompatible and allow easy handling, thus ensuring high precision in guiding surgical instruments [12-14].

Light-curing resins are materials that solidify under the action of ultraviolet light or another suitable light source. They are widely used in dentistry for the creation of surgical guides due to their ability to provide fine details and a smooth surface. Materials such as epoxy and acrylate resins are common in this field [12-14].

Both polymers and light-curing resins allow the creation of surgical guides with micrometric precision, essential for the success of dental interventions. These materials are biocompatible, reducing the risk of side effects and ensuring optimal integration with oral tissues [13-15].

Polymers offer an excellent balance between flexibility and durability, allowing the creation of guides that can withstand the mechanical forces applied during surgery. Both polymers and light-curing resins can be easily customized to fit each patient's specific anatomy, ensuring a perfect fit and precise guidance of surgical instruments. The use of these materials allows for the rapid and economical production of surgical guides, making them accessible for a wide range of dental practices [15-17].

3D printing is one of the most common methods of manufacturing surgical guides from light-curing polymers and resins. This technology allows for the creation of complex and detailed structures that are tailored to the specific needs of the patient [16-17].

Biocompatible and bioactive materials

Biocompatible materials are essential in the development of surgical guidelines for dentistry, as they must be accepted by the body without causing side effects. Biocompatibility ensures that the materials will not cause inflammation, allergies, or other immunological reactions when implanted or used in the oral cavity[15-17].

Titanium and its alloys are highly biocompatible and are commonly used in dental implantology due to their corrosion resistance and osseointegration ability. Although they are more often used for implants, they can also be used for structural parts of surgical guides, especially in procedures that require increased durability and mechanical strength [16-18].

Poly(lactic-co-glycolic) Acid (PLGA) is a biodegradable and biocompatible polymer often used in medical devices. It is used for temporary surgical guides, which break down in the body after performing their function [15-18].

Bioactive materials

Bioactive materials have the property of interacting positively with the surrounding tissues, stimulating bone regeneration and integration with the patient's biological structures. These materials are not only accepted by the body but actively contribute to its healing and regeneration [14-16].

Hydroxyapatite is a calcium phosphate that mimics the mineral structure of natural bone. It is often used in covering surgical guidelines to stimulate osseointegration and promote rapid bone healing [15-17].

BioStic® and other bioactive polymer, materials are polymers that have been treated to include bioactive agents, which stimulate tissue regeneration. Surgical guides made of such polymers can facilitate rapid healing and integration into bone or gum tissue, reducing the patient's recovery time [16-18].

Properties and advantages

Bioactive materials, such as hydroxyapatite, stimulate the growth and integration of bone tissue, ensuring better implant fixation and faster healing. Biocompatible materials reduce the risk of postoperative complications, ensuring a safer and more efficient healing process. Biodegradable materials, such as PLGA, break down in the body after performing their function, eliminating the need for subsequent surgery for removal. To produce surgical guides from biocompatible and bioactive materials, advanced 3D printing and bioprinting technologies are used. These techniques allow the creation of complex structures, personalized for each patient, which ensure perfect adaptation and optimal functionality [15-18].

Advanced technologies in the production of surgical guides

3D printing is one of the most revolutionary technologies used in making surgical guides. This allows for the fast and precise manufacture of customized devices tailored to the patient's anatomy. By using light-curing polymers and resins, 3D printing can create complex guides with micrometer accuracy, which is essential for the success of surgeries [18-21].

CAD/CAM (computer-aided design and computer-aided manufacturing) systems are essential in the design and production of surgical guides. These technologies allow the detailed design of guides based on three-dimensional imaging (CT or CBCT), ensuring precise surgical planning and accurate execution. CAD/CAM also facilitates the seamless integration of surgical guides with the instruments and implants used[17-20].

Laser technologies are used to cut and shape surgical guide materials with extreme precision. Lasers can be used to create channels and holes exactly where needed, ensuring that the guides fit perfectly and provide precise targeting of surgical instruments[18-21].

The use of advanced imaging, such as computed tomography (CT) and cone beam computed tomography (CBCT), allows detailed images of the patient's anatomy to be obtained. These images are used to create accurate digital models that form the basis of surgical guidelines. Computer-aided surgical navigation, based on real-time imaging, allows surgeons to monitor and adjust procedures during surgery, ensuring maximum accuracy [18-21].

Bioprinting is an emerging technology that involves the use of cells and biomaterials to create functional biological structures. In the context of surgical guidelines, bioprinting can allow for the creation of guidelines that not only guide surgical instruments but also actively interact with the patient's tissues to promote healing and integration [18-21].

Fig 3. Surgical guides fabricated by a) DLP, b) PolyJet, c) SLA printers [21]

Advantages and challenges

Surgical guidelines bring multiple benefits, including increased precision in implant placement, reduced intraoperative and postoperative risks, and improved efficiency of dental procedures. They allow for minimally invasive interventions, which leads to reduced recovery time and minimal postoperative discomfort for patients. The use of advanced technologies such as CAD/CAM and 3D printing ensures accurate customization and high reproducibility of results [22,23].

However, there are also challenges. The high upfront costs for purchasing and maintaining advanced equipment can be prohibitive for some dental practices. The complexity of technologies requires specialized training, and the time required to design and manufacture custom guides can be considerable. Additionally, there is a risk of over-reliance on technology, which can affect practitioners' traditional surgical skills [22,23].

Conclusions

Surgical guides are a fundamental pillar in modern dentistry, contributing significantly to improving the quality and safety of dental interventions. Next, this article will explore recent innovations in the materials used to make surgical guides and the advanced technologies that make these advancements possible.

Surgical guides are essential tools in modern dentistry, providing a combination of precision, safety, and efficiency that significantly improves clinical outcomes and patient satisfaction.

The choice of the type of surgical guide depends on the specifics of the procedure, its complexity, and the individual needs of the patient. Each type of surgical guide offers distinct advantages, helping to increase the accuracy, safety, and efficiency of dental interventions.

Light-curing polymers and resins are cutting-edge materials in the realization of surgical guides due to their exceptional properties and the versatility they offer. The use of these materials contributes significantly to improving the accuracy, safety, and efficiency of modern dental interventions.

The use of biocompatible and bioactive materials in the development of surgical guidelines is an important step towards safer, more efficient interventions with superior results in modern dentistry. These materials not only ensure compatibility with human tissues but also actively contribute to their healing and integration.

References

1. Mangano F, Veronesi G. *Digital versus Analog Procedures for the Prosthetic Restoration of Single Implants: A Randomized Controlled Trial with 1 Year of Follow-Up.* **Biomed Res Int**. 2018, 18. 5325032. doi: 10.1155/2018/5325032.
2. Schneider D, Sax C, Sancho-Puchades M, Hämmerle CHF, Jung RE. *Accuracy of computer-assisted, template-guided implant placement compared with conventional implant placement by hand in vitro study*. **Clin Oral Implants Res**. 2021, 32, 9. 1052-1060. doi: 10.1111/clr.13799.

3. Dioguardi M, Spirito F, Quarta C, Sovereto D, Basile E, Ballini A, Caloro GA, Troiano G, Lo Muzio L, Mastrangelo F. *Guided Dental Implant Surgery: Systematic Review*. **J Clin Med**. 2023, 13, 12. 1490. doi: 10.3390/jcm12041490.
4. Tahmaseb A, Wismeijer D, Coucke W, Derksen W. *Computer technology applications in surgical implant dentistry: a systematic review*. **Int J Oral Maxillofac Implants**. 2014. 29 Suppl:25-42. doi: 10.11607/jomi.2014suppl.g1.2.
5. Shi, Y., Wang, J., Ma, C. et al. *A systematic review of the accuracy of digital surgical guides for dental implantation*. **Int J Implant Dent**. 2023, 25, 9. 38. doi: 10.1186/s40729-023-00507-w.
6. Voulgarakis A., Strub J.R., Att W. *Outcomes of implants placed with three different flapless surgical procedures: A systematic review*. **Int. J. Oral Maxillofac. Surg**. 2014, 43, 4. 476-86. doi: 10.1016/j.ijom.2013.10.024.
7. Lin G.H., Chan H.L., Bashutski J.D., Oh T.J., Wang H.L. *The effect of flapless surgery on implant survival and marginal bone level: A systematic review and meta-analysis*. **J. Periodontol**. 2014, 85, 5. e91-103. doi: 10.1902/jop.2013.130481.
8. Hang-Nga Mai, DDS, MS,aSo-Young Choi, DDS, PhD,bSung-Tak Lee, DDS, MS, and Du-Hyeong Lee, DDS, PhD. *Optimizing accuracy in computer-guided implant surgery with superimposition-anchor microscrew system: A clinical report*. **The Journal of Prosthetic Dentistry**. 2018, 120, 5. 789.e1-789.e5. doi: 10.1016/j.prosdent.2018.04.014.
9. Moraschini V., Velloso G., Luz D., Barboza E.P. *Implant survival rates, marginal bone level changes, and complications in full-mouth rehabilitation with flapless computer-guided surgery: A systematic review and meta-analysis*. **Int. J. Oral Maxillofac. Surg**. 2015, 44, 7. 892-901. doi: 10.1016/j.ijom.2015.02.013.
10. Velasco-Ortega E., Jiménez-Guerra A., Ortiz-Garcia I., Garrido N.M., Moreno-Muñoz J., Núñez-Márquez E., Rondón-Romero J.L., Cabanillas-Balsera D., López-López J., Monsalve-Guil L. *Implant Treatment by Guided Surgery Supporting Overdentures in Edentulous Mandible Patients. Int. J. Environ.* **Res. Public Health**. 2021, 11, 18. 11836. doi: 10.3390/ijerph182211836.
11. Lopes A., Maló P., de Araújo Nobre M., Sanchez-Fernández E. *The NobelGuide® All-on-4® Treatment Concept for Rehabilitation of Edentulous Jaws: A Prospective Report on Medium- and Long-Term Outcomes*. **Clin**. **Implant. Dent. Relat**. *Res.* 2015. 17 Suppl 2:e406-16. doi: 10.1111/cid.12260.
12. Velasco-Ortega E., Cracel-Lopes J.L., Matos-Garrido N., Jiménez-Guerra A., Ortiz-Garcia I., Moreno-Muñoz J., Núñez-Márquez E., Rondón-Romero J.L., López-López J., Monsalve-Guil L. *Immediate Functional Loading with Full-Arch Fixed Implant-Retained Rehabilitation in Periodontal Patients: Clinical Study*. **Int. J. Environ. Res. Public Health**. 2022. 19, 20. 13162. doi: 10.3390/ijerph192013162
13. D'Haese J., Van De Velde T., Elaut L., De Bruyn H. *A prospective study on the accuracy of mucosally supported stereolithographic surgical guides in fully edentulous maxillae*. **Clin. Implant. Dent. Relat. Res**. 2012, 14. 293-303. doi: 10.1111/j.1708-8208.2009.00255.x.
14. Velasco-Ortega E., Del Rocío Jiménez-Martin I., Moreno-Muñoz J., Núñez-Márquez E., Rondón-Romero J.L., Cabanillas-Balsera D., Jiménez-Guerra Á., Ortiz-García I., López-López J., Monsalve-Guil L. *Long-Term Treatment Outcomes of Implant Prostheses in*

Partially and Totally Edentulous Patients. **Material**s. 2022, 15, 4910. https://doi.org/10.3390/ma15144910

15. Dioguardi M., Spirito F., Sovereto D., Alovisi M., Aiuto R., Garcovich D., Crincoli V., Laino L., Cazzolla A.P., Caloro G.A., et al. *The Prognostic Role of miR-31 in Head and Neck Squamous Cell Carcinoma: Systematic Review and Meta-Analysis with Trial Sequential Analysis*. **Int. J. Environ. Res. Public Health**. 2022, 19, 9. 5334. doi: 10.3390/ijerph19095334
16. Marra R., Acocella A., Rispoli A., Sacco R., Ganz S.D., Blasi A. *Full-mouth rehabilitation with immediate loading of implants inserted with computer-guided flap-less surgery: A 3-year multicenter clinical evaluation with oral health impact profile*. **Implant. Dent.** 2013, 22, 5. 444-52. doi: 10.1097/ID.0b013e31829f1f7f.
17. Derksen W., Wismeijer D., Flügge T., Hassan B., Tahmaseb A. *The accuracy of computer-guided implant surgery with tooth-supported, digitally designed drill guides based on CBCT and intraoral scanning. A prospective cohort study*. **Clin. Oral Implant. Res**. 2019, 30, 10. 1005-1015. doi: 10.1111/clr.13514.
18. Malo P., de Araujo Nobre M., Lopes A. *The use of computer-guided flapless implant surgery and four implants placed in immediate function to support a fixed denture: Preliminary results after a mean follow-up period of thirteen months*. **J. Prosthet. Dent.** 2007, 97, 6. S26-34. doi: 10.1016/S0022-3913(07)60005-5.
19. Azari A., Nikzad S. *Flapless implant surgery: Review of the literature and report of 2 cases with computer-guided surgical approach*. **J. Oral Maxillofac. Surg. Off. J. Am. Assoc. Oral Maxillofac. Surg**. 2008, 66, 5. 1015-21. doi: 10.1016/j.joms.2007.12.010.
20. Van Assche N., Quirynen M. *Tolerance within a surgical guide*. **Clin. Oral Implant. Res**. 2010, 21, 4. 455-8. doi: 10.1111/j.1600-0501.2009.01836.x.
21. Anunmana C, Ueawitthayasuporn C, Kiattavorncharoen S, Thanasrisuebwong P. *In Vitro Comparison of Surgical Implant Placement Accuracy Using Guides Fabricated by Three Different Additive Technologies*. **Applied Sciences**. 2020, 10, 7791. https://doi.org/10.3390/app10217791.
22. D'Haese J., Vervaeke S., Verbanck N., De Bruyn H. *Clinical and radiographic outcome of implants placed using stereolithographic guided surgery: A prospective monocenter study*. **Int. J. Oral Maxillofac. Implant**. 2013, 28. 205-15. doi: 10.11607/jomi.2618.
23. Hultin M., Svensson K.G., Trulsson M. *Clinical advantages of computer-guided implant placement: A systematic review*. **Clin. Oral Implant. Res**. 2012, 23, 6. 124-35. doi: 10.1111/j.1600-0501.2012.02545.x.

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