Universidad Europea

GRADUATION PROJECT

Degree in Dentistry

Assessing the Standardization of Dental Implant Planning with Guided Surgery: An Analysis of Usage Frequency and Comparison of Available Software.

Madrid, academic year 2025/2026

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RESUMEN

Introducción: La cirugía guiada para implantes se ha convertido en una técnica digital cada vez más adoptada en implantología, mejorando la precisión, la predictibilidad y la eficiencia del flujo de trabajo. Sin embargo, persiste variabilidad en su uso clínico, en la accesibilidad relacionada con el coste y en la selección del software de planificación.

Objetivos: Este estudio tuvo como objetivo evaluar la frecuencia de uso de la cirugía guiada entre implantólogos, analizar su impacto clínico percibido e identificar las plataformas de software utilizadas actualmente en los flujos de trabajo de implantología guiada, con especial atención a la evaluación del nivel de estandarización.

Metodología: Se realizó un estudio descriptivo transversal basado en encuesta entre 50 implantólogos. Se distribuyó un cuestionario de 11 ítems mediante muestreo por conveniencia y muestreo en bola de nieve. La encuesta abordó la frecuencia de uso, las indicaciones clínicas, la selección de software, el impacto clínico y financiero percibido, y la integración en el flujo de trabajo. Los datos se recopilaron a través de una plataforma en línea y se analizaron de forma descriptiva.

Resultados: La cirugía guiada fue utilizada por el 66% de los participantes, con un 41% empleándola en algunos casos y un 24% en la mayoría de los casos. La técnica se aplicó con mayor frecuencia en casos de arcada completa y en casos de múltiples implantes. Un total del 82,5% de los clínicos informó un impacto positivo (puntuaciones de 4–5/5), citando mayor precisión, predictibilidad y eficiencia. El coste fue identificado como una limitación importante. El software utilizado incluyó BlueSky, Nemotech, RealGuide, coDiagnostiX, 3Shape, Exoplan, Dental Wings, Smile in a Box, Magellan, Atomica e Implantation.

Conclusiones: Los hallazgos ponen de manifiesto una brecha entre el avance tecnológico y su implementación clínica estandarizada. La cirugía guiada está ampliamente adoptada, pero se aplica de forma selectiva más que rutinaria. Sus beneficios clínicos son ampliamente reconocidos; sin embargo, el coste y la preferencia del clínico limitan su uso universal. Se recomienda establecer guías clínicas más claras y protocolos estandarizados para el uso de la cirugía guiada, con el fin de apoyar la toma de decisiones basada en la evidencia y mejorar la relación coste-efectividad. La diversidad de plataformas de software refleja variabilidad en las preferencias de los clínicos, los flujos de trabajo clínicos y las marcas disponibles. La selección del software parece ser principalmente subjetiva, influida por la preferencia del clínico y la compatibilidad con el flujo de trabajo.

PALABRAS CLAVE Odontología, Cirugía guiada, Odontología digital, Implantología, Software

ABSTRACT

Introduction: Guided implant surgery has become an increasingly adopted digital technique in implantology, improving accuracy, predictability, and workflow efficiency. However, variability remains in its clinical use, cost-related accessibility, and the selection of planning software.

Objectives: This study aimed to evaluate the frequency of use of guided surgery among implantologists, assess its perceived clinical impact, and identify the software platforms currently used in guided implant workflows, with a focus

on evaluating the level of standardization.

Methodology: A cross-sectional, survey-based descriptive study was conducted among 50 implantologists. An 11-item questionnaire was distributed using convenience and snowball sampling. The survey addressed frequency of use, clinical indications, software selection, perceived clinical and financial impact, and workflow integration. Data were collected through an online platform and analyzed descriptively.

Results: Guided surgery was used by 66% of participants, with 41% using it in some cases and 24% in most cases. The technique was most frequently applied in full-arch and multiple implant cases. A total of 82.5% of clinicians reported a positive impact (scores 4–5/5), citing increased accuracy, predictability, and efficiency. Cost was identified as a major limitation. The software used included BlueSky, Nemotech, RealGuide, coDiagnostiX, 3Shape, Exoplan, Dental Wings, Smile in a Box, Magellan, Atomica, and Implantation.

Conclusions: The findings highlight a gap between technological advancement and its standardized clinical implementation. Guided surgery is widely adopted but applied selectively rather than routinely. Its clinical benefits are well recognized; however, cost and clinician pereference limit its universal use. Clearer clinical guidelines for standardized protocols for the use of guided surgery to support evidence-based decision-making and improve cost-effectiveness is recommended.

The diversity of software platforms reflects variability of clinician preference, clinical workflows, and brands. Software selection appears to be primarily subjective, influenced by clinician preference and workflow compatibility

KEYWORDS

Dentistry, Guided surgery, Digital dentistry, Implantology, Software

ÍNDICE

1. **INTRODUCTION**

1.1 Digital Dentistry and Implantology

Digital dentistry encompasses the integration of computer-aided technology into diagnostic, surgical, and restorative workflows. Core components of this digital transformation include **computer-aided design and manufacturing (CAD/CAM)**, which enables the precise fabrication of prosthetic restorations; **intraoral scanning**, which provides highly accurate digital impressions of the dentition and soft tissues; **cone-beam computed tomography (CBCT)**, which allows three-dimensional visualization of maxillofacial structures; and **three-dimensional (3D) printing**, which facilitates the production of surgical guides and customized prosthetic components. Collectively, these technologies have advanced treatment precision, efficiency, and interdisciplinary collaboration within dental practice. (1,2)

Within this framework, **guided implant surgery** has emerged as a pivotal application of digital dentistry, allowing clinicians to virtually plan and execute implant placement with computer-generated surgical templates. This approach enhances the predictability and reproducibility of implant positioning, leading to improved clinical outcomes and reduced operator-dependent variability. (1,2)

1.1.1 Comparison of guided surgery with free hand: accuracy and reproducibility

Quantitative evidence demonstrates that implants placed using guided surgery exhibit significantly lower angular, coronal, and apical deviation values compared with those placed using conventional free-hand methods. These findings highlight the superior accuracy and reproducibility of guided surgery, emphasizing its clinical value in achieving precise implant positioning and minimizing surgical errors.(3,4)

1.1.2 Static vs Dynamic guided surgery

Guided implant surgery can be performed through two main approaches: **static** and **dynamic** systems. In the **static technique**, the clinician preoperatively determines the implant position through virtual planning software and subsequently fabricates a customized surgical stent to guide implant placement according to the predesigned trajectory. In contrast, **dynamic navigation systems** employ optical tracking technology with real-time visual feedback, enabling the clinician to continuously monitor the osteotomy and implant placement within the alveolar bone during surgery.This study focuses specifically on the static guided surgery system, as it remains the most widely used and accessible technique in clinical practice due to its predictability, cost-effectiveness, and integration with existing digital workflows. (5)

1.1.3 Static Guided-surgery protocol

The following protocol outlines the standardized digital workflow for implant placement using the static guided surgery technique (6–9):

1- Preoperative assessment and enrolment of patient (health screening, consent, case type, can be partially or fully edentulous, or a single tooth restoration).

2- Acquisition of CBCT scan for bony anatomy.

3- Acquisition of intra-oral scan (or optical scan) of dentition/mucosa.

4- Digital data registration: merge CBCT DICOM data with intra-oral scan (STL) by either surface registration or fiducial marker registration.

5- Virtual implant planning: define implant size, position, angulation, depth according to prosthetic and anatomical constraints.

6- Design of surgical guide: depending on the case can be tooth-supported, tooth-mucosa supported, or bone supported, design of guide sleeve, guide support, fixation, etc.

7- Fabrication of surgical guide (typically stereolithographic – SLA) per virtual plan.

8- Verification of the surgical guide in the patient's mouth for correct fit and seating.

9- Surgical phase: Use of the surgical guide during implant osteotomy and placement, following guide sleeve and drilling sequence.

10- Post-operative CBCT acquisition (or equivalent) to measure deviations between planned and actual implant positions.

11- After appropriate healing (or immediate provisional in some cases) final prosthetic restoration.

12- Data analysis: measurement of angular, coronal/apical (and sometimes depth/global) deviations to assess accuracy.

1.1.4 Learning curve

Clinicians should recognize that guided surgery presents a distinct learning curve. Proficiency in the digital workflow—from data acquisition and virtual planning to surgical guide handling—significantly reduces the risk of technical complications and enhances procedural predictability once competence is achieved.(1)

1.1.5 Common Software, their Features, and Purpose

Modern implant-planning software offers a comprehensive workflow that supports clinicians from diagnostics through surgical execution. The software commonly included in the literature includes BlueSky, RealGuide, CodiagnostiX, Exoplan, and 3Shape. Key modules and features usually include: (10–12)

- Data import and registration: The software integrates DICOM data from CBCT scans and STL meshes from intra-oral or extra-oral scans. Registration algorithms align bone anatomy with surface morphology, enabling a prosthetically-driven implant plan.
- Anatomical visualization and segmentation: Users can segment key anatomical structures (e.g., nerves, sinuses, bone contours) and visualize them in 3D or cross-sections. This supports risk assessment and suitable implant positioning.
- Virtual prosthetic setup: Many systems allow a digital mock-up of the planned restoration (crown, bridge, full arch). This helps determine implant position based on final prosthetic outcome, ensuring correct angulation, depth and emergence profile.
- Implant library and planning tools: Embedded implant manufacturer libraries let users select implant type, diameter, length, surface characteristics. Tools enable position, angulation, depth adjustments and simulation of adjacent prosthetic components.
- Guide-design module: Once the plan is defined, software supports design of surgical guides: choosing support type (tooth, mucosa, bone), determining sleeve positions, fixation pins, path of insertion, drilling sequence, and export (typically STL) for 3D printing.
- Export and compatibility functions: The software can export STL or other formats for guide fabrication, import digital intra-oral scan data for provisional/prosthetic planning, and sometimes link to lab workflows or 3D printers.
- Reporting and accuracy tools: Some systems provide tools for post-operative comparison: overlaying planned and placed implants, measuring deviations (angular, coronal, apical) and generating reports for quality assurance or audit.
- Usability and workflow integration features: User-interface design, file-format compatibility, cloud storage, customized drill-sequences, implant libraries, and training modules all impact how easily software integrates into clinical workflow.

Each feature serves a specific purpose: improving safety (via anatomical segmentation), enhancing prosthetic outcomes (via virtual set-up), increasing surgical precision (via guide-design module), and enabling standardization and documentation (via reporting). The combination of these features is what distinguishes advanced planning software in guided-implant workflows.

1.2 Hypothesis

Guided surgery is not yet fully standardized in routine implant practice, and free-hand placement remains widely used, potentially due to the increased cost and workflow changes associated with guided surgery.

1.3 Aim of the study

This study aims to evaluate whether the technique has achieved clinical standardization, explore potential factors influencing its adoption, and identify the software platforms currently used in guided implant workflows

1. OBJECTIVES

2.1 Primary objective

Measure the frequency of use of the guided surgery technique among implantologists

2.1.1 Specific objectives

To Evaluate the clinical impact of the use of the guided surgery technique

To Identify and compare available dental implant planning software.

1. **MATERIAL AND METHODS**

A total of 50 implantologists were invited to complete a questionnaire. Data collected from the questionnaire will be analyzed to address the study objectives and will be presented in the Results and Discussion, with key points summarized in the Conclusions.

Study design: Cross-sectional, survey-based descriptive study.

Participant criteria:

- Inclusion: Dental professionals with experience in the field of implantology.
- Exclusion: No experience in the use and application of implants.

Sampling: Convenience sampling complemented by snowball sampling.

Recruitment: Conducted through social media, email, and face-to-face communication. Target sample size: 50–100 respondents.

Questionnaire development:The questionnaire begins with an introductory page and consent form. It contains 11 items organized into thematic sections addressing:– professional experience with guided surgery– frequency and context of use– software currently used– perceived clinical and financial impact– software features and limitations– learning difficulty– ease of integration into the clinical workflow.

The full questionnaire is provided in the Annexes.

Response types included: Likert scale, open-ended, multiple-choice, and yes-or-no formats.

Platform used: Microsoft Forms.

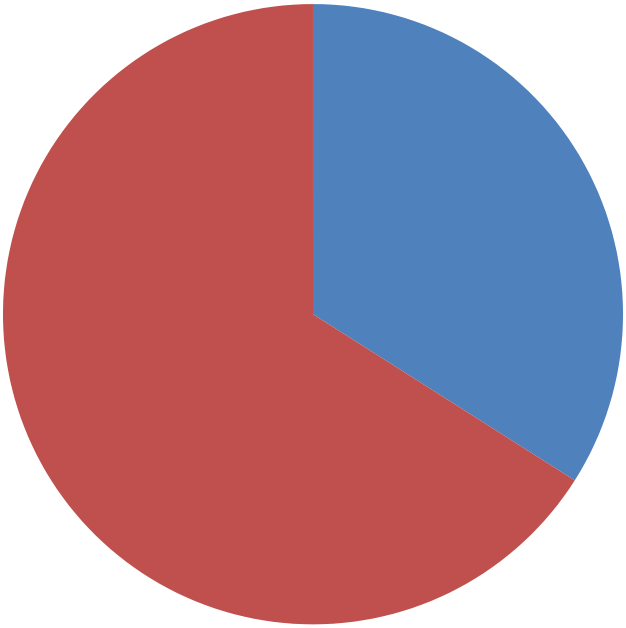
Data storage will be done electronically in anonymized form.

Data collection will be conducted during the 2025–2026 academic year.

1. **RESULTS**

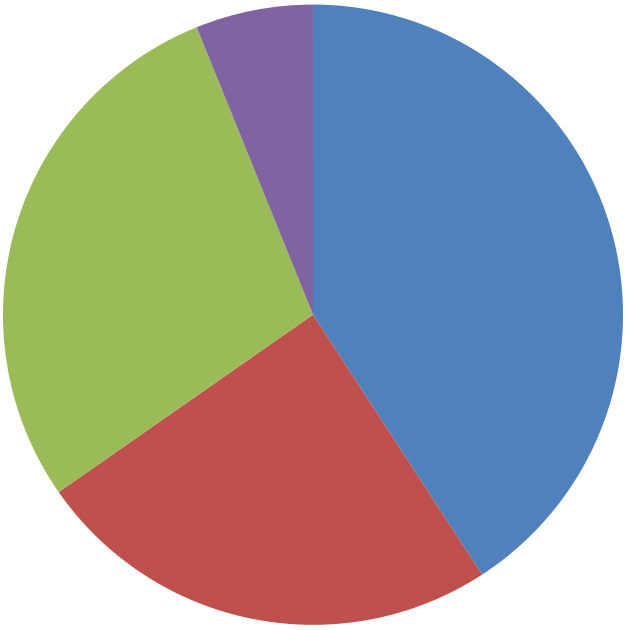
50 implantologists participated in the survey. The results obtained from the questionnaire are presented below.

Frequency of use of Guided surgery among implantologists:



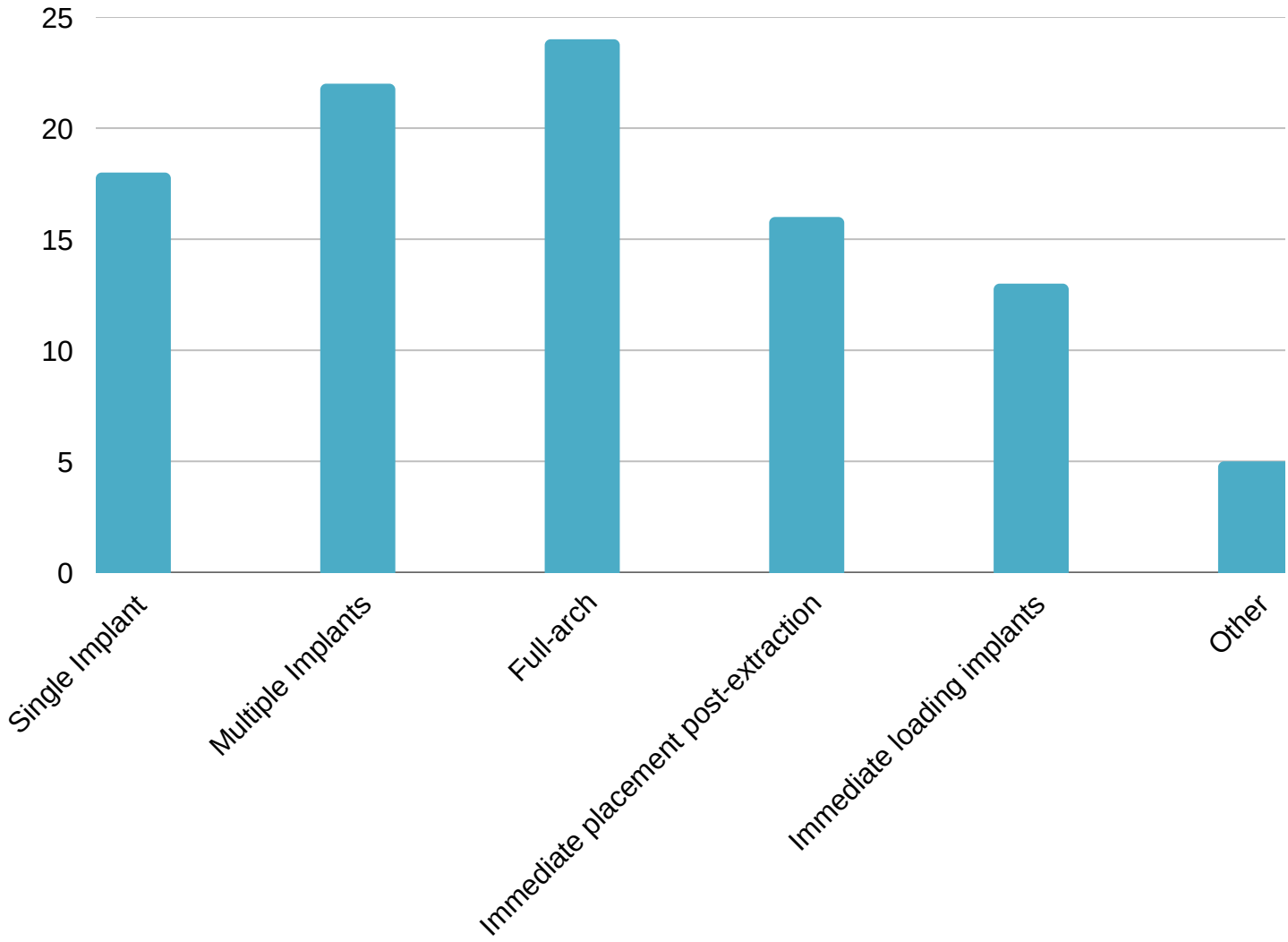
Regarding the use of the guided surgery system: 66% of the implantologists reported using the guided-surgery workflow in their clinic [Figure 1].

Frequency of use of the guided surgery system per case:



Concerning the frequency of its use in the clinic: 41% reported using the system for some of the cases, 29% reported not using it, 24% reported using it for most of their cases, and 6% reported using it for half their cases [Figure 2].

Types of cases done with guided surgery



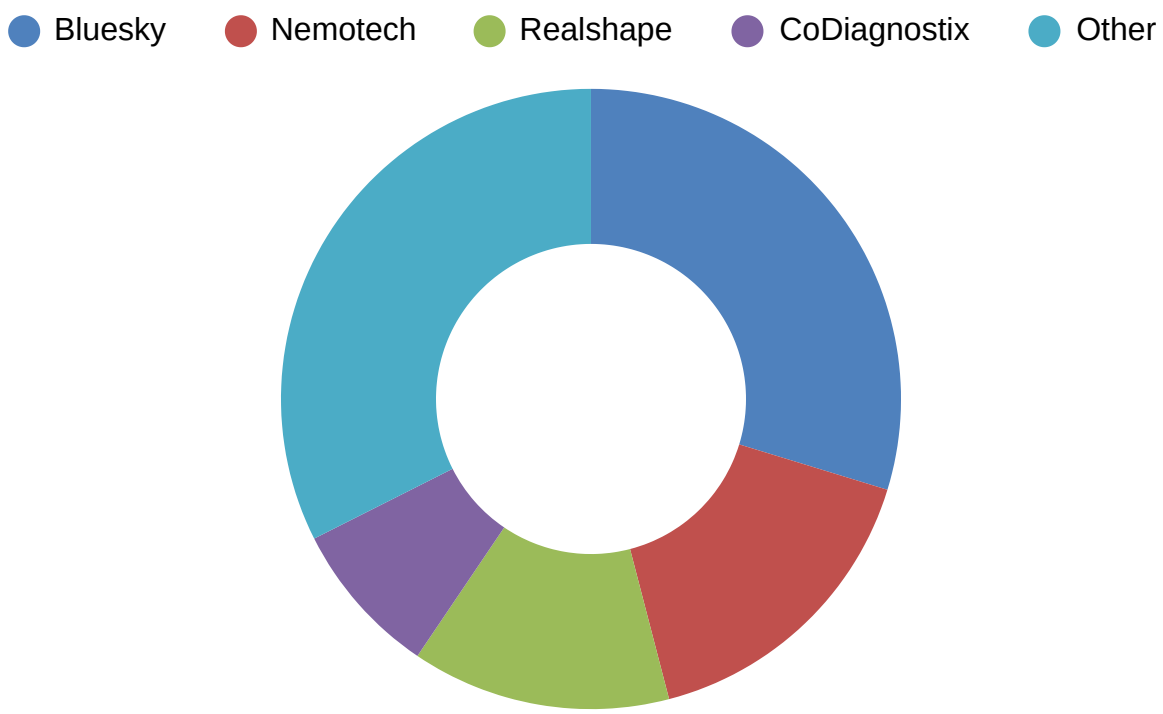
Concerning the type of cases in which implantologists use the guided surgery system: 24 responded for full-arch cases, 22 for multiple implants, 18 for single implants, 16 for immediate placement post-extraction, 13 immediate loading implants, and 5 responded with other [Figure 4].

In relation to the effect of guided surgery on the implantologists' clinical and financial outcomes, 19 out of the 50 implantologists in an open-ended manner optionally answered and the following themes were reported:

- Faster or more efficient surgical procedures (26%)
- Increased predictability of outcomes (e.g., immediate loading, treatment planning) (21%)
- Higher treatment cost or additional financial burden for the patient (21%)
- Improved surgical precision and implant positioning (16%)
- Positive overall impact (16%)
- No impact/Neutral (10%)

With respect to the impact guided surgery had on the clinician's practice, a scale of 1-5 was presented and 82.5% of the implantologists reported a score of 4 or 5.

The software used:



Regarding the software implantologists use for treatment planning: 30% used BlueSky, 16% Nemotech, 14% Realguide, 8% Codiagnostix, 3Shape, Atomica, Dentalwings, Exoplan, Implantation, Magellan, and Smile in a box [Figure 3]

1. **DISCUSSION**

This study evaluated the frequency of use of guided surgery among implantologists, its perceived clinical and financial impact, and the software used in guided implant workflows. The findings provide insight into current clinical practices and contribute to the understanding of variability in the adoption of digital implant planning systems.

Frequency of Use of Guided Surgery

The results showed that **66% of implantologists reported using guided surgery**, while **34% did not use it**. Regarding frequency of use per case, **41% of respondents reported using guided surgery in some cases**, while only **24% used it in most cases**. This indicates that although guided surgery is widely adopted, it has not yet replaced conventional free-hand techniques in routine clinical practice. This partial adoption may be explained by the increased treatment cost and clinician preference.

Indications

The most common indications for guided surgery in this study were **full-arch cases and multiple implant placements**, followed by single implants and immediate protocols. The higher usage in full-arch cases can be explained by the absence of natural tooth landmarks, making guided systems particularly valuable for ensuring correct implant positioning and angulation; Moreover, Recent literature directs the use of surgical guides for zygomatic implants, surgical guides manufactured for osteotomy/osteocteomy procedures, and maxillary sinus floor elevation. (13)

Clinical and Financial Impact

A significant proportion of clinicians (**82.5%**) reported a high positive impact of guided surgery on their clinical practice. Qualitative responses further highlighted **increased surgical precision, improved predictability, and reduced operative time**. These findings are supported by multiple systematic reviews, which demonstrate lower angular, coronal, and apical deviations in guided implant placement compared to free-hand techniques (3,6,13,14).

However, **increased treatment cost** was identified as a limitation. Financial considerations may be the main barrier to the widespread adoption of the technique. (15)

Available Software

The software identified in this study were **BlueSky (30%)**, **Nemotech (16%)**, **RealGuide (14%)**, **coDiagnostiX (8%)**, **3Shape, Exoplan, Dental Wings, Smile in a Box, Magellan, Atomica, and Implantation**.

This distribution indicates a **high variability in software selection**, with no single dominant platform. Similar findings have been reported in the literature, where multiple software solutions coexist due to differences in cost, user interface, implant libraries, and compatibility with laboratory workflows (9–11).

Overall interpretation

The absence of a clearly preferred software suggests that software choice is influenced by **clinician preference, accessibility, and integration capabilities**, rather than differences in clinical performance.

The general standardization of the guided implant surgery workflow may be associated with an increase in the overall cost of implant treatment, which is already considered relatively high in routine clinical practice.

Although guided surgery has been shown to improve accuracy and reproducibility compared to free-hand implant placement, it may not be necessary in straightforward cases where clinicians can achieve satisfactory outcomes using conventional approaches. This supports and may explain why guided surgery is applied selectively rather than routinely amongst the majority of participants in the questionnaire.

Furthermore, the use of digitally fabricated surgical guides may enhance intra- and inter-operator reproducibility, potentially reducing variability associated with clinician experience. However, the higher financial cost associated with digital workflows—including software, imaging, and guide fabrication—may limit its widespread implementation. (16)

These findings suggest that, while guided surgery represents a safer and more reproducible outomces, its routine use must be balanced against economic considerations. Future efforts should focus on optimizing cost-efficiency and defining clear clinical indications to support a more standardized and evidence-based application of guided implant surgery. (15)

Limitations and Future Recommendations

The findings of this study should be interpreted with caution due to the relatively limited sample size and the use of non-probability sampling methods which may restrict the generalizability of the result; Furthermore, the current literature provides limited evidence regarding the standardization of guided implant surgery workflows. Future research aiming to establish clearer protocols and criteria to support standardized clinical decision-making in guided implantology is recommended. A possible area for future investigation is whether the selective use of guided surgery should primarily be based on subjective clinical judgment or objective criteria. Identifying and validating measurable parameters—such as case complexity, anatomical limitations, and prosthetic requirements—could support more consistent and evidence-based decision-making and assist clinicians in determining when its application is most beneficial.

1. **CONCLUSIONS**

The guided surgery technique is used by 2 out of every 3 implantologists, with nearly a quarter using it for most of their cases. The clinical impact of its use is increased efficiency, predictability, and accuracy. Guided surgery is widely adopted but is generally applied selectively rather than routinely. Its clinical benefits are well recognized; however, cost and clinician pereference variability limit its universal use. The findings highlight a gap between technological advancement and its standardized clinical implementation. Clearer clinical guidelines for standardized protocols for the use of guided surgery for means of evidence based decision making to increase the cost-effectivness is recommended.

Software selection appears to be primarily influenced by clinician preference, accessibility, and workflow integration.

1. **SUSTAINABILITY**

The standardization of guided implant surgery protocols has the potential to contribute to more sustainable healthcare by optimizing both clinical outcomes and resource utilization. By establishing clear criteria for when guided surgery is indicated, clinicians can apply the technique selectively in cases where its benefits are most significant, such as complex or high-risk scenarios. This targeted use may help avoid unnecessary costs associated with routine application in simpler cases, thereby reducing the overall financial burden on patients.At the same time, patients can still benefit from the improved accuracy, predictability, and safety associated with guided surgery when it is clinically justified. From an economic perspective, this approach promotes more efficient allocation of resources by balancing technological advantages with cost-effectiveness. Furthermore, reducing unnecessary procedures and optimizing treatment planning

may contribute to long-term sustainability by minimizing complications, revisions, and additional interventions. Overall, the implementation of standardized, evidence-based protocols in guided implant surgery may support both clinical efficiency and economic sustainability within modern dental practice.

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1. **ANNEXE**

TFG 79 Questionnaire: Frequency of use of the guided surgery technique – Fill in form