Keywords
Guided implant surgery, Conventional implant placement, Computer-assisted implant surgery, Dynamic navigation, Static guided surgery

Authors
[1*]Sunil S Nayak (Corresponding author)
Associate Professor, Department of Oral and Maxillofacial Surgery, Manipal College of Dental Sciences, Manipal Academy of Higher Education, Manipal, India
Email ID: sunil.nayak@manipal.edu
Orcid ID: 0000-0003-4659-6500

[2]Dr. Rohini Parui
Postgraduate, Department of Public Health Dentistry, Kalinga Institute of Dental Sciences (KIDS), Kalinga Institute of Industrial Technology (KIIT) Deemed to be University, Bhubaneswar, Odisha
Email ID: rohiniparui99@gmail.com
ORCID ID : 0009-0003-5009-8069

[3]Dr. Hasti Bhalani
General Dentist, Department of Dentistry, College of Dental Sciences and Hospital, Maharaja Krishnakumarsinhji Bhavnagar University, Amargadh, Gujarat
Email ID: drhastibhalani93@gmail.com
ORCID ID: 0009-0009-9104- 2858

[4]Dr. Shilpa Mailankote
Reader, Department of Public Health Dentistry, Nitte (Deemed to be University) AB Shetty Memorial Institute of Dental Sciences, Deralakatte, Mangalore
E-mail ID: shilpa@nitte.edu.in

[5]Mita Mandal
Reader, Department of Orthodontics, Guru Nanak Institute of Dental Science & Research,West Bengal.
Email ID: mitamandal2010@gmail.com
ORCID ID: 0000-0003-4359-821X

[6]Dr. Rohit M
Senior Lecturer, Department of Prosthodontics, SRM Dental College, Ramapuram, Chennai
Email ID: rohit.s0422@gmail.com
ORCID ID: 0000-0003-4493-5644

[7]Minakshi Bhattacharjee
Associate Professor
Programme of Biotechnology, Faculty of Science, Assam down town University, Assam
E-mail ID: minakshi.bhattacharjee@adtu.in
ORCID ID:0000-0002-4931-8912

Received: 11.03.2026
Revised: 16.04.2026
Accepted: 22.05.2026
Doi:10.1922/ejprd.v34i1s.1386

European Journal of Prosthodontics and Restorative Dentistry (2026) 34 (1s), 136-145

# Guided Implant Surgery versus Conventional Implant Placement: A Systematic Review of Accuracy and Complications

**Abstract**

**Background:** One great advantage of guided implant placement over freehand is the ability to plan the implant placement, make precise incisions and predict the outcome of the clinical scenario.

**Objective:** This systematic review aimed to evaluate the accuracy of implant placement and complications of guided implant surgery versus conventional implant placement.

**Methods:** The PRISMA 2020 guidelines were used for the review. Manual reference screening and electronic searches on PubMed and Google Scholar databases were carried out. A total of 241 records were identified and 11 studies of mixed design were included in the qualitative synthesis.

**Results:** The results revealed that the accuracy of implant placement was generally superior for guided implant surgery (static and dynamic computer-assisted systems) than for freehand implant surgery. The guided systems were found to have lesser deviations in the coronal, apical, and angular directions and transfer of digital planning was more in the guided systems. In a few studies, it was also observed that guided surgery had a positive effect on reduced pain and comfort after surgery and reduced complications related to positioning. Nevertheless, there was a correlation between a higher learning curve, technical complexity and procedural cost with the guided implant surgery. Cost, ease of procedure and ease of workflow were all advantages of conventional placement.

**Conclusion:** Guided implant surgery appears to be a reliable and effective method for enhancing implant placement accuracy, although further comparative clinical evidence is required to confirm its effect on surgical complications.

## 1. INTRODUCTION

Dental implantology has emerged as one of the most reliable and well-established modalities of treatment to replace missing teeth and restore oral functions, esthetics and patient comfort. The improvement of the implant materials, imaging and digital technology has greatly enhanced the survival rates of implants and the long-term success rates of prosthetics over the past decades (J. D'haese et al., 2017). Proper implant placement is essential to effective implant therapy since incorrect placement can undermine the rehabilitation of prosthetics, esthetics, and biomechanical stability, as well as the adjacent body organs (Feng et al., 2022; Kivovics et al., 2022).

In the past, implants were installed by freehand methods of surgery whereby positioning of the implants depended mainly on the experience of the clinician and also the anatomy. Even though the traditional approach of implanting them freehand is still used, angulation, depth, and location of the implants may vary, particularly in anatomically complicated cases (Kasradze et al., 2021). To address these shortcomings, computer-aided and digitally guided implant surgery was introduced to enhance surgical accuracy and predictability of treatment (Schnutenhaus et al., 2021). The guided implant surgery technique uses digital planning, CBCT images, intraoral or extraoral imaging, and computer-aided transfer systems to enhance the precision of implant placement. The primary guiding methods in the studies included were the use of static computer-assisted implant surgery, dynamic navigation, fully guided implant placement, and zygomatic implant rehabilitation with bone-supported guides. In static guided surgery, a surgical template is used to transfer the virtual implant plan to a patient, in dynamic navigation, intraoperative tracking of drill position, depth and angulation can be performed in real time. Thus, the comparison of guided and conventional approaches to implant placement in this review is primarily based on the dynamic navigation and freehand surgery, the static guide and freehand surgery, the static and dynamic CAIS and the fully guided surgery and guided zygomatic implant placement (Fan et al., 2023).

Combining cone-beam computed tomography (CBCT), intraoral scanning, digital planning software and three-dimensional imaging has revolutionized contemporary implant processes as clinicians can now see the anatomical structures precisely in preoperative cases (Saini et al., 2024). Guided surgery protocol has shown better accuracy on implant placement, angular deviation, and better predictability of the surgery than the traditional methods (Cao et al., 2026; Li et al., 2026).

Traditional implantation, also known as freehand implant surgery, involves clinical skills of the surgeon, interpretation of anatomy, and manual placement when inserting the implants. Although conventional implant placement is cost-effective and clinically versatile, it is highly reliant on operator experience and can result in higher variability of implant angulation and positioning (Tallarico et al., 2018). Freehand surgery may be especially difficult when there is limited bone volume, closeness to critical anatomical structures, or intricate rehabilitation needs of the prosthetic.

Even though skilled clinicians can attain good results using the traditional methods, poor implant positioning might predispose patients to more complications with prosthetics, biomechanical overloading, and aesthetic restrictions (Gargallo-Albiol et al., 2019). As a result, a comparison of guided and freehand approaches to the placement of implants has become a more relevant issue in modern implant dentistry.

Proper positioning of the implants is a very important factor to successful rehabilitation supported by implants. Accurate positioning of implants results in ideal emergence profiles of the prosthetic, good distribution of the load of the occlusives, and long-term stability of the peri-implants (R. D'haese et al., 2022; Kivovics et al., 2022). Conversely, improper implant angulation or depth can challenge the alignment of the prosthetic and predispose it to implant failure or peri-implant complications. One more significant factor of surgical accuracy is preventing harm to the nearby anatomical elements like the inferior alveolar nerve, maxillary sinu, and adjacent teeth roots (Seo & Juodzbalys, 2018). Guided surgery systems are designed to minimize these risks by providing the opportunity to perform anatomically controlled and prosthetically driven operations to place implants.

Dental implants could be accompanied by surgical, prosthetic, and biological complications. The risks of surgery are hemorrhage, nerve damage, sinus perforation, guide instability, and incorrect angulation of the implants (Schnutenhaus et al., 2021). Some of the complications of prosthetics include loosening of screws, misfit of the framework, occlusal instability, and fracture of the prosthetic. Long-term issues like peri-implant mucositis and peri-implantitis affecting implant survival and peri-implant tissue health are still biological complications (Gonçalves Esteves Rodrigues Lima, 2026). Also, the aspect of soft tissue stability and bone regeneration are important towards the success of the long term implant. Modern literature has emphasized the use of soft tissue substitutes, bone grafting, and peri-implant tissue augmentation in enhancing implant outcomes and esthetic rehabilitation (Assem et al., 2022; Tavelli et al., 2025).

Despite the extensive number of studies that have compared guided implant surgery and traditional freehand implant placement, there are still controversies in terms of their relative accuracy, clinical effectiveness, complications, patient satisfaction, and prognosis. Multiple studies have found that guided surgery enhances the accuracy of implants and the postoperative morbidity, whereas other studies show that guided and freehand methods do not differ significantly (García-Valdez et al., 2025). The growing use of digital implant technologies, CBCT-based planning systems, and robotic-assisted surgical strategies require new comparative evidence of their clinical outcomes and reliability. Systematic review of guided surgery versus conventional placement of implants is thus significant to evidence-based clinical judgment and future technological development of implant dentistry.

The aim of this systematic review was to compare guided implant surgery and conventional implants placement in regard to implant-placement accuracy and complications involved. The review was narrowed down to angular deviation, coronal and apical deviation, transfer between digital planning and clinical placement of implants, implant survival, postoperative complications and patient-reported outcomes where possible. Special focus was on research on comparative studies of dynamic navigation, static guided surgery, fully guided implant placement, guided zygomatic implant surgery, and conventional freehand implant placement.

## 2. Methodology

### 2.1 Research Design

The research was performed in the form of a literature review, which allowed assessing and comparing the clinical effectiveness, accuracy, and outcome of guided implant surgery and traditional freehand techniques of implant placement in dental implantology. To promote



 

transparency and reproducibility in the methodology, it was planned and presented as per the guidelines of the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA 2020).
The review targeted articles that evaluated the static guided surgery, dynamic navigation system, computer assisted implant surgery and traditional free hand implant placement with special attention to implant accuracy, deviation, complications, precision, implant survival and surgical outcomes.

### 2.2 Data Sources and Search Strategy

An extensive search was performed in PubMed and Google Scholar databases to find electronic literature. Further pertinent research was derived using manual reference screening of articles included and pertinent review articles. The search has been conducted to find the studies published between January 2014 and December 2026.
Only articles that include human participants, are published in English or languages understandable by English, and are in full-text articles were eligible to be included. Medical Subject Headings (MeSH) were used to develop the search terms that included Boolean operators (AND and OR) and combinations of keywords that dealt with guided implant surgery and traditional methods of implant placement. The exact search string used in the database search was:
(("Dental Implants"[Mesh] OR "dental implant*" OR "implant placement") AND ("guided implant surgery" OR "computer-guided implant surgery" OR "guided surgery" OR "static guided surgery" OR "dynamic navigation" OR "computer-assisted implant surgery" OR "surgical guide*" OR "template-guided implant*") AND ("conventional implant placement" OR "freehand implant placement" OR "free-hand implant surgery" OR "traditional implant placement") AND (accuracy OR deviation OR precision OR complications OR "surgical complications" OR "implant failure" OR outcomes)).
The search plan was made to exclude the studies that lacked investigation on guided and conventional implant surgery methods focusing on the surgical precision, deviation analysis, complications and treatment results.

### 2.3 Eligibility Criteria

The screening process was preceded by the predefinition of the eligibility criteria. The studies had to examine guided implant surgery which could be either the static guided surgery, dynamic navigation, computer-assisted implant surgery, or template-guided implant placement and implant placement and compared them with the traditional or freehand implant place procedures.
Qualified studies were randomized clinical trials, cohort studies, retrospective observational studies, comparative clinical studies, systematic reviews, and clinically relevant observational studies. The studies had to report results based on accuracy of the implant placement, angular deviation, linear deviation, surgical precision, complications, implant survival, or postoperative results.
Articles were filtered out when they were not related to dental implant surgery, non-healthcare usage, or when there was insufficient outcome data, when the article was a conference abstract, when the data were duplicated, or when the article was not written in English. The review did not also include animal studies, laboratory studies, editorials, technical notes or opinion papers.

### 2.4 Study Selection Process

The process of study selection was in accordance with the PRISMA flow framework which includes identification, screening, eligibility assessment, and the final stages of inclusion. A total of 241 records were first found by searching databases and screening references by hand. Out of these, 200 records were retrieved in PubMed and Google Scholar databases, and 41 other records were found during manual reference checking and other sources. The 106 studies were left after elimination of the duplicates to be screened on the title and abstract. In the screening phase, 56 studies were filtered out as they did not fit the purpose of the review. Then 50 full-text articles were evaluated to determine their eligibility. Following the thorough screening, 39 articles have been eliminated based on the irrelevancy of subject matter, conference abstracts only, non-health domains, language barriers, or redundancy in data. Lastly, 11 studies passed all the eligibility factors and were incorporated into the ultimate analysis of the qualitative synthesis and review.

### 2.5 Data Extraction

All studies included were independently extracted using a standardized extraction framework that was created specifically to extract the data in this review. The information that was extracted consisted of author details, year of publication, country of study, study design, sample size, number of implants placed, implant placement technique, surgical guidance system used, comparator group, and outcome variables.
The studies yielded clinical outcome variables such as accuracy of implant placement, coronal and apical deviation, angular deviation, implant survival rate, surgical complications, postoperative pain, patient satisfaction, intraoperative findings, and overall treatment outcomes.
In case the data was available, the data on software systems, CBCT planning techniques, three-dimensional superimposition studies, STL-based measurements, and navigation technologies were also obtained to measure the technological dissimilarities between guided and conventional implant surgery guidelines.

### 2.6 Outcome Measures

The main results measured in this review consisted of the accuracy of the implants placement, the linear deviation at the coronal and apical levels, the angular deviation, the accuracy in surgery, the survival of the implants, and the rate of complications. Postoperative pain, patient satisfaction, duration of surgery, intraoperative complications, quality-of-life outcomes, and predictability of treatment were examples of secondary outcomes. Some incorporated articles utilized three-dimensional radiographic examinations, CBCT-based preparation, and STL model comparisons and morphometric analysis to quantify implant accuracy and surgical precision.

### 2.7 Quality Assessment

The quality of the methodology of the included studies was analysed on the basis of the study design and quality of the reporting of each article. Randomized clinical trials and comparative studies were appraised critically in relation to the methodological rigor, consistency of the study and reporting of the outcomes. The study methods of observational and systematic reviews were evaluated regarding the understandability of the method, the reporting comprehensiveness, the sufficiency of the sample and the risk of bias. The differences in study design, implant systems, navigation systems, surgical procedures and reporting methods led to the adoption of qualitative synthesis approach over quantitative meta-analysis.

### 2.8 Data Synthesis and Analysis

The synthesized data were analyzed qualitatively to compare guided and conventional freehand implant placement methods among the studies included. The results were evaluated with regard to the accuracy of implants, surgical accuracy, complications, implant survival, postoperative results, and patient-related factors. They compared the method of static guided surgery, dynamic navigation systems, computer-assisted implant surgery, and the traditional freehand implant placement methods. The review has highlighted the clinical significance of guided surgical technologies to enhance the precision of implant placement, minimization of surgical deviations and also taking into account the complications and clinical constraints.

## 3. Results

### 3.1 Overview of Included Studies

The studies included were mixed design, including randomized, prospective, observational, clinical, case-based, and review-based evidence, met the inclusion criteria for qualitative synthesis traditional freehand implant placement methods. Figure 1. PRISMA 2020 flow diagram of how the studies included in the systematic review will be identified, screened, and their eligibility assessed and included.

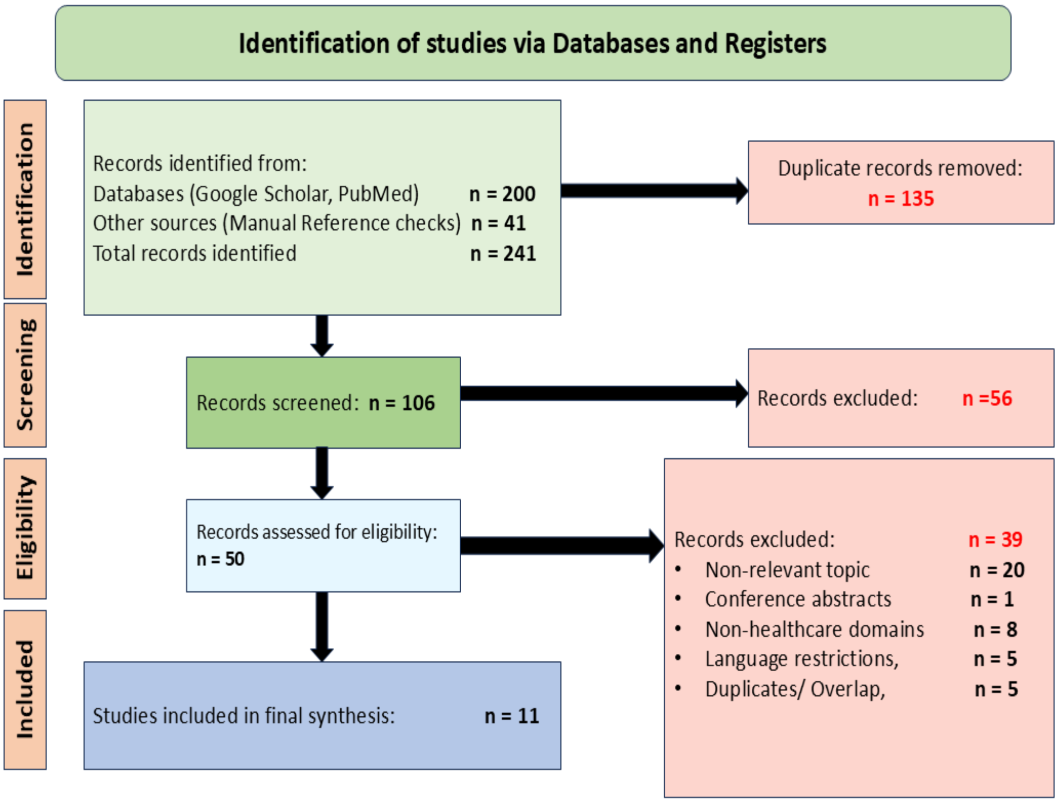


**Figure 1. PRISMA Flow Diagram Showing Identification, Screening, Eligibility, and Inclusion of Studies**

### 3.2 Accuracy Outcomes

The majority of the studies that were included were able to prove that guided implant surgery offers a higher-quality of implant positioning than conventional freehand implant placement. Lower angular deviation, decreased coronal and apical displacement, and enhance surgical precision were linked with the use of the use of static guided surgery, dynamic navigation systems, and computer-assisted implant surgery. Characteristics of Included Studies shown in Table 1.

**Table 1. Characteristics of Included Studies**

| Author | Study Design | Main Focus | Guided Technique |
|---|---|---|---|
| (Aydemir & Arısan, 2020) | Split-mouth randomized controlled clinical trial | Accuracy of dynamic navigation versus freehand implant placement | Dynamic navigation vs conventional freehand |

| | | | |
|---|---|---|---|
| (Younes et al., 2019) | Randomized controlled trial | Accuracy and efficiency of freehand, pilot-drill guided, and fully guided implant surgery | Freehand vs pilot-guided vs fully guided surgery |
| (Younis et al., 2024) | Prospective clinical study | Accuracy of dynamic navigation, static surgical guides, and freehand placement | Dynamic navigation vs static guide vs freehand |
| (Lorenzetti et al., 2021) | Case report | Zygomatic implant accuracy | Preoperative Scan Digital Impression |
| (Oh & Lee, 2020) | Research study | Full-Arch Implant-Supported Prosthesis | Actual Position of Implants |
| (Feng et al., 2022) | Research study | Maxillofacial Prosthetics | Technological Leap |
| (Alshadidi et al., 2026) | Randomized controlled trial | Clinical accuracy, recovery, stability, and patient outcomes in freehand, pilot-drilled, and fully guided surgery | Freehand vs pilot-drilled vs fully guided |
| (Azevedo et al., 2024, 2024) | Prospective clinical study | Accuracy of immediate implant placement using static and dynamic CAIS in esthetic zone | Static CAIS vs dynamic CAIS |
| (García-Valdez et al., 2025) | Systematic Review | Quality of life and satisfaction | Guided implantology |
| (Al-Anssari et al., 2023) | Clinical Investigation | Surgical guide accuracy | Fully guided surgery |
| (Gallo et al., 2023) | Retrospective Cohort Study | Zygomatic implant accuracy | Bone-supported guided surgery |

A number of studies have noted that CBCT-based planning together with digital surgical guidance enhanced transfer of virtual implant planning to the operating field. The use of dynamic navigation systems especially showed better real-time accuracy during the surgical procedure and more accurate positioning of the implants than freehand techniques.

Observational studies conducted retrospectively on zygomatic implants have shown that there are low linear and angular deviations between planned and placed implants meaning that there are clinically acceptable levels of accuracy, and high levels of predictability of the procedure. The summary of the outcomes of the accuracy was based on the final evidence-base included, and the primary clinical studies were prioritized, and only the supporting interpretation of the systematic reviews in the cases of relevance.

### 3.3 Quantitative Deviation Analysis

Some of them quantitatively assessed the deviation in the placement of implants comparing the planned and placed position of the implants through three dimensional analyses on the basis of CBCT. The most frequent outcomes that were reported were coronal deviation, apical deviation, angular deviation and the three-dimensional measures of displacement. Guided implant surgery proved to be always smaller than traditional freehand implant placement.

Investigations of the schemes of dynamic and stationary guidance systems showed comparatively low values of angular deviation and enhanced consistency of implant positioning. The values of surface displacement tended to stay within the clinical acceptable levels, which shows the proper transfer of digital planning into clinical implementation.

The deviation values were slightly higher in the posterior sites of implantation than in the anterior areas due to restricted accessibility of the area and high complexity of the procedure involved. However, guided systems had a better positional accuracy in most anatomical sites. Table 2. Quantitative deviation results of guided implant surgery such as coronal, apical, angular and three dimensional deviations.

**Table 2. Quantitative Deviation Findings in Guided Implant Surgery**

| Outcome Variable | Reported Findings | Clinical Interpretation | Reference |
|---|---|---|---|
| Coronal deviation | Lower in guided surgery | Improved implant positioning | (Aydemir & Arısan, 2020) |
| Apical deviation | Reduced compared with freehand placement | Better apical control | (Younes et al., 2019) |
| Angular deviation | Mostly below 2° | Clinically acceptable accuracy | (Younis et al., 2024) |
| Surface displacement | 0.22-0.26 mm | High surgical precision | (Lorenzetti et al., 2021) |

| | | | |
|---|---|---|---|
| Three-dimensional deviation | Minimal deviation values | Accurate virtual-to-clinical transfer | (Oh & Lee, 2020) |
| Implant positioning precision | Higher with guided systems | Improved treatment predictability | (Feng et al., 2022) |

**3.4 Complications and Implant Survival**

The rate of complications across the studies included was inconsistent; but guided implant surgery usually yielded positive clinical results with better surgical predictability. Guided surgical systems minimized the chances of poor angulation of implants, positioning mistakes, and anatomical issues.

The majority of the studies claimed high survival rates of implants with guided implant placement and few intraoperative complications. There were no significant surgical failures, or severe guide-related complications that were common in the conducted reviews. In a number of comparative studies, guided surgery showed decreased postoperative pain, inflammation, and medication use.

Dynamic navigation systems were also linked to better intraoperative visualization and communication between clinicians and patients in the planning of treatments and surgery. Table 3. Comparison of postoperative outcomes, complications and implant survival of guided and conventional techniques of implant placement.

**Table 3. Complications and Implant Survival Outcomes**

| Clinical Outcome | Guided Implant Surgery | Conventional Implant Placement | Reference |
|---|---|---|---|
| Implant survival | High survival rates reported | Generally high | (Aydemir & Arısan, 2020) |
| Postoperative pain | Lower in several studies | Higher pain levels reported | (Younes et al., 2019) |
| Surgical precision | Higher precision | Operator-dependent variability | (Younis et al., 2024) |
| Positioning-related complications | Reduced | Increased deviation risk | (Lorenzetti et al., 2021) |
| Implant angulation errors | Lower | Higher | (Oh & Lee, 2020) |
| Inflammation and medication use | Reduced | Increased postoperative discomfort | (Feng et al., 2022) |

**3.5 Patient-Reported Outcomes**

Questionnaires were used to measure patient-centered outcomes in terms of postoperative pain, treatment satisfaction, oral health-related quality of life, anxiety, and surgical comfort. Guided surgery on implants was mostly attributed to enhanced patient comfort, less pain after surgery and positive acceptance of treatment.

The use of dynamic navigation systems especially enhanced the patient experience as they allowed the real-time visualization of the implant placement procedures and enhanced communication between clinicians and patients. Other studies also found shorter recovery, and reduced intraoperative anxiety in patients who received guided surgery protocols.

Nonetheless, a few studies did not find statistically significant differences in general patient satisfaction when comparing guided and conventional implant surgery methods, indicating that surgical skills, patient expectations, and complexity of the procedure also play a role in patient perception. Table 4. Patron-reported outcomes of directed implant surgery such as pain, quality of life, satisfaction, and surgical comfort.

**Table 4. Patient-Reported Outcomes in Guided Implant Surgery**

| Outcome Variable | Findings | Assessment Tool | Reference |
|---|---|---|---|
| Postoperative pain | Reduced pain levels | VAS | (Aydemir & Arısan, 2020) |
| Quality of life | Improved oral health-related quality of life | OHIP/OHRQoL | (Younes et al., 2019) |
| Patient satisfaction | Generally favorable outcomes | VAS/Likert scales | (Younis et al., 2024) |
| Treatment acceptance | Higher acceptance of digital surgery | PREMs | (Lorenzetti et al., 2021) |
| Anxiety reduction | Reduced intraoperative anxiety | s-DAI | (Oh & Lee, 2020) |
| Surgical comfort | Better intraoperative comfort | VAS | (Feng et al., 2022) |

**4. Discussion**

The current systematic review compared the effectiveness of guided implant surgery and the traditional freehand delivery of implants with an accent on the accuracy of the implant placement and the related complications. The results showed that the positional accuracy of computer-assisted implant surgery tends to be better than the traditional freehand methods. The majority of the included studies consisted of lower angular deviation, decreased coronal, and apical displacement along with enhanced surgery precision in guided implant systems (Chen et al., 2025; Pisla et al., 2025). The execution of the virtual implant planning into the operating field was always better in dynamic navigation systems, compared to the use of a static guided surgery protocol, thus increasing predictability in the positioning of implants (Knipper et al., 2024; Sankar et al., 2025)

In terms of complications the guided implant surgery had been found to have less positioning-related errors and less discomfort after surgery in some studies. Nonetheless, other studies also have noted insignificant differences between guided and traditional methods, especially whereby procedures are conducted by skilled clinicians (Jaemsuwan et al., 2023). These results suggest that surgical technique and operator experience have a great impact on the results of implants.

A large part of the reason behind the enhanced accuracy of guided implant surgery can be attributed to developments in the digital planning technologies and surgical navigation systems. CBCT images, intraoral scanning, and computer-aided planning of treatment enable clinicians to determine the anatomical structures accurately prior to surgery and to arrange the location of implants based on the needs of prostheses (J. D'haese et al., 2017). Stereolithographic surgical templates are used to supervise implant drills physically to reduce human error and deviation by guiding the digital treatment plan in the creation of these guides (Seo & Juodzbalys, 2018).

The dynamic navigation systems are used to enhance the precision of surgical procedures as they include real-time visualization and tracking of the implant placement process (Block et al., 2017). Such systems enable constant tracking of drill angulation and depth in comparison to patient anatomy, increasing control intraoperative and minimizing anatomical complications (Jiang et al., 2023). The recent advances in the field of augmented reality and robotic-assisted navigation have also proven to be promising in terms of accuracy and safety with regard to complicated implantation processes (Ma et al., 2025; Nava et al., 2026).

Although there are some advantages to guided implant surgery, it has a number of limitations that can influence the standard practice of guided implant surgery. The high cost of the digital equipment, CBCT imaging, a navigation software, and surgical guide fabrication is one of the primary concerns (Gargallo-Albiol et al., 2019). The other significant drawback is the learning curve that comes with the digital implant procedures and navigation technologies. The correct utilization of guided systems involves clinician education, software expertise, and knowledge of digital principles of treatment planning (Senthil et al., 2023). Implant accuracy can also be impaired by technical issues, like guide instability, inaccurate guide seating, software calibration errors, or deviation when template is fabricated (Shi et al., 2023). Moreover, dynamic navigation systems can take a longer time to operate in the early stages of the implementation due to equipment installation and calibration (Schnutenhaus et al., 2021). The implementation of prefabricated templates to guide implant angulation and positioning in surgery can be avoided by experienced surgeons (Tahmaseb et al., 2018). Traditional implant placement is also characterized by reduced overall costs of the procedure and an easier clinical workflow due to the lack of a complex digital planning and other special equipment (Gargallo-Albiol et al., 2019). In the case of regular implantation and a good anatomy, the traditional methods can offer clinically satisfying results with less complexity of treatment.

The results of the current review are in line with those of earlier systematic reviews that found a higher accuracy of implant placement with guided surgery as opposed to freehand methods. Similar results were found by Tahmaseb et al. and Bover-Ramos et al. who showed lesser angular and linear deviation in computer-guided placing of implants (Bover-Ramos et al., 2018; Tahmaseb et al., 2018). Werny et al. have also reported a better positional transfer accuracy in computer-assisted implant surgery (Werny et al., 2025).

Nevertheless, the clinical meaning of improved accuracy should be interpreted carefully. Better positional accuracy does not automatically guarantee lower complication rates in every clinical situation. The included studies suggest that guided implant surgery may be particularly useful in immediate implant placement, full-arch digital workflows, fully guided implant placement, and complex zygomatic implant cases. However, clinical outcomes remain influenced by patient anatomy, bone quality, guide stability, surgical access, digital planning accuracy, and operator experience (Nava et al., 2026).

When choosing between the guided and conventional implant placement methods, clinicians ought to take into account patient anatomy, availability of bones, complexity of surgery, financial considerations and experience of the operator. Guided surgery can be of significant benefit to less competent clinicians as well as extremely challenging restorative situations.

One advantage of this review is the synthesis of recent evidence pertaining to dynamic navigation, static guided surgery, fully guided implant placement, guided zygomatic implant surgery and conventional freehand implant placement. The review was limited, however, by the mixed design of the studies included, reporting of outcomes and the inclusion of some evidence from reviews and individual cases. Future studies should focus on long-term randomized controlled trials and prospective comparative trial studies involving standardized methods of coronal deviation, apical deviation, angular deviation, implant survival, complications, post-operative pain, patient reported outcomes.

## 5. Conclusion

This systematic review aimed to investigate and compare the accuracy of guided implant surgery versus conventional freehand implant placement and complications. The results suggest that guided implant surgery, both static and dynamic computer-assisted systems, generally increase the accuracy of implant positioning, decreases the angular deviation, linear deviations, and improves the surgical precision of the procedure, as compared to freehand implant surgery. Digital planning technologies, CBCT integration and navigation systems play a major role in the enhancement of prosthetically driven implant placement and anatomical safety. Guided implant surgery also showed benefits for minimising positioning related complications, postoperative pain and surgical errors in several studies included. Dynamic navigation systems additionally provided better real-time surgical control and enhanced predictability of treatment. However, considering these advantages, conventional implant placement is still clinically relevant due to its reduced cost, increased intraoperative flexibility, and workflow in routine implant cases, especially performed by experienced clinicians. The review also noted key challenges with guided implant surgery, such as increased expense, technology complexity, dependency on equipment and the learning curve of digital workflows. Additionally, the included studies differed in terms of study design, outcome reporting, and follow-up period, which limited direct comparison between the studies. In conclusion, guided implant surgery is a dependable and efficient technique that can enhance the precision and efficiency of implant placement while reducing surgical risks. However, more long-term RCTs with uniform reporting systems are needed to develop more robust clinical evidence on the comparative effectiveness, safety, and cost-effectiveness of guided and conventional implant placement.

**References**


1. Al-Anssari, H. B., Al-Anee, A. M., & Al-Demirchi, J. Y. (2023). Accuracy of surgical guide in fully guided dental implant surgery. https://www.academia.edu/download/99394661/latest.pdf
2. Alshadidi, A. A. F., Aldosari, L. I. N., Alshehri, A. H. A., Binduhayym, R. I. H., Kondaveeti, R., Gurumurthy, V., & Vaddamanu, S. K. (2026). The efficacy of freehand, pilot drilled and fully guided implant surgery in partially edentulous patients: A randomized control trial. PloS One, 21(1), e0341894.
3. Assem, N. Z., Pazmiño, V. F. C., Caliente, E. A., da Silva Dalben, G., Soares, S., & de Almeida, A. L. P. F. (2022). Bone substitutes vs. autogenous bone graft for regeneration of the anterior maxillary alveolar process with horizontal bone resorption: Systematic review. The Journal of Oral Implantology. https://search.proquest.com/openview/9339968a9e9f14eeade9ee3e25190aaf/1?pq-origsite=gscholar&cbl=31216
4. Aydemir, C. A., & Arısan, V. (2020). Accuracy of dental implant placement via dynamic navigation or the freehand method: A split-mouth randomized controlled clinical trial. Clinical Oral Implants Research, 31(3), 255–263. https://doi.org/10.1111/clr.13563
5. Azevedo, M., Correia, F., & Faria Almeida, R. (2024). Accuracy of implant guided surgery in fully edentulous patients: Prediction vs. actual outcome—Systematic review. Journal of Clinical Medicine, 13(17), 5178.
6. Block, M. S., Emery, R. W., Lank, K., & Ryan, J. (2017). Implant Placement Accuracy Using Dynamic Navigation. International Journal of Oral & Maxillofacial Implants, 32(1). https://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=08822786&AN=121352331&h=HJH76a8vIqDnkajy24wtiZSQzVsSWqWZtXitnP%2Bgebf0U%2BiWe4PiBA3mEoAQTCey5txLUlUtl9x%2F7L49tnSA3A%3D%3D&crl=c
7. Bover-Ramos, F., Viña-Almunia, J., Cervera-Ballester, J., Peñarrocha-Diago, M., & García-Mira, B. (2018). Accuracy of Implant Placement with Computer-Guided Surgery: A Systematic Review and Meta-Analysis Comparing Cadaver, Clinical, and In Vitro Studies. International Journal of Oral & Maxillofacial Implants, 33(1). https://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=08822786&AN=127731814&h=54VcCrMgE5K%2Bv7tEQKgjGE053ASonvauLDuAaFI05i8SNrrvqGnMAl4LDdSWJfnqQzXW%2BXJJXHrcsObZApUWmA%3D%3D&crl=c
8. Cao, S., Fan, J., Shao, L., Sun, Q., Xu, T., Ai, D., Fu, T., Xiao, D., Song, H., Zhang, T., & Yang, J. (2026). Robot-Assisted Osteotomy and Reconstruction with AR Guidance in Maxillofacial Reconstructive Surgery. Cyborg and Bionic Systems, 0(ja). https://doi.org/10.34133/cbsystems.0590
9. Chen, J., Ding, Y., Cao, R., Zheng, Y., Shen, L., Wang, L., & Yang, F. (2025). Accuracy of a Novel Robot-Assisted System and Dynamic Navigation System for Dental Implant Placement: A Clinical Retrospective Study. Clinical Oral Implants Research, 36(6), 725–735. https://doi.org/10.1111/clr.14420
10. D'haese, J., Ackhurst, J., Wismeijer, D., De Bruyn, H., & Tahmaseb, A. (2017). Current state of the art of computer-guided implant surgery. Periodontology 2000, 73(1), 121–133. https://doi.org/10.1111/prd.12175
11. D'haese, R., Vrombaut, T., Hommez, G., De Bruyn, H., & Vandeweghe, S. (2022). Accuracy of Guided Implant Surgery Using an Intraoral Scanner and Desktop 3D-Printed Tooth-Supported Guides. International Journal of Oral & Maxillofacial Implants, 37(3). https://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=08822786&AN=157519507&h=yCSI%2BaVfq4dNaBzgBsNGzVnU%2B3BsV3a8Y5IbvKiXPx5CPSuZmUBaZzPON9WBmBy%2FCgcD2MLWC%2BkPDl%2BKhX3xiA%3D%3D&crl=c
12. Fan, S., Saenz-Ravello, G., Diaz, L., Wu, Y., Davo, R., Wang, F., Magic, M., Al-Nawas, B., & Kaemmerer, P. W. (2023). The accuracy of zygomatic implant placement assisted by dynamic computer-aided surgery: A systematic review and meta-analysis. Journal of Clinical Medicine, 12(16), 5418.
13. Feng, Y., Su, Z., Mo, A., & Yang, X. (2022). Comparison of the accuracy of immediate implant placement using static and dynamic computer-assisted implant system in the esthetic zone of the maxilla: A prospective study. International Journal of Implant Dentistry, 8(1), 65. https://doi.org/10.1186/s40729-022-00464-w
14. Gallo, F., Zingari, F., Bolzoni, A., Barone, S., & Giudice, A. (2023). Accuracy of zygomatic implant placement using a full digital planning and custom-made bone-supported guide: A retrospective observational cohort study. Dentistry Journal, 11(5), 123.
15. García-Valdez, D., Velasco-Ortega, E., Ortiz-Garcia, I., Monsalve-Guil, L., López-López, J.,

Núñez-Márquez, E., Matos-Garrido, N., Jiménez-Guerra, Á., Moreno-Muñoz, J., & Rondón-Romero, J. L. (2025). Impact of Guided Implant Dentistry on Patient Quality of Life, Satisfaction, and Psychological Well-Being: A Systematic Review. Journal of Clinical Medicine, 14(18), 6638.

16. Gargallo-Albiol, J., Barootchi, S., Salomó-Coll, O., & Wang, H. (2019). Advantages and disadvantages of implant navigation surgery. A systematic review. Annals of Anatomy-Anatomischer Anzeiger, 225, 1–10.
17. Gonçalves Esteves Rodrigues Lima, C. M. (2026). Risk factors and diagnostic parameters of peri-implantitis: A prospective cohort study. https://docta.ucm.es/entities/publication/729990cd-d2a1-48df-8f1e-6c7a0f80379c
18. Jaemsuwan, S., Arunjaroensuk, S., Kaboosaya, B., Subbalekha, K., Mattheos, N., & Pimkhaokham, A. (2023). Comparison of the accuracy of implant position among freehand implant placement, static and dynamic computer-assisted implant surgery in fully edentulous patients: A non-randomized prospective study. International Journal of Oral and Maxillofacial Surgery, 52(2), 264–271.
19. Jiang, J., Zhang, J., Zhang, Y., Huang, Z., Qian, K., & Pan, J. (2023). Computer-Aided Dynamics Intraoperative Navigation in Oral Medicine: A Review. https://www.researchsquare.com/article/rs-3162954/latest
20. Kasradze, D., Segalyte, E., & Kubilius, R. (2021). Influence of clinical and technical parameters on accuracy of guided implant placement. Systematic review and meta-analysis. Journal of Osseointegration, 13(4), 198–219.
21. Kivovics, M., Takács, A., Pénzes, D., Németh, O., & Mijiritsky, E. (2022). Accuracy of dental implant placement using augmented reality-based navigation, static computer assisted implant surgery, and the free-hand method: An in vitro study. Journal of Dentistry, 119, 104070.
22. Knipper, A., Kuhn, K., Luthardt, R. G., & Schnutenhaus, S. (2024). Accuracy of Dental Implant Placement with Dynamic Navigation—Investigation of the Influence of Two Different Optical Reference Systems: A Randomized Clinical Trial. Bioengineering, 11(2), 155.
23. Li, Z., Qi, Z., Wu, Z., Zhang, L., & Xu, Q. (2026). Cooperative integrated surgical robots for high-performance targeted therapies. The Innovation. https://www.cell.com/the-innovation/fulltext/S2666-6758(26)00057-3
24. Lorenzetti, M., Lorenzetti, V., Carossa, M., Cavagnetto, D., & Mussano, F. (2021). Using a Preoperative Scan Digital Impression and a Digital Index to Build Immediate Interim Full-Arch Implant-Supported Prosthesis. A Case Report and Proof of Concept. Applied Sciences, 11(3), 996. https://doi.org/10.3390/app11030996
25. Ma, L., Shi, Z., Wu, X., Zhang, W., Wang, L., Guo, B., Yang, F., Zheng, Y., & Ding, Y. (2025). Accuracy and safety of dynamic navigation combined with augmented reality for multiple-site implant surgery: A case report. Journal of Oral Implantology, 1(aop). https://joi.kglmeridian.com/view/journals/orim/aop/article-10.1563-aaid-joi-D-25-00174/article-10.1563-aaid-joi-D-25-00174.xml
26. Nava, P., Sabri, H., Hazrati, P., Nava, C., Saleh, M. H. A., & Wang, H. (2026). Accuracy of Static, Dynamic, and Robotic Guided Surgery in Immediate Implant Placement: A Systematic Review and Network Meta-Analysis. Clinical Oral Implants Research, 37(5), 525–542. https://doi.org/10.1111/clr.70100
27. Oh, S.-M., & Lee, D.-H. (2020). Validation of the Accuracy of Postoperative Analysis Methods for Locating the Actual Position of Implants: An In Vitro Study. Applied Sciences, 10(20), 7266. https://doi.org/10.3390/app10207266
28. Pisla, D., Bulbucan, V., Hedesiu, M., Vaida, C., Pusca, A., Mocan, R., Tucan, P., Dinu, C., & Pisla, D. (2025). Accuracy of navigation and robot-assisted systems for dental implant placement: A systematic review. Dentistry Journal, 13(11), 537.
29. Saini, R. S., Bavabeedu, S. S., Quadri, S. A., Gurumurthy, V., Kanji, M. A., Kuruniyan, M. S., Binduhayyim, R. I. H., Avetisyan, A., & Heboyan, A. (2024). Impact of 3D imaging techniques and virtual patients on the accuracy of planning and surgical placement of dental implants: A systematic review. DIGITAL HEALTH, 10, 20552076241253550. https://doi.org/10.1177/20552076241253550
30. Sankar, H., Shalini, M., Rajagopalan, A., Gupta, S., Kumar, A., & Shouket, R. (2025). Dental implant placement accuracy with robotic surgery compared to free-hand, static and dynamic computer assisted techniques: Systematic review and meta-analysis. Journal of Oral Biology and Craniofacial Research, 15(1), 69–76.
31. Schnutenhaus, S., Edelmann, C., Knipper, A., & Luthardt, R. G. (2021). Accuracy of dynamic computer-assisted implant placement: A systematic review and meta-analysis of clinical and in vitro studies. Journal of Clinical Medicine, 10(4), 704.
32. Senthil, S., Vijayalakshmi, R., Mahendra, J., & Ambalavanan, N. (2023). Current opinion on guided implant surgery. Bioinformation, 19(6), 786.
33. Seo, C., & Juodzbalys, G. (2018). Accuracy of guided surgery via stereolithographic mucosa-supported surgical guide in implant surgery for edentulous patient: A systematic review.

Journal of Oral & Maxillofacial Research, 9(1), e1.

34. Shi, Y., Wang, J., Ma, C., Shen, J., Dong, X., & Lin, D. (2023). A systematic review of the accuracy of digital surgical guides for dental implantation. International Journal of Implant Dentistry, 9(1), 38. https://doi.org/10.1186/s40729-023-00507-w
35. Tahmaseb, A., Wu, V., Wismeijer, D., Coucke, W., & Evans, C. (2018). The accuracy of static computer-aided implant surgery: A systematic review and meta-analysis. Clinical Oral Implants Research, 29(S16), 416–435. https://doi.org/10.1111/clr.13346
36. Tallarico, M., Esposito, M., Xhanari, E., Caneva, M., & Meloni, S. M. (2018). Computer-guided vs freehand placement of immediately loaded dental implants: 5-year postloading results of a randomised controlled trial. Eur J Oral Implantol, 11(2), 203–213.
37. Tavelli, L., Barootchi, S., Akhondi, S., Tseng, E. S., Garcia-Valenzuela, F. S., Urban, I. A., & Wang, H. (2025). Long-term stability of soft tissue augmentative procedures at implant sites. Periodontology 2000, prd.70016. https://doi.org/10.1111/prd.70016
38. Werny, J. G., Frank, K., Fan, S., Sagheb, K., Al-Nawas, B., Narh, C. T., & Schiegnitz, E. (2025). Freehand vs. computer-aided implant surgery: A systematic review and meta-analysis—part 1: accuracy of planned and placed implant position. International Journal of Implant Dentistry, 11(1), 35. https://doi.org/10.1186/s40729-025-00622-w
39. Younes, F., Eghbali, A., De Bruyckere, T., Cleymaet, R., & Cosyn, J. (2019). A randomized controlled trial on the efficiency of free-handed, pilot-drill guided and fully guided implant surgery in partially edentulous patients. Clinical Oral Implants Research, 30(2), 131–138. https://doi.org/10.1111/clr.13399
40. Younis, H., Lv, C., Xu, B., Zhou, H., Du, L., Liao, L., Zhao, N., Long, W., Elayah, S. A., Chang, X., & He, L. (2024). Accuracy of dynamic navigation compared to static surgical guides and the freehand approach in implant placement: A prospective clinical study. Head & Face Medicine, 20(1), 30. https://doi.org/10.1186/s13005-024-00433-1