

Review

Guided Versus Freehand Dental Implant Placement: Where We Stand? A Narrative Review Based on a Systematic Literature Search

Hamzah Shabana ^{1,†}, Lobo Markovic ^{1,†}, Roberto Di Felice ², Tommaso Lombardi ³  and Alexandre Perez ^{1,*} ¹ Unit of Oral Surgery and Implantology, Division of Oral and Maxillofacial Surgery, Department of Surgery, Faculty of Medicine, University Hospitals of Geneva, University of Geneva, 1205 Geneva, Switzerland² Private Practice, Studio Roberto di Felice, Viale Buozzi 6, 63074 San Benedetto del Tronto, Italy³ Unit of Oral Medicine and Oral Maxillofacial Pathology, Division of Oral and Maxillofacial Surgery, Department of Surgery, Faculty of Medicine, University Hospitals of Geneva, University of Geneva, 1205 Geneva, Switzerland; tommaso.lombardi@unige.ch

* Correspondence: alexandre.perez@hcuge.ch

† These authors contributed equally to this work.

Abstract

Dental implant placement has evolved from conventional freehand techniques toward digitally guided workflows integrating cone-beam computed tomography (CBCT), computer-aided design/computer-aided manufacturing (CAD/CAM), and dynamic navigation systems. Although guided surgery improves positional accuracy, its clinical relevance compared with freehand placement remains debated. This narrative review, based on a systematic and structured literature search following predefined selection criteria, analyzes studies published between 2000 and 2025 comparing guided and freehand implant placement regarding accuracy, survival, complications, biological outcomes, and workflow efficiency. Searches of PubMed/MEDLINE, Embase, and Web of Science identified 40 eligible human clinical studies for qualitative synthesis. Guided placement consistently demonstrated greater positional accuracy, with angular deviations of approximately 2–4° versus 5–9° for freehand placement and linear deviations reduced by about 1 mm. Nevertheless, implant survival rates were high and comparable for both techniques, generally exceeding 95% across short- and medium-term follow-up. Overall complication rates were low; guided approaches reduced anatomical risk and improved prosthetic predictability in complex or multi-implant cases, while freehand placement allowed greater intraoperative flexibility and tactile feedback, potentially optimizing primary stability in variable bone conditions. Marginal bone loss and peri-implant tissue outcomes were similar between approaches. Guided workflows required additional planning time and costs but enhanced reproducibility in complex rehabilitations. Guided and freehand implant placement should therefore be considered complementary strategies, with optimal outcomes depending on case selection, surgical expertise, and the balanced integration of digital technologies into contemporary implant practice.

Academic Editor: Corina
Marilena Cristache

Received: 1 April 2026

Revised: 11 May 2026

Accepted: 12 May 2026

Published: 19 May 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and conditions of the [Creative Commons Attribution \(CC BY\)](https://creativecommons.org/licenses/by/4.0/) license.

Keywords: dental implants; guided surgery; freehand implant placement; dynamic navigation; surgical accuracy; implant survival; prosthetic outcomes; peri-implant tissue; workflow efficiency; digital dentistry

1. Introduction

Dental implantology has undergone profound and continuous evolution over the past five decades, transitioning from a biologically driven, analog discipline to a technologically enhanced, digitally oriented field. Since the pioneering work of Brånemark and colleagues in the late 1960s and 1970s, the concept of osseointegration has provided the biological foundation for predictable tooth replacement using endosseous implants [1]. Early implant placement protocols relied almost exclusively on meticulous clinical examination, two-dimensional radiographic imaging, and the surgeon's anatomical knowledge and manual skills. Despite the absence of digital planning tools, these freehand implant placements yielded high implant survival rates and long-term clinical success when fundamental biological and prosthetic principles were respected [2–4].

Over time, the focus of implant dentistry progressively shifted from mere implant survival toward prosthetically driven positioning, esthetic integration, and long-term peri-implant tissue stability. This paradigm shift was accompanied by the introduction of advanced imaging modalities, particularly cone-beam computed tomography (CBCT), which allowed three-dimensional visualization of anatomical structures, bone morphology, and spatial relationships previously inaccessible with conventional radiography [5]. Concurrently, the emergence of computer-aided design and computer-aided manufacturing (CAD/CAM) technologies enabled the translation of virtual planning into physical surgical guides, giving rise to guided implant surgery.

Guided implant placement has rapidly gained popularity and is frequently promoted as a means to enhance accuracy, reduce surgical risks, and improve prosthetic predictability. Static computer-guided systems, in particular, aim to replicate the virtual implant plan with high fidelity by constraining drilling direction, angulation, and depth through a prefabricated surgical template [6–8]. More recently, dynamic navigation systems have further expanded the digital armamentarium, providing real-time feedback during implant placement. As a result, digital guidance is increasingly perceived—sometimes implicitly—as a benchmark of modern implant practice.

However, the growing enthusiasm for guided surgery has also raised important clinical and scientific questions. While numerous studies have demonstrated improved accuracy compared with freehand implant placement under controlled conditions, the clinical relevance of this increased accuracy remains debated, particularly in straightforward cases [9–11]. Moreover, the widespread adoption of guided surgery has occurred in parallel with increasing treatment costs, additional planning steps, and potential technical complications related to guide fabrication, fit, and stabilization [12]. These considerations underscore the need for a critical and balanced appraisal of guided implant placement versus freehand implant placement.

Freehand implant placement surgery, far from being obsolete, continues to play a central role in daily clinical practice. Experienced clinicians have long relied on tactile feedback, real-time assessment of bone density and cortical thickness, and intraoperative adaptability to optimize implant positioning and primary stability [13,14]. Importantly, freehand placement does not equate to “blind” surgery; rather, it is grounded in comprehensive preoperative planning, prosthetically driven decision-making, and detailed anatomical understanding. Long-term data indicate that implants placed freehand, when guided by sound principles, achieve survival and success rates comparable to those obtained with guided approaches in many clinical scenarios [15–17].

From a biological perspective, the ability to modulate drilling protocols based on bone quality is a key advantage of freehand surgery. Adjustments in drilling speed, pressure, and sequence may influence primary stability, bone microdamage, and ultimately osseointegration, particularly in low-density bone [18]. In contrast, guided protocols

may limit such intraoperative flexibility, potentially constraining the surgeon's ability to respond to unexpected anatomical findings or variations in bone density encountered during surgery.

The debate between guided and freehand implant placement should therefore not be framed as a binary or dogmatic choice. Instead, it reflects a broader discussion on how technological advancements should be integrated into clinical practice without diminishing the role of surgical judgment and experience. Overreliance on digital tools risks transforming implant surgery into a purely technical procedure, whereas neglecting technological progress may limit precision in complex or high-risk cases. Striking an appropriate balance between these approaches is essential to optimizing patient outcomes.

Despite the abundance of publications comparing guided and freehand implant placement, the existing literature is heterogeneous with respect to study design, outcome measures, and follow-up duration. Variability in definitions of accuracy, success, and complications complicates direct comparisons and limits the generalizability of conclusions [19]. Furthermore, while short-term accuracy outcomes are frequently reported, long-term clinical data—particularly beyond five years—remain scarce.

This review is timely and essential given the rapid evolution of digital implant workflows and the increasing adoption of dynamic navigation systems. A critical gap exists in the current literature: while previous reviews have focused almost exclusively on positional accuracy, they often overlook broader clinical implications. Our synthesis addresses this by integrating vital outcomes such as biological performance, surgical complications, cost-effectiveness, and the impact of the learning curve, providing a more holistic perspective for the clinician.

Therefore, the aim of the present narrative review, conducted using a systematic literature search approach, is to critically evaluate the current evidence comparing guided and freehand implant placement. By synthesizing data published between 2000 and 2025, this review seeks to clarify the respective advantages and limitations of both techniques, examine their biological and clinical implications, and provide evidence-based recommendations for clinical decision-making. The primary objective of this review is to provide a comprehensive comparison between guided implant placement and freehand implant placement. Beyond positional accuracy, we investigate a broad spectrum of clinical indicators, ranging from survival rates and biological parameters to surgical complications. Additionally, the review explores the practical dimensions of digital workflows, specifically addressing cost-effectiveness and the role of operator experience in the learning process. Rather than advocating for one approach over the other, this review emphasizes the importance of case selection, surgeon experience, and the judicious integration of technology to achieve predictable and biologically sound implant outcomes.

2. Materials and Methods

2.1. Study Design

This narrative review was conducted following a systematic literature search methodology to identify all relevant publications comparing guided and freehand dental implant placement from 2000 to 2025. While the synthesis is narrative, the search strategy, inclusion/exclusion criteria, and data extraction were structured to ensure reproducibility and minimize bias. The study design integrates quantitative data from individual studies into a qualitative narrative framework, allowing comprehensive evaluation of clinical, prosthetic, and biological outcomes. Although the review follows PRISMA guidelines and employs a systematic and reproducible search strategy, the present work should be considered a structured narrative review rather than a systematic review or meta-analysis. Accordingly,

the synthesis is qualitative in nature and does not include quantitative data pooling. No review protocol was registered (e.g., PROSPERO) for this study.

2.2. Search Strategy

A comprehensive electronic search was conducted in PubMed/MEDLINE, Embase, and Web of Science to identify studies published between January 2000 and December 2025. The search strategy combined controlled vocabulary (MeSH and Emtree terms) and free-text keywords related to dental implants, guided implant surgery, and freehand implant placement. The search strategy was adapted for each database. In PubMed/MEDLINE, the search strategy included Medical Subject Headings (MeSH) and free-text keywords related to dental implants and guided or freehand implant placement. In Embase, the search strategy was adapted using Emtree controlled vocabulary and keywords addressing dental implants and guided or freehand surgical techniques. In Web of Science, a topic search (TS) was performed using keywords related to dental implants, guided surgery, and freehand implant placement. The detailed search strategies used for each database are reported below.

Keywords included: (“dental implants” OR “implant dentistry”) AND (“guided surgery” OR “computer-guided” OR “static guide” OR “dynamic navigation”) AND (“freehand” OR “conventional placement”) AND (“accuracy” OR “survival” OR “clinical outcome” OR “prosthetic outcomes”)

Filters applied: Human studies, English language, publications from 2000 to 2025. References of relevant reviews and included articles were manually screened to identify additional studies.

Database	Search strategy
PubMed/MEDLINE	((“Dental Implants” [Mesh] OR “dental implant *”[tiab] OR “implant * dentistry”[tiab] OR “oral implant *”[tiab] OR “tooth implant *”[tiab] OR “teeth implant *”[tiab]) AND ((“computer-aided implant surgery”[tiab] OR “computer-guided implant surgery”[tiab] OR “dental implant guide”[tiab] OR “dental implant placement guide”[tiab] OR “dynamic navigation”[tiab] OR “fully-guided placement”[tiab] OR “guide device”[tiab] OR “guided dental implant”[tiab] OR “guided method”[tiab] OR “guided placement”[tiab] OR “guided surgery”[tiab] OR “guiding device”[tiab] OR “navigation-guided implant placement”[tiab] OR “static guided surgery”[tiab] OR “static surgical guide *”[tiab] OR “template-guided surgery”[tiab]) OR ((“freehand implant placement”[tiab] OR “conventional implant placement”[tiab] OR “non-guided implant placement”[tiab] OR “traditional implant surgery”[tiab] OR “freehand dental implant”[tiab] OR “freehand implant * placement”[tiab] OR “freehand method *”[tiab] OR “freehand surg *”[tiab] OR “manual implant placement”[tiab] OR “manual surgery”[tiab] OR “non-guided surgery”[tiab]))) AND (2000:2026[pdat])

Database	Search strategy
Embase	(('tooth implant' /exp OR 'dental implant *':ti,ab,kw OR 'implant * dentistry':ti,ab,kw OR 'oral implant *':ti,ab,kw OR 'tooth implant *':ti,ab,kw OR 'teeth implant *':ti,ab,kw) AND (('guiding device' /exp OR 'dental implant guide' /exp OR 'computer-aided implant surgery':ti,ab,kw OR 'computer-guided implant surgery':ti,ab,kw OR 'dental implant guide':ti,ab,kw OR 'dental implant placement guide':ti,ab,kw OR 'dynamic navigation':ti,ab,kw OR 'fully-guided placement':ti,ab,kw OR 'guide device':ti,ab,kw OR 'guided dental implant':ti,ab,kw OR 'guided method':ti,ab,kw OR 'guided placement':ti,ab,kw OR 'guided surgery':ti,ab,kw OR 'navigation-guided implant placement':ti,ab,kw OR 'static guided surgery':ti,ab,kw OR 'static surgical guide *':ti,ab,kw OR 'template-guided surgery':ti,ab,kw) OR ('freehand technique' /exp OR 'freehand implant placement':ti,ab,kw OR 'conventional implant placement':ti,ab,kw OR 'non-guided implant placement':ti,ab,kw OR 'traditional implant surgery':ti,ab,kw OR 'freehand dental implant':ti,ab,kw OR 'freehand implant * placement':ti,ab,kw OR 'freehand method *':ti,ab,kw OR 'freehand surg *':ti,ab,kw OR 'manual implant placement':ti,ab,kw OR 'manual surgery':ti,ab,kw OR 'non-guided surgery':ti,ab,kw))) AND [2000–2025]/py
Web of Science	(TS = ("dental implant *" OR "implant * dentistry" OR "oral implant *" OR "tooth implant *" OR "teeth implant *") AND (TS = ("computer-aided implant surgery" OR "computer-guided implant surgery" OR "dental implant guide" OR "dental implant placement guide" OR "dynamic navigation" OR "fully-guided placement" OR "guide device" OR "guided dental implant" OR "guided placement" OR "guided surgery" OR "guiding device" OR "navigation-guided implant placement" OR "static guided surgery" OR "static surgical guide *" OR "template-guided surgery") OR TS = ("freehand implant placement" OR "conventional implant placement" OR "non-guided implant placement" OR "traditional implant surgery" OR "freehand dental implant" OR "freehand implant * placement" OR "freehand method *" OR "freehand surg *" OR "manual implant placement" OR "manual surgery" OR "non-guided surgery")))) AND PY = (2000–2026)

Inclusion criteria:

- Human clinical studies (randomized controlled trials, prospective or retrospective cohorts, case series ≥ 10 implants)
- Studies reporting guided and/or freehand implant placement
- Studies providing quantitative or qualitative outcomes on implant accuracy, survival, complications, or prosthetic success
- Minimum follow-up of 6 months

Exclusion criteria:

- Animal or in vitro studies
- Case reports with fewer than 10 implants
- Studies focusing exclusively on orthodontic mini-implants or zygomatic implants
- Articles without clinical, radiographic, or prosthetic outcomes

2.3. Study Selection and Data Extraction

All references were imported into a reference management software (Zotero version 7.0 for macOS, and duplicate records were additionally checked using the TERA Deduplicator tool), and duplicate records were removed before screening.

Three independent reviewers (H.S., L.M. and A.P.) screened all titles and abstracts for eligibility. Full texts were obtained for potentially relevant studies. Discrepancies were resolved by discussion among the three reviewers.

Data included:

- Study design and setting
- Number and type of implants
- Guidance type (static guide, dynamic navigation, freehand)
- Implant location and bone type
- Accuracy metrics (angular, coronal, apical deviations)
- Implant survival and success
- Complications (surgical, prosthetic, biological)
- Follow-up duration

A standardized extraction table ensured consistency and allowed synthesis of quantitative and qualitative data.

2.4. Quality Assessment

Methodological quality was assessed using the Cochrane risk-of-bias tool for randomized studies and the Newcastle–Ottawa Scale for observational studies. Studies were categorized as high, moderate, or low quality. Risk-of-bias assessment informed the interpretation of the results and was considered in the Discussion when evaluating the strength and reliability of the available evidence. However, it was not used as an exclusion criterion, in line with the narrative nature of the synthesis.

3. Results

3.1. Study Selection and Characteristics

The Literature Search and Study Selection Process Followed a PRISMA-Style Methodology (Figure 1).

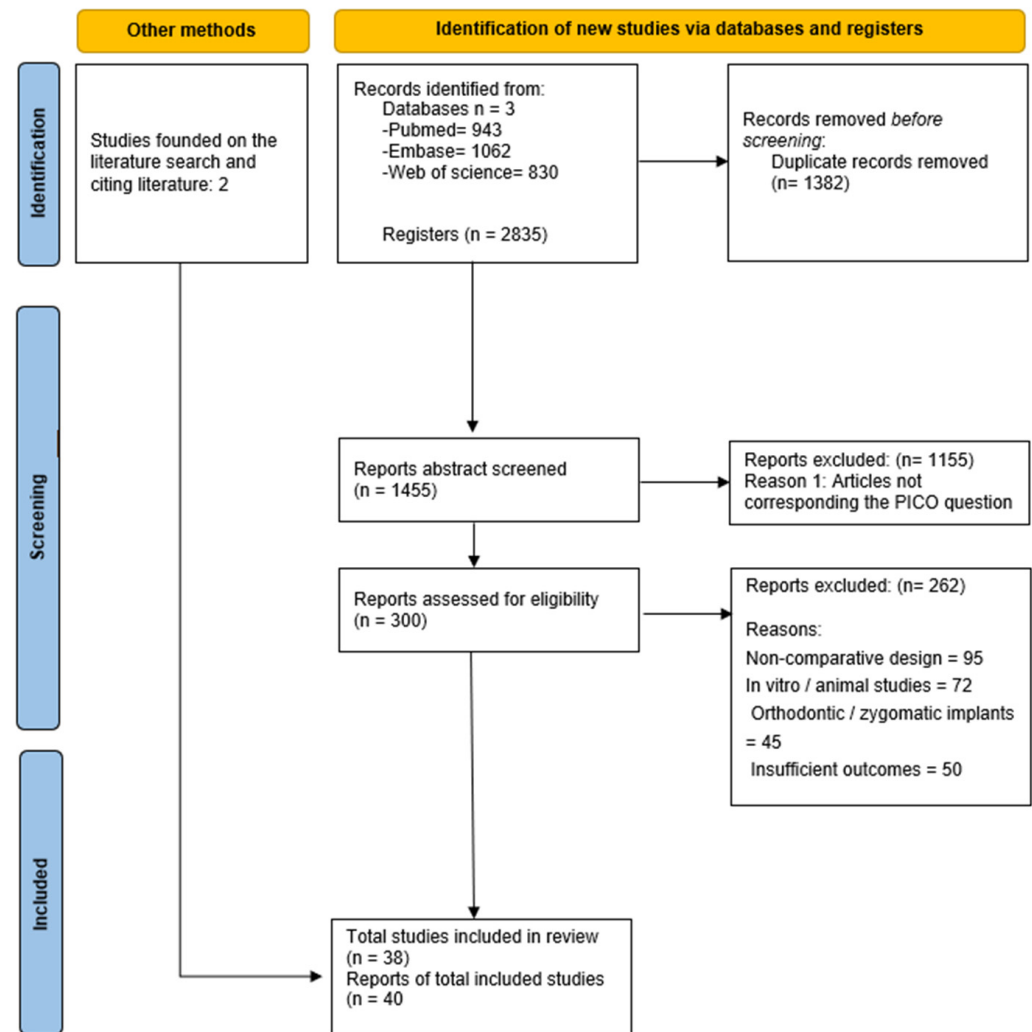


Figure 1. PRISMA flow chart and number of results for each step of the research.

An electronic search of PubMed/MEDLINE, Embase, and Web of Science identified a total of 2835 records related to dental implant placement techniques (guided implant placement vs. freehand placement). After removing duplicate records, 1455 unique records remained for screening based on titles and abstracts. A total of 1155 records were excluded due to irrelevance, non-human studies, in vitro or animal experiments, or the absence of reported clinical outcomes. Three hundred full-text were assessed for eligibility, of which 260 articles were excluded for the following reasons: non-comparative designs (no guided vs. freehand comparison), in vitro or animal studies, studies focusing on zygomatic or orthodontic mini-implants, or insufficient clinical, radiographic, or prosthetic outcomes. Following full-text screening, 38 studies met the inclusion criteria and two studies were identified through manual reference screening. Ultimately, 40 studies satisfied all eligibility criteria and were included in the narrative synthesis.

To enhance clarity and address study heterogeneity, we categorized the evidence into key clinical dimensions. This thematic framework includes guidance modality (static guided surgery, dynamic navigation, or freehand placement), anatomical location (maxilla vs. mandible; anterior vs. posterior), case complexity, and operator experience, where documented in the primary literature.

The main clinical outcomes evaluated were implant accuracy, survival, complications, peri-implant tissue stability, and workflow efficiency. The included evidence comprised randomized trials, prospective and clinical studies, retrospective studies, and secondary

evidence, as summarized in Table 1. Among these, several primary clinical studies provided quantitative data on coronal, apical, and angular deviations, while systematic reviews and meta-analyses contributed higher-level evidence on accuracy, survival, and complication rates. All 40 included studies are presented in Table 1.

Table 1. Summary of the 40 included studies grouped by study design, sample characteristics, interventions, outcomes, follow-up, and level of evidence. Evidence levels were assigned according to study design: high evidence for systematic reviews, meta-analyses, and umbrella reviews; high–moderate evidence for randomized controlled trials; moderate evidence for prospective and clinical studies; and low evidence for retrospective studies and case series. Narrative or non-systematic reviews were grouped within secondary evidence for descriptive purposes but were interpreted separately from systematic reviews and meta-analyses.

Study	Study Design	Sample Size	Comparison/Guidance Type	Outcomes	Assessment Timepoint/Follow-Up	Evidence Level
RANDOMIZED CONTROLLED TRIALS (RCTs)—High–moderate evidence						
Pozzi et al., 2014 [8]	Multicentre RCT	51 patients	Guided vs. freehand	Survival, complications, MBL	1-year clinical follow-up	High–moderate
Tallarico et al., 2018 [9]	RCT	20 patients (62 implants)	Guided vs. freehand	Survival, complications, MBL	5-year clinical follow-up	High–moderate
Smitkarn et al., 2019 [10]	RCT	52 patients (60 implants)	Static guided vs. freehand	Accuracy	Immediate postoperative CBCT-based accuracy assessment	High–moderate
Chandran et al., 2023 [11]	RCT	61 patients (80 implants)	Static guided vs. freehand	Accuracy	Immediate postoperative CBCT-based accuracy assessment	High–moderate
Vercruyssen et al., 2014 [12]	RCT	59 patients	Guided vs. navigation vs. pilot	Accuracy	Immediate postoperative CBCT matching	High–moderate
Vercruyssen et al., 2015 [13]	RCT	60 patients	Guided vs. navigation vs. pilot	Accuracy	Immediate postoperative CBCT matching	High–moderate
Orban et al., 2022 [14]	RCT	40 patients (40 implants)	Half-guided machine vs. manual	Accuracy	Immediate postoperative CBCT deviation analysis	High–moderate
Younes et al., 2018 [15]	RCT	32 patients (71 implants)	FH vs. pilot vs. guided	Accuracy	Immediate postoperative CBCT analysis	High–moderate
Aydemir and Arisan, 2020 [16]	Split-mouth RCT	32 patients (86 implants)	Dynamic vs. freehand	Accuracy	Immediate postoperative CBCT deviation analysis	High–moderate
Varga et al., 2020 [17]	RCT	101 patients (207 implants)	Guided vs. freehand	Accuracy	Immediate postoperative CBCT analysis	High–moderate
PROSPECTIVE/CLINICAL STUDIES—Moderate evidence						
Block et al., 2017 [18]	Prospective clinical	478 patients (714 implants)	Dynamic vs. freehand	Accuracy	Immediate navigation-based deviation assessment	Moderate
Sun et al., 2020 [19]	Comparative clinical	128 implants	Multi-arm: FH vs. SG vs. DN	Accuracy	Immediate postoperative deviation analysis	Moderate
Huang et al., 2023 [20]	Prospective clinical	48 implants	Guide vs. freehand	Accuracy	Immediate postoperative CBCT analysis	Moderate
Younis et al., 2024 [21]	Prospective clinical	65 patients (94 implants)	Dynamic vs. static vs. FH	Accuracy	Immediate postoperative deviation analysis	Moderate
Al-Harbi and Sun, 2009 [22]	Clinical	40 implants	SLA guide	Accuracy	Immediate postoperative radiographic assessment	Moderate
Vasak et al., 2011 [23]	Prospective	86 implants	NobelGuide	Accuracy	Immediate postoperative CT-based assessment	Moderate
Arisan et al., 2010 [24]	Clinical	54 patients (294 implants)	Guide systems comparison	Accuracy	Immediate postoperative CT-based assessment	Moderate
Pettersson et al., 2012 [25]	Clinical	25 jaws (139 implants)	Guided	Accuracy	Immediate postoperative radiographic analysis + 1-year follow-up	Moderate

Table 1. Cont.

Study	Study Design	Sample Size	Comparison/Guidance Type	Outcomes	Assessment Timepoint/Follow-Up	Evidence Level
Di Giacomo et al., 2012 [26]	Prospective	12 patients (60 implants)	SLS guides	Accuracy, complications	Immediate postoperative CBCT analysis + 30-month clinical follow-up	Moderate
Ozan et al., 2009 [27]	Clinical	110 implants	CT guides	Accuracy	Immediate postoperative CT-based assessment	Moderate
Vieira et al., 2013 [28]	Prospective	14 patients (62 implants)	Guided flapless	Accuracy	Immediate postoperative CBCT analysis	Moderate
D'haese et al., 2012 [29]	Clinical/literature-based synthesis	Multiple studies	SLA guides	Accuracy, complications	Immediate assessment based on literature synthesis	Moderate
Behneke et al., 2012 [30]	Prospective	Clinical	Guided flapless	Accuracy	Immediate postoperative radiographic analysis	Moderate
Van de Wiele et al., 2015 [31]	Clinical	Edentulous cases	Mucosa-supported guides	Accuracy	Immediate postoperative CBCT analysis	Moderate
RETROSPECTIVE STUDIES—Low evidence						
Ku et al., 2022 [32]	Retrospective	Guided only	Computer-guided	Accuracy	Immediate postoperative CBCT analysis	Low
Ma et al., 2023 [33]	Retrospective	55 cases	Dynamic navigation	Accuracy	Immediate navigation-based deviation analysis	Low
Cassetta et al., 2013 [34]	Retrospective	20 patients (227 implants)	SLA guides	Accuracy	Immediate postoperative CT matching	Low
SECONDARY EVIDENCE—High evidence						
Jung et al., 2009 [35]	Systematic review	32 studies	Computer-assisted	Accuracy	Not applicable	High
Schneider et al., 2009 [36]	Systematic review	Multiple studies	Guided	Accuracy, outcomes	Not applicable	High
D'haese et al., 2012 [37]	Review	31 studies	SLA guides	Accuracy	Not applicable	Moderate
Hultin et al., 2012 [38]	Systematic review	28 studies	Guided	Clinical benefit	Not applicable	High
Van Assche et al., 2012 [39]	Meta-analysis	19 studies	Guided	Accuracy	Not applicable	High
Block and Emery, 2016 [40]	Review	—	Static vs. dynamic	Accuracy	Not applicable	Moderate
Tahmaseb et al., 2018 [41]	Meta-analysis	20 studies	Guided	Accuracy	Not applicable	High
Abdelhay et al., 2021 [42]	Meta-analysis	8 studies	Guided vs. FH	Failure rates	Not applicable	High
Abad-Coronel et al., 2024 [43]	Systematic review	3 studies	Digital guides	Accuracy	Not applicable	High
Vercruyssen et al., 2015 [13]	Narrative review	—	Guided workflow	Workflow	Not applicable	Moderate
Gargallo-Albiol et al., 2020 [44]	Meta-analysis	Multiple studies	Guided vs. FH	Accuracy	Not applicable	High
Reiff et al., 2026 [45]	Meta-analysis	Multiple studies	FH vs. static vs. dynamic	Accuracy	Not applicable	High
Tomar et al., 2025 [46]	Umbrella review	Multiple studies	Guided vs. FH	Outcomes	Not applicable	High

Narrative or non-systematic reviews were grouped under secondary evidence for descriptive purposes but were not considered equivalent to systematic reviews, meta-analyses, or umbrella reviews in terms of methodological strength. Overall, heterogeneity was mainly driven by differences in study design, guidance modality, anatomical site, and clinical indication. The main outcomes are summarized in Table 2.

Table 2. Summary of clinical outcomes reported in studies comparing guided and freehand implant placement.

Outcome	Guided Placement	Freehand Placement	Main Conclusion	Level of Evidence	Supporting References
Implant accuracy—angular deviation	2–4°	5–9°	Guided placement consistently provides higher positional accuracy	High—meta-analyses + RCTs	[10–14,17,18,20,21,23,24,26,39,44,45]
Coronal deviation	0.7–1.2 mm	1.5–2.5 mm	Guided placement improves prosthetically driven positioning	High	[10–14,17,18,20,21,23,24,26,39,44,45]
Apical deviation	1.0–1.5 mm	2.0–3.0 mm	Guided placement reduces apical deviation	High	[10–14,17,18,20,21,23,24,26,39,44,45]
Implant survival	95–100%	93–99%	No clinically significant difference in survival rates was consistently reported	High	[8,9,11,13,20,37,39,40,44]
Early implant failure	Rare, <5%	Rare, <5%	Early failure rates were comparable between techniques	Moderate–High	[37,38,40,42]
Marginal bone loss—1 year	0.2–1.0 mm	0.2–1.0 mm	Peri-implant bone stability was generally comparable	Moderate	[8,9,12,17,21]
Biological complications	Low incidence	Low incidence	No consistent significant differences were reported	Moderate	[8,9,12,17,21,37,40,42]
Surgical complications	Reduced risk near anatomical structures	Slightly higher positional variability	Guided placement may improve safety in complex or anatomically constrained cases	Moderate	[8,9,22,23,26,27,37,44]
Prosthetic outcomes	High prosthetic predictability	Acceptable in simple cases	Guided placement is particularly beneficial in esthetic, multi-unit, and prosthetically demanding cases	Moderate	[8,9,23,25–27,39,40,44]
Operative workflow	Longer planning and setup time	Shorter planning time	Freehand placement remains faster for routine cases, whereas guided workflows improve predictability in complex cases	Moderate	[8,9,13,16,22,25,26,44]
Clinical flexibility	Limited intraoperative adaptability	High intraoperative adaptability	Freehand placement is advantageous when intraoperative adaptation to bone quality or anatomy is required	Moderate	[8,9,13,16,18,20,22,25,26,33,44]

3.2. Implant Accuracy

The accuracy of dental implant placement has been consistently reported as higher with guided implant placement compared with conventional freehand approaches. Across the primary clinical accuracy studies included in this review, guided implant placement achieved lower angular, coronal, apical, depth, and lateral deviations than freehand placement, mental navigation, or pilot-drill template approaches [10–14,17,18,20,21,23,24,26,39,44,45]. Coronal deviations were generally reduced to 0.7–1.2 mm, and apical deviations to 1.0–1.5 mm, with improved precision, particularly in tooth-supported guides and anatomically constrained sites.

Dynamic navigation systems demonstrated comparable accuracy to static guides, with the advantage of real-time intraoperative adjustment [16,18,21]. This feature is particularly beneficial in anatomically challenging cases, full-arch rehabilitations, or multi-implant procedures where precise angulation is critical.

Evidence from systematic reviews and meta-analyses supports these findings, reporting significant reductions in coronal, apical, and angular deviations for guided versus freehand implant placement [22–24,44]. Pooled data indicate reductions in angular deviation of approximately 3–4° and in coronal/apical deviations of ~1 mm, confirming that both static and dynamic systems enhance the predictability and reproducibility of implant positioning. Operator experience significantly influences implant placement accuracy, particularly in freehand procedures. Experienced clinicians generally achieve lower angular, coronal, and apical deviations, whereas less experienced operators show greater variability. Guided systems may reduce this operator-dependent variability by standardizing implant positioning, especially in multi-unit rehabilitations or anatomically complex cases.

However, the clinical relevance of improved accuracy depends on the case. In straight-forward single-tooth posterior sites with sufficient bone volume, deviations associated with freehand placement may remain clinically acceptable. Thus, statistical superiority in accuracy does not always translate into a meaningful clinical benefit [12,19].

Overall, current evidence from clinical studies and systematic reviews indicates that guided implant placement provides greater positional accuracy than freehand placement. Static and dynamic guidance systems reduce coronal, apical, and angular deviations, with the greatest clinical benefit observed in complex, prosthetically demanding, or anatomically constrained cases.

3.3. Implant Survival and Clinical Outcomes

Both guided and freehand implant placement approaches achieved high survival rates, consistently exceeding 95% across primary clinical studies and systematic reviews, with follow-up periods ranging from 6 months to over 5 years [8,9,37,39,40,42,44]. In primary clinical trials, static and dynamic guided techniques demonstrated implant survival rates between 95% and 100%, while freehand placement achieved comparable outcomes, typically 93–99%.

Systematic reviews and meta-analyses confirmed these findings, showing no statistically significant differences in overall implant survival between guided and freehand approaches in routine clinical scenarios. Guided placement may offer an advantage in complex or anatomically challenging cases, such as multiple adjacent implants, limited bone volume, or sites requiring precise prosthetic alignment. In these situations, even minor positional deviations may affect prosthetic outcomes and long-term predictability.

Short-term prosthetic outcomes appear comparable between guided and freehand techniques, particularly when procedures are performed by experienced clinicians. Most studies reported satisfactory restoration fit, occlusion, and esthetic integration. Freehand placement may also allow intraoperative adaptation to bone density, which can help optimize primary stability in low-density maxillary bone [17,21]. Overall, evidence from clinical studies and high-level reviews indicates that both guided and freehand implant placement achieve excellent survival rates. Although guided techniques improve positional accuracy, this does not consistently translate into higher implant survival in routine cases [37,40,44,45,47,48]. Therefore, the clinical benefit of guided systems is mainly case-dependent and appears most relevant in prosthetically demanding or anatomically complex situations [37,40,44,45,49].

3.4. Complications

Both guided and freehand implant placement techniques are associated with low overall complication rates, though the type and frequency vary depending on surgical complexity, operator experience, and anatomical considerations.

Guided surgery has been shown to reduce the risk of critical anatomical injuries, particularly in sites adjacent to the maxillary sinus, inferior alveolar nerve, or mental foramen [22,23,26,27,37,44].

Minor complications specifically related to guide use included poor seating or stabilization of the surgical guide, limited irrigation during drilling, soft-tissue interference, fabrication errors leading to positional deviations, and prosthetic complications related to workflow inaccuracies [22,23,26,27,37,44]. Surgical complications with guided approaches were generally minor and resolved intraoperatively without long-term consequences. Freehand placement exhibited higher variability, especially in complex, multi-unit, or anterior esthetic cases, but allowed immediate adaptation to unexpected anatomical features or cortical variations, which can optimize primary stability in low-density bone.

Biological complications, including early implant failure, peri-implantitis, and marginal bone loss, were largely comparable between guided and freehand techniques. Short-term peri-implant marginal bone loss ranged from 0.2 to 1.0 mm in the first year, with no significant differences [12,17,21]. Guided placement may improve bone preservation in anatomically challenging sites, while freehand placement provides flexibility to adapt to variations in bone density.

Prosthetic complications, such as screw loosening, crown misfit, or esthetic discrepancies, were rare and did not differ consistently between guided and freehand implants in studies with experienced clinicians [11,13,20]. Guided techniques facilitate prosthetic restoration in complex or multi-unit cases, whereas freehand placement generally yields clinically acceptable outcomes in single-tooth or posterior sites.

Overall, both guided and freehand implant placement demonstrate low complication rates. Differences between techniques are mainly related to case complexity rather than the surgical approach itself.

3.5. Biological Considerations

The biological response to dental implants is influenced by both surgical technique and implant positioning, with direct implications for osseointegration, marginal bone stability, and peri-implant soft tissue health. Guided implant placement, whether static or dynamic, offers high positional accuracy and reduced surgical trauma, as precise osteotomy preparation minimizes cortical perforation, excessive bone compression, and unnecessary flap elevation. This controlled approach can enhance primary stability, particularly in sites with limited bone volume, low-density maxillae, or complex anatomical configurations [6,8,17]. Additionally, guided techniques facilitate minimally invasive flapless procedures, which are associated with reduced postoperative inflammation, faster soft tissue healing, and improved patient comfort.

Conversely, freehand implant placement provides tactile feedback that enables real-time assessment of bone density, modulation of drill speed and pressure, and prevention of microfractures—factors that can positively influence osseointegration and primary stability [17,18].

Short-term outcomes of marginal bone loss and peri-implant soft tissue stability are generally comparable between guided and freehand approaches, with reported bone loss ranging from 0.2 to 1.0 mm within the first year [12,17,21]. However, guided placement can provide biological advantages in anatomically challenging or multi-implant cases, ensuring optimal angulation and depth, reducing stress concentrations, and promoting favorable load distribution for prosthetic rehabilitation.

In summary, both guided and freehand techniques demonstrate favorable biological outcomes. Guided placement is associated with improved precision and reduced surgical

trauma, whereas freehand techniques offer greater intraoperative adaptability, particularly in variable bone conditions.

3.6. Operative Time and Workflow Efficiency

Guided implant placement can influence both surgical duration and overall workflow efficiency. Static guided procedures generally require additional preoperative steps, including digital planning, guide fabrication, and verification of guide fit. These steps may increase the total treatment time, but do not necessarily prolong the intraoperative phase in straightforward cases [8,9,13,16,22,25,26,44]. Dynamic navigation systems avoid physical guide fabrication but require calibration, setup, and intraoperative registration, which may modestly increase procedure time, particularly during the initial learning phase. However, they allow real-time adjustments and may improve workflow efficiency in complex or multi-implant cases [16,18,21,40,50]. Overall, guided implant placement increases preoperative planning and setup time but may improve workflow predictability in complex or multi-implant cases. Freehand placement reduces preparatory requirements and remains more time-efficient in routine cases, although it may involve greater intraoperative variability depending on case complexity and operator experience.

3.7. Indications and Clinical Scenarios

The clinical application of guided implant placement varies according to anatomical location, extent of edentulism, and case complexity, with evidence supporting its preferential use in certain scenarios.

Anterior vs. posterior regions: Guided techniques are particularly beneficial in the anterior esthetic zone, where precise angulation, depth control, and soft tissue preservation are critical for optimal esthetic outcomes. In posterior regions, guided placement can improve accuracy near critical anatomical structures such as the maxillary sinus, inferior alveolar nerve, or mental foramen, reducing the risk of intraoperative complications [7,13,22,23,39,44].

Partial vs. complete edentulism: In partially edentulous cases, guided surgery facilitates the placement of single implants or small fixed prostheses with high precision, often using tooth-supported guides for enhanced stability. In fully edentulous arches, guided systems particularly dynamic navigation enable accurate multi-implant placement and full-arch rehabilitation, improving prosthetic fit and reducing the need for intraoperative adjustments [13,18,21,25,31,40].

Complex cases: Guided placement is most advantageous in anatomically challenging situations, including narrow ridges, limited inter-arch space, proximity to vital structures, or cases requiring immediate provisionalization. By providing preoperative planning and controlled osteotomy execution, guided systems enhance predictability and reduce variability, which can be critical in multi-unit or full-arch reconstructions.

Reported limitations: Despite these advantages, several limitations are noted. Guided surgery requires preoperative planning, laboratory support, and equipment, which may not be readily available in all clinical settings. In some cases, intraoperative adjustments are limited, and inaccuracies can occur if guides are improperly seated or fabricated. Freehand placement retains the advantage of real-time adaptability, allowing the surgeon to respond to unexpected anatomical variations [17,18].

This treatment-oriented distinction supports the use of guided and freehand approaches as complementary strategies rather than competing techniques.

4. Discussion

The present narrative review, conducted with a systematic search approach, highlights the key clinical considerations in guided versus freehand implant placement. Both strategies possess distinct advantages, limitations, and roles within contemporary implantology. To address heterogeneity in a more structured manner, the findings are discussed according to four key dimensions: (1) guidance modality, (2) anatomical location, (3) case complexity, and (4) operator-related factors. Over the past two decades, the evolution from freehand techniques to guided workflows has generated a substantial body of comparative evidence, reflecting a multifactorial clinical reality influenced by anatomical, procedural, and operator-dependent factors [1–4,6–8,10–12,14,15,20,25–36]. This discussion synthesizes the findings from technical, biological, procedural, and educational perspectives. The available evidence suggests that guided and freehand approaches should be considered complementary, each contributing to implant success through different clinical and operator-dependent mechanisms.

4.1. Advantages and Limitations of Guided Surgery

Guided implant surgery represents a transformative technological advancement, allowing clinicians to translate three-dimensional virtual planning into precise clinical outcomes. By integrating cone-beam computed tomography (CBCT), digital treatment planning software, and CAD/CAM-fabricated surgical guides, guided techniques enable controlled implant positioning, angulation, and depth according to the preoperative plan [4–8,20,21]. When stratified by guidance modality, static systems demonstrate the highest positional accuracy in controlled settings, while dynamic navigation systems show comparable accuracy with increased intraoperative flexibility. Systematic reviews and meta-analyses consistently demonstrate reduced coronal, apical, and angular deviations with guided placement compared with freehand methods, particularly in complex anatomical scenarios and full-arch rehabilitations [10–14,17–24,32,35,36,39,41,44,45]. Such improvements in spatial precision are clinically significant in challenging sites, where even minor deviations may compromise prosthetic outcomes or endanger adjacent structures.

The precision afforded by guided placement contributes directly to prosthetic predictability, facilitating optimal emergence profiles, inter implant spacing, and support for definitive restorations [7,9,10,22,23,37]. Guided workflows also reduce the likelihood of iatrogenic injury to vital structures, including the maxillary sinus, inferior alveolar nerve, and adjacent dentition [7,8,10,22,26,38]. Furthermore, guided workflows offer educational advantages for novice surgeons by providing structured operative frameworks, visual feedback, and reduced cognitive load [10,11,13,23,35,36,40].

Despite these advantages, guided surgery relies on multiple interdependent steps, including CBCT quality, virtual plan fidelity, guide fabrication accuracy, and intraoperative stabilization [22–26,35,36,41,44]. Errors at any stage can propagate, resulting in clinically significant deviations. Rigid adherence to guides may restrict intraoperative adaptability, preventing modification of drilling angulation, depth, or sequence in response to variations in bone density, cortical thickness, or unexpected anatomy [17,18,25,27,35,36]. Reduced tactile feedback can compromise optimization of primary stability and prevention of microfractures, particularly in low-density posterior maxilla [17,25,30,35]. Guided workflows also incur higher costs, require additional planning time, and involve logistical complexities [12,26,28,51,52].

Emerging technologies, particularly dynamic navigation and other real-time computer-assisted workflows, are being investigated to address some of these limitations [16,18,21,40,48,53–55]. Dynamic navigation systems offer real-time visual guidance without constraining intraoperative

flexibility, while augmented reality overlays can preserve tactile perception. Early evidence suggests improved precision and adaptability, although high-quality long-term validation remains limited.

4.2. *Advantages and Limitations of Freehand Surgery*

Freehand implant placement remains highly relevant due to its flexibility, intraoperative adaptability, and preservation of tactile feedback [17,18,20,27–29]. When stratified by anatomical location and bone quality, freehand placement shows particularly reliable outcomes in posterior regions with adequate bone volume, where minor deviations have limited prosthetic impact. Experienced surgeons can adjust drilling sequence, depth, and angulation based on direct assessment of bone quality, cortical thickness, and anatomical variations encountered during surgery [17,18,20,27,35,36]. This flexibility is particularly advantageous in low-density posterior maxilla, irregular ridges, multi-rooted extraction sites, or when subtle intraoperative adjustments are required [18,28,29,35].

The ability to modulate drilling pressure, speed, and sequence is crucial for optimizing primary stability, minimizing microfractures, and promoting predictable osseointegration [13,17,18,25,30]. Tactile feedback allows surgeons to account for cortical density, bone anisotropy, and the mechanical environment required for optimal bone healing—factors that cannot always be fully controlled with static guides [18,25,29,56,57].

From a procedural standpoint, freehand surgery offers cost-effectiveness and a simplified workflow. It does not require guide fabrication, complex digital planning, or additional imaging beyond standard CBCT [13,26,40,44,58]. When combined with comprehensive preoperative planning and prosthetically driven positioning, freehand techniques can achieve survival and success rates comparable to guided approaches, particularly for single-tooth or routine posterior cases [11–13,17,27,45].

However, freehand placement is more operator-dependent. Minor deviations in complex, multi-unit, or esthetically demanding cases may compromise implant angulation, prosthetic emergence profiles, inter implant distances, and long-term functional and esthetic outcomes [19,27,31,44,52].

4.3. *Critical Reflection: Balancing Technology and Clinical Judgment*

The integration of guided and freehand approaches requires balancing technological precision with clinical judgment.

Historical and contemporary evidence demonstrates that prosthetically driven, anatomically respectful, and biologically sound freehand placement can yield high survival rates and predictable functional outcomes [1–4,11,14,15,47]. Guided systems enhance precision but cannot replace the surgeon's expertise in bone biology, tactile perception, or intraoperative decision-making.

A critical finding across the literature is that operator experience significantly moderates study outcomes. In routine clinical scenarios, experienced practitioners consistently demonstrate superior precision during freehand placement, thereby minimizing the disparity in accuracy between conventional and guided modalities. This suggests that the relative benefit of guided systems may be most pronounced during the learning curve or in cases of extreme complexity.

Clinical decision-making should be individualized. Guided techniques are most advantageous for complex, multi-unit, anterior esthetic cases, or when anatomical risks are elevated, whereas freehand placement remains preferable for single posterior teeth or routine scenarios [8–11,13,17,21,39,44,50]. Hybrid approaches that combine preoperative digital planning with freehand execution provide reference guidance while preserving tactile feedback, adaptability, and the ability to respond to intraoperative challenges [17,18,22,29,41].

Educationally, guided systems allow structured visualization of planned positions and can accelerate skill acquisition for novice surgeons. However, freehand training is essential to develop tactile perception, intraoperative adaptability, and problem-solving skills, preventing overreliance on technology [10,17,20,23,35,36]. Optimally, training curricula should integrate both approaches, emphasizing the complementary nature of digital guidance and manual proficiency. Virtual simulations, model-based exercises, and intraoperative mentoring ensure a comprehensive skill set that balances digital and analog competencies.

4.4. Educational Implications and Surgeon Experience

Operator experience represents a critical determinant of implant placement accuracy and overall clinical outcomes, influencing both freehand and guided implant procedures. The evidence included in this review consistently demonstrates that surgical expertise significantly reduces variability in implant positioning, particularly in freehand techniques, where outcomes are highly dependent on tactile perception, spatial orientation, and intraoperative decision-making [11,17,20,27,35,36].

Importantly, this operator dependency also contributes to methodological heterogeneity across included studies, as variability in surgeon experience, training level, and case volume may partially confound reported differences between guided and freehand techniques. In novice or less experienced clinicians, guided implant systems provide substantial educational and clinical benefits. Static and dynamic guidance reduce cognitive load by translating preoperative digital planning into a structured intraoperative protocol [10,11,23,35,36]. This improves procedural confidence, standardizes surgical execution, and enhances early learning of implant positioning principles, including angulation, depth control, and prosthetically driven placement. In this context, guided systems act as a safety and training tool, minimizing the risk of critical deviations and iatrogenic complications during the learning curve [6,9,24]. However, this benefit is most pronounced during the early learning phase, and its magnitude tends to decrease as operator experience increases, suggesting a clear interaction between learning curve progression and the relative added value of guided systems.

Conversely, experienced surgeons demonstrate a higher baseline level of accuracy in freehand implant placement due to refined psychomotor skills, improved tactile feedback interpretation, and advanced understanding of anatomical variability [17,18,27]. As a result, the incremental benefit of guided systems in routine cases may be less pronounced in this group. However, even among experienced clinicians, guided and navigation-assisted approaches remain particularly valuable in anatomically complex situations, esthetic zones, or multi-implant rehabilitations, where cumulative errors can significantly impact prosthetic outcomes [6,9,21]. This suggests that guided systems do not replace surgical expertise but rather complement it, particularly in cases where anatomical risk or prosthetic complexity exceeds the safety margin of conventional freehand execution.

Importantly, guided implant systems should be viewed as complementary educational tools rather than substitutes for fundamental surgical training. Overreliance on digital workflows without sufficient development of freehand skills may limit the surgeon's ability to manage unexpected intraoperative situations, such as variations in bone density, anatomical constraints, or guide misfit [17,18,25,35,36]. Therefore, maintaining proficiency in freehand techniques remains essential to ensure comprehensive surgical competence and intraoperative adaptability. In addition, a balanced training approach is essential, as exclusive dependence on guided workflows may reduce exposure to anatomical variability and intraoperative decision-making, which are critical for long-term clinical autonomy.

From an educational perspective, modern implant training programs should integrate both guided and freehand approaches in a structured manner. Early exposure to guided

surgery can facilitate conceptual understanding of three-dimensional planning and prosthetically driven implant positioning, while progressive training in freehand techniques fosters tactile sensitivity, adaptability, and intraoperative problem-solving skills [10,23,35,36]. Simulation-based training, virtual planning exercises, and supervised clinical experience represent valuable adjuncts in bridging these two competencies. Such a dual-training model may help optimize the learning curve by accelerating early competency acquisition while ensuring the development of independent surgical judgment. Overall, the relative impact of guided versus freehand approaches appears to be strongly context-dependent, being influenced not only by operator experience but also by case complexity, anatomical constraints, and stage of the learning curve, which may partly explain the variability reported across the literature.

Overall, guided implant systems serve both clinical and educational roles, particularly supporting training and decision-making in less experienced operators.

4.5. Clinical Implications and Recommendations

These insights inform practical decision-making, guiding clinicians in selecting the most appropriate approach based on case complexity, anatomical considerations, and procedural requirements. Guided surgery is particularly indicated in multi-unit rehabilitations, esthetically demanding anterior cases, and anatomically complex situations, while freehand techniques remain suitable for routine posterior teeth, single-unit cases, or scenarios requiring intraoperative flexibility [6,9,11,17,21]. From a stratified perspective, the data suggest that guided modalities offer a critical advantage in complex, multi-unit, and anterior esthetic cases where precision is paramount. Conversely, conventional freehand techniques maintain their status as a reliable and efficient alternative for straightforward single-tooth rehabilitations in the posterior region, provided adequate clinical expertise is available.

A key consideration when interpreting differences in implant placement accuracy is the distinction between statistical and clinical significance. Although deviations of approximately 1 mm and 3–4° are frequently reported as statistically significant in comparative studies, their clinical relevance is highly context-dependent [6,9,11,17,21,32,36]. In routine clinical situations, such as single posterior implants with adequate bone volume and sufficient prosthetic space, these differences generally do not translate into meaningful effects on implant survival or marginal bone loss. However, these deviations become clinically relevant in anatomically or prosthetically demanding situations, including the anterior esthetic zone, cases with limited interdental space, proximity to critical anatomical structures (e.g., inferior alveolar nerve or maxillary sinus), and multi-implant or full-arch rehabilitations, where cumulative positional errors may affect prosthetic fit and occlusal relationships. Importantly, improved positional accuracy does not automatically translate into superior clinical outcomes across all indications. The clinical benefit of guided implant placement should therefore be interpreted in a case-specific manner rather than as a universal advantage.

Moreover, increasing evidence suggests that beyond a certain threshold, further improvements in angular or linear accuracy may have diminishing clinical returns, particularly in straightforward posterior cases with adequate bone support, where biological and prosthetic outcomes remain comparable between guided and freehand approaches despite measurable differences in implant positioning.

From a clinical decision-making perspective, a simplified treatment-oriented framework can be proposed. Freehand or guided approaches are both acceptable for single posterior implants with sufficient bone volume. Guided or hybrid workflows are preferable in anterior esthetic or space-limited cases. Guided or navigation-assisted approaches are

recommended for multiple implants or full-arch rehabilitations, while guided surgery is strongly indicated in anatomically high-risk situations. This stratification reinforces the complementary rather than hierarchical nature of both approaches.

In addition, operator experience and the learning curve represent key determinants of clinical outcomes, particularly for freehand implant placement, where accuracy and complication rates are strongly influenced by surgical expertise. Guided systems may reduce but not eliminate this dependency, and their effectiveness is also affected by the clinician's familiarity with digital planning workflows, highlighting the importance of structured training and case selection during the adoption phase.

From an economic perspective, the choice between guided and freehand implant placement should also consider cost–benefit balance rather than accuracy alone. Guided workflows involve additional costs related to CBCT acquisition, planning software, surgical guide fabrication, and increased preoperative time. While these costs may not be justified in straightforward cases such as single posterior implants with sufficient bone volume where freehand techniques provide comparable clinical outcomes, they may be offset in complex scenarios.

In particular, in anatomically challenging cases, esthetic zones, or multi-implant rehabilitations, guided surgery may reduce the risk of surgical complications, prosthetic misalignment, and the need for corrective interventions, thereby potentially improving overall treatment efficiency and long-term predictability. However, current evidence on cost-effectiveness remains limited and heterogeneous, and robust comparative economic analyses are lacking [13,16,22,25,26,40,44,52].

Overall, the available evidence suggests that cost-effectiveness and clinical benefit should not be interpreted solely through accuracy metrics, but rather through a broader evaluation including case complexity, complication risk, operative time, and potential downstream corrective procedures, which may influence the overall value of guided workflows.

Therefore, the economic justification of guided implant placement should be considered on a case-by-case basis, integrating clinical complexity, operator experience, and the potential consequences of positional inaccuracies.

Maintaining proficiency in freehand techniques is critical, even when guided workflows are available. Preoperative digital planning can serve as a reference for freehand execution, providing measurements, angles, and simulations without constraining intraoperative decision-making [13,18,22,29,40,47,59–62]. A hybrid mindset ensures patient safety, prosthetic accuracy, and optimized biological outcomes while preserving the surgeon's manual competence. From a practical clinical perspective, a case-based stratification helps refine decision-making. Guided implant surgery is often particularly useful in anatomically or prosthetically demanding situations, including the anterior esthetic zone, cases with limited bone availability or proximity to critical anatomical structures (e.g., inferior alveolar nerve or maxillary sinus), as well as multiple implant and full-arch rehabilitations where cumulative positioning errors may influence prosthetic outcomes. However, this preferential indication should be interpreted with caution, as a surgeon's experience plays a central role in managing complex clinical situations. In certain cases, particularly when dealing with anatomical variability, heterogeneous bone quality, or unexpected intraoperative conditions, a freehand or hybrid approach may offer greater flexibility and allow adjustments that are not possible with a rigid surgical guide. In contrast, freehand implant placement remains a valid and efficient option for straightforward single-tooth posterior cases with adequate bone volume and favorable anatomy, particularly in the hands of experienced clinicians. In addition, freehand techniques may offer advantages in terms of intraoperative flexibility, reduced cost, and faster workflow in low-complexity situations.

Overall, rather than a strict dichotomy between techniques, a complementary approach appears more appropriate, in which the choice between guided, freehand, or hybrid workflows depends on both case complexity and the operator's level of expertise.

Overall, the choice of technique should be based on a case-by-case assessment integrating anatomical complexity, prosthetic demands, and operator experience rather than a universal preference for one approach. Based on these clinical considerations, a conceptual comparison of guided and freehand implant placement workflows is presented in Figure 2.

Conceptual comparison of guided and freehand dental implant placement workflows

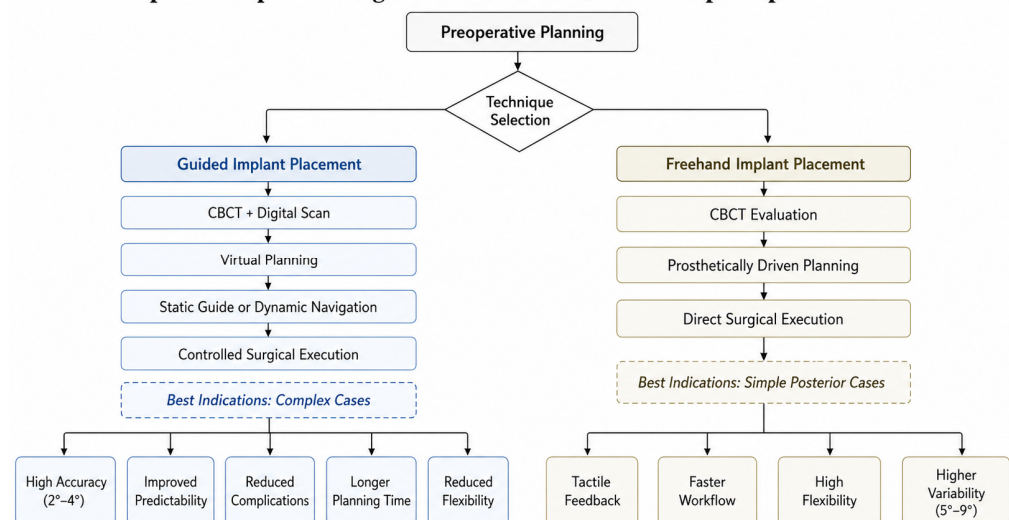


Figure 2. Conceptual comparison of guided and freehand dental implant placement workflows. Guided approaches rely on CBCT-based digital planning and static guides or dynamic navigation systems, offering higher positional accuracy and improved predictability at the expense of longer planning time and reduced intraoperative flexibility. Freehand placement relies on conventional surgical execution with tactile feedback, providing greater intraoperative adaptability and a faster workflow but higher operator-dependent variability. The figure summarizes the main procedural steps, clinical indications, and complementary roles of both approaches.

4.6. Limitations of Included Studies

Despite extensive investigation, studies comparing guided and freehand placement exhibit substantial heterogeneity in study design, sample size, follow-up duration, implant systems, outcome measures, and definitions of accuracy [6,9,12,19,21,26,52,58]. A substantial source of variability across the included studies lies in methodological and clinical heterogeneity, which directly impacts the strength and generalizability of the conclusions. Differences in study design (randomized controlled trials, prospective cohorts, retrospective analyses, and secondary evidence) introduce inherent variability in internal validity and risk of bias, limiting direct comparability of reported outcomes [10–14,19,21,26,35,36,41,44,45,58]. In addition, outcome definitions—particularly for implant accuracy, success, and complications—are not fully standardized across studies, with variations in measurement protocols (CBCT-based vs. navigation-based assessments) and reporting of coronal, apical, and angular deviations [10–14,19,21,28,35,36,41,44,45,53]. Operator experience further contributes to heterogeneity, as outcomes in freehand implant placement are highly dependent on surgical expertise, whereas guided systems tend to reduce but not eliminate this variability [11,17,20,27,35,36]. Anatomical location and case complexity also represent major modifying factors, with anterior esthetic zones, full-arch rehabilitations, and anatomically constrained sites showing different risk-benefit profiles compared with straightforward posterior single-tooth cases [6,9,11,17,21,32,36]. Collectively, this heterogeneity limits the possibility of drawing uniform, high-certainty conclusions

across all clinical scenarios and explains why observed advantages of guided techniques may appear more pronounced in controlled or complex settings than in routine practice. Consequently, the findings of this review should be interpreted as context-dependent rather than universally applicable, reinforcing the need for standardized reporting frameworks and stratified analyses in future research.

A rigorous appraisal of the evidence requires a critical consideration of potential biases. Publication bias may overrepresent guided techniques, as studies reporting statistically significant superior precision are often prioritized for publication over those showing equivalence. Furthermore, the risk of selection bias remains a concern due to the prevalence of non-randomized designs and operator-dependent case selection. Finally, our decision to exclude non-English literature may have introduced a language bias, potentially narrowing the global perspective of our synthesis. These limitations should be carefully weighed when interpreting the clinical applicability of our findings.

These limitations highlight the need for standardized, high-quality, long-term comparative studies to better inform clinical guidelines, refine case selection, and evaluate the biological and prosthetic implications of both techniques [10–14,19,21,35,36,41,44,45,53–55]. Future research should also consider patient-centered outcomes, workflow efficiency, cost-effectiveness, and the clinical impact of emerging technologies such as dynamic navigation and augmented reality technologies on precision, safety, and education.

In addition, from a clinical guideline perspective, robust evidence with follow-up periods of ≥ 5 years remains limited for key outcome parameters. In particular, there is insufficient high-quality data assessing marginal bone loss progression, peri-implantitis rates, and long-term prosthetic complications between guided and freehand implant placement. Consequently, current conclusions are predominantly based on short- to medium-term outcomes focused on surgical accuracy rather than true long-term biological and prosthetic success.

Based on these evidence gaps, four priority directions for future research can be identified. First, multicenter randomized controlled trials with standardized protocols and extended follow-up periods are required to better evaluate long-term clinical outcomes. Second, dedicated cost-effectiveness studies are needed to assess the economic justification of guided technologies in both routine and complex cases. Third, comparative clinical trials focusing on static versus dynamic navigation systems in anatomically challenging scenarios should be prioritized to clarify their relative indications. Finally, future studies should integrate standardized patient-centered outcome measures, including functional satisfaction, quality of life, and treatment efficiency, to better align scientific evidence with clinical decision-making and guideline development. These limitations and potential sources of bias (including publication bias, selection bias, and language bias) reinforce the need for cautious interpretation of the reported differences between guided and freehand implant placement techniques, particularly given the methodological heterogeneity of the included studies.

5. Conclusions

In conclusion, guided and freehand implant placement represent complementary clinical strategies, each with distinct advantages and inherent limitations. The available evidence indicates that guided techniques improve positional accuracy; however, this does not consistently translate into superior clinical outcomes, such as implant survival, in routine cases, highlighting the importance of a context-dependent interpretation of the data. Optimal clinical outcomes require a tailored approach that considers anatomical complexity, prosthetic requirements, patient-specific factors, and operator expertise. Maintaining proficiency in both techniques enables clinicians to benefit from the precision of

digital guidance when indicated while preserving the ability to adapt intraoperatively in dynamic clinical situations. Educational programs should therefore integrate both guided workflows and conventional freehand training to support the development of adaptable, technically competent, and biologically oriented clinicians. It should also be acknowledged that this review is subject to methodological limitations, including its narrative design, heterogeneity of included studies, and absence of quantitative synthesis, which should be considered when interpreting the findings. Ultimately, clinical decision-making integrating technological innovation and clinical judgment remains central to achieving safe, predictable, and biologically sound implant therapy.

Author Contributions: Conceptualization, A.P., R.D.F. and T.L.; methodology, A.P. and T.L.; writing—original draft preparation, A.P., H.S., L.M. and T.L.; writing—review and editing, A.P., T.L. and R.D.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Brånemark, P.I.; Zarb, G.A.; Albrektsson, T. *Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry*; Quintessence: Chicago, IL, USA, 1977.
2. Lekholm, U.; Zarb, G.A. Patient selection and preparation. In *Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry*; Brånemark, P.I., Zarb, G.A., Albrektsson, T., Eds.; Quintessence: Chicago, IL, USA, 1985; pp. 199–209.
3. Trisi, P.; Rao, W. Bone classification: Clinical-histomorphometric comparison. *Clin. Oral Implant. Res.* **1999**, *10*, 1–7.
4. Esposito, M.; Hirsch, J.M.; Lekholm, U.; Thomsen, P. Biological factors contributing to failures of osseointegrated oral implants. I. Success criteria and epidemiology. *Eur. J. Oral Sci.* **1998**, *106*, 527–551. [[CrossRef](#)]
5. Chrcanovic, B.R.; Albrektsson, T.; Wennerberg, A. Smoking and dental implants: A systematic review and meta-analysis. *J. Dent.* **2015**, *43*, 487–498. [[CrossRef](#)]
6. Lombardi, T.; Perez, A. Integration and Innovation in Digital Implantology—Part II: Emerging Technologies and Converging Workflows. *Appl. Sci.* **2025**, *15*, 12789. [[CrossRef](#)]
7. Scolozzi, P.; Michelini, F.; Crottag, C.; Perez, A. Computer-Aided Design and Computer-Aided Modeling (CAD/CAM) for Guiding Dental Implant Surgery: Personal Reflection Based on 10 Years of Real-Life Experience. *J. Pers. Med.* **2023**, *13*, 129. [[CrossRef](#)]
8. Pozzi, A.; Tallarico, M.; Marchetti, M.; Scarfò, B.; Esposito, M. Computer-guided versus free-hand placement of immediately loaded dental implants: 1-year post-loading results of a multicentre randomised controlled trial. *Eur. J. Oral Implantol.* **2014**, *7*, 229–242. [[PubMed](#)]
9. Tallarico, M.; Meloni, S.M.; Khanari, E.; Pisano, M.; Cochran, D.L. Computer-guided vs freehand placement of immediately loaded dental implants: 5-year post-loading results of a randomised controlled trial. *Eur. J. Oral Implantol.* **2018**, *11*, 203–213. [[PubMed](#)]
10. Smitkarn, P.; Subbalekha, K.; Mattheos, N.; Pimkhaokham, A. The accuracy of single-tooth implants placed using fully digital-guided surgery and freehand implant surgery. *J. Clin. Periodontol.* **2019**, *46*, 949–957. [[CrossRef](#)] [[PubMed](#)]
11. Chandran, S.K.R.; Goyal, M.; Mittal, N.; George, J.S. Accuracy of freehand versus guided immediate implant placement: A randomized controlled trial. *J. Dent.* **2023**, *136*, 104620. [[CrossRef](#)]
12. Vercruyssen, M.; Coucke, W.; Naert, I.; Jacobs, R.; Teughels, W.; Quirynen, M. Depth and lateral deviations in guided implant surgery: An RCT comparing guided surgery with mental navigation or the use of a pilot-drill template. *Clin. Oral Implant. Res.* **2015**, *26*, 1315–1320. [[CrossRef](#)]
13. Vercruyssen, M.; Laleman, I.; Jacobs, R.; Quirynen, M. Computer-supported implant planning and guided surgery: A narrative review. *Clin. Oral Implant. Res.* **2015**, *26*, 69–76. [[CrossRef](#)]

14. Orban, K.; Frentzen, M.; Kuebler, A.C.; Hanken, H.; Obrecht, M.; Wermker, K. Accuracy of half-guided implant placement with machine-driven or manual insertion: A prospective randomized clinical trial. *Clin. Oral Investig.* **2022**, *26*, 1035–1043. [\[CrossRef\]](#)
15. Younes, F.; Cosyn, J.; De Bruyckere, T.; Cleymaet, R.; Bouckaert, E.; Eghbali, A. A randomized controlled study on the accuracy of free-handed, pilot-drill guided and fully guided implant surgery in partially edentulous patients. *J. Clin. Periodontol.* **2018**, *45*, 721–732. [\[CrossRef\]](#)
16. Aydemir, C.A.; Arisan, V. Accuracy of dental implant placement via dynamic navigation or the freehand method: A split-mouth randomized controlled clinical trial. *Clin. Oral Implant. Res.* **2020**, *31*, 255–263. [\[CrossRef\]](#) [\[PubMed\]](#)
17. Varga, E., Jr.; Antal, M.; Major, L.; Kiscsatári, R.; Braunitzer, G.; Piffkó, J. Guidance means accuracy: A randomized clinical trial on freehand versus guided dental implantation. *Clin. Oral Implant. Res.* **2020**, *31*, 417–430. [\[CrossRef\]](#) [\[PubMed\]](#)
18. Block, M.S.; Emery, R.W.; Lank, K.; Ryan, J. Implant Placement Accuracy Using Dynamic Navigation. *Int. J. Oral Maxillofac. Implant.* **2017**, *32*, 92–99. [\[CrossRef\]](#)
19. Sun, T.M.; Lee, H.E.; Lan, T.H. Comparing Accuracy of Implant Installation with a Navigation System (NS), a Laboratory Guide (LG), NS with LG, and Freehand Drilling. *Int. J. Environ. Res. Public Health* **2020**, *17*, 2107. [\[CrossRef\]](#)
20. Huang, L.; Liu, L.; Yang, S.; Khadka, P.; Zhang, S. Evaluation of the accuracy of implant placement by using implant positional guide versus freehand: A prospective clinical study. *Int. J. Implant Dent.* **2023**, *9*, 45. [\[CrossRef\]](#)
21. Younis, H.; Lv, C.; Xu, B.; Zhou, H.; Du, L.; Liao, L.; Zhao, N.; Long, W.; Elayah, S.A.; Chang, X.; et al. Accuracy of dynamic navigation compared to static surgical guides and the freehand approach in implant placement: A prospective clinical study. *Head Face Med.* **2024**, *20*, 30. [\[CrossRef\]](#) [\[PubMed\]](#)
22. Al-Harbi, S.A.; Sun, A.Y. Implant Placement Accuracy When Using Stereolithographic Template as a Surgical Guide: Preliminary Results. *Implant Dent.* **2009**, *18*, 46–56. [\[CrossRef\]](#)
23. Vasak, C.; Watzak, G.; Gahleitner, A.; Strbac, G.; Schemper, M.; Zechner, W. Computed tomography-based evaluation of template (NobelGuide™)-guided implant positions: A prospective radiological study. *Clin. Oral Implant. Res.* **2011**, *22*, 1157–1163. [\[CrossRef\]](#) [\[PubMed\]](#)
24. Arisan, V.; Karabuda, Z.C.; Özdemir, T. Accuracy of Two Stereolithographic Guide Systems for Computer-Aided Implant Placement: A Computed Tomography-Based Clinical Comparative Study. *J. Periodontol.* **2010**, *81*, 43–51. [\[CrossRef\]](#)
25. Pettersson, A.; Komiyama, A.; Hultin, M.; Näsström, K.; Klinge, B. Accuracy of Virtually Planned and Template Guided Implant Surgery on Edentate Patients. *Clin. Implant Dent. Relat. Res.* **2012**, *14*, 527–537. [\[CrossRef\]](#)
26. Di Giacomo, G.A.; da Silva, J.V.; da Silva, A.M.; Paschoal, G.H.; Cury, P.R.; Szarf, G. Accuracy and Complications of Computer-Designed Selective Laser Sintering Surgical Guides for Flapless Dental Implant Placement and Immediate Definitive Prosthesis Installation. *J. Periodontol.* **2012**, *83*, 410–419. [\[CrossRef\]](#)
27. Ozan, O.; Turkyilmaz, I.; Ersoy, A.E.; McGlumphy, E.A.; Rosenstiel, S.F. Clinical Accuracy of 3 Different Types of Computed Tomography-Derived Stereolithographic Surgical Guides in Implant Placement. *J. Oral Maxillofac. Surg.* **2009**, *67*, 394–401. [\[CrossRef\]](#) [\[PubMed\]](#)
28. Vieira, D.M.; Sotto-Maior, B.S.; Barros, C.A.V.S.; Reis, E.S.; Francischone, C.E. Clinical Accuracy of Flapless Computer-Guided Surgery for Implant Placement in Edentulous Arches. *Int. J. Oral Maxillofac. Implant.* **2013**, *28*, 1347–1351. [\[CrossRef\]](#) [\[PubMed\]](#)
29. 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. [\[CrossRef\]](#)
30. Behneke, A.; Burwinkel, M.; Behneke, N. Factors influencing transfer accuracy of cone beam CT-derived template-based implant placement. *Clin. Oral Implant. Res.* **2012**, *23*, 416–423. [\[CrossRef\]](#)
31. Van de Wiele, G.; Teughels, W.; Vercruyssen, M.; Coucke, W.; Temmerman, A.; Quirynen, M. The accuracy of guided surgery via mucosa-supported stereolithographic surgical templates in the hands of surgeons with little experience. *Clin. Oral Implant. Res.* **2015**, *26*, 1489–1494. [\[CrossRef\]](#)
32. Ku, J.K.; Kim, B.J.; Yun, P.Y.; Lee, J.K. Accuracy of dental implant placement with computer-guided surgery: A retrospective cohort study. *BMC Oral Health* **2022**, *22*, 8. [\[CrossRef\]](#)
33. Ma, L.; Jiang, W.; Zhang, B.; Qu, X.; Ning, G.; Zhang, X.; Lyu, P. A retrospective study of dynamic navigation system-assisted implant placement. *BMC Oral Health* **2023**, *23*, 759. [\[CrossRef\]](#)
34. Cassetta, M.; Giansanti, M.; Di Mambro, A.; Calasso, S.; Barbato, E. Accuracy of Two Stereolithographic Surgical Templates: A Retrospective Study. *Clin. Implant Dent. Relat. Res.* **2013**, *15*, 448–459. [\[CrossRef\]](#)
35. Jung, R.E.; Schneider, D.; Ganeles, J.; Wismeijer, D.; Zwahlen, M.; Hammerle, C.H.F.; Tahmaseb, A. Computer technology applications in surgical implant dentistry: A systematic review. *Int. J. Oral Maxillofac. Implant.* **2009**, *24*, 92–109.
36. Schneider, D.; Marquardt, P.; Zwahlen, M.; Jung, R.E. A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. *Clin. Oral Implant. Res.* **2009**, *20*, 73–86. [\[CrossRef\]](#) [\[PubMed\]](#)
37. D'haese, J.; Van De Velde, T.; Komiyama, A.; Hultin, M.; De Bruyn, H. Accuracy and complications using computer-designed stereolithographic surgical guides for oral rehabilitation by means of dental implants: A review of the literature. *Clin. Implant Dent. Relat. Res.* **2012**, *14*, 321–335. [\[CrossRef\]](#) [\[PubMed\]](#)

38. Hultin, M.; Svensson, K.G.; Trulsson, M. Clinical advantages of computer-guided implant placement: A systematic review. *Clin. Oral Implant. Res.* **2012**, *23*, 124–135. [[CrossRef](#)]
39. Van Assche, N.; Vercruyssen, M.; Coucke, W.; Teughels, W.; Jacobs, R.; Quirynen, M. Accuracy of computer-aided implant placement. *Clin. Oral Implant. Res.* **2012**, *23*, 112–123. [[CrossRef](#)]
40. Block, M.S.; Emery, R.W. Static or Dynamic Navigation for Implant Placement—Choosing the Method of Guidance. *J. Oral Maxillofac. Surg.* **2016**, *74*, 269–277. [[CrossRef](#)]
41. Tahmaseb, A.; Wu, V.; Wismeijer, D.; Coucke, W.; Evans, C. The accuracy of static computer-aided implant surgery: A systematic review and meta-analysis. *Clin. Oral Implant. Res.* **2018**, *29*, 416–435. [[CrossRef](#)]
42. Abdelhay, N.; Prasad, S.; Gibson, M.P. Failure rates associated with guided versus non-guided dental implant placement: A systematic review and meta-analysis. *BDJ Open* **2021**, *7*, 31. [[CrossRef](#)] [[PubMed](#)]
43. Abad-Coronel, C.; Vandeweghe, S.; Vela Cervantes, M.D.; Tobar Lara, M.J.; Mena Córdova, N.; Aliaga, P. Accuracy of Implant Placement Using Digital Prosthetically-Derived Surgical Guides: A Systematic Review. *Appl. Sci.* **2024**, *14*, 7422. [[CrossRef](#)]
44. Gargallo-Albiol, J.; Barootchi, S.; Marqués-Guasch, J.; Wang, H.L. Fully Guided Versus Half-Guided and Freehand Implant Placement: Systematic Review and Meta-analysis. *Int. J. Oral Maxillofac. Implant.* **2020**, *35*, 1159–1169. [[CrossRef](#)]
45. Reiff, F.S.; Kroeger, A.; Roehling, S.; Reiff, C.; Kebschull, M. Accuracy of Freehand, Static, and Dynamic Computer-Assisted Implant Placement: A Systematic Review and Meta-Analysis. *J. Periodontal Res.* **2026**, *61*, 111–137. [[CrossRef](#)]
46. Tomar, S.; Chaudhary, P.; Ganguly, A. Comparing the clinical outcomes of guided and freehand dental implant surgery: An umbrella review of systematic reviews and meta-analyses. *J. Prosthet. Dent.* **2025**, in press. [[CrossRef](#)]
47. Nickenig, H.J.; Wichmann, M.; Hamel, J.; Schlegel, K.A.; Eitner, S. Evaluation of the difference in accuracy between implant placement by virtual planning data and surgical guide templates versus the conventional free-hand method—A combined in vivo–in vitro technique using cone-beam CT (Part II). *J. Cranio-Maxillofac. Surg.* **2010**, *38*, 488–493. [[CrossRef](#)]
48. Naeini, E.N.; Atashkadeh, M.; De Bruyn, H.; D’Haese, J. Narrative review regarding the applicability, accuracy, and clinical outcome of flapless implant surgery with or without computer guidance. *Clin. Implant Dent. Relat. Res.* **2020**, *22*, 454–467. [[CrossRef](#)]
49. Avila-Ortiz, G.; Gonzalez-Martin, O.; Couso-Queiruga, E.; Wang, H.L. Outcome measures and methods of assessment of soft tissue augmentation interventions in the context of dental implant therapy: A systematic review of clinical studies published in the last 10 years. *Clin. Oral Implant. Res.* **2023**, *34*, 51–61. [[CrossRef](#)]
50. Jorba-García, A.; Camps-Font, O.; Figueiredo, R.; González-Barnadas, A.; Valmaseda-Castellón, E. Accuracy of dental implant placement with or without the use of a dynamic computer-assisted implant surgery system: A randomized clinical trial. *Clin. Oral Implant. Res.* **2023**, *34*, 438–449. [[CrossRef](#)] [[PubMed](#)]
51. Halabi, D.; Slutzkey, G.; Meir, H.; Sebaoun, A.; Beitlittum, I. Freehand versus computer-guided implant placement: Early implant failures in a case-control study. *Quintessence Int.* **2024**, *55*, 548–558. [[CrossRef](#)]
52. Yogui, F.C.; Verri, F.R.; de Luna Gomes, J.M.; Lemos, C.A.A.; Cruz, R.S.; Pellizzer, E.P. Comparison between computer-guided and freehand dental implant placement surgery: A systematic review and meta-analysis. *Int. J. Oral Maxillofac. Surg.* **2021**, *50*, 242–250. [[CrossRef](#)] [[PubMed](#)]
53. Kaewsiri, D.; Panmekiate, S.; Subbalekha, K.; Mattheos, N.; Pimkhaokham, A. The accuracy of static vs. dynamic computer-assisted implant surgery in single tooth space: A randomized controlled trial. *Clin. Oral Implant. Res.* **2019**, *30*, 505–514. [[CrossRef](#)]
54. Spille, J.; Jin, F.; Behrens, E.; Açı, Y.; Lichtenstein, J.; Naujokat, H.; Gülses, A.; Flörke, C.; Wiltfang, J. Comparison of implant placement accuracy in two different preoperative digital workflows: Navigated vs. pilot-drill-guided surgery. *Int. J. Implant Dent.* **2021**, *7*, 45. [[CrossRef](#)]
55. Yimarj, P.; Subbalekha, K.; Dhaneuan, K.; Siriwatana, K.; Mattheos, N.; Pimkhaokham, A. Comparison of the accuracy of implant position for two-implant-supported fixed dental prosthesis using static and dynamic computer-assisted implant surgery: A randomized controlled clinical trial. *Clin. Implant Dent. Relat. Res.* **2020**, *22*, 672–678. [[CrossRef](#)]
56. Perez, A.; Hamzah, S.; Lombardi, T. Immediate versus Delayed Implant Placement after Anterior Single Tooth Extraction: The Timing Randomized Controlled Clinical Trial. *Appl. Sci.* **2023**, *13*, 9368. [[CrossRef](#)]
57. Perez, A.; Valente, N.A.; Trottet, L.; Chatelain, S.; Alfonsi, F.; Barone, A. Immediate implants in the esthetic area: Our perspective and clinical guidelines. *J. Oral Sci. Rehabil.* **2018**, *4*, 16–23.
58. Perez, A.; Maman, A.; Di Donna, E.; Lombardi, T. Implant Placement in a Cemento-Osseous Dysplasia: A case report. *Discuss. Clin. Cases* **2021**, *8*, 6–10. [[CrossRef](#)]
59. Colombo, M.; Mangano, C.; Mijiritsky, E.; Krebs, M.; Hauschild, U.; Fortin, T. Clinical applications and effectiveness of guided implant surgery: A critical review based on randomized controlled trials. *BMC Oral Health* **2017**, *17*, 150. [[CrossRef](#)]
60. Marlière, D.A.A.; Demétrio, M.S.; Picinini, L.S.; Oliveira, R.G.; Chaves Netto, H.D.M. Accuracy of computer-guided surgery for dental implant placement in fully edentulous patients: A systematic review. *Eur. J. Dent.* **2018**, *12*, 153–160. [[CrossRef](#)]

61. Tahmaseb, A.; Wismeijer, D.; Coucke, W.; Derksen, W. Computer technology applications in surgical implant dentistry: A systematic review. *Int. J. Oral Maxillofac. Implant.* **2014**, *29*, 25–42. [[CrossRef](#)]
62. D'haese, J.; Ackhurst, J.; Wismeijer, D.; De Bruyn, H.; Tahmaseb, A. Current state of the art of computer-guided implant surgery. *Periodontology* **2000**, *73*, 121–133. [[CrossRef](#)]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.