

REVIEW

Stackable Surgical Guides in Full-Arch Implant Rehabilitation: What They Can Deliver and Where the Evidence Still Constrains Use — A Critical Narrative Review

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Abstract: Objectives: This review examines the current role of stackable surgical guides in full-arch implant rehabilitation, with particular attention to what these systems can reliably achieve in clinical practice and where the available evidence remains insufficient to support broader claims. Materials and methods: A critical narrative review of PubMed/MEDLINE and Scopus was conducted and updated through August 2026. The search combined the terms “stackable,” “sequential,” and “modular” surgical guides with “dental implant,” “full arch,” “bone reduction,” “accuracy,” and “immediate loading.” Clinical studies, evidence syntheses, and relevant laboratory investigations were assessed individually. Because of the heterogeneity of the available literature and the narrative design of the review, no meta-analysis or formal risk-of-bias assessment was performed. Results: Stackable systems use a stable base with interchangeable components to maintain the planned reference throughout bone management, implant placement, and prosthetic transfer. The available clinical evidence remains limited. A 2024 scoping review identified only 12 case reports or case series, including 25 patients, 27 arches, and 173 implants, and accuracy was quantified in only four of these reports. More recent clinical studies provide additional information, although their findings remain specific to the protocols investigated. In one retrospective series involving 60 implants placed with a rigid, bone-fixed base, mean angular, neck, and apical deviations were 1.25°, 0.96 mm, and 1.07 mm, respectively. The first in vivo comparison with other forms of static guide support found no overall accuracy advantage for stackable guides and reported the greatest vertical discrepancy in the stackable group (0.26 mm; $P < .001$). In the 43-arch STAGE cohort, approximately 93% of arches were loaded on the day of surgery, while 274 of 284 implants had osseointegrated at four months. Implant replacements and provisional fractures were nevertheless reported. Conclusions: Current evidence supports stackable guides primarily as a method for maintaining a common planned reference throughout successive surgical and restorative steps. In appropriately selected cases, they can facilitate prosthetically driven implant placement, guided or selective bone reduction, and immediate provisionalization. Available studies, however, do not establish superiority over conventional guidance, identify one stackable design as preferable to another, provide validated criteria for bone reduction, or demonstrate advantages in patient-reported outcomes or cost-effectiveness.

Keywords: Dental Implants; Surgery, Computer-Assisted; Immediate Dental Implant Loading; Dental Prosthesis, Implant-Supported; Dental Arch

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1. Introduction

Immediate fixed rehabilitation of a terminal dentition or a completely edentulous arch requires several clinical and digital steps to remain coordinated. The intended tooth position must first be related to the facial and occlusal plan and subsequently transferred to the available bone, the required restorative space, the planned implant positions, and finally the provisional restoration. Maintaining this

relationship during surgery can be difficult. Extractions, flap elevation, and alveolar reduction may modify or remove anatomical landmarks that were initially used to position a conventional surgical guide. Consequently, a guide that seats accurately at the beginning of the procedure may become less reliable after the surgical anatomy has changed.

Static computer-assisted implant surgery improves the reproducibility of implant positioning, but discrepancies between planned and actual implant positions remain clinically relevant. A systematic review including 20 clinical studies reported mean deviations of 1.2 mm at the entry point, 1.4 mm at the apex, and 3.5° in angulation. The authors also emphasized the heterogeneity of the available data and the need to maintain an appropriate safety margin around critical anatomical structures [1]. Subsequent evidence has similarly shown that guide support, fixation, sleeve design, and manufacturing procedures can influence accuracy, while methods used to measure deviations remain insufficiently standardized [2,3]. These findings provide useful background for static guided implant surgery in general, but they should not be interpreted as direct evidence of the accuracy of stackable systems.

Stackable surgical guides were developed to address a related but distinct clinical challenge: maintaining a consistent reference throughout successive surgical and restorative procedures. In these systems, a stabilized base remains in position while different components are connected sequentially for bone reduction, osteotomy preparation, implant placement, and prosthetic indexing [4–6]. This arrangement may help preserve the relationship between the prosthetically driven plan and the surgical field even when the local anatomy changes during treatment. Its effectiveness, however, still depends on accurate initial positioning and stable fixation of the reference base. Incomplete seating after flap elevation or interference from residual teeth or soft tissues may compromise the position of the base. Any discrepancy introduced at this stage may subsequently affect every component connected to it.

Previous reviews have mainly described the available techniques and their reported outcomes. A systematic review from our group summarized the techniques, workflows, and short-term outcomes reported for stackable surgical guides over a ten-year period [7]. A separate scoping review of stackable metallic and magnetic guides used in immediate-loading protocols evaluated eight studies involving 351 implants and reported considerable heterogeneity, together with a substantial lack of validated patient-reported data [8]. The purpose of the present review is therefore different from simply determining whether stackable guides can be used successfully. We critically examine the clinical tasks for which these systems currently have supporting evidence, the points at which transfer errors may occur during the sequential workflow (Figure 1), and the practical decisions that determine whether the planned sequence can be safely continued (Figure 2). Given the heterogeneity of the available evidence, non-comparable outcomes are not pooled and individual design variants are not ranked beyond what the existing data support.

2. Materials and Methods

This critical narrative review was based on targeted searches of PubMed/MEDLINE and Scopus, with the final search updated on 26 August 2026. Search terms included “stackable guide,” “stackable surgical template,” “sequential template,” “modular guide,” and “full-arch implant,” combined with “bone reduction,” “osteotomy,” “accuracy,” “immediate loading,” “provisional,” and “patient-reported outcome.” Reference lists from recent systematic and scoping reviews, as well as from the primary studies included in the review, were also examined to identify additional relevant publications.

English-language, full-text articles were considered when they described the use of a stackable or sequential guide for full-arch implant rehabilitation, assessed implant-placement or bone-reduction accuracy, reported clinical or prosthetic outcomes, or investigated design and manufacturing factors with a potential influence on transfer accuracy. Studies addressing static guided implant surgery more broadly were considered only when they provided relevant information regarding measurement, safety, or manufacturing. As this was a critical narrative review rather than a systematic review, no PRISMA flow diagram, formal risk-of-bias assessment, or meta-analysis was performed. Numerical findings reported in the review were attributed to their original studies, with study design, sample characteristics, endpoints, and relevant limitations considered when interpreting the results.

The methodology also has limitations inherent to the narrative-review design. The literature search was restricted to PubMed/MEDLINE and Scopus and to publications available in English. Study selection and appraisal were not performed independently by two reviewers, and no formal risk-of-bias instrument was applied. In addition, the available evidence is limited and heterogeneous, which increases the possibility of selection bias. The findings should therefore be interpreted as a structured clinical assessment of the available literature rather than as a quantitative estimate of treatment effect.

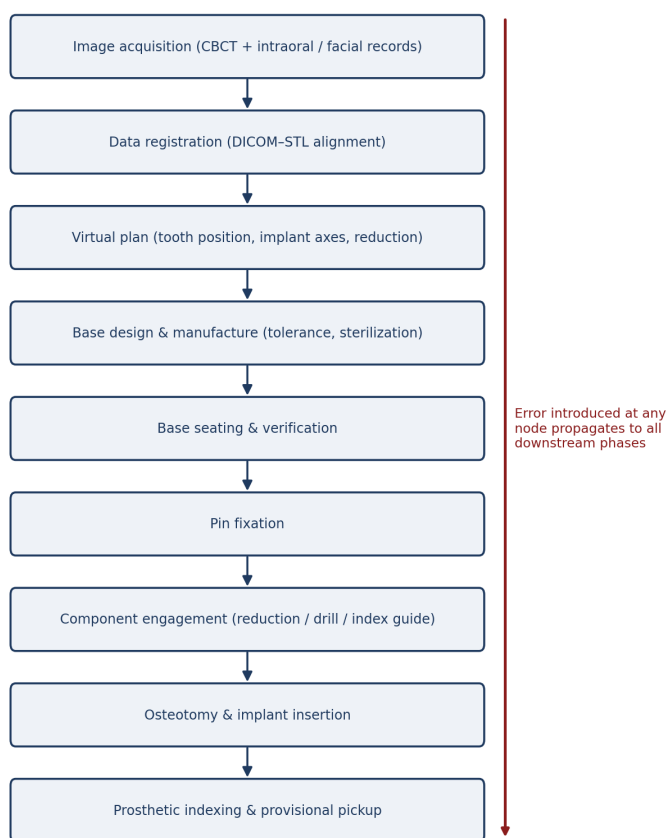
3. The Stackable Concept: One Planned Reference Across Multiple Phases

A stackable system generally consists of a reference base and two or more removable components. Initial positioning of the base may rely on the remaining teeth, mucosa, a duplicate denture, an external index, or a dedicated positioning guide, after which the base is usually secured with lateral fixation pins. Once fixed, it provides a common support for the components used during bone reduction, osteotomy preparation, or implant placement, and prosthetic transfer. Different systems use screws, pins, geometric keys, ball attachments, cones, or magnets to connect these components. The guides themselves may be produced by resin printing, milling, or additive manufacturing in metal [4,5].

The main purpose of this arrangement is to maintain the same spatial reference throughout the different stages of treatment. Provided that the base remains accurately positioned and stable, each successive component can reproduce the planned relationship even after teeth have been extracted or the alveolar ridge has been modified. This is particularly relevant when the provisional restoration is fabricated before surgery, since its transfer depends on reproducing the planned relationship between implant positions and the restorative components.

The accuracy of the workflow therefore depends on more than the number or design of the individual components. Errors may occur during image acquisition, data registration, base positioning, pin fixation, guide fabrication, component seating, drilling, implant insertion, or prosthetic transfer. When these stages depend on the same reference base, an error introduced early in the workflow may also influence subsequent stages (Figure 1). Reducing the need to reposition separate guides may simplify the sequence, but it does not compensate for inaccurate initial positioning. For this reason, the position and stability of the reference base should be verified throughout the procedure. The base, then, is best treated as a clinical reference to be checked and rechecked — not as proof that the virtual plan has actually been transferred.

Figure 1: Propagation of reference errors through a stackable workflow. AI assistance was used to create the illustration (Claude Opus 4.8, Anthropic). The authors reviewed and verified the final diagram and take full responsibility for its accuracy and content.



4. Current Applications and Reported Outcomes

4.1. Integrated prosthetic planning and bone management

Stackable systems allow implant placement and, when indicated, alveolar reduction to be planned in relation to the intended definitive restoration. In full-arch rehabilitation, bone reduction may be required to correct an irregular or knife-edge ridge, provide adequate width for implant placement, create sufficient restorative space, reposition the prosthetic transition zone, or coordinate

the occlusal plane and smile line [9]. The decision to perform alveolar reduction, as well as the amount of bone to be removed, should therefore be based on the planned restoration and the residual anatomy rather than on the availability of a reduction guide.

Several clinical reports have incorporated facial information, planned tooth position, osteotomy, and implant placement within the same digital workflow. Fu et al. described an esthetically driven approach in which the planned lip and tooth positions were used to coordinate maxillary osteotomy and immediate rehabilitation with six implants [10]. A scalloped-guide proof-of-concept technique used selective bone reduction to preserve interproximal bone and facilitate a pink-free FP1 restoration in an appropriately selected case [11]. These reports demonstrate the clinical feasibility of incorporating bone management into a prosthodontically driven digital workflow, although they do not provide evidence that a particular reduction design is generally superior.

Alveolar reduction is not required in every stackable protocol. Cristache et al. reported four maxillary cases treated with low-profile restorative components without planned alveolar reduction. A tissue- or mixed-supported pinned base was used, followed by delivery of immediate long-term provisional restorations [12]. These cases demonstrate that the sequential transfer provided by a stackable system can also be used when bone reduction is not indicated. The indication and extent of alveolar reduction should therefore remain independent biological and prosthetic decisions.

4.2. Study-specific implant-placement accuracy

Clinical studies evaluating implant-placement accuracy have provided additional information beyond the earlier technique reports. In a retrospective study of 15 completely edentulous patients receiving 60 implants, Bjelica et al. evaluated a bone-supported, pin-fixed, magnetically connected resin system after flap elevation and alveolar reduction. Mean angular deviation was $1.25 \pm 0.80^\circ$, while mean three-dimensional deviations were 0.96 ± 0.57 mm at the implant neck and 1.07 ± 0.56 mm at the apex. Mean depth discrepancy was 0.37 ± 0.58 mm [13]. These results describe the performance of a specific workflow used by an experienced operator. The retrospective design, absence of a comparator, CBCT-based registration, and inclusion of multiple implants within individual patients limit conclusions regarding superiority or generalizability.

The first in vivo study directly comparing stackable guides with other types of static guide support was reported by Eldabe et al. The study included 86 implants placed using bilateral tooth-supported, unilateral tooth-supported, mucosa-supported, and stackable bone-supported guides. No statistically significant differences were identified between groups for angular, coronal, or apical global deviations. A significant difference was found for vertical discrepancy, with the stackable group showing the highest value (0.26 ± 0.06 mm; $P < .001$), together with a mean angular deviation of $5.42 \pm 1.16^\circ$ [14]. Interpretation is limited by the small, non-randomized, stackable subgroup of 3 patients and 19 implants, the absence of blinding, and the use of a single magnetic connection system. Bjelica et al. also evaluated a magnetically connected system but reported substantially lower deviations with a rigidly bone-fixed base [13]. The different results obtained with systems sharing a magnetic connection indicate that connector type cannot be considered independently from base support, fixation, component seating, and the overall stability of the reference system.

Cristache et al. evaluated another clinical configuration in four patients receiving 25 maxillary implants. Mean coronal, apical, and angular discrepancies were 0.87 ± 0.50 mm, 2.04 ± 0.69 mm, and $2.67 \pm 1.25^\circ$, respectively [12]. The greater apical than coronal deviation is compatible with the effect of angular error over the length of an implant. However, the small case-series design does not allow these values to be considered representative of expected performance. The study does show that successful clinical treatment and one-year implant survival may occur despite measurable transfer discrepancies.

Evidence from guided implant surgery more broadly also illustrates the limitations of interpreting mean deviation values in isolation. In a prospective study of mucosa-supported guides involving 13 edentulous maxillae, D'haese et al. reported a mean angular deviation of 2.60° , while the maximum deviation reached 8.86° [15,16]. Although this study did not evaluate a stackable workflow and should not be interpreted as a direct comparator, it demonstrates the potential difference between mean values and individual deviations. Anatomical safety margins and intraoperative verification therefore remain necessary regardless of the reported average accuracy.

The limited comparative evidence available for stackable systems remains specific to individual designs and manufacturing protocols. Hameed and Hebeshe placed 24 implants using stackable guides manufactured either from selective-laser-melted cobalt–chromium or digital-light-processed resin and reported lower coronal, apical, and angular deviations with the metal configuration [17]. However, the material and manufacturing method differed simultaneously, the sample was small, and the study involved terminal maxillary dentitions. The findings therefore cannot establish a general advantage of metal over resin stackable guides.

In a 12-model in-vitro study, Tallarico et al. found that modular guidance produced accuracy broadly comparable with conventional fully guided implant placement, although screw fixation and operator experience influenced some deviations, particularly following simulated bone reduction [18]. Laboratory studies of conventional surgical guides have similarly shown that sleeve design, fabrication by printing or milling, resin type, printer, and sterilization procedures can affect accuracy, with results varying according to the specific configuration [19–21]. These findings emphasize the importance of controlling the complete guide, instrumentation, manufacturing, and operator workflow rather than attributing accuracy to a single material or design feature.

Beretta et al. described a different approach for assessing transfer accuracy using a dedicated “number guide” screwed onto the fixed base to improve intraoperative registration of scan bodies. The technique was applied in 10 patients receiving 47 one-piece implants with immediate provisionalization, with greater placement precision reported in the mandible than in the maxilla [22]. As a single-arm case series without a comparator, the study provides preliminary evidence for a standardized method of intraoperative accuracy assessment rather than an estimate of comparative effectiveness.

4.3. Prosthetic indexing and immediate provisionalization

Transfer of a prefabricated provisional restoration is an important application of the stackable workflow. Prosthetic components can be indexed to the same reference base used during implant guidance, helping to maintain the planned vertical dimension, midline, occlusal plane, and restorative position after the surgical phase. Clinical techniques and cohort studies have used magnetically retained components, while mechanical keys, pins, screws, and ball attachments represent alternative methods of indexing [4,23]. These different connection methods have demonstrated clinical feasibility, but the available evidence does not establish their equivalence or the superiority of one approach.

The 2024 scoping review by Lan et al. identified 12 case reports or case series involving 25 patients, 27 arches, and 173 implants. Immediate loading was reported in 11 of the included studies, while implant-placement accuracy was quantified in only four. No prospective comparative study was identified [4]. The available literature at that time therefore primarily supported technical feasibility, with insufficient evidence for comparative effectiveness.

A larger clinical dataset was subsequently provided by the STAGE study. Thirty-five patients with 43 treated arches, including 15 arches in native bone and 28 following grafting, received 284 implants using a stackable workflow. Approximately 93% of arches (40 of 43) were loaded on the day of surgery. At the four-month reverse-torque assessment, 10 implants (3.5%) had failed to osseointegrate and were replaced, corresponding to an early osseointegration success of 96.5%. Because the failed implants were replaced and treatment continued, this value represents early osseointegration rather than final implant survival. All 35 patients subsequently received definitive fixed rehabilitation, with 100% prosthetic success reported at one year. Five provisional prostheses fractured, and complications occurred in a limited number of patients. Bruxism was significantly associated with implant loss (Fisher exact $P = .0002$) [24]. This association is consistent with broader evidence concerning immediate full-arch loading and bruxism as a risk factor for implant loss [25–28]. The STAGE study supports the feasibility of the workflow in a heterogeneous clinical population, including reconstructed arches, but its retrospective, single-arm design does not allow implant survival or complications to be attributed specifically to the stackable guide.

In the four-patient series reported by Cristache et al., all 25 implants survived to one year, and one patient required two unscheduled occlusal adjustments [12]. Although these outcomes are favorable, the small uncontrolled sample does not provide a reliable estimate of complication rates. Taken together, the available studies indicate that immediate provisionalization can be achieved with stackable workflows when appropriate clinical conditions are present. The decision to proceed with immediate loading remains dependent on primary stability, implant distribution, restorative design, occlusion, patient-related risk factors, and clinical judgment.

4.4. Emerging patient-reported outcomes

Patient-reported outcomes have received limited attention in the literature on stackable workflows. De Araújo Nobre et al. prospectively followed 16 patients who received 20 immediately loaded full-arch interim prostheses. Ten rehabilitations were performed using a bone-fixed stackable workflow and ten using freehand surgery followed by photogrammetry [29,30]. OHIP-14 was recorded at 10 days and at two, four, and six months, together with study-specific assessments of comfort and chewing. At six months, the overall mean OHIP-14 score was low, while comfort and chewing received high ratings [29,31].

Interpretation of these findings is limited by the absence of a pretreatment OHIP-14 baseline, incomplete description of allocation between workflows, inclusion of patients treated in both arches, and the descriptive rather than inferential analysis. Two prostheses failed, two implants were lost, and mechanical complications were reported in half of the patients. The study demonstrates that validated patient-reported outcome measures can be incorporated into the assessment of these workflows, but the available data are insufficient to determine whether stackable guidance provides an advantage in oral health-related quality of life.

5. Evidential and Methodological Constraints

5.1. The evidence base remains heterogeneous

The main limitation of the available literature is its methodological and clinical heterogeneity. The 2024 scoping review identified only case reports and case series [4]. More recent studies have added clinical accuracy and outcome data, but most remain small, retrospective, or uncontrolled [12,13,24,29]. Considerable variation also exists between studies in patient characteristics, treated arch, grafting procedures, guide support and fixation, number of components, guide material, drilling protocol, implant design, loading criteria, operator experience, and outcome assessment. Because many of these variables differ simultaneously, their individual contribution to the reported outcomes cannot be determined with confidence.

Table 1: Overview of evidence relevant to current stackable-guide practice. For each study, the table presents the comparator, sample size and relevant denominators, follow-up period, accuracy results and reported outliers, measurement method, clustering, and a note on the certainty of interpretation. AI assistance (Claude, Anthropic) was used to format and organize the table. All data were extracted from the cited primary sources and verified by the authors, who take full responsibility for their accuracy.

Study & design	Sample & protocol	Comparator	Follow-up	Accuracy: mean (max / outlier)	Measurement & clustering	Principal limitation & interpretive weight
Lan et al., 2024 [4]; Scoping review	12 case reports/series; 25 patients, 27 arches, 173 implants	None	NA	Accuracy quantified in only 4/12 reports	Descriptive charting	Maps feasibility & design diversity; no prospective comparison — very limited
Cristache et al., 2024 [12]; Case series	4 patients, 25 maxillary implants; pinned tissue/mixed base; no reduction	None	1 yr	0.87 coronal / 2.04 apical / 2.67° (max NR)	Postop CBCT; implant-level	Immediate rehab without reduction feasible; very small, uncontrolled — very limited
Bjelica et al., 2026 [13]; Retrospective	15 patients, 60 implants; bone-supported, pinned, magnetic; with reduction	None	(accuracy endpoint)	1.25° / 0.96 neck / 1.07 apex / 0.37 depth (apex max 2.17)	Postop CBCT superimposition; patient- & arch-level reported	Rigidly bone-fixed protocol; no comparator, single operator, no PROM — limited
Eldabe et al., 2026 [14]; Comparative in vivo (nonrandom, unblinded)	31 patients, 86 implants; stackable subgroup 3 pt / 19 impl; magnetic	3 other static supports	12 mo	Stackable 5.42° / 1.70 coronal / 1.72 apical / 0.26 vertical (highest, P<.001); no group difference in angular/coronal/apical	Digital registration; patient-level averaging (clustering handled)	Tiny stackable subgroup, unblinded, single system — limited, but the only direct comparison
Beretta et al., 2026 [22]; Case series	10 patients, 47 one-piece implants; 'number-guide' registration; immediate loading	None	NR	Deviation magnitudes NR in abstract; greater precision in mandible than maxilla	Number-guide scan-body registration	No comparator; numeric data pending — very limited; proof of concept for accuracy capture
Hameed & Hebeshi, 2023 [17]; Clinical comparison	24 implants; SLM Co–Cr vs DLP resin stackable guides	Metal vs resin (bundled)	NR	Lower coronal/apical/angular with metal	Postop deviation	Small; material & manufacturing method confounded — limited
Tallarico et al., 2024 [18]; in vitro	12 mandibular models; conventional / modular / modular-after-reduction	Conventional guidance	NA	Modular ≈ conventional; fixation & experience affected some deviations	Model-based	Not a clinical outcome study — indirect evidence
Levy-Bohbot et al., 2025 (STAGE) [24]; Retrospective cohort	35 patients, 43 arches, 284 implants; native + grafted bone	None	4 mo (12 mo prosthetic)	40/43 arches same-day loaded; 274/284 osseointegrated (96.5%); 5 provisional fractures	Clinical / reverse-torque; arch-level	Single-arm, heterogeneous cohort — limited
de Araújo Nobre et al., 2025 [29]; Prospective mixed-workflow	16 patients, 20 arches, 80 implants; 10 stackable / 10 freehand + photogrammetry	Freehand + photogrammetry (not inferential)	6 mo	OHIP-14 low at 6 mo; comfort/chewing high; 2 prosthesis & 2 implant failures	OHIP-14; descriptive	No pretreatment baseline, no inferential comparison — limited

Abbreviations: Co–Cr, cobalt–chromium; DLP, digital light processing; NA, not applicable; NR, not reported; OHIP-14, 14-item Oral Health Impact Profile; PROM, patient-reported outcome measure; SLM, selective laser melting.

Direct comparisons with conventional static guidance, dynamic navigation, or freehand implant placement remain limited. Even studies comparing different stackable configurations frequently involve changes in several design variables at the same time [17,32]. This is also evident in the two relevant datasets published in 2026. One study using a rigidly bone-fixed system with magnetic connections reported relatively low placement deviations [13], whereas another study evaluating a magnetically connected stackable system against other guide-support configurations found the highest vertical discrepancy in the stackable subgroup [14]. Although both systems used magnetic connections, their accuracy differed considerably. These findings suggest that connector type alone is unlikely to determine clinical accuracy. At present, the evidence is insufficient to establish the general superiority of bone-, mucosa-, or tooth-supported bases, magnetic or mechanical indexing, printed resin or metallic components, or sleeved versus sleeveless guidance.

5.2. Accuracy measures are not interchangeable with clinical success

Coronal, apical, angular, and depth deviations represent different aspects of implant-placement accuracy. Their reported values may also be influenced by the registration method, imaging resolution, implant length, measurement software, and the method used for postoperative assessment, including CBCT, scan bodies, or surface scans. For static computer-assisted implant surgery in general, a safety margin of at least 2 mm from critical anatomical structures has been recommended [1,33], while individual stackable studies have also applied linear and angular acceptance thresholds based on ITI Consensus recommendations [13]. However, stackable-specific reporting standards and clinically validated acceptance thresholds have not yet been established [4].

For this reason, mean placement deviation alone should not be considered a surrogate for clinical success. Mean values may conceal individual outliers and do not directly establish anatomical safety, passive prosthetic fit, or long-term biological outcomes.

The statistical unit used for analysis is another relevant consideration. Multiple implants placed within the same patient or arch are not independent observations. Analyses that treat each implant independently may therefore overestimate statistical precision. Future studies should include patient- and arch-level reporting, account for clustering, define clinically relevant margins prospectively, and document the sequence of potential errors from data acquisition to definitive prosthetic connection.

5.3. Bone-reduction accuracy and indications remain underdeveloped

Bone reduction is an important component of many stackable protocols, but its accuracy has received considerably less investigation than implant-placement accuracy. Most available reports describe the indication for alveolar reduction or the method used to guide it, while relatively few compare the planned reduction surface with the postoperative ridge [4,9,34]. Guided instrumentation may improve control of bur or saw position, but it does not eliminate the possibility of under-reduction, over-reduction, irregular contouring, thermal injury, or extension beyond the planned reduction.

Criteria for determining the required amount of bone reduction are also not standardized. Several factors may influence this decision, including restorative space, soft-tissue thickness, smile line, prosthetic transition-zone position, available bone width, implant trajectory, restorative material, and access for hygiene. At present, prospective evidence linking specific amounts of planned bone reduction with improved patient outcomes is lacking. Bone-reduction guides should therefore be regarded as instruments for transferring a previously established surgical and prosthetic plan rather than as a means of determining how much bone should be removed.

5.4. Cumulative error and intraoperative verification

Transfer errors may arise at multiple stages of the workflow, including acquisition of facial and intraoral records, CBCT imaging, DICOM–STL registration, virtual tooth arrangement, base design, manufacturing, sterilization, guide seating and fixation, component connection, drill–sleeve interaction, osteotomy preparation, implant insertion, abutment seating, and prosthetic indexing. When a common reference base is used throughout the procedure, an error introduced early in the sequence may also affect subsequent components (Figure 1).

Clinical verification is therefore required throughout the procedure. Full seating and stability of the base should be confirmed before fixation and reassessed after extraction and flap elevation. Each subsequent component should engage passively, and the connection interface should remain free of interference. Irrigation and drill access must also be maintained. If the clinical anatomy prevents reliable execution of the planned sequence, modification or discontinuation of the guided protocol may be necessary. Limited mouth opening, increased posterior guide height, bulky components, mobile mucosa, thin or irregular bone, and restricted access for fixation pins may all interfere with execution [4,5,35,36]. Alternative fixation, freehand correction, dynamic navigation, or delayed prosthetic conversion should therefore be considered during preoperative planning as possible rescue options (Figure 2).

5.5. Learning curve, resources, and patient-centered value

Stackable workflows require substantial preparation before surgery. Accurate records, coordinated surgical and prosthetic planning, appropriate design, validated manufacturing procedures, trial assembly, and communication between the clinician and dental laboratory are all required. Operator experience may also influence accuracy in modular guided procedures [18,37]. Additional guide

components and fixation devices may increase planning requirements, material use, sterilization procedures, and overall cost. Although reduced chair time and lower treatment costs have been proposed as potential advantages, these claims are currently supported mainly by qualitative observations, as formal time-and-motion and cost-effectiveness comparisons are lacking [4,24,29].

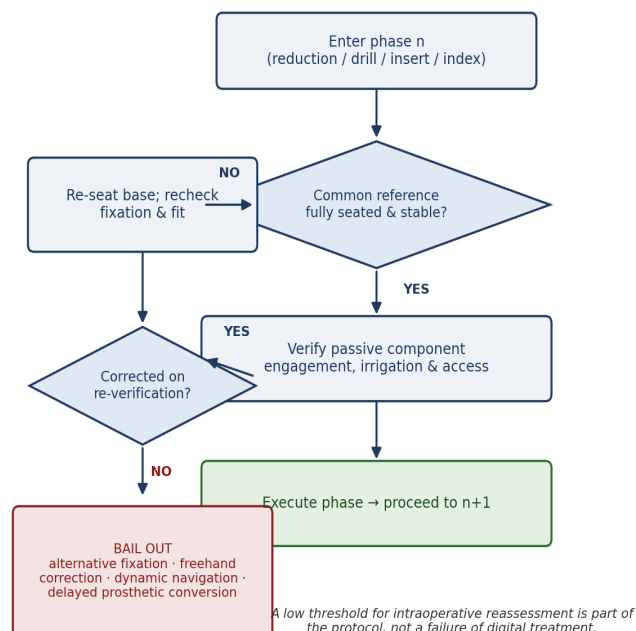
Evidence regarding long-term outcomes is similarly limited. Most published studies focus on implant-placement accuracy, immediate provisionalization, or short-term implant survival. Comparative information regarding definitive prosthesis fit, maintenance requirements, marginal bone changes, peri-implant disease [38], hygiene, speech, esthetic outcomes, complications, and the need for revision remains scarce. Future studies evaluating patient-reported outcomes should include pretreatment baseline measurements, validated instruments, predefined follow-up intervals, and statistical methods that account for repeated measurements and treatment of both arches. Until such evidence becomes available, technical feasibility alone cannot establish a patient-centered advantage.

6. Where This Leaves the Clinician

Based on the available evidence, stackable guides should primarily be considered a method for maintaining a controlled spatial reference throughout full-arch treatment rather than an independent guarantee of placement accuracy. Their clinical value may be greatest when surgical procedures alter the anatomy during treatment and the original prosthetic plan must remain related to bone management, implant positioning, and delivery of a prefabricated provisional restoration. In these situations, maintaining the same reference throughout the procedure may reduce the need for repeated guide repositioning, additional intraoperative records, or extensive modification of the provisional restoration.

Planning should begin with the intended definitive restoration and an independent assessment of whether alveolar reduction is required. The reference base should have a reproducible seating position and adequate fixation while allowing direct clinical verification whenever possible. Component height and insertion paths should be evaluated during digital planning and, when appropriate, verified on a printed model. This is particularly relevant in posterior regions and in patients with limited mouth opening. Manufacturing and sterilization procedures should be validated for the material being used, and the complete assembly should be checked before surgery.

Figure 2: Go/no-go decision and bailout algorithm for each phase of the stackable workflow. AI assistance was used to create the illustration (Claude Opus 4.8, Anthropic). The authors designed, reviewed, and verified the algorithm and take full responsibility for its accuracy and content.



During treatment, progression from one component to the next should depend on confirmation that the common reference remains fully seated and stable (Figure 2). If stability and seating are maintained, the sequential components can transfer the planned relationship from the virtual design through implant placement and provisionalization. If the reference position becomes uncertain, continuing with subsequent components may transfer the discrepancy to later stages of treatment. The reference should therefore be reassessed whenever seating or stability is questionable, and the guided sequence should be modified or discontinued when reliable transfer can no longer be confirmed.

Patients should also be informed about the clinical limitations of the workflow. Stackable guidance may facilitate same-day fixed rehabilitation, but it does not ensure that immediate loading will always be possible or eliminate the risks of implant failure, prosthetic complications, or subsequent maintenance. The decision to proceed with immediate loading remains dependent on primary stability, implant distribution, bone conditions, occlusal risk, and clinical judgment. Based on current evidence, selection of guide support, connection design, and material should be individualized according to the anatomy of the case, verified guide fit, surgical access, instrument compatibility, manufacturing quality, and operator experience. There is currently insufficient evidence to support the universal superiority of any specific configuration.

7. Conclusion

Stackable surgical guides extend static computer-assisted implant surgery by maintaining a common prosthetically planned reference throughout successive stages of full-arch rehabilitation, including bone management, implant placement, and provisional restoration. Clinical studies have reported placement deviations within ranges previously described for static computer-assisted implant surgery. However, the available studies are heterogeneous, generally involve small samples, and provide very limited direct comparative evidence. Consequently, the current data do not demonstrate that stackable systems provide greater placement accuracy than conventional static guidance. In the available controlled comparison, stackable guides did not show superior overall accuracy compared with other static guide supports and presented the greatest vertical discrepancy among the evaluated groups [14].

Current clinical evidence nevertheless indicates that stackable workflows can be used successfully for immediate full-arch provisionalization, including in selected grafted or anatomically complex cases. Published selective-reduction and no-reduction protocols further demonstrate that alveolar reduction is not an inherent requirement of the stackable approach. The primary function of these systems is to maintain and transfer the planned spatial relationship between successive surgical and restorative stages.

The evidence supporting these workflows remains limited by small and heterogeneous clinical studies, infrequent assessment of bone-reduction accuracy, limited comparisons between different system designs, and insufficient information on long-term outcomes, patient-reported measures, treatment time, and cost. Reliable clinical use therefore depends on stable positioning of the reference base and verification of its seating throughout the procedure. Further prospective comparative studies are required to evaluate arch-level placement accuracy, bone-reduction accuracy, definitive prosthetic outcomes, validated patient-reported measures, and workflow costs before the relative advantages of stackable systems or specific design configurations can be established.

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Authors' contribution

Conceptualization, E.A.R. and I.S.; methodology, A.M.C. and E.A.R.; literature search and screening, A.M.C., F.M.T. and A.T.; data curation, F.M.T., A.T. and L.R.; formal analysis, E.A.R., I.S. and E.B.; visualization, A.M.C. and F.M.T.; writing—original draft preparation, E.A.R. and A.M.C.; writing—review and editing, I.S., E.B., L.R., V.D.S., F.M.T. and A.T.; supervision, I.S., V.D.S. and E.B.; project administration, A.M.C. and E.A.R. All authors have read and agreed to the published version of the manuscript.

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Ethics approval and consent to participate

Not applicable

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