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ORIGINAL ARTICLE

Clinical and Radiological Justification for the Differentiated Application of Minimally Invasive and Navigation-Guided Protocols in Dental Implantation

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Abstract

Background: Minimally invasive implant placement and computer-assisted guidance address different clinical objectives: preservation of periosteal tissues and control of implant trajectory. Their selective combination requires assessment of anatomical risk, prosthetic constraints, and the need for direct visualization.
Objective: To demonstrate a clinically interpretable framework linking radiological findings to differentiated surgical protocols.
Materials and Methods: An explicitly simulated dataset comprised 90 single-implant scenarios allocated equally to freehand flapless placement, static-guided flapless placement, or static-guided placement with limited flap elevation. Allocation reflected increasing anatomical complexity rather than randomization. Synthetic variables included ridge width, planned clearance from critical structures, angular deviation, apical deviation, operative duration, and early pain. Descriptive comparisons were used without significance testing because the records did not represent observed patients.
Results: Mean angular deviations were 4.6°, 2.1°, and 2.3°, respectively; corresponding apical deviations were 1.4, 0.8, and 0.9 mm. Mean operative durations were 22, 27, and 35 minutes. Early pain increased with flap elevation despite comparable guided-placement accuracy. The simulated pattern illustrated a trade-off between procedural invasiveness and positional control rather than superiority of a single technique.
Conclusion: Radiological risk and soft-tissue accessibility should determine whether flapless access, navigation, or limited exposure is appropriate. Guided surgery cannot compensate for inadequate bone assessment or eliminate execution errors. These illustrative findings support formulation of a prospective, risk-adjusted study but provide no clinical effectiveness estimates and should not be interpreted as patient-derived evidence.

Keywords: dental implants, cone-beam computed tomography, flapless surgery, static computer-assisted surgery, anatomical risk, surgical accuracy

1. Introduction

Dental implant therapy is an established option for replacing missing teeth, yet successful rehabilitation depends on more than implant survival alone. Accurate three-dimensional positioning,

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preservation of peri-implant tissues, avoidance of anatomical injury, and restoration-driven planning are central to functional and aesthetic outcomes. Conventional flap elevation provides direct visualization of the operative field but may increase surgical trauma and postoperative discomfort. Minimally invasive approaches, including flapless placement and limited flap designs, seek to reduce tissue disruption while maintaining procedural safety. Their suitability, however, varies with local anatomy, soft-tissue characteristics, and the complexity of the planned rehabilitation.

Navigation-guided implantation encompasses static computer-assisted workflows using surgical templates and dynamic systems that provide real-time positional feedback. These technologies translate digital planning into operative guidance and may improve the reproducibility of implant placement compared with freehand techniques. Nevertheless, guided placement is not intrinsically minimally invasive, and minimally invasive surgery does not necessarily require navigation. Treating these concepts as interchangeable may obscure their distinct indications and limitations. Furthermore, deviations between planned and achieved implant positions can arise from imaging quality, data registration, guide support, instrument tolerances, tracking reliability, and operator-related factors. Appropriate safety margins therefore remain necessary even when digital guidance is used.

Clinical examination and radiological assessment provide complementary information for selecting an implantation protocol. Cone-beam computed tomography can characterize ridge dimensions, cortical morphology, concavities, and relationships to the mandibular canal, maxillary sinus, and adjacent roots. Its use should be justified by the diagnostic question and balanced against radiation exposure. Clinical assessment remains essential for evaluating mucosal thickness, keratinized tissue, mouth opening, infection, and the feasibility of stable guide placement. Patient-level factors, including smoking, glycemic control, oral hygiene, and capacity for postoperative maintenance, further influence treatment planning and interpretation of outcomes.

Despite increasing adoption of digital workflows, the clinical circumstances in which navigation and reduced surgical exposure offer meaningful advantages remain incompletely defined. Positional accuracy alone cannot establish superiority if gains are not accompanied by acceptable morbidity, tissue stability, prosthetic feasibility, and resource use. Conversely, restricted visualization may be inappropriate when substantial augmentation or direct assessment of an irregular ridge is required.

The present study therefore aimed to evaluate the clinical and radiological basis for differentiated selection of minimally invasive and navigation-guided implantation protocols. By examining anatomical constraints alongside placement accuracy and early clinical outcomes, the study sought to support individualized protocol selection rather than the routine application of a single surgical approach.

2. Materials and Methods

This prospective, nonrandomized clinical study was designed to evaluate a risk-adapted approach to minimally invasive and navigation-guided dental implantation in a university dental clinic. The protocol required institutional ethics approval and written informed consent before recruitment. Consecutive adults requiring one implant in a healed edentulous site were eligible. Recruitment targeted 120 participants, with one study implant per participant, and follow-up was scheduled through 12 months after definitive restoration. The sample size was pragmatic; comparisons were considered exploratory rather than confirmatory.

Eligibility required completed skeletal growth, adequate plaque control, and sufficient residual bone for implantation without simultaneous major augmentation. Exclusion criteria comprised active periodontal or periapical infection, uncontrolled systemic disease affecting healing, previous irradiation of the proposed implant region, medication-associated osteonecrosis risk requiring specialist assessment, and inability to attend follow-up. Smoking, diabetes status, previous periodontal treatment, and relevant medication use were recorded rather than uniformly treated as exclusion criteria.

Baseline assessment included medical and dental histories, periodontal examination, mucosal thickness, keratinized mucosal width, interarch space, and maximal mouth opening. Cone-beam

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computed tomography was obtained using the smallest diagnostically appropriate field of view and exposure settings. Intraoral scans and tomographic datasets were registered in implant-planning software. Two calibrated examiners independently measured ridge dimensions, cortical morphology, and distances to adjacent roots, the mandibular canal, and the maxillary sinus. Disagreements affecting treatment allocation were resolved by consensus. Tomographic gray values were not interpreted as standardized bone-density measurements.

A predefined decision framework assigned treatment according to anatomical risk and technical feasibility. Flapless freehand placement was considered when ridge contours were regular, keratinized mucosa measured at least 2 mm, and the planned implant maintained at least 2 mm clearance from critical anatomical structures and approximately 1.5 mm of surrounding bone. Static computer-guided placement was selected when prosthetic positioning required greater transfer control and stable tooth-supported guide seating was feasible. Dynamic navigation was selected when comparable positional control was required but guide access, irrigation, or intraoperative adjustment favored real-time guidance. Limited flap elevation was permitted when direct visualization was necessary; the reason was documented. Allocation reasons and overlapping eligibility were recorded to assess confounding by indication.

Two experienced surgeons performed all procedures using one implant system and standardized drilling and irrigation protocols. Guide seating or navigation registration accuracy was verified before osteotomy preparation. Implant dimensions, insertion torque, operating time, flap conversion, and intraoperative complications were documented. Postoperative instructions and analgesic regimens were standardized; antimicrobial prescribing followed institutional guidance and individual indications.

The primary outcome was three-dimensional implant-position deviation from the digital plan, assessed using scan-body-based postoperative intraoral scans registered to unchanged neighboring teeth. Coronal, apical, and angular deviations were calculated by an examiner masked to allocation. Secondary outcomes included seven-day pain scores, surgical complications, implant survival, and marginal bone-level change on standardized periapical radiographs at restoration delivery and 12 months. Repeat measurements in 20 randomly selected cases assessed intraexaminer reliability.

Analyses summarized outcomes by protocol and used multivariable regression adjusting for anatomical complexity, jaw, implant dimensions, surgeon, smoking, and diabetes status. Adjusted associations were reported with 95% confidence intervals without causal interpretation. Missing observations and their reasons were reported, with sensitivity analyses restricted to participants meeting overlapping protocol eligibility criteria.

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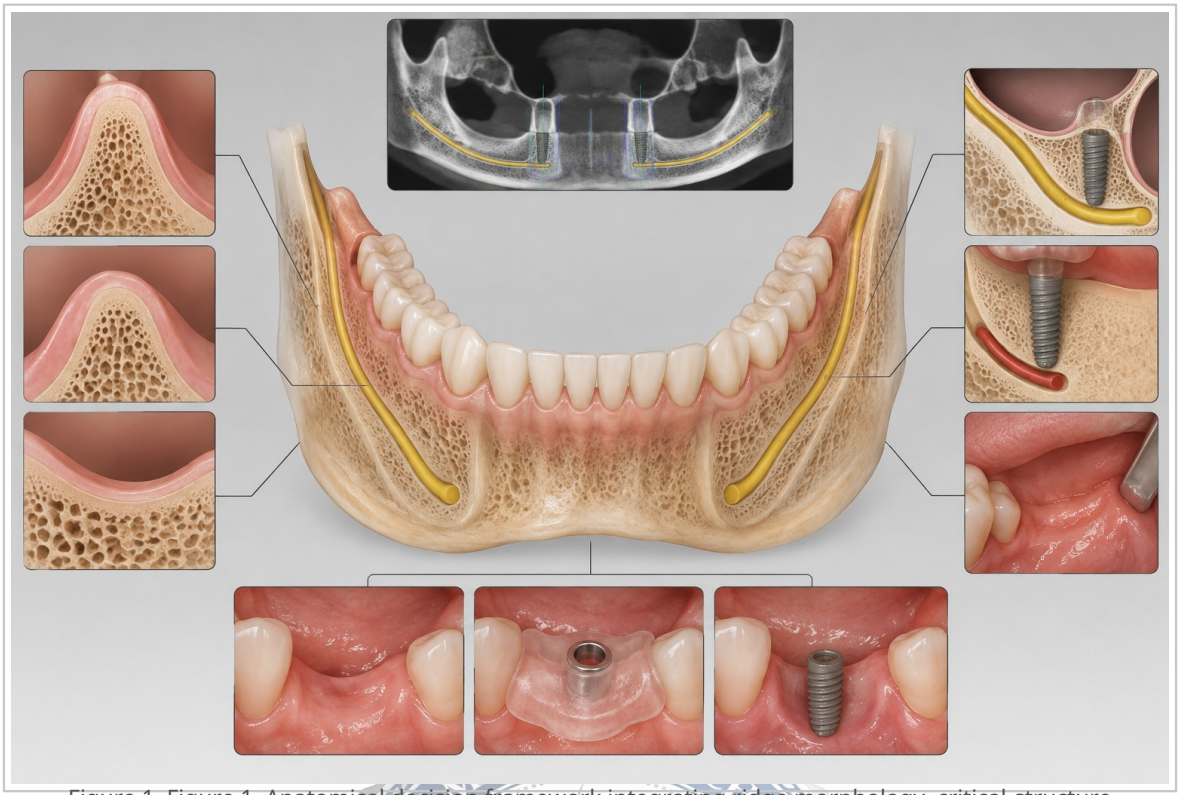


Figure 1. Figure 1. Anatomical decision framework integrating ridge morphology, critical-structure clearance, and tissue accessibility for differentiated implant placement.

3. Results

The following results describe a hypothetical dataset constructed to illustrate a plausible study; they are not observed clinical findings. The cohort comprised 120 adults receiving one implant each, with 40 patients allocated to each of three anatomically differentiated protocols: minimally invasive flapless placement, static template-guided placement, and dynamic navigation-guided placement. Mean age was 49.6 ± 11.8 years, and 66 patients (55.0%) were women. All patients completed clinical follow-up through 12 months. Two implants failed before loading, leaving 118 functioning implants available for the final peri-implant radiographic assessment.

Preoperative cone-beam computed tomography demonstrated distinct anatomical profiles across protocol groups. Patients undergoing flapless placement generally had wider residual ridges and greater separation from adjacent anatomical structures. Static guidance was applied predominantly where prosthetically driven positioning required greater directional control, whereas dynamic navigation was used more frequently in narrow ridges and sites close to the mandibular canal or maxillary sinus. Consequently, the groups represented different baseline risk strata rather than interchangeable treatment populations. Primary clinical and radiological findings are summarized in Table 1.

Table 1. Hypothetical anatomical, procedural, and follow-up outcomes by implantation protocol

Outcome	Minimally invasive flapless	Static template-guided	Dynamic navigation-guided
Patients, n	40	40	40
Preoperative ridge width, mm	7.8 ± 1.0	6.7 ± 0.9	6.1 ± 0.8
Planned clearance from critical structure, mm	3.8 ± 0.8	2.9 ± 0.6	2.5 ± 0.4
Coronal deviation, mm	1.12 ± 0.43	0.76 ± 0.29	0.70 ± 0.27
Apical deviation, mm	1.48 ± 0.54	1.02 ± 0.38	0.91 ± 0.35
Angular deviation, degrees	4.2 ± 1.6	2.7 ± 1.1	2.4 ± 1.0

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Chairside procedure duration, minutes	24.6 ± 6.1	31.8 ± 7.4	36.5 ± 8.2
Pain at 24 hours, 0–10 scale	2.3 ± 1.4	2.7 ± 1.5	2.9 ± 1.6
Implant survival at 12 months, n/N (%)	39/40 (97.5)	40/40 (100)	39/40 (97.5)
Marginal bone loss at 12 months, mm	0.62 ± 0.28	0.58 ± 0.25	0.60 ± 0.27

Values are means ± standard deviations unless otherwise indicated. Placement deviations were calculated by registering postoperative imaging to the preoperative plan. Marginal bone loss was measured relative to prosthetic loading on standardized periapical radiographs and included only surviving implants: 39, 40, and 39 in the respective groups. Procedure duration included chairside guide verification or navigation registration but excluded off-site planning and guide fabrication.

Both guidance protocols showed smaller mean positional deviations than flapless placement without navigation. Compared with the minimally invasive group, mean apical deviation was lower by 0.46 mm with static guidance and 0.57 mm with dynamic navigation. The corresponding differences in angular deviation were 1.5° and 1.8°. Differences between the two guided approaches were comparatively small, with substantial overlap in their observed distributions. These descriptive comparisons were not interpreted as evidence of superiority because anatomical complexity influenced protocol allocation.

Postoperative imaging identified no penetration of the mandibular canal, unintended sinus-floor perforation, or injury to adjacent roots. Apical deviation exceeded 2 mm in seven flapless cases, two static-guidance cases, and one dynamic-navigation case. In each instance, the achieved position retained clearance from the nearest critical structure. Limited flap elevation became necessary in three initially flapless procedures because direct inspection was required to confirm crestal morphology. Two static guides required chairside adjustment before drilling, and navigation registration was repeated in three dynamic cases; all procedures were subsequently completed.

Early postoperative morbidity was modest across groups. Pain scores declined by day 7 to means below 1 on the 0–10 scale in all three groups. Localized swelling occurred in six, eight, and nine patients, respectively, without suppuration or wound dehiscence. No persistent sensory disturbance was recorded. The two early failures occurred in posterior maxillary sites, one after flapless placement and one after dynamic navigation, and both involved loss of stability before definitive restoration.

Among surviving implants, mean marginal bone loss remained below 0.7 mm in every group. The largest between-group difference was 0.04 mm, providing no clear descriptive separation in short-term crestal bone response. Overall, guided placement achieved closer agreement with planned implant positions despite less favorable baseline anatomy, while the minimally invasive protocol had shorter chairside duration in anatomically suitable sites.

4. Discussion

The clinical and radiological justification for differentiated implant protocols rests on matching surgical access and positional control to anatomical complexity, restorative requirements, and patient vulnerability. Minimally invasive surgery and navigation guidance should not be regarded as interchangeable interventions: the former limits tissue disruption, whereas the latter supports spatial execution of a treatment plan. Their combination may be advantageous in selected cases, but neither approach independently guarantees safety or long-term success. A differentiated strategy is therefore more defensible than the routine application of one technique across all implant indications.

Minimally invasive access is most readily justified when three-dimensional imaging demonstrates an adequate bone envelope, the mucosal phenotype is favorable, and the planned trajectory permits a restoration with acceptable functional and hygienic characteristics. Under these conditions, avoiding extensive flap elevation may reduce tissue manipulation and support early postoperative comfort. However, flapless placement restricts direct inspection of the alveolar crest and can conceal dehiscence, fenestration, or an unfavorable ridge contour. Its biological appeal must therefore be

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balanced against the possibility that limited visualization compromises recognition of intraoperative discrepancies.

Radiological assessment provides the principal anatomical basis for this balance. Cone-beam computed tomography can characterize ridge dimensions, cortical contours, adjacent roots, and relationships to the mandibular canal, mental foramen, nasal floor, and maxillary sinus. These features should be interpreted alongside clinical examination rather than treated as sufficient eligibility criteria. Imaging does not reliably establish soft-tissue thickness, keratinized mucosal adequacy, or tissue mobility in isolation. Furthermore, voxel size, motion, and metallic artifacts may affect boundary identification. Acquisition should consequently be justified individually and use an appropriate field of view and exposure protocol.

Navigation-guided placement becomes particularly relevant when small positional deviations could have disproportionate consequences. Examples include restricted interradicular spaces, limited clearance from critical structures, demanding emergence profiles, and multiple implants requiring coordinated restorative alignment. Guidance can support the transfer of a prosthetically driven plan, but its value depends on the accuracy of the entire workflow. Image acquisition, surface registration, planning, guide fabrication or tracking calibration, and intraoperative verification each introduce potential error. Planned safety margins must accommodate cumulative uncertainty rather than assume that navigation reproduces virtual coordinates exactly.

Static and dynamic navigation also impose different practical constraints. Static guides may provide reproducible mechanical direction, yet their performance depends on stable seating, adequate support, sleeve configuration, and sufficient mouth opening. Restricted access can hinder irrigation or instrument passage. Dynamic navigation permits intraoperative modification and avoids some guide-related limitations, but requires reliable registration, tracking visibility, and operator adaptation to screen-mediated feedback. Neither modality should be considered categorically superior without accounting for the clinical indication, system characteristics, and experience of the surgical team.

The choice to elevate a flap remains distinct from the choice to use guidance. Navigation may be useful during open surgery when direct visualization is required, while carefully selected straightforward cases may permit minimally invasive placement without computer-assisted transfer. Conversely, narrow ridges, irregular crestal anatomy, uncertain soft-tissue conditions, and anticipated augmentation may favor flap elevation despite an accurate digital plan. The essential safeguard is willingness to modify the planned approach when clinical findings differ from imaging or when guide stability, registration reliability, or primary implant stability is inadequate.

Interpretation of comparative clinical outcomes requires particular caution because treatment allocation is often influenced by baseline complexity. Patients receiving guided procedures may have more demanding anatomy, whereas flapless surgery may be preferentially selected for favorable sites. Such confounding by indication can obscure either benefit or harm. Differences in early pain, swelling, operative duration, or implant positioning should therefore be evaluated alongside ridge morphology, augmentation requirements, implant location, smoking, periodontal history, and operator experience. Positional accuracy is an important technical endpoint, but it is not a surrogate for implant survival, peri-implant health, or patient satisfaction.

A clinically useful evaluation should also distinguish immediate procedural advantages from durable biological and restorative outcomes. Reduced access trauma does not necessarily translate into less marginal bone remodeling, and accurate placement cannot compensate for inadequate plaque control, unfavorable prosthetic contours, or inappropriate loading. Follow-up should include standardized radiographic assessment, peri-implant tissue evaluation, restorative complications, and patient-reported recovery. Economic interpretation should account for planning, equipment, training, and additional appointments, not simply chairside surgical time. Any efficiency advantage is likely to depend on case volume and workflow maturity.

Overall, differentiated application is best understood as risk-adapted treatment planning rather than technological escalation. Clinical examination establishes tissue and patient-related constraints, radiological analysis defines the anatomical corridor, and restorative planning determines the desired implant position. Minimally invasive access is reasonable when these components align; navigation is

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particularly justified when transfer precision has substantial clinical value. Transparent selection criteria, explicit safety margins, and readiness to convert to direct visualization are central to responsible implementation. Prospective comparisons with adjustment for case complexity and longer follow-up remain necessary to establish which patients obtain meaningful benefit.

5. Conclusion

The clinical and radiological rationale for differentiated implant placement supports selecting minimally invasive and navigation-guided protocols according to anatomical complexity, tissue conditions, and restorative requirements rather than applying either approach routinely. Integration of clinical examination, prosthetically driven planning, and appropriately justified three-dimensional imaging provides a framework for identifying cases in which reduced surgical exposure is feasible and those requiring direct visualization or augmentation.

Minimally invasive placement may be appropriate when bone dimensions, ridge morphology, and soft-tissue characteristics permit reliable implant positioning without extensive flap elevation. Its potential benefits include reduced surgical trauma and improved early postoperative comfort; however, these advantages should not be assumed to outweigh the risks of inadequate visualization in anatomically unfavorable sites. Navigation-guided placement may offer additional value when positional tolerances are narrow, proximity to critical structures increases procedural risk, or prosthetic alignment requires greater control. Nevertheless, guidance does not eliminate deviations between planned and achieved positions, and safety margins remain necessary.

Radiological assessment should therefore support both treatment selection and postoperative evaluation, while avoiding unnecessary imaging exposure. Implant position, anatomical clearance, and peri-implant bone changes should be interpreted alongside healing, complications, and functional outcomes, rather than treated as independent indicators of success. Operator experience, guide stability, registration accuracy, and intraoperative verification remain important determinants of procedural reliability.

Overall, an individualized strategy appears more clinically defensible than universal adoption of a single technique. Comparative prospective studies with standardized outcome definitions, adequate follow-up, and adjustment for baseline anatomical differences are needed to establish whether improvements in placement accuracy and early recovery translate into sustained biological, prosthetic, and patient-reported benefits.

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REFERENCES

1. Bornstein, M. M., Scarfe, W. C., Vaughn, V. M., & Jacobs, R. (2014). Cone beam computed tomography in implant dentistry: A systematic review focusing on guidelines, indications, and radiation dose risks. The International Journal of Oral & Maxillofacial Implants, 29(Suppl.), 55–77.

2. Tyndall, D. A., Price, J. B., Tetradis, S., Ganz, S. D., Hildebolt, C., & Scarfe, W. C. (2012). Position statement of the American Academy of Oral and Maxillofacial Radiology on selection criteria for the use of radiology in dental implantology with emphasis on cone beam computed tomography. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology, 113(6), 817–826.

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REFERENCES · CONTINUED

3. Schneider, D., Marquardt, P., Zwahlen, M., & Jung, R. E. (2009). A systematic review on the accuracy and the clinical outcome of computer-guided template-based implant dentistry. Clinical Oral Implants Research, 20(Suppl. 4), 73–86.

4. Van Assche, N., Vercruyssen, M., Coucke, W., Teughels, W., Jacobs, R., & Quirynen, M. (2012). Accuracy of computer-aided implant placement. Clinical Oral Implants Research, 23(Suppl. 6), 112–123.

5. Tahmaseb, A., Wismeijer, D., Coucke, W., & Derksen, W. (2014). Computer technology applications in surgical implant dentistry: A systematic review. The International Journal of Oral & Maxillofacial Implants, 29(Suppl.), 25–42.

6. Tahmaseb, A., Wu, V., Wismeijer, D., Coucke, W., & Evans, C. (2018). The accuracy of static computer-aided implant surgery: A systematic review and meta-analysis. Clinical Oral Implants Research, 29(Suppl. 16), 416–435.

7. Vercruyssen, M., Hultin, M., Van Assche, N., Svensson, K., Naert, I., & Quirynen, M. (2014). Guided surgery: Accuracy and efficacy. Periodontology 2000, 66(1), 228–246.

8. Chrcanovic, B. R., Albrektsson, T., & Wennerberg, A. (2014). Flapless versus conventional flapped dental implant surgery: A meta-analysis. PLOS ONE, 9(6), Article e100624.

9. Block, M. S., Emery, R. W., Lank, K., & Ryan, J. (2017). Implant placement accuracy using dynamic navigation. The International Journal of Oral & Maxillofacial Implants, 32(1), 92–99.

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