ISSN 0973-2063 (online) 0973-8894 (print)

Bioinformation 22(10): 6565-6569 (2026)

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BIOINFORMATION
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BIOMEDICAL INFORMATICS

www.bioinformation.net

Volume 22(10)

Research Article

Received October 1, 2026; Revised October 31, 2026; Accepted October 31, 2026, Published October 31, 2026

DOI: 10.6026/973206300226565

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

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Edited by Ritik Kashwani
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Citation: Verma *et al.* Bioinformation 22(10): 6565-6569 (2026)

A comparative evaluation of flapless versus open flap implant placement techniques on post-operative healing and marginal bone loss

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ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 6565-6569 (2026)
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Abstract:
Limited prospective evidence directly compares flapless and open flap implant placement regarding post-operative morbidity, peri-implant healing and marginal bone preservation. Therefore, it is of interest to compare the flapless implant placement (Group A, n = 35) with the conventional open flap technique (Group B, n = 35) in 70 partially edentulous patients, assessing post-operative pain, swelling, healing index, implant survival and marginal bone loss over 12 months. Flapless surgery showed significantly lower pain and swelling, superior early soft-tissue healing, shorter operative time and reduced 12-month marginal bone loss (0.48 ± 0.19 mm vs 0.72 ± 0.24 mm; $p < 0.001$), while implant survival was comparable between groups (97.1% vs 94.3%; $p = 0.55$). Flapless implant placement is preferable for appropriately selected patients with adequate bone volume and keratinised tissue, whereas the open flap approach remains essential when augmentation, anatomical visualisation or soft-tissue modification is required. These findings strengthen evidence-based implant treatment planning by providing 12-month comparative outcomes that support technique selection according to anatomical conditions and expected clinical outcomes.

Keywords: Flapless implant surgery, open flap implant placement, marginal bone loss (MBL), post-operative healing, implant survival, crestal bone preservation, minimally invasive implantology

Background:
Osseointegrated dental implants have become the standard of care for the rehabilitation of partially and fully edentulous patients, offering predictable long-term outcomes and improving quality of life **[1].** The surgical technique used for implant placement is a critical variable influencing both short-term healing and long-term peri-implant bone stability. Two principal approaches have been established: the conventional open flap technique, which involves raising a mucoperiosteal flap to expose the alveolar crest and the flapless technique, in which a tissue punch or narrow incision is used to access the implant site without full flap elevation **[2].** The open flap approach has been the standard technique for decades, providing direct visualisation of the alveolar bone, enabling simultaneous bone augmentation procedures and facilitating precise implant positioning. Its principal disadvantages are greater surgical trauma, post-operative pain, swelling and the risk of crestal bone resorption related to periosteal stripping and disruption of the local blood supply **[3].** Flapless implant placement was introduced to minimise these drawbacks by preserving the soft tissue envelope and periosteal blood supply, thereby reducing operative time, patient morbidity and the interval between surgery and prosthetic loading **[4].** Marginal bone loss (MBL) around implants is a key indicator of peri-implant health and long-term implant success. Early crestal bone remodelling in the first year following placement is influenced by multiple factors including the surgical technique, implant design, implant-abutment connection, occlusal loading and the presence of keratinised mucosa **[5].** Several systematic reviews and randomised controlled trials have investigated differences in MBL between flapless and open flap approaches, with inconsistent results attributable to heterogeneous patient populations, varying follow-up periods and differences in implant systems **[6, 7].** Therefore, it is of interest to report for well-designed prospective studies with standardised outcome measures and adequate follow-up to inform clinical decision-making.

Materials and Methods:

Study design and ethical approval:

This prospective, randomised, parallel-group controlled clinical study was conducted at the Department of Periodontology & Oral Implantology and the Department of Prosthodontics, Crown & Bridge across participating institutions between January 2022 and March 2024. Ethical approval was obtained from the Institutional Review Boards of all participating centres. The study was registered with the Clinical Trials Registry-India (CTRI/2022/01/040187). Written informed consent was obtained from all participants prior to enrolment.

Inclusion and exclusion criteria:

Patients aged 18–65 years with a single missing tooth in the posterior mandible or maxilla, adequate bone volume (minimum bone height 10 mm, width 6 mm) confirmed by CBCT, a minimum of 2 mm keratinised tissue at the implant site and good systemic health were eligible for inclusion. Patients were excluded if they had uncontrolled diabetes, active periodontal disease, a history of radiotherapy to the head and neck, current smoking of more than 10 cigarettes per day, bisphosphonate use, pregnancy or lactation, or required simultaneous bone augmentation procedures.

Randomisation and blinding:

Seventy patients were randomised 1:1 using a computer-generated block randomisation sequence (block size 4, allocation ratio 1:1) prepared by an independent statistician. Allocation was concealed using sealed opaque envelopes opened at the time of surgery. Outcome assessors and the radiographic analyst were blinded to group allocation; blinding of the operating surgeon was not feasible given the nature of the interventions.

Surgical protocols:

All procedures were performed under local anaesthesia by experienced implantologists. In Group A (flapless), a tissue punch of diameter equal to the implant platform was used to remove a circular tissue disc, followed by sequential osteotomy preparation using a surgical guide without flap reflection. In Group B (open flap), a crestal incision with mesial and distal releasing incisions was made and a full-thickness mucoperiosteal flap was elevated to expose the alveolar crest. In both groups, implants of identical dimensions (Nobel Biocare Nobel Active, 4.3 mm × 11.5 mm) were placed at bone level using a torque-controlled unit. Healing abutments were placed immediately; primary wound closure was achieved in Group B. No prophylactic antibiotics were prescribed; patients received ibuprofen 400 mg three times daily for three days.

Outcome measures:

Primary outcomes were post-operative pain (VAS 0–100 mm at 24, 72 and 168 hours), post-operative swelling (facial measurement at 24 and 72 hours), soft-tissue healing index (Landry–Turnbull–Howley scale at 7 and 14 days), operative time (minutes) and marginal bone loss (MBL, mm) at 3, 6 and 12 months measured on standardised periapical radiographs using a long-cone paralleling technique with film holders. Secondary outcomes included implant survival at 12 months (defined as absence of mobility, pain, suppuration or radiographic peri-implant radiolucency) and patient satisfaction on a five-point Likert scale at four weeks.

Statistical analysis:

Data were analysed using SPSS version 26.0. Continuous variables are presented as mean ± SD. Between-group comparisons used the independent-samples t-test or Mann–Whitney U-test as appropriate. Repeated measures were analysed with mixed-model ANOVA. Implant survival was compared using the chi-square test. A p-value of < 0.05 was considered statistically significant.

Results:

Seventy patients (35 per group) were enrolled; 67 completed the 12-month follow-up (Group A: n = 34; Group B: n = 33). Two patients in Group B and one in Group A were lost to follow-up. Baseline demographic and clinical characteristics were comparable between groups **(Table 1).** Post-operative pain was significantly lower in the flapless group at 24 hours (VAS 24.6 ± 10.3 vs 41.8 ± 13.2, $p < 0.001$) and at 72 hours (14.2 ± 7.8 vs 27.4 ± 9.6, $p < 0.001$); no significant difference was observed at 168 hours ($p = 0.14$). Facial swelling was significantly less in Group A at 24 hours ($p < 0.001$) and 72 hours ($p = 0.002$). Healing index scores were significantly superior in Group A at both 7 days ($p < 0.001$) and 14 days ($p = 0.003$). Mean operative time was significantly shorter in the flapless group (18.4 ± 4.2 min vs 32.7 ± 6.8 min, $p < 0.001$). Marginal bone loss was significantly lower in Group A at all-time points: at 3 months (0.18 ± 0.09 vs 0.31 ± 0.12 mm, $p < 0.001$), 6 months (0.32 ± 0.14 vs 0.54 ± 0.18 mm, $p < 0.001$) and 12 months (0.48 ± 0.19 vs 0.72 ± 0.24 mm, $p = 0.001$). Twelve-month implant survival was 97.1% (Group A) vs 94.3% (Group B); this difference was not statistically significant ($p = 0.55$). Patient satisfaction was significantly higher in Group A at four weeks ($p = 0.01$). Full results are presented in **(Tables 3)**.

Table 1: Baseline demographic and clinical characteristics

Variable	Group A: Flapless (n = 35)	Group B: Open Flap (n = 35)
Age, mean ± SD (years)	38.4 ± 9.6	39.1 ± 10.2
Female, n (%)	18 (51.4)	17 (48.6)
Jaw: maxilla, n (%)	19 (54.3)	20 (57.1)
Bone height, mean ± SD (mm)	13.2 ± 1.8	13.0 ± 1.9
Bone width, mean ± SD (mm)	7.4 ± 0.9	7.3 ± 1.0
Keratinised tissue width, mean ± SD (mm)	3.2 ± 0.7	3.1 ± 0.8
Pre-op VAS pain, mean ± SD (mm)	8.4 ± 5.2	8.1 ± 4.9

Table 2: Post-operative pain, swelling, healing index and operative time

Parameter	Group A: Flapless	Group B: Open Flap	p-value
VAS pain 24 h (mm)	24.6 ± 10.3	41.8 ± 13.2	<0.001*
VAS pain 72 h (mm)	14.2 ± 7.8	27.4 ± 9.6	<0.001*
VAS pain 168 h (mm)	5.1 ± 3.4	7.2 ± 4.1	0.14 (NS)
Swelling 24 h (mm)	2.1 ± 0.8	4.6 ± 1.2	<0.001*
Swelling 72 h (mm)	1.2 ± 0.6	2.8 ± 0.9	0.002*
Healing index, Day 7 (score)	4.3 ± 0.5	3.1 ± 0.7	<0.001*
Healing index, Day 14 (score)	4.7 ± 0.4	4.1 ± 0.6	0.003*
Operative time (min)	18.4 ± 4.2	32.7 ± 6.8	<0.001*

** Statistically significant (p < 0.05); NS = not significant*

Table 3: Marginal bone loss (mm) and implant survival at follow-up

Time point	Group A: Flapless	Group B: Open Flap	p-value
MBL at 3 months (mm)	0.18 ± 0.09	0.31 ± 0.12	<0.001*
MBL at 6 months (mm)	0.32 ± 0.14	0.54 ± 0.18	<0.001*
MBL at 12 months (mm)	0.48 ± 0.19	0.72 ± 0.24	0.001*
Implant survival at 12 months	97.1% (34/35)	94.3% (33/35)	0.55 (NS)
Patient satisfaction (4 weeks)	4.6 ± 0.4	4.1 ± 0.6	0.01*

** Statistically significant (p < 0.05); NS = not significant*

Discussion:

The present study showed that flapless implant placement was associated with significantly lower early post-operative pain, reduced facial swelling, and superior soft-tissue healing and shorter operative time compared with the conventional open flap technique. These findings are consistent with the biological rationale for flapless surgery: preservation of the periosteal blood supply and the soft-tissue envelope reduces localised tissue trauma and the ensuing acute inflammatory response **[8].** A recent systematic review and meta-analysis similarly reported that flapless placement produced significantly lower pain scores and patient-reported morbidity in the first 72 post-operative hours compared with flap surgery, with no difference in long-term survival **[9].** The significantly lower MBL observed in the flapless group at all-time points (0.48 vs 0.72 mm at 12 months) is clinically meaningful. Crestal bone preservation following flapless placement has been attributed to the intact periosteum maintaining the vascular supply to the alveolar crest, thereby limiting the osteoclastic remodelling triggered by periosteal stripping in the open flap technique **[10].** These values fall well within the established threshold for implant success (MBL < 1.5 mm in the first year) **,** but the inter-group difference is consistent with findings from recent RCTs reporting 0.2–0.3 mm lower crestal resorption with flapless techniques over 12 months**.** The absence of a statistically significant difference in 12-month implant survival (97.1% vs 94.3%, p = 0.55) confirms that both techniques achieve clinically acceptable success rates when patient selection criteria are rigorously applied. This finding aligns with systematic review data reporting pooled survival rates of 96–99% for both approaches over follow-up periods of 12–36 months **[11].** The critical determinant of flapless success is patient selection: adequate bone volume and width, a minimum of 2 mm keratinised tissue and the use of CBCT-guided surgical planning are prerequisites for predictable outcomes **[12].** The open flap technique retains clear indications where direct bone visualisation is required: simultaneous guided bone regeneration, correction of bony defects, management of fenestrations or dehiscences and cases with limited keratinised tissue requiring soft-tissue augmentation **[13].** Digital technologies including CBCT-based surgical guides, dynamic navigation and immediate loading protocols are progressively extending the indications for flapless placement while maintaining precision **[14].** Flap elevation under these circumstances would negate the advantage of a guided approach, reinforcing the value of flapless surgery in digitally planned implantology **[15].** Limitations of the study include the restriction to single posterior-tooth implants, the 12-month follow-up that does not capture longer-term bone stability and the inclusion of only fully dentate patients with adequate native bone, limiting generalisability to cases requiring simultaneous augmentation. Inter-operator variability was minimised through protocol standardisation and calibration, but multi-centre contributions introduce inherent variability in tissue handling. Future long-term RCTs should evaluate MBL beyond 36 months and investigate the influence of implant macro-design and platform-switching on the comparative bone-preservation advantage of flapless surgery.

Conclusion:

Flapless implant placement significantly reduces early post-operative morbidity and 12-month crestal bone resorption without compromising implant survival in appropriately selected patients. Open flap surgery remains essential when augmentation, anatomical visualisation, or soft-tissue management is required. Careful patient selection, CBCT-guided planning and surgeon expertise are critical determinants of flapless implant success.

Acknowledgement:

The authors thank all participants and the administrative staff of the participating institutions for their support in conducting this study.

Conflict of interest: The authors declare no conflict of interest.

Funding: No external funding was received for this study.

Ethical approval:

Ethical approval was obtained from the Institutional Review Boards of all participating centres. The study was registered

with the Clinical Trials Registry – India (CTRI/2022/01/040187). Written informed consent was obtained from all participants prior to enrolment.

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