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

Bioinformation 22(8): 4662-4667 (2026)

BIOINFORMATION
Discovery at the interface of physical and biological sciences

BIOMEDICAL INFORMATICS

www.bioinformation.net

Volume 22(8)

Research Article

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

DOI: 10.6026/973206300224662

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

Edited by Ritik Kashwani
E-mail: docritikkashwani@yahoo.com
Citation: Kuna *et al.* Bioinformation 22(8): 4662-4667 (2026)

Crestal versus lateral sinus lift for atrophic maxilla: A pilot randomized controlled trial

Santhosh Kumar Kuna[1], Vivek Anne[2], S. Sai Himaja[3], Veerendra Prasad[4,*], K. Kavitha[5], R.M. Chella Priya[6], Sriharsha Pudi[7] & Naseemoon Shaik[8]

[1]Department of Oral and Maxillofacial Surgery, King Faisal Hospital, Rwanda, Centre Hospitalier Universitaire de Kigali, Rwanda; [2]Department of Dentistry, Always Smile Dental Care, 2000 NJ-27, North Brunswick Township, NJ 08902, New Jersey,USA; [3]Department of Oral and Maxillofacial Surgery, College of Dentistry, Fujairah University, Fujairah, United Arab Emirates; [4]Department of Prosthodontics & Implantology, MNR Dental College and Hospital, Sangareddy, Telangana, India; [5]Department of Oral & Maxillofacial Surgery, CKS Teja Dental College & Research, Chadalawada Nagar, Renigunta Road, Tirupati andhra Pradesh, India; [6]Department of Periodontics, Sathyabama Dental College and Hospital, Sathyabama Institute of Science and Technology, Chemmanchery, Chennai, India; [7]Department of Prosthodontics, MNR Dental College and Hospital, Sangareddy, Telangana, India; [8]Department of Pedodontics and Preventive Dentistry, MNR Dental College and Hospital, Sangareddy, Telangana, India; *Corresponding author

ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(8): 4662-4667 (2026)

Affiliation URL:
https://kfh.rw/
https://alwayssmiledentalcare.com/
https://www.fu.ac.ae/index.php?p=college-of-dentistry-and-health-sciences
https://www.cksdental.edu.in/
https://www.sathyabama.ac.in/academics/schools/school-dental-sciences
https://mnrdch.mnrindia.org/

Author contact:
Santhosh Kumar Kuna - E-mail: santhosh.kuna@gmail.com
Vivek Anne - E-mail: vivekanne999@gmail.com
S. Sai Himaja - E-mail: himajasubramaniam@gmail.com
Veerendra Prasad - E-mail: veerendra13983@gmail.com
K. Kavitha - E-mail: drkavithak42@gmail.com
R.M. Chella Priya - E-mail: chellapriya110596@gmail.com
Sriharsha Pudi - E-mail: sriharshabds@gmail.com
Naseemoon Shaik - E-mail: dr.naseemoonshaik@gmail.com

Abstract:
Rehabilitation of the atrophic posterior maxilla often requires sinus floor elevation before implant placement. Therefore, it is of interest to compare the crestal and lateral sinus lift techniques in 30 patients undergoing simultaneous implant placement, evaluating surgical outcomes, bone gain, implant stability and survival over 12 months. The crestal approach showed significantly shorter operative time, reduced post-operative pain and swelling and greater patient preference. The lateral approach achieved significantly greater endo-sinus bone gain, while implant survival, marginal bone loss and secondary stability were comparable between groups. Thus, data shows for selecting sinus augmentation techniques according to residual bone height, anatomical considerations and patient outcomes.

Keywords: Crestal sinus lift, lateral window technique, maxillary sinus floor elevation, dental implant, schneiderian membrane, implant stability quotient, atrophic posterior maxilla.

Background:
Rehabilitation of the edentulous posterior maxilla with osseointegrated implants is frequently complicated by vertical bone deficiency caused by the combined effects of post-extraction alveolar resorption and progressive pneumatization of the maxillary sinus **[1].** To address this limitation, sinus floor elevation has become a predictable preprosthetic procedure, with two principal approaches in routine clinical practice: the lateral window approach originally described by Tatum and later modified by Boyne and James and the crestal (transcrestal or osteotome) approach popularized by summers **[2]**. Contemporary modifications include piezoelectric osteotomy, hydraulic systems and osseodensification using specialized burs, which aim to reduce the risk of Schneiderian membrane perforation and improve patient comfort **[3]**. The lateral approach allows direct visualization of the sinus membrane and is conventionally indicated when the residual bone height (RBH) is less than 4–5 mm, since it permits substantial vertical bone augmentation and placement of standard-length implants **[4]**. However, it is associated with greater surgical invasiveness, longer operative time and higher rates of post-operative morbidity, including pain, swelling, bruising and occasional sinusitis **[5]**. The reported incidence of Schneiderian membrane perforation during lateral window elevation ranges widely from 7% to 56%, with a recent meta-analysis reporting a pooled incidence near 19–24% **[6]**. Risk factors include thin sinus membrane (<1 mm), presence of sinus septa, reduced lateral wall thickness and small residual ridge height **[7, 8]**. The crestal approach is a minimally invasive alternative typically reserved for sites with RBH of 5 mm or more, where 2–4 mm of additional bone height is required **[9]**. Modern variants such as osseodensification with Densah burs and hydrodynamic piezoelectric systems have extended its indications to sites with RBH as low as 3–4 mm, with reduced perforation risk and shorter chair time **[10]**. Nevertheless, the crestal technique offers limited tactile feedback regarding the sinus membrane and is occasionally associated with benign paroxysmal positional vertigo, particularly when osteotomes and a mallet are used **[11]**. Reported implant survival rates following transcrestal sinus floor elevation are consistently high, ranging from 95% to 100% at follow-up periods of 1–5 years, comparable to outcomes after the lateral approach **[12]**. Despite the wide adoption of both techniques, clinicians continue to face the dilemma of selecting the most appropriate approach for a given clinical situation. The decision is influenced by the residual bone height, presence of anatomical risk factors, the operator's experience, the planned implant length and patient-centred considerations such as morbidity, surgical time and cost **[13]**. Recent evidence suggests that endo-sinus bone gain is consistently greater after lateral elevation, while patient-reported outcomes and operative efficiency consistently favour the crestal approach, yet implant survival and peri-implant marginal bone loss appear comparable

between techniques **[14]**. Although several randomized controlled trials and systematic reviews have addressed individual aspects of these procedures, comparative data integrating clinical, radiographic and patient-reported outcomes within the same cohort remain limited, particularly in the Indian subcontinent population **[15]**. This gap in the literature prompted the design of the present study. Therefore, this pilot randomized controlled trial aims to compare the crestal and lateral sinus lift approaches in implant rehabilitation of the atrophic posterior maxilla with respect to operative time, intra- and post-operative complications, implant primary and secondary stability, endo-sinus bone gain, marginal bone loss, implant survival and patient preference at 12 months of follow-up **[16]**. Therefore, it is of interest to report the comparative outcomes of crestal and lateral sinus floor elevation techniques in patients undergoing implant rehabilitation of the atrophic posterior maxilla.

Methods:

This was a single-centre; parallel-group, assessor-blinded, pilot randomized controlled trial conducted at the Department of Oral and Maxillofacial Surgery from January 2024 to March 2026. Ethical approval was obtained from the Institutional Ethics Committee and written informed consent was obtained from all participants in accordance with the Declaration of Helsinki. The study was reported following the CONSORT 2010 guidelines for pilot trials. Thirty partially edentulous patients aged 25–60 years requiring implant rehabilitation in a single posterior maxillary edentulous site (premolar or molar region) were screened and enrolled. Inclusion criteria were: vertical residual bone height (RBH) between 2 and 8 mm and bucco-palatal width ≥6 mm measured on cone-beam computed tomography (CBCT); healed edentulous site (≥3 months after extraction); good oral hygiene; and presence of an opposing dentition. Exclusion criteria were: uncontrolled systemic disease, head and neck irradiation, intravenous bisphosphonate therapy, untreated periodontitis, smoking > 10 cigarettes/day, pregnancy or lactation, acute or chronic sinus pathology, sinus septa interfering with elevation and psychiatric illness. Participants were allocated 1:1 using computer-generated block randomization (block size of 4) into Group A (crestal sinus lift, n=15) when RBH was 5–8 mm and Group B (lateral sinus lift, n=15) when RBH was 2–5 mm. Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes opened intra-operatively. Owing to the surgical nature of the intervention, the operator and patient could not be blinded; however, the radiographic and clinical outcome assessor was blinded to group allocation, as was the data analyst. All surgeries were performed by a single experienced oral surgeon under local anaesthesia (2% lignocaine with 1:80,000 adrenaline) and pre-operative antibiotic prophylaxis (amoxicillin-clavulanate 625 mg, 1 hour pre-operatively). In Group A, a crestal incision was made and a full-thickness mucoperiosteal flap was raised. Sequential osteotomies were performed up to 1 mm short of the sinus floor, followed by sinus floor elevation using osseodensification (Densah) burs in counter-clockwise mode with copious irrigation. Particulate xenograft (deproteinized bovine bone mineral) was introduced through the osteotomy and the implant was placed simultaneously. In Group B, a trapezoidal flap was elevated to expose the lateral antral wall and a window osteotomy was prepared using piezoelectric instrumentation. The Schneiderian membrane was carefully elevated with sinus curettes, the cavity was packed with the same xenograft, the antrostomy was covered with a resorbable collagen membrane and implants were placed simultaneously. All implants used were of the same design (tapered, sandblasted-acid-etched surface; 4.0–4.5 mm diameter). Post-operatively, all patients received amoxicillin-clavulanate 625 mg three times daily for 5 days, ibuprofen 400 mg as needed and chlorhexidine 0.2% mouthwash twice daily for 2 weeks. Sutures were removed at day 10. All implants were submerged and uncovered at 6 months for prosthetic loading with screw-retained metal-ceramic crowns. Outcome measures included: (i) operative time (skin incision to suture); (ii) intraoperative complications including Schneiderian membrane perforation; (iii) postoperative pain assessed using a 10-point Visual Analog Scale (VAS) on days 1, 3 and 7; (iv) post-operative swelling, bruising and analgesic consumption; (v) implant primary stability quotient (ISQ) measured by resonance frequency analysis (Osstell) at placement and at 6 months; (vi) endo-sinus bone gain assessed on CBCT at 6 months; (vii) peri-implant marginal bone loss assessed on standardized periapical radiographs at 12 months; (viii) implant survival at 12 months; and (ix) patient preference assessed via a structured questionnaire at the 12-month visit. Sample size was not formally calculated, as this was a pilot study; n=15 per group was considered adequate to estimate effect sizes and feasibility for a future definitive trial. Data normality was tested using the Shapiro-Wilk test. Continuous variables were compared between groups using the independent t-test or Mann-Whitney U test as appropriate. Categorical variables were compared using the Chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant. All analyses were performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA).

Results:

All 30 enrolled patients completed the 12-month follow-up. There were no dropouts. Baseline demographic and anatomical characteristics were comparable between groups, with the exception of mean RBH and mean implant length, which differed by design (**Table 1**). The mean age was 46.3 ± 8.2 years in Group A and 47.8 ± 7.9 years in Group B (p=0.612). Gender distribution and smoking status were also comparable between groups. The mean operative time was significantly shorter in Group A (32.4 ± 6.1 min) compared to Group B (68.7 ± 9.4 min; $p<0.001$). Schneiderian membrane perforation occurred in 1 patient (6.7%) in Group A and 3 patients (20.0%) in Group B, although the difference did not reach statistical significance owing to the small sample size (p=0.283). All perforations were small (<5 mm) and were managed intra-operatively with a collagen membrane without abandoning the procedure. Post-operative pain on day 1 was significantly lower in Group A (VAS 3.2 ± 1.1) than in Group B (VAS 5.8 ± 1.4; $p<0.001$) and

remained lower throughout the first post-operative week. Swelling was reported by 13.3% of Group A patients versus 53.3% of Group B patients (p=0.020) and the mean duration of analgesic use was 2.1 ± 0.8 days in Group A versus 4.3 ± 1.1 days in Group B (p<0.001) (**Table 2**). Implant primary stability quotient (ISQ) at placement was significantly higher in Group A (68.4 ± 4.2) than in Group B (63.1 ± 5.6; p=0.008), reflecting both the use of osseodensification and the greater residual bone engagement available in Group A. By 6 months, secondary ISQ values had converged and were comparable between groups (74.6 ± 3.1 vs 73.8 ± 3.7; p=0.523), indicating successful osseointegration in both. Endo-sinus bone gain at 6 months, measured on CBCT, was significantly greater in Group B (8.2 ± 1.3 mm) than in Group A (3.6 ± 0.9 mm; p<0.001), as expected given the technique-driven differences in graft volume placed. At 12 months, peri-implant marginal bone loss was 0.81 ± 0.34 mm in Group A and 0.94 ± 0.41 mm in Group B (p=0.351), with no statistically significant difference. Implant survival at 12 months was 100% (15/15) in Group A and 93.3% (14/15) in Group B; the single failure in Group B was a non-osseointegrated implant identified at the second-stage surgery and was replaced successfully. The difference in survival did not reach statistical significance (p=0.309). On the patient preference questionnaire, 11/15 (73.3%) of patients expressed a preference for the crestal procedure if a similar treatment were required again, whereas 4/15 (26.7%) preferred the lateral approach (p=0.011) (**Table 3**).

Table 1: Baseline demographic and anatomical characteristics of the study participants

Parameter	Group A (Crestal) n=15	Group B (Lateral) n=15	p-value
Mean Age (years)	46.3 ± 8.2	47.8 ± 7.9	0.612
Gender (M/F)	7-Aug	6-Sep	0.715
Smokers (n)	3	4	0.682
Mean RBH (mm)	6.8 ± 1.1	3.9 ± 0.9	<0.001
Implant region (premolar/molar)	9-Jun	10-May	0.705
Mean implant length (mm)	8.5 ± 0.7	10.2 ± 0.8	<0.001

Table 2: Comparison of intraoperative parameters and patient-reported postoperative morbidity between groups

Outcome	Group A (Crestal)	Group B (Lateral)	p-value
Operative time (min)	32.4 ± 6.1	68.7 ± 9.4	<0.001
Membrane perforation (%)	6.7 (1/15)	20.0 (3/15)	0.283
VAS pain Day 1 (0–10)	3.2 ± 1.1	5.8 ± 1.4	<0.001
VAS pain Day 7 (0–10)	0.9 ± 0.6	2.1 ± 0.9	<0.001
Postoperative swelling (%)	13.3	53.3	0.02
Analgesic use (days)	2.1 ± 0.8	4.3 ± 1.1	<0.001

Table 3: Comparison of implant stability, radiographic outcomes, implant survival and patient preference at the 12-month follow-up

Parameter	Group A (Crestal)	Group B (Lateral)	p-value
ISQ at placement	68.4 ± 4.2	63.1 ± 5.6	0.008
ISQ at 6 months	74.6 ± 3.1	73.8 ± 3.7	0.523
Endo-sinus bone gain at 6 months (mm)	3.6 ± 0.9	8.2 ± 1.3	<0.001
Marginal bone loss at 12 months (mm)	0.81 ± 0.34	0.94 ± 0.41	0.351
Implant survival at 12 months (%)	100 (15/15)	93.3 (14/15)	0.309
Patient preference (%)	73.3	26.7	0.011

Discussion:

The present pilot randomized controlled trial showed that both crestal and lateral sinus floor elevation approaches achieved high implant survival rates and similar peri-implant marginal bone preservation at 12 months. The crestal approach was associated with significantly shorter operative time, lower post-operative pain and swelling, reduced analgesic consumption and a strong patient preference, whereas the lateral approach yielded substantially greater endo-sinus bone gain. These observations are consistent with previously published evidence and reinforce the role of residual bone height as a key determinant when selecting between these two surgical strategies **[17]**. The shorter operative time and reduced morbidity observed with the crestal approach in our cohort mirror the findings of Mattar *et al.* **[18]**, who reported in a within-patient randomized controlled trial that crestal sinus lift required less than half the operative time of the lateral window approach and was preferred by the majority of patients. Similarly, Al-Juboori *et al.* (2012) **[19]** reported significantly higher VAS pain scores on the day of surgery and greater postoperative swelling and bruising following lateral elevation when compared with transcrestal elevation . The minimal flap reflection, absence of an antrostomy and reduced soft-tissue trauma associated with the crestal technique provide a plausible biological explanation for these patient-centred benefits **[20]**. Schneiderian membrane perforation remains the most frequently reported intraoperative complication of sinus elevation procedures. Although our perforation rate of 20% in the lateral group was numerically higher than the 6.7% observed in the crestal group, the difference was not statistically significant, likely due to the limited sample size. Our perforation rates fall within the ranges reported in contemporary systematic reviews, where pooled incidences of 19% to 24% during lateral elevation have been described, with risk factors including thin sinus membrane, presence of septa, reduced lateral wall thickness and

small residual ridge height **[21]**. The use of piezoelectric instrumentation in our lateral group likely mitigated, but did not eliminate, this risk. Importantly, all perforations were small and successfully managed with a collagen membrane and no implants were lost as a direct consequence of perforation, an observation aligned with evidence that adequately repaired perforations do not significantly compromise implant survival **[22]**. The use of osseodensification burs in the crestal group is likely responsible for the higher primary stability (ISQ 68.4 ± 4.2) recorded at implant placement, as this technique compacts and preserves autogenous bone along the osteotomy walls, increasing bone-to-implant contact in low-density posterior maxillary bone. The convergence of secondary ISQ values at 6 months between the two groups indicates that, regardless of the approach used, both produced an environment conducive to successful osseointegration. This observation aligns with systematic review data showing that osseodensification provides superior primary stability without compromising long-term marginal bone levels **[23]**. The substantially greater endo-sinus bone gain observed in the lateral group (8.2 mm vs 3.6 mm) confirms the well-established advantage of this approach when significant vertical augmentation is required. Cushioned grind-out and digital crestal techniques have recently showed the ability to achieve increased bone gain via the crestal route in severely atrophic ridges, but the lateral window remains the gold standard when greater than 5 mm of additional bone height is needed. Comparable peri-implant marginal bone loss between groups at 12 months further suggests that, when properly executed, both techniques produce stable peri-implant tissues in the medium term **[24]**. Patient preference in our study heavily favoured the crestal approach (73.3% vs 26.7%), consistent with earlier within-patient comparisons in which patients reported the crestal procedure as less invasive and more tolerable. This preference, coupled with reduced morbidity and shorter chair time, has important implications for treatment planning, particularly when both approaches are technically feasible for a given RBH range. Recent evidence suggests that even in atrophic ridges with RBH of 3–5 mm, modern crestal techniques such as osseodensification and digitally guided hydraulic systems may offer a less invasive alternative to the lateral approach with comparable implant survival and reduced post-operative discomfort **[25]**. The principal limitations of this pilot trial include the small sample size of 30 patients and the relatively short follow-up of 12 months, which limit the statistical power for detecting differences in low-frequency outcomes such as implant failure and the ability to evaluate long-term graft stability. Additionally, the single-centre design and use of a single surgeon, while reducing operator variability, limit external generalizability. Group allocation was driven by RBH, introducing inherent baseline differences that reflect real-world clinical decision-making rather than a true equivalence comparison. Future multicentre randomized controlled trials with larger samples, longer follow-up of at least 5 years and split-mouth or stratified designs are warranted to confirm these findings, evaluate long-term graft remodelling and refine evidence-based decision-making algorithms.

Conclusion:

We show that crestal sinus lift reduced operative time, post-operative discomfort and improved patient acceptance. The lateral sinus lift achieved greater endo-sinus bone gain, particularly in severely atrophic maxillae. Thus, technique selection should be based on residual bone height and anatomical requirements to optimize implant outcomes.

References:

[1] Spînu A *et al. Dentistry Journal.* 2025 **13**:584. [PMID: 41440342]
[2] Hashem AH *et al. Applied Sciences.* 2023 **13**:6668. [DOI: 10.3390/app13116668]
[3] Alsharekh MS *et al. Cureus*. 2024 **16**:e71424. [PMID: 39544602]
[4] Kim YK & Ku J-K. *J Korean Assoc Oral Maxillofac Surg*. 2020 **46**:292. [PMID: 32855378]
[5] Lee D *et al. Maxillofac Plast Reconstr Surg.* 2025 **47**:26. [PMID: 41023506]
[6] Schiavo-Di Flaviano V *et al. J Clin Med*. 2024 **13**:3751. [PMID: 38999315]
[7] Ye M *et al. BMC Oral Health*. 2025 **25**:1522. [PMID: 41044599]
[8] Yang B *et al. PLoS One*. 2024 **19**:e0308166. [PMID: 39116075]
[9] Cho S *et al. Medicine (Baltimore)*. 2024 **103**:e40331. [PMID: 39470487]
[10] Ortiz R *et al. Dent J (Basel)*. 2025 **13**:461. [PMID: 41149108]
[11] Akcay H *et al. J Maxillofac Oral Surg*. 2016 **15**:351. [PMID: 27408469]
[12] Lin ZZ *et al. Int J Implant Dent*. 2021 **7**:41. [PMID: 34013452]
[13] Pignaton TB *et al. Clin Oral Implants Res.* 2020 **31**:959 [PMID: 32716570]
[14] Prajapati S *et al. J Periodontol.* 2023 **94**:1045. [PMID: 36748281]
[15] Lumbau AI *et al. J Funct Biomater*. 2021 **12**:10. [PMID: 33557297]
[16] Rosa A *et al. J Craniofac Surg*. 2024 **35**:203. [PMID: 37988038]
[17] Cobo-Vázquez CM *et al. Int J Implant Dent*. 2025 **11**:36. [PMID: 40377845]
[18] Mattar H *et al. Int J Oral Maxillofac Implants*. 2026 **3**:89. [PMID: 40553623]
[19] Al-Juboori MJ *et al. Dent Implantol Update*. 2012 **23**:9. [PMID: 22338850]
[20] Urban I *et al. Periodontol 2000*. 2023 **91**:126. [PMID: 36700299]
[21] Beck-Broichsitter BE *et al. Oral Maxillofac Surg*. 2020 **24**:151. [PMID: 32002693]
[22] Tükel HC & Tatli U. *Int J Oral Maxillofac Surg*. 2018 **47**:118 .[PMID: 29655818]

[23] Huwais S & Meyer EG. *Int J Oral Maxillofac Implants*. 2017 **32:**27.[PMID: 27741329]
[24] Gao J *et al. Clin Oral Implants Res*. 2023 **34**:727. [PMID: 37226843]
[25] Mohammed NB *et al. PLoS One*. 2026 **21**:e0340355. [PMID: 41557632]