Original Article

Validity of Mandibular Segmental Osteoperiosteal Flap With Simultaneous Dental Implant and Alloplast Interpositional Material Placement: A Retrospective Study

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ABSTRACT

Background: Vertical bone augmentation in the atrophic posterior mandible remains challenging in implant dentistry. The mandibular segmental osteoperiosteal flap technique with simultaneous implant placement offers an alternative to staged procedures, potentially reducing treatment time while maintaining predictable outcomes.Objective: To evaluate clinical validity and radiographic outcomes of mandibular segmental osteoperiosteal flap with simultaneous dental implant placement and interpositional alloplastic material augmentation.Methods: This retrospective study analyzed 20 patients (mean age 35.90 ± 6.90 years; 75% female) who underwent segmental osteoperiosteal flap surgery with simultaneous implant placement between 2018-2023. Patients had posterior mandibular bone height of 5-8 mm with minimum 6-month follow-up. Procedures utilized tricalcium phosphate interpositional grafting and 3.75×10 mm implants. Cone-beam computed tomography assessments evaluated vertical bone height gain, crestal bone loss, and bone density changes at 6 months postoperatively. Results: All implants achieved 100% survival rate. Mean vertical bone gain was 4.10 ± 0.51 mm, increasing from preoperative 6.01 ± 0.95 mm to 10.11 ± 1.08 mm postoperatively ($p < 0.001$). Mean crestal bone loss measured 0.98 ± 0.88 mm. Complications included soft tissue dehiscence in 6 cases (30%) and delayed bleeding in 2 cases (10%), with no implant failures. Conclusions: Mandibular segmental osteoperiosteal flap with simultaneous implant placement demonstrates predictable outcomes for vertical bone augmentation, achieving significant bone height gain while reducing treatment duration compared to staged approaches.

Key Words : Bone augmentation, dental implants, osteoperiosteal flap, posterior mandible, simultaneous placement, vertical ridge augmentation

Received: 05 September 2025**, Accepted:** 03 October 2025

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ISSN: 2090-097X, ‚September 2025, Vol. 16, No. 4

INTRODUCTION

Implant placement in the posterior mandible presents significant clinical challenges, primarily due to insufficient bone width and height in these regions. Following tooth extraction, the physiological pattern of bone remodeling often results in compromised bone dimensions that complicate conventional implant therapy.[1,2] The characteristic bone resorption pattern in the posterior mandible follows a predictable sequence: initial buccal plate collapse occurs in a lingual direction due to compromised vascular supply. This phenomenon results from disruption of the periodontal ligament during extraction, which contains essential vascular networks that nourish the buccal cortical bone. The subsequent compromise in blood circulation leads to progressive bone resorption.[3] Following buccal plate collapse, vertical alveolar ridge height progressively diminishes. In severe cases, complete alveolar ridge resorption may occur, positioning the inferior alveolar nerve at the crestal level. Such anatomical changes render restoration of adequate width and height particularly challenging for clinicians.[4,5]

DOI: 10.21608/omx.2025.420777.1310

While both vertical and horizontal ridge deficiencies complicate conventional implant placement, vertical bone defects present greater clinical challenges compared to horizontal deficiencies. The literature extensively documents numerous predictable techniques for managing horizontal ridge defects, whereas vertical augmentation remains more technically demanding.[6] Placement of standard-length implants in areas with insufficient mandibular height is often contraindicated and may result in complications including: discrepant bone heights between edentulous and dentulous regions, increased prosthetic crown height leading to unfavorable crown-to-root ratios, and potential overloading resulting in marginal bone loss.Various treatment modalities have been developed to address insufficient bone height, ranging from autogenous block grafts harvested from intraoral donor sites (ramus or symphysis) to guided bone regeneration (GBR) techniques. Autogenous grafts remain the gold standard due to their osteogenic, osteoinductive, and osteoconductive properties. Alternative approaches include non-resorbable membrane techniques using polytetrafluoroethylene (PTFE) membranes for vertical bone augmentation, though these carry increased risk of soft tissue dehiscence.8The mandibular segmental osteoperiosteal flap technique, performed simultaneously with implant placement and interpositional bone graft materials, represents a more predictable approach for vertical bone height restoration in posterior mandibular regions. This technique offers improved cost-effectiveness and reduced incidence of soft tissue complications.[9] Reconstruction of alveolar defects in the mandible presents both functional and esthetic challenges. The mandibular segmental osteoperiosteal flap (SOPF) technique allows for three-dimensional repositioning of an alveolar segment while preserving its vascular supply. This method facilitates bone augmentation and provides improved conditions for implant placement. However, the decision to place implants simultaneously versus in a staged manner remains controversial, with limited comparative outcome data available in the current literature.[10] Cone-beam computed tomography (CBCT) has revolutionized the assessment and treatment planning for complex reconstructive procedures involving the posterior mandible. The three-dimensional imaging capabilities of CBCT provide essential information that cannot be obtained through conventional two-dimensional radiography, making it indispensable for successful outcomes in mandibular segmental osteoperiosteal flap procedures. CBCT imaging enables precise measurement of available bone height, width, and density, allowing clinicians to accurately assess the relationship between the alveolar crest and the inferior alveolar nerve canal. This information is crucial for determining the feasibility of vertical bone augmentation and simultaneous implant placement.[11,12] Additionally, CBCT facilitates identification of anatomical significantly impact surgical planning and patient safety.[13]The ability to visualize bone morphology and quality through CBCT imaging allows for optimal selection of implant dimensions, positioning, and angulation prior to surgery. Virtual implant planning software, combined with CBCT data, enables clinicians to simulate the surgical procedure and anticipate potential complications.[14,15] Furthermore, CBCT imaging is essential for evaluating post-operative healing, bone graft integration, and long-term implant stability, providing objective measures of treatment success.[16] The aim of this study was to evaluate the clinical validity and outcomes of mandibular segmental osteoperiosteal flap with simultaneous dental implant placement and interpositional alloplastic material augmentation performed as a single-stage procedure, specifically assessing vertical bone gain and implant integration success.

Materials and Methods

Study Design and Population

This retrospective study approved with IRB no.(85) Suez Med . It was analyzed records of 20 patients who presented with atrophic posterior mandibles and underwent ridge augmentation using segmental osteoperiosteal flap technique with simultaneous dental implant placement and alloplastic interpositional material. Patient records were retrieved from the outpatient clinic of the Oral and Maxillofacial Surgery Department at the Faculty of Dentistry, Minya and Suez Universities, spanning the period from 2018 to 2023. Inclusion criteria comprised: patients aged ≥18 years; vertical bone height in the posterior mandible measuring 5-8 mm; and availability **o**f at least 6 months of postoperative clinical and radiographic follow-up records. Exclusion criteria included:

Surgical Protocol

All patients underwent identical surgical procedures in the posterior mandible following this standardized protocol: Regional anesthesia was administered via inferior alveolar and lingual nerve blocks. A full-thickness mucoperiosteal flap was elevated following a paracrestal incision extending along the entire edentulous area, complemented by two vertical releasing incisions. Vertical osteotomies were performed using a piezoelectric surgical device, positioned at least 2 mm from adjacent dentulous areas (anterior and posterior). A horizontal osteotomy was executed 4 mm from the mandibular canal roof, extending from buccal to lingual cortices while preserving the intact lingual mucoperiosteum. Implant site preparation was completed prior to osteoperiosteal flap mobilization. A bibeveled chisel osteotome was utilized to refine the osteotomy and elevate the bone segment. The mobilized osteoperiosteal segment was stabilized using inserted implants (Frontier™ implants; GMI, Spain; 3.75 mm diameter × 10 mm length). (Figure1)

Fig (1):surgical intervention

Interpositional alloplastic grafting was performed using tricalcium phosphate granules (Iceberg™ TCP, 99.99% purity, 0.5-1 mm particle size). Buccal flap undermining and advancement accommodated the increased vertical dimension, followed by tension-free closure using interrupted or continuous suturing techniques.

Postoperative Management

Standardized postoperative medication protocols included: amoxicillin-clavulanic acid 1 g twice daily for one week; dexamethasone 8 mg intramuscularly immediately postoperatively; ibuprofen 600 mg three times daily for three days; and chlorhexidine mouthwash three times daily for one week.

Assessment Methods

Radiographic analysis: CBCT measurements were obtained preoperatively and at 6 months postoperatively to evaluate vertical bone height gain, peri-implant crestal bone loss, and gray values (ROI) of the repositioned bone segment. A standardized dual-scan protocol was implemented for each patient using cone-beam computed tomography (Scanora® 3D with AutoSwitchTM, Soredex, Helsinki, Finland). The imaging system utilized a CMOS flat panel detector with an isotropic voxel size of 133 μm, focal spot size of 0.5 mm, and slice thickness of 1 mm. Exposure parameters were standardized at 85 kVp and 16 mA, with a 10-second scanning duration and 3-second pulsed exposure time. The field of view dimensions measured 7 cm (height) × 14.5 cm (width) × 10 cm (depth). Precise positioning was achieved using three laser light beams to center the region of interest within the scanning field, with primary reconstruction completed within 2 minutes. The dual-scan protocol consisted of one acquisition with the patient wearing a radiographic template and a second scan of the template alone. DICOM datasets were imported into OnDemand 3D software (version 1.0.9, Cybermed Inc., Korea) for secondary reconstruction and image processing. Three-dimensional image overlapping and treatment planning analyses were performed using this specialized software platform. Clinical evaluation: Postoperative follow-up documented clinical outcomes including wound dehiscence, bleeding, graft displacement, implant mobility, and implant failure.

Sample Size Calculation

Sample size determination was performed using G*Power version 3.1.9.7, based on previous research findings (Nguyen et al., 2019). Power analysis was designed to provide adequate statistical power for two-sided hypothesis testing. With an alpha level of 0.05, beta of 0.1 (power = 90%), and effect size (d) of 0.78665 derived from previous studies, the calculated sample size was 20 patients. This sample size was sufficient to detect significant differences in bone height (mm), gray values, and crestal bone loss (mm) between pre- and postoperative measurements.[10,11]

Statistical Analysis

Values were presented as mean ± standard deviation and range values. Data normality was assessed using the Kolmogorov-Smirnov test, which indicated normal distribution. Paired sample t-test was used for comparing related samples, while one-sample t-test determined significance of differences between actual mean values and normal standards. The significance level was set at $p \leq 0.05$. Statistical analysis was performed using SPSS 23.0 (Statistical Package for Scientific Studies, SPSS, Inc., Chicago, IL, USA) for Windows.

Results

Demographic Characteristics

The study population comprised 20 patients with a mean age of 35.90 ± 6.90 years (range: 26-47 years), indicating a predominantly young to middle-aged adult cohort. Gender distribution showed a female predominance, with 15 participants (75.0%) being female and 5 participants (25.0%) being male (Table 1).

Table 1: Demographic data distribution among study group

Age	Total (n=20)	Sex	Total (n=20)
Mean±SD	35.90±6.90	Male	5 (25.0%)
Range	26-47	Female	15 (75.0%)

Clinical Outcomes and Complications

All implants demonstrated successful osseointegration with a 100% survival rate at the 6-month follow-up period. No implant failures or graft detachment were observed throughout the study period. However, soft tissue complications occurred in 6 cases (30%), presenting as graft or implant exposure. Additionally, 2 patients (10%) experienced delayed postoperative bleeding associated with localized inflammatory responses (Table 2).

Table 2: Clinical outcomes and complications

Total number	dehis-cence	bleeding	graft detach-ments	implant looseness or loss
N= 20	N=6 (30%)	N=2 (10%)	N=0	N=0

Radiographic Outcomes

Vertical Bone Height Gain

CBCT analysis demonstrated significant vertical bone augmentation following the surgical procedure. Mean preoperative bone height measured 6.01 ± 0.95 mm, which increased to 10.11 ± 1.08 mm at 6 months postoperatively, yielding a mean vertical bone gain of 4.10 ± 0.51 mm (range: 3-5 mm). Paired t-test analysis revealed a highly significant difference between pre- and postoperative measurements ($t = 36.11$, $p < 0.001$), confirming the clinical efficacy of the procedure (Table 3).

Table 3: Vertical bone height measurements and statistical analysis

Bone hieght "mm"	Preoper-ative	6 month postop-erative	Vertical bone gain (mm)	Paired t-test	p-value
Mean±SD	6.01±0.95	10.11±1.08	4.10±0.51	36.11	<0.001**
Range	4.5-7.5	8.5-12.2	3-5		

Bone Density Analysis

Gray value measurements showed a slight decrease in bone density from preoperative to postoperative periods, with a mean difference of -57.68 ± 150.32 gray values. Although this change achieved statistical significance ($p = 0.047$), the clinical relevance remains questionable. Preoperative gray values ranged from 475 to 1237, while postoperative values ranged from 465 to 1229, indicating considerable inter-patient variability in bone quality. Individual changes ranged from -524 to +79 gray values, suggesting that while some patients experienced decreased bone density, others showed slight improvements (Figure 2,3).

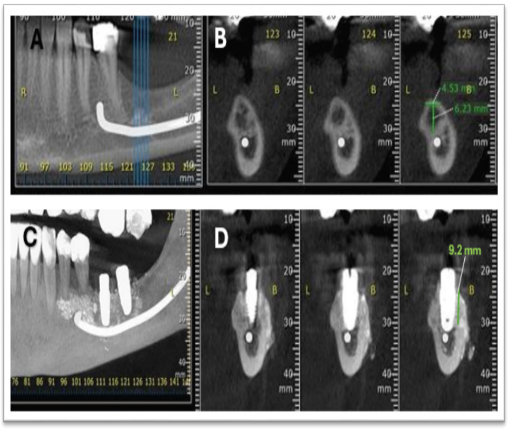

Figure 2: CBCT imaging demonstrating mandibular segmental osteoperiosteal flap with simultaneous implant placement. Upper row shows preoperative assessment: (A) Panoramic reconstruction showing atrophic posterior mandible, (B) Cross-sectional views revealing insufficient vertical bone height. Lower row displays 6-month postoperative outcomes: (C) Panoramic reconstruction (with MIP) showing successful implant integration, (D) Cross-sectional views demonstrating significant vertical bone gain.

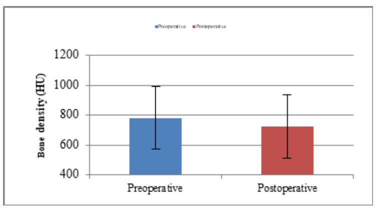

Fig. (3): Showing the mean ± SD values, for the comparison between different Preoperative and postoperative regarding bone density

Peri-implant Crestal Bone Loss

Mean crestal bone loss measured 0.98 ± 0.88 mm (range: 0-3 mm) at 6 months postoperatively. One-sample t-test analysis comparing this value to the accepted normal standard of 0.50 mm revealed a statistically significant difference ($t = 2.427$, $p = 0.025$), with a mean excess of 0.48 mm beyond the expected physiological bone remodeling (Table 4).

Table 4: Crestal bone loss analysis compared to normal standard

Crestal bone loss (mm)	Actual value	Normal standard	t-test	p-value
Mean±SD	0.98±0.88	0.50	2.427	0.025*
Range	0-3			

**p-value <0.05 is significant*

Discussion

Various techniques have been employed for posterior mandibular vertical bone augmentation, including autogenous onlay bone blocks, titanium mesh-assisted regeneration, polytetrafluoroethylene (PTFE) membrane-guided bone regeneration, and distraction osteogenesis. The mandibular segmental osteoperiosteal flap represents a viable alternative treatment modality offering distinct advantages over conventional approaches for posterior mandibular vertical bone defect reconstruction.[12]The osteoperiosteal flap concept, originally established in segmental orthognathic surgery, involves spatial repositioning of bone segments while preserving the investing periosteum and its vascular supply. This principle has been successfully adapted for reconstructive alveolar surgery through interpositional bone grafting techniques, commonly referred to as "sandwich grafting." Related applications include alveolar split grafts, edentulous alveolar repositioning osteotomies, and distraction osteogenesis procedures.[13] Literature predominantly favors two-stage approaches over simultaneous implant placement protocols. The conventional paradigm suggests that allowing adequate bone healing prior to implant placement enhances osseointegration predictability and stability. However, single-stage procedures offer compelling advantages, including reduced surgical interventions, decreased overall treatment time, and improved patient acceptance. Conversely, single-stage approaches have been associated with unpredictable bone resorption rates, potentially compromising primary implant stability and prosthetic positioning.[14] A retrospective evaluation of iliac onlay bone grafts reported mean bone height reductions of 1.33 ± 0.81 mm at 3 months and 3.05 ± 1.63 mm at 1 year post-augmentation, compared to immediate post-surgical measurements.17 In contrast, the current study demonstrated superior outcomes with mean crestal bone loss of 0.98 mm at 6 months, supporting the validity and superiority of simultaneous implant placement with segmental osteoperiosteal flap augmentation. The present study's results validate the single-stage approach for simultaneous grafting and implant placement, demonstrating predictable outcomes with acceptable success rates. Limited literature exists regarding simultaneous implant placement with osteoperiosteal flap procedures, with most research focusing on guided bone regeneration, autologous bone blocks, and alveolar distraction osteogenesis.[15,16] A retrospective evaluation of iliac onlay bone grafts reported mean bone height reductions of 1.33 ± 0.81 mm at 3 months and 3.05 ± 1.63 mm at 1 year post-augmentation, compared to immediate post-surgical measurements.17 In contrast, the current study demonstrated superior outcomes with mean crestal bone loss of 0.98 mm at 6 months, supporting the validity and superiority of simultaneous implant placement with segmental osteoperiosteal flap augmentation.It is crucial to acknowledge that cone-beam computed tomography does not produce true Hounsfield Units (HU) as generated by medical computed tomography scanners. CBCT systems utilize different reconstruction algorithms, beam spectra, and detector technologies, resulting in gray values that are not standardized across different machines or protocols.18,19 The gray values obtained from CBCT should be interpreted as relative measurements that provide qualitative rather than quantitative bone density information.20 These values serve primarily as indicators of relative bone density changes over time within the same imaging protocol, rather than absolute bone mineral density measurements.[21] The slight decrease in gray values observed in this study should therefore be interpreted cautiously, recognizing the inherent limitations of CBCT in quantitative bone density assessment. Future research utilizing standardized protocols and calibration phantoms may provide more reliable bone density evaluations.[22] The primary advantage of simultaneous implant placement with mandibular segmental osteoperiosteal flap is the significant reduction in treatment duration. Conventional vertical bone augmentation using non-resorbable membranes requires 6-8 months for bone formation, followed by implant placement and an additional 3-month healing period before prosthetic rehabilitation. The current approach eliminates these staged procedures while reducing surgical complexity and potential complications. The interpositional grafting technique enhances graft stability through implant-mediated fixation of the osteoperiosteal segments. Autogenous bone block procedures, while effective, are associated with notable complications including paresthesia, wound dehiscence with graft exposure, and screw exposure.[23] The present study recorded dehiscence in 6 of 20 cases (30%) without implant loss or graft detachment. Comparative systematic reviews of simultaneous implant placement with autogenous onlay bone grafts report wound dehiscence and graft exposure rates of 11.7-62.5%, with graft loss occurring in 5.4-25% of cases.[14] These findings suggest comparable or superior complication profiles for the osteoperiosteal flap technique. Several limitations warrant acknowledgment: the relatively small sample size, retrospective design, and short-term follow-up period limit generalizability. The predominant female population (75%) may influence outcome interpretation. Additionally, the inherent limitations of CBCT gray value measurements for bone density assessment, as discussed above, require careful interpretation of the bone quality findings. Long-term follow-up studies with larger patient cohorts are necessary to establish the predictability and longevity of this technique.

Conclusion

Mandibular segmental osteoperiosteal flap with simultaneous dental implant placement represents a valid and effective procedure for vertical bone augmentation in atrophic mandibles. The technique demonstrates predictable outcomes with acceptable success rates while reducing treatment time and surgical complexity. Interpositional grafting enhances graft stability, promotes favorable osseointegration, and facilitates bone healing. However, careful patient selection, meticulous surgical technique, and recognition of imaging limitations remain essential for optimal outcomes and proper interpretation of treatment results.

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