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Comparison of Flap and Flapless Implant Placement; A 4 Year Outcome on Soft Tissue Health, Bone loss and Implant Stability

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Abstract

Aims: Comparative analysis of the implant stability quotient (ISQ), surrounding bone density, patient comfort, soft tissue health, and crestal bone loss (CBL) after four years of follow-up between the flap and flapless implant insertion techniques.

Methods and Material: A clinical study was conducted to place 40 implants in partially edentulous arches by raising mucoperiosteal flap (MF group) or by flapless (FL group) technique. Pain scores, soft tissue health, ISQ, CBL and bone density around implants was evaluated at specified time intervals for 4 years.

For pain scores, the data were compared using the paired t test; for the remaining parameters, the Z test and ANOVA were used, and a p value of less than 0.05 was deemed statistically significant.

Results: Significantly better patient comfort and soft tissue health in FL group was observed. Flapless group

also had better but statistically insignificant results for crestal bone loss, implant stability, bone density. MF group had more CBL, decrease in ISQ and bone density at 4 years contrary to FL group.

Conclusions: Flapless technique can offer better results for patient comfort and soft tissue health, though adequate experience, good quality and quantity of bone are a prerequisite.

Keywords: Bone density, Randomized Controlled Trial (RCT), Dental Implants, Surgical Flaps, Alveolar Bone Loss.

Introduction

Successful long-term rehabilitation of a missing tooth or a completely edentulous arch by dental implants has revolutionized the field of dentistry.

When inserting dental implants, a flap is typically raised to improve visibility of the surgical site and guarantee that anatomic landmarks are seen and recognised. In cases when there is adequate bone and minimal risk of problems, flapless implant implantation may be an option [1]. During the flapless implant placement, the surgeon is working with limited visibility of the bone around the surgical site and there are chances of bone perforations or placement of implants in an unfavourable angulation, therefore thorough clinical and radiographic examination is a prerequisite. For these situations surgical guides can help the operator to place an implant in the appropriate position [2] or alternatively by raising the flap. Post-surgical tissue loss has been reported in the literature while placing implants by raising the mucoperiosteal flap and therefore elevating flaps for implant placement may lead to less than ideal aesthetic outcome [3].

Operators require techniques, ideally a particular test or tests, that predict implant survival during implant installation, before prosthodontic treatment, and during recalls. The stability of implants can be evaluated using a variety of techniques. A few of them were intrusive, but non-invasive techniques like resonance frequency analysis and periotest have since developed [4].

During the first year of prosthetic loading, Adell et al. were the first to measure and report marginal bone loss, with an average of 1.2 mm. Years after the first, the average bone loss was less than 0.2 mm annually [5].

In all three stages of implant evaluation, treatment, and maintenance, radiographs are an essential tool for evaluating bony architecture. In addition to evaluating crestal bone, cone beam computed tomography can also analyse bone density and bone-to-implant contact, which have been found to be indicators of implant success [5].

This research has laid emphasis on the approach of surgical procedure used and its effect on ISQ, crestal bone loss, bone density around implant, soft tissue health and patient comfort on functional loading of implants. This study compared the functional loading of implants placed by tissue punch versus traditional flap surgery in patients who were partially edentulous. It also examined the patient's comfort during the first stage of surgery, primary stability, secondary stability, crestal bone loss, bone density, and soft tissue healing.

Material and Methods

Research hypothesis

Flapless technique will have better implant stability, crestal bone loss, bone density and soft tissue healing as compared to conventional flap surgical procedure in partially edentulous patients.

Subjects and Methods

Study design: Patients with partial dentures participated in the current investigation, which was a prospective, randomised, single-blind, controlled experiment with parallel arms conducted at the prosthodontics department. All patients involved in this study gave their written

informed consent, and the study was conducted in accordance with the Helsinki Declaration's tenets. Patient confidentiality was preserved. Our institute's ethics committee accepted the study design. (Ref no. SDC/MISC/2014).

Eligibility criteria (Inclusion/exclusion criteria) Patients were selected based on the inclusion and exclusion criteria as described in Table *1*.

Patient Recruitment

The CONSORT recommendations were followed in the distribution and selection of patients (Figure 1). The participant's medical and dental history was documented at the first screening session, and specific inclusion and exclusion criteria were used (Table 1). The study only included nonsmokers who needed therapy in the posterior edentulous span, and patients were not informed of their group assignment.

Twenty implants were implanted using the mucoperiosteal flap (MF) technique and twenty were inserted using a tissue punch flapless (FL) technique in this prospective, single-center, randomised controlled experiment. Every patient had a stable repaired occlusion (either mutually protected or canine-guided), with an occluso-gingival height of at least 7 mm. Grafting was not necessary because CBCT and clinical exams guaranteed sufficient bone dimensions (at least 1 mm around the implant, D2 or D3 quality) to sustain implants of at least 3.75 mm diameter and 10 mm length.

Randomization was achieved using a balanced permuted block method (block size = 6), with allocation concealment ensured by the SNOSE technique. Patients were blinded to their group allocation, but surgeons and evaluators were not, which may have introduced observer bias.

Implant stability quotient (ISQ), as determined by the Resonance Frequency Analyser (Osstell®) at three months following second stage surgery and at four years, was the main outcome. The mean of four directional values—buccal, lingual/palatal, mesial, and distal—was used to compute ISQ. Secondary outcomes included crestal bone loss measured by intraoral periapical radiographs (using a 1 mm IOPA grid) at baseline, 9 months, and 4 years, peri-implant soft tissue health measured by the modified gingival index (mGI) at 9 months and 4 years, and pain scores using a 10-point visual analogue scale (recorded at 3 hours, 24 hours, 48 hours, and day 7).

The MF group underwent surgery using a typical sequential osteotomy and a mid-crestal incision with full-thickness flap elevation. 4-0 black braided silk was used for sutures. In the FL group, flap elevation and suturing were avoided by using a tissue punch over the surgical site while being guided by a template.

The implants had an internal hex connector and measured between 3.75 and 4.2 mm in diameter and 11.75 and 13 mm in length. Despite stringent protocols, certain human errors affected follow-up: two patients in each group were excluded from final ISQ evaluation due to refusal of prosthesis removal, and minor variability in radiograph angulation and ISQ threading technique may have affected consistency.

The total follow-up period was 4 years. Despite meticulous planning, practical challenges like compliance issues, observer bias, and procedural variability underline the importance of rigorous standardization and larger multi-center trials for validation.

Post-surgical procedure

Intraoral periapical radiographs using a 1 mm grid and paralleling cone technique were taken at baseline, 9 months, and 4 years to assess crestal bone levels. Patients received antibiotics (Amoxicillin 500 mg + Clavulanate

125 mg) and analgesics (Paracetamol + Diclofenac) for 5 days, along with postoperative instructions and VAS charts for pain assessment. Follow-ups were scheduled at 7 days (suture removal), 3 months (second-stage surgery), 9 months, and 4 years. Prosthetic rehabilitation was done using metal-ceramic restorations. CBCT scans (Galileos-Sirona) with 15 × 8.5 cm FOV and 14-second scan time were taken at 9 months and 4 years to measure bone density (in Hounsfield Units) using Blue Sky Plan software. Measurements were taken at crestal, mid, and apical levels on all four implant aspects. The radiographic evaluator was blinded to minimize bias, though minor interpretation errors and CBCT calibration inconsistencies may have influenced results.

Data were analyzed using SPSS v20 with appropriate parametric and non-parametric tests.

Results

Twenty implants were inserted using the flapless (FL) approach and twenty using the mucoperiosteal flap (MF) technique in this prospective investigation. Sixty percent of the patients were male, and the mean age was 35.35 ± 9.26 years. 26 implants were positioned in the mandible and 14 in the maxilla. The groups' baseline demographics (age, gender, and tooth distribution) were similar.

During the 4-year follow-up, two patients in each group were excluded due to refusal for prosthesis removal and ISQ recording. However, no clinical complications were noted in these cases. A total of 18 implants per group were analyzed at the 4-year mark. Minor deviations and inconsistency in follow-up compliance represented human errors impacting full data collection.

At 3, 24, and 48 hours after surgery, the FL group's pain scores, as measured by the VAS scale, were noticeably lower. Both groups experienced less pain by the seventh day. At nine months, the FL group's modified gingival index values (1 ± 0.471) showed better soft tissue health than the MF group's (2 ± 0.699), with a statistically significant difference ($p < 0.05$).

At 9 months (1.03 ± 0.65 mm) and 4 years (1.52 ± 0.43 mm), the MF group experienced a higher mean crestal bone loss than the FL group (0.87 ± 0.23 mm and 1.33 ± 0.33 mm, respectively), but this difference was not statistically significant. Both groups' primary and secondary implant stability (ISQ) improved over time, with the FL group exhibiting a little rise at 4 years. Bone density measured in HU decreased in the MF group over time but increased in the FL group, likely due to preserved periosteal blood supply. Despite minor inconsistencies in data recording and patient compliance, outcomes favoured the flapless approach in terms of comfort and soft tissue preservation.

Discussion

Implant dentistry has seen significant innovation compared to other dental specialties, including the evolution of implant systems, diagnostics, and surgical techniques[6]. With an emphasis on crestal bone loss and implant stability, Albrektsson et al. developed criteria for implant success[7]. Branemark's protocols in the 1970s introduced extensive flap surgeries to expose bone and ensure anatomical safety during implant placement. While this method offers better visualization, it compromises soft tissue and vascular integrity, especially in edentulous areas where the periosteum is the primary blood source.

In contrast, flapless implant placement preserves periosteal blood supply and soft tissue architecture. It is often preferred in cases with sufficient bone and low risk of complications. Patient comfort was assessed via visual analogue scale (VAS), and significantly less postoperative pain was reported in the flapless group at 3, 24, and 48 hours[8,9]. This is attributed to less soft tissue

trauma, absence of sutures, and minimal tissue manipulation. However, by the 7th postoperative day, pain levels were similar in both groups, aligning with expected healing timelines[1].

Blood supply disruption from flap elevation negatively impacts bone healing. The periosteum, referred to as the "umbilical cord of the bone," plays a crucial role in revascularization and bone remodeling[10]. Studies have shown that flap elevation reduces vascular support, leading to crestal bone loss[11]. However, some studies argue that flapless surgery may also negatively influence bone remodeling due to insufficient saline contact during drilling[9,12]. Moreover, technical errors like inaccurate stent positioning or over preparation of the site can skew results, reflecting limitations in clinical execution rather than procedural faults.

Katsoulis et al. discovered no long-term variations in bone levels between procedures, despite Jeong et al.'s support for flapless surgery in minimising crestal bone loss[12,13]. Contradictory findings by other researchers indicate higher bone loss in flapless cases due to deeper implant placement[14].Even though the flapless group in our study had less bone loss after three, nine, and four months, the differences were not statistically significant, perhaps as a result of operator variability and the small sample number.

Albrektsson and Qian et al. argued that crestal bone loss is not solely a result of surgical technique but may be a response to foreign body reactions, clinical handling, and patient-specific factors[7,15]. Qian et al. noted that infection may occur secondarily after tissue damage. In our study, bone loss at 4 years remained within the acceptable limit of 0.2 mm/year, requiring no intervention.[15]

There are two types of implant stability: primary (mechanical) and secondary (biological), which are crucial for implant success[7]. Implant design, surgical technique, and bone quality all affect primary stability[16]. ISQ, insertion torque, and Periotest are commonly used for assessment. In the initial healing phase, ISQ values drop due to bone remodeling before rising with osseointegration[17,18]. Andersson et al. found implants with low primary stability showed gradual stability increase, while highly stable implants experienced a temporary dip before stabilizing again.

Our results showed no significant difference in secondary stability between groups. However, the flapless group showed a marginal ISQ increase from 75.7 at 3 months to 78.59 at 4 years, while the flap group had a slight decrease (76.9 to 75.97), likely due to crestal bone loss. Cortical bone thickness has a strong correlation with ISQ values; thus, compromised blood supply in the flap group might explain the lower ISQ[19].

Bone quality, evaluated via Hounsfield Units (HU) on CBCT, reflects healing potential. According to Sugiura et al., D1 bone (above 1250 HU) is highly dense but less vascular. In our study, initial bone density at 9 months was higher in the flap group (1343 HU) versus flapless (1219 HU). However, at 4 years, flapless implants showed improved density (1271 HU) while flap group density decreased (1129 HU). Though not statistically significant, these results suggest better long-term remodeling with flapless surgery. Errors like inconsistent CBCT interpretation and variations in HU calibration between devices may have impacted results[19].

Modified gingival index (MGI) was used to assess peri-implant soft tissue health. Our findings showed better scores for the flapless group, aligning with Jeong et al., indicating superior soft tissue healing. Esposito et al., however, argued that no conclusive evidence exists favoring flapless surgery in soft tissue outcomes[7,23].

Color and texture changes post-implant placement may also be influenced by implant materials and pre-existing tissue conditions, which were not fully standardized in this study[24].

The study was limited by its single-center design, small sample size, and possible operator bias, despite its meticulous implementation. Long-term results may be impacted by implant locations that differ in depth or angulation. Furthermore, ISQ results may be inconsistent due to angulation and device variability, and VAS pain rating is subjective. Despite its value, bone density measures could not be a reliable indicator of biological quality or mineral content[1,24,25].

The current study emphasises how crucial it is to maintain vascular and soft tissue integrity throughout implant procedures. Due to human error, varying patient anatomy, and procedural irregularities, flapless surgical findings should be interpreted cautiously, even if it may provide advantages in terms of patient comfort, peri-implant tissue preservation, and possibly less crestal bone loss.

Future multi-center trials with larger cohorts, longer follow-ups, and standardized protocols are needed. Including variables like systemic conditions, smoking habits, and different jaw locations may provide more generalizable and conclusive data on the effectiveness of flap versus flapless techniques in implant dentistry.

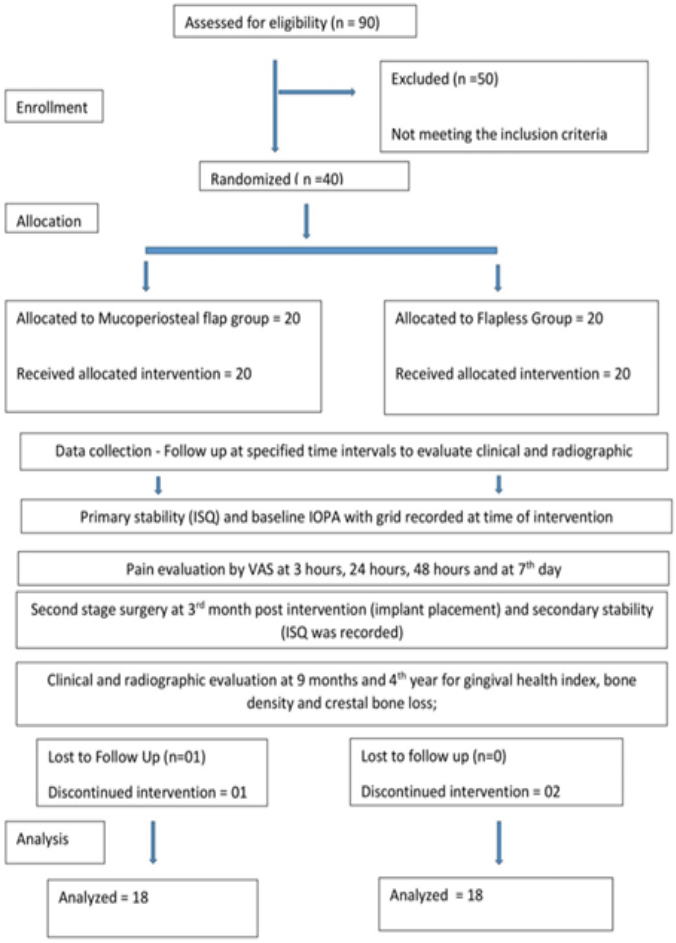

Figure 1: Patient selection following CONSORT guidelines

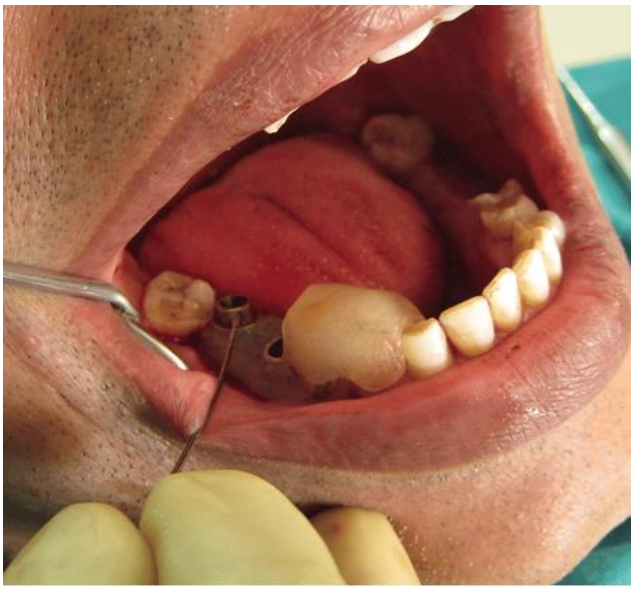

Figure 2: Placement of surgical template

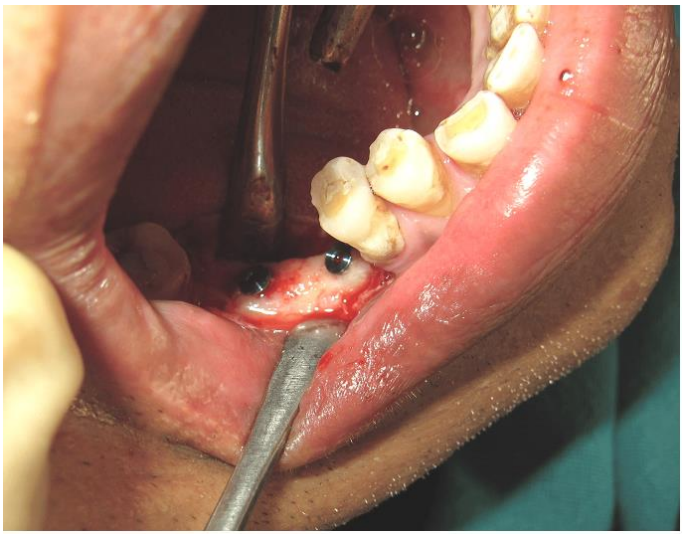

Figure 3: Implants placed after osteotomy

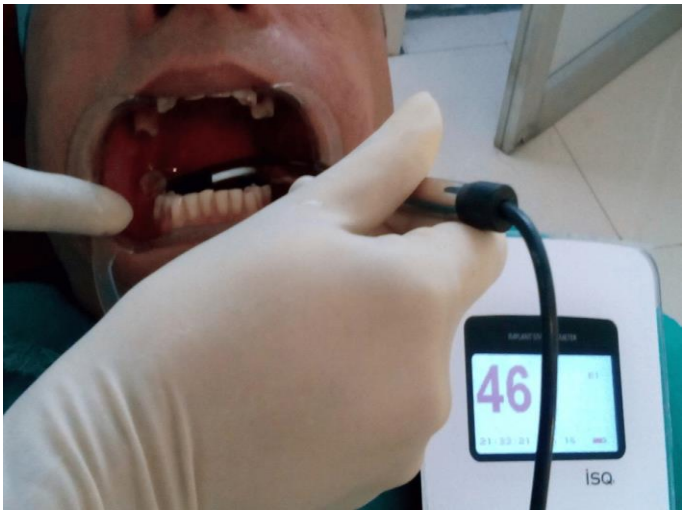

Figure 4: Recording of Primary implant stability quotient with Resonance Frequency Analyzer.

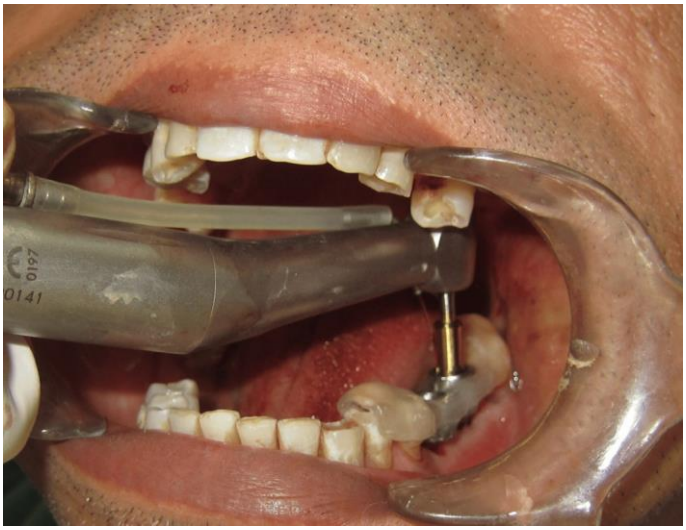

Figure 5: Incision of mucoperiosteum by tissue punch through surgical template in flapless group

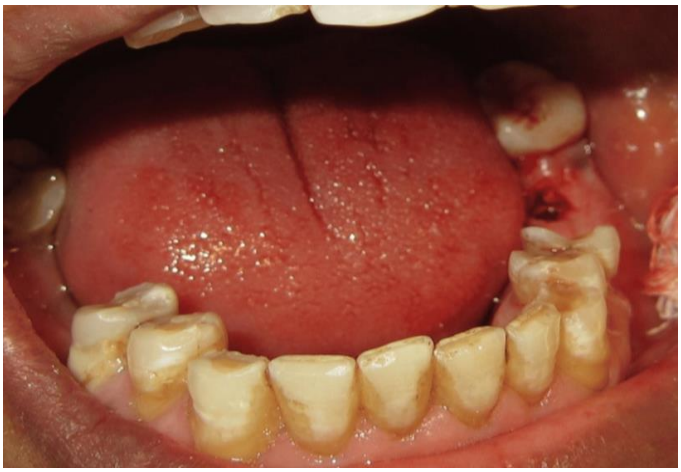

Figure 6: Implants placed after osteotomy for flapless group

Table 1: Inclusion and Exclusion criteria

Sn.	Inclusion criteria	Exclusion criteria
1.	Age between 25 – 50 yrs	Patients with complicated medical history like uncontrolled diabetes, recent history of cardiac arrest
2.	Residual bone height > 13mm from the inferior alveolar canal	Patients with history of radiotherapy in maxillofacial region
3.	Delay of at least 12 months between extraction and implant placement	Presence of periapical pathology in adjacent tooth/teeth.
4.	Patients requiring replacement of tooth/teeth in partially edentulous arches (posterior region only)	Untreated periodontitis

5.	Patients with adequate bone width without the need for bone grafting.	Severe Bruxism or clenching habits Smokers
6.	Healthy oral mucosa, without periodontal pathosis and absence of active caries	Inadequate mouth opening such that instrumentation for implant insertion is not possible
7.	Non smokers	Debilitating temporomandibular joint pathosis.
8.	Ability to understand and to sign the informed consent	Requirement of bone grafting or soft tissue augmentation.

Table 2: Modified Gingival Index

0	No bleeding when a periodontal probe is passed along the mucosal margin adjacent to the implant
1	Isolated bleeding spots visible
2	Blood forms a confluent red line on mucosal margin
3	Heavy or profuse bleeding

Table 3: Comparison of the two groups with respect to gender, age and tooth distribution of patients at baseline

	Mucoperiosteal group (n= 20)		Flapless group (n= 20)		Total (n=40)		Test statistic, p value
	No.	%	No.	%	No.	%	
Gender							
Female	5	25	11	55	16	40	3.75, 0.05*
Male	15	75	9	45	24	60	
Tooth No.							
14	1	5.0	0	0.0	1	2.5	
15	1	5.0	2	10.0	3	7.5	
16	1	5.0	2	10.0	3	7.5	
24	1	5.0	0	0.0	1	2.5	
25	1	5.0	2	10.0	3	7.5	
26	1	5.0	1	5.0	2	5	
27	0	0.0	1	5.0	1	2.5	
							15.84, 0.31@
34	1	5.0	0	0.0	1	2.5	
35	2	10.0	2	10.0	4	10	
36	1	5.0	6	30.0	7	17.5	193.5, 0.866#

37	1	5.0	0	0.0	1	2.5	
44	0	0.0	1	5.0	1	2.5	
45	2	10.0	0	0.0	2	5	
46	7	35.0	2	10.0	7	22.5	
47	0	0.0	1	5.0	1	2.5	
Age (Mean, SD)	34.95, 8.97		35.75, 9.77		35.35, 9.27		

Table 4: Comparison between flap & flapless technique for different pain scores/criteria

Type of Pain	Probablity of Z-Score Between Flap & Flapless Technique In Pain Scores (VAS Scores)			
	AT 3 HRS	AT 24 HRS	AT 48 HRS	After 7 Days
No Pain (0-1)	P<.05 (SIG.) $Z_{(}$cal)=4.11P>.05 (N.S.) $Z_{(}$cal)=8.82			
Mild (1-3)	P<.05 (SIG.) $Z_{(}$cal)=3.02	P<.05 (SIG.) $Z_{(}$cal)=2.98	P<.05 (SIG.) $Z_{(}$cal)=3.48	----
Mild- Moderate (3-5)	P<.05 (SIG.) $Z_{(}$cal)=2.61P<.05 (SIG.) $Z_{(}$cal)=2.71P<.05 (SIG.) $Z_{(}$cal) =3.55			----
Moderate (5-7)	----	----	----	----
Severe (7-9)	----	----	----	----
Worst (9-10)	----	----	----	----

*p ≤ 0.05 – clinically significant

Table 5: Comparison between the MF group and the FL group for the parameters of soft tissue health by mGI, CBL, ISQ & density of bone around implants

Parameter	Time Interval	MF	FL	p-Value
mGI (mm)	9 MONTHS	2 ±0.699	1 ±0.471	0.031*
CBL (mm)	9 MONTHS	1.03 ±0.65	0.87 ±0.23	0.114
ISQ Bone density around implants (HU)	4 YEARS	1.52±0.43	1.33±0.33	0.636
	3 MONTHS	76.9 ±5.9	75.7 ±7.08	0.462
	4 YEARS	75.97 ±4.98	78.59 ±6.31	0.215
	9 MONTHS	1343 ±257.71	1219.4 ±108.7	0.443
	4 YEARS	1129.57±202.87	1271.76 ±363.3	0.195

*p ≤ 0.05 – clinically significant

mGI - Modified gingival index

MF - Mucoperiosteal flap

CBL - Crestal bone loss

group FL - Flapless group

ISQ - Implant stability quotient

HU - Hounsfield Unit

Conclusions

The current study's findings show that implants inserted using a flapless technique considerably improve patient comfort and soft tissue health. Although there was no discernible difference between the two groups, the flapless group exhibited superior primary stability, secondary stability, bone density, and crestal bone loss. As a result, there is no discernible difference between the two treatments in terms of implant stability at average follow-up.

Additional long-term studies with a bigger sample size and comparable loading regimens should be carried out in order to precisely evaluate the benefits of flapless surgical procedures.

Additional Information

Disclosures

Human subjects: All study subjects either provided or waived their consent for treatment and open access publication. The Institutional Ethical Committee gave SDC/MISC/2014 its clearance. Swami Vivekanand Subharti University's institutional ethical committee gave its approval to the study design (Ref number. SDC/MISC/2014). Animal participants: Every author has attested that neither tissue nor human subjects were used in this investigation. Conflicts of interest: All authors affirm the following in accordance with the ICMJE uniform disclosure form: Information on payment and services: All writers have stated that no organisation provided financial assistance for the work they submitted. Financial ties: Each author has stated that they have no financial ties to any organisations that would be interested in the work they submitted, either now or in the last three years. Other relationships: Every author has stated that the submitted work was not impacted by any other relationships or activities.

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