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Evaluation of Tunnel Technique with a Subperiosteal Bag Versus Buccally Flap in Augmentation of Narrow Alveolar Ridge for Dental Implant Placement

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Abstract: Aim: This study was carried out to evaluate clinically and radio graphically using of tunnel technique with a sub periosteal bag versus buccally flap in narrow alveolar ridge augmentation for implant placement. **Objectives:** Primary objective: bone width and bone density, secondary objective: soft tissue augmentation **Subjects and methods:** Twenty patients with narrow ridge were divided randomly into two groups. Group 1: 10 patients received buccally flap combined with allograft bone and collagen membrane. Group 2: 10 implant sites received tunnel subperiosteal bag combined with allograft bone and collagen membrane. Clinical and radiographic parameters were gathered at baseline, 6 and 9 months. **Results:** There were statistically significant differences between Group I & Group II at 6,9 months regarding alveolar ridge width, peri-implant probing depth (PPD),implant stability quotient (ISQ*)*, Changes in marginal bone loss (MBL)and bone density measurements (BD) And vice versa, no statistically significant differences at6, 9 months in modified plaque index (mPI) and modified sulcus bleeding index (mSBI). **Conclusions:** Tunnel technique with subperiosteal bag combined with allogeneic bone was an effective technique in increasing ridge width with less marginal bone loss than buccal flap technique, the pre-implant site condition was improved with the tunnel technique compared to the buccal flap technique.

Keywords: *Narrow alveolar ridge, Minimal invasive technique, Tunnel technique, Subperiosteal bag, Buccal flap technique, Allogenic bone graft .*

Introduction

Tissue deficiencies, both hard and soft, are commonly seen after extended periods of edentulism. Following tooth extraction, bone resorption can result in the loss of up to 50% of the original bone width within the first two years. This significant bone loss often necessitates bone augmentation to create a suitable foundation for implant placement, ensuring proper prosthetic positioning, stability, and aesthetic outcomes.(1)

Guided bone regeneration (GBR) has proven to be an effective method for restoring the horizontal and vertical dimensions of the alveolar ridge. Barrier membranes used in GBR not only promote the proliferation of specific cell types but also prevent the invasion of unwanted cells into the bony defect.(2)

An ideal grafting material for ridge augmentation should be easy to handle, exhibit excellent biocompatibility to support graft integration or remodeling, and provide a highly osteoconductive scaffold for osteogenic cells. Bone allografts meet these criteria exceptionally well, offering benefits such as an unlimited supply, reduced operative trauma and blood loss, no donor site morbidity, and a very low antigenic potential.(3)

Tunnel-like approaches, which avoid vertical releasing incisions, have been proposed to manage hard and soft tissue deficiencies. These techniques aim to minimize tissue trauma, enhance blood supply, and promote smooth wound healing, resulting in less wound dehiscence, lower membrane exposure, and reduced morbidity compared to open GBR techniques.(4)

Tunnel flaps that preserve papillae integrity and avoid vertical incisions may not only reduce postoperative morbidity but also improve flap blood supply, leading to more favorable wound healing. Consequently, tunnel-like approaches have been used for root coverage, soft tissue augmentation, and regenerative therapy. The tunnel technique has also been associated with reduced membrane exposure, patient morbidity, and antibiotic usage compared to open flap techniques.(5)

The buccal flap technique is a simple and minimally invasive surgical method that can be performed as either a one-stage or two-stage procedure. It is applicable in both posterior and anterior regions, as well as at single and multiple adjacent implant sites. This technique is based on the concept of an apically positioned flap but differs in that the flap must be highly flexible to gain volume. The buccal flap technique is widely used to provide primary closure over the bone graft, minimizing tension on the graft. Excessive tension can lead to dehiscence and graft exposure, which may result in significant graft resorption or loss.(6)

PATIENTS AND METHODS

This study was designed as a randomized, controlled, clinical trial and carried out on patients with partial edentulous narrow alveolar ridge, seeking to receive dental implant. Patients were selected from the outpatient clinics Department of Oral Medicine and Periodontology, Faculty of Dentistry Al- Azhar University – Assiut branch.

Ethical issues

1. Approval to conduct the study was sought and granted by the ethical committee, Faculties of Dentistry, Al-Azhar University.
2. Consent from the patients of the study was sought both verbally and in written form before the work.

These patients were divided randomly into two groups

Group 1: 10 patients received buccally flap combined with allograft bone and collagen membrane.

Group 2: 10 patients received tunnel subperiosteal bag combined with allograft bone and collagen membrane.

Presurgical preparation

Following the initial examination, all patients received phase 1 periodontal therapy full mouth supragingival and subgingival SRP procedure under local anesthesia using ultrasonic and hand instrumentation with meticulous oral hygiene instructions. Four weeks after Phase I therapy, Radiographic preparation each edentulous site was evaluated through examination of periapical radiographs and CBCT to assess bone quality and quantity, to assess the ridge height and width of the supporting bone and to locate the major anatomical features. Preoperative medications therapy All patients underwent antibiotic 3 days before surgery 875mg

Amoxicillin and potassium clavulanate equivalent to 125 mg of clavulanic acid (Augmentin 1gm tablet) to cover the surgical and postsurgical period during the healing process.

Surgical Procedures

All the surgical procedures were performed by the same person. Before surgery, the patients were rinsed with 20 ml chlorhexidine gluconate 0.12% solution (hexitol) for 30 second as a topical antimicrobial agent. The surgical site was locally anaesthetizied using Artinibsa 40mg/0.01 mg/ml (Articaine hydrochloride+ Epinephrine).

Group II: Once the bony defect was identified, a subcrestal incision with two curvilinear-beveled incisions was made, and it was extended with two cut-back incisions at the vestibular ends. The incision was made down to the bone. A full-thickness flap was then elevated using a periosteal elevator. Care was taken to avoid unnecessary dissection or trauma to the palatal tissues. After the dissection was completed, decortication of the alveolar ridge was performed using a round bur mounted on a low-speed handpiece. In the premolars areas, taking care to protect the dissected tissues with a periosteal elevator during the procedure. Maxxeus allograft bone graft was mixed with the patient's blood and inserted into the defect area. The bone graft was packed into the site, and then a collagen membrane was adapted, inserted and stabilized with a subperiosteal suture. The flap was advanced coronally and sutured first at the crestal part with tension-free primary closure, followed by suturing of the non-keratinized mobile vestibular tissue area using simple interrupted resorbable sutures (Vicryl 5-0, Ethicon).

Group II: Once the bony defect was identified, a vertical incision was made mesially to the graft site. The incision was precise, extending down to the bone with a scalpel to ensure it was clean and straight, minimizing tissue trauma. The tissue was then gently dissected with a periosteal elevator, lifting the periosteum off the bone. The elevator was carefully inserted under the periosteum at the edge of the incision, and a sweeping motion was used to gradually separate it from the. To create the subperiosteal pocket, the periosteum was carefully dissected from the underlying bone using the periosteal elevator. The dissection extended beyond the bone defects and along the alveolar crest until the tunnel flap was tension-free and ready for the insertion of the graft. After completing the dissection and creating the pocket, the tissues were handled gently to avoid tearing or unnecessary trauma. Suction or gauze was used to control bleeding and maintain a clear field of vision.

Subperiosteal bag preparation: The bilayer collagen membrane were extraorally perforated, folded, and sutured with a resorbable suture to create a "bag" with an opening. The bag were perforated only in one side which closed to narrow alveolar ridge. The bag was then inserted inside the subperiosteal tunnel with the perforated side facing the alveolar ridge and the non-perforated side facing the flap. Maxxeus allograft bone was mixed with the patient's blood and inserted into the subperiosteal bag using an insulin plastic syringe. The bone graft was packed into bag, and simple interrupted resorbable sutures (Vicryl 5-0, Ethicon) were used to achieve primary closure of the vertical incision.

Implant placement:

After 6 months of ridge augmentation, insertion of the implants fixture (*Vitronex* Elite *Implants*) of diameter 3.75 -4.5mm. According to manufacture instructions. Careful screwing and seating of these tapered implants into the bone was performed until all exposed threads were submerged and the platform remained flush with the crestal bone wth gaining primary stability of the implants and fixation in its position and implants were evaluated for primary stability. Cover screws were then fixed to the implants. For group 1: buccal pedical part of flap, de-epithelized, bent, shifted buccally, creating a dead space underneath the flap and sutured. Oral hygiene recommendations were provided including the use of soft tooth brush. Further advices included adhering to a soft diet and avoiding trauma to the gingival tissue at the implant sites especially in the first few weeks.

Implant success evaluation

Implant success was determined according to an assessment of implant stability, pain, infection, and radiolucency around the implant.

The definition of implant success was defined according to the following 4 criteria:[7]

(1) Absence of clinically detectable implant mobility.

(2) Absence of pain or any subjective sensation.

(3) Absence of recurrent peri-implant infection.

(4) Absence of radiolucency around the implant.

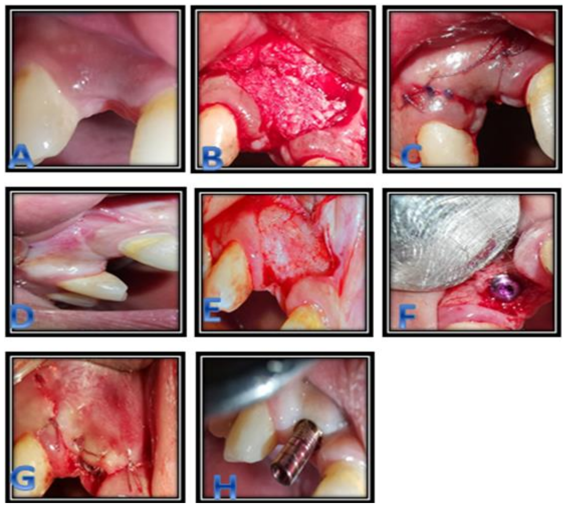

Fig.1: Clinical photographs of a 33-year-old female patient with narrow alveolar ridge treated with buccal flap technique and allograft bone for ridge augmentation and implant placement after 6 months of the augmentation showing; A-Preoperative narrow alveolar ridge, B-Buccal flap reflection and allogeneic bone graft, C-Suturing of the flap, D-6 months postoperative ridge augmentation, E- Buccal flap reflection 6 months after augmentation for implant placement, F- Implant placement, G-Suturing after implant placement, H-Abutment placement after 6months of implant placement.

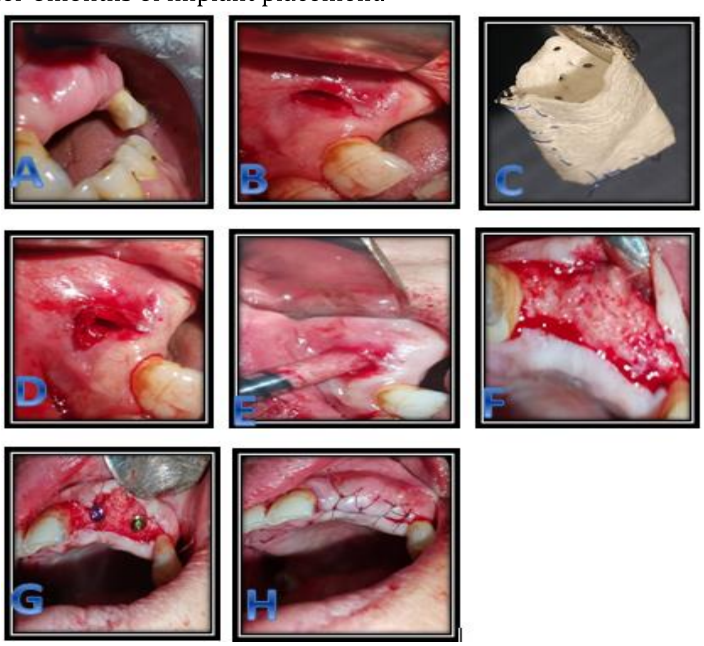

Fig.2: Clinical photographs of a 36-year-old male patient with narrow alveolar ridge treated with tunnel technique with sub periosteal bag filled with allograft bone for ridge augmentation and implant placement after

6 months of the augmentation showing; A-Preoperative narrow alveolar ridge, B-Tunnel incision and reflection and ready to receive the bag and graft, C-Collagen perforated and sutured bag ready to inserted in to its tunnel, D-Collagen perforated and sutured bag inserted in to its taunnel, E-Allogenic bone inserted in to the subperiosteal bag, F-Flap reflection after 6 months of augmentation for implant placement, G-implants placement in the augmented ridge, H- Suturing after implant closure.

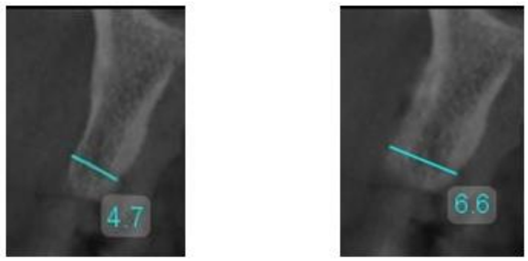

Fig 3: CBCT showing pre & post-operative alveolar ridge width (GroupI)

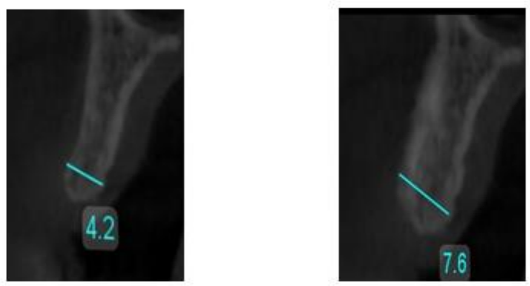

Fig 4: CBCT showing pre & post-operative alveolar ridge width (GroupII)

Evaluations of ridge augmentation and implant placement :

Evaluations were done in two stages

i) **-Firstly: ridge augmentation.**

A- Clinical evaluation:

Clinical evaluations were done at baseline and 6 months after ridge augmentation including ridge width.

B- Radiographic evaluation:

Radiographic evaluations were done at baseline and 6 months after ridge augmentation by using of CBCT for assessment of ridge width and bone density.

ii) -Secondary: implant placement.

a. Clinical evaluation:

Clinical evaluations were done at baseline, 6 and 9 months after implant placement including:

1- **Implant primary stability** :all implants well evaluate for primary stability once after implant insertion with an Osstell Mentor magnetic resonance device that uses resonance frequency analysis for determining implant stability.[8]

2- **The assessment of soft tissue changes**: was done using William's periodontal probe.[9]

3- **Modified sulcus bleeding index** [10]: at 4 aspects around the implants: score 0, no bleeding when a periodontal probe is passed along the gingival margin adjacent to the implant; score 1, isolated bleeding spot visible; score 2, blood forms a confluent red line on margin; and score 3, heavy or profuse bleeding.

4- Peri-implant probing depth (PPD)[11,12]: Distance from the crest of gingival margin to the bottom of the gingival sulcus at four sites around implants using a UNC 15 color coded plastic periodontal probe. Distances will be rounded up to the nearest millimeter.

5-Modified Plaque Iindex (mPI) [10]: To assess plaque accumulation around marginal area around implants as following: 0 (no plaque detected), 1 (plaque recognized only by running a probe along margin), 2 (plaque visible to the naked eye) and 3 (abundance of soft matter).

b. Radiographic Evaluation:

1) Pre-operative and Post-operativ ridge width:

Ridge widths were measured with cone beam computed tomography (CBCT). The reference points and lines were used; two points will marked at the outer surface of labial and palatal cortical plates apical 2 mm to the crest of alveolar bone. Tangential line will be drawn passing through the labial and palatal points and then the distance between these two points will be measured. With millimeters in the day of the implant placement (baseline) and on the follow-up visits at 6 and 9 months.[13]

2) Measuring of marginal bone level (MBL):

Marginal bone loss around the implant was evaluated using periapical radiographs. The exposure from x ray machine was received by size2 Woodpecker I-Sensor. The images, manipulated by the Image J software program, were taken on the day of the implant placement (baseline) and at follow-up visits at 6 and 9 months. The distance from a reference point at the implant to the most coronal point where the marginal bone contacts the implant was measured. Measurements were made mesially and distally for each implant.[14]

3) **Measuring of bone density (BD):** Average bone density was determined around implant using CBCT. At the generated cross- sectional view, the area to be measured which called regions of interest (ROI), will be selected and traced. The readings were taken in Hounsfield Unit (HU). Bone density was measured before ridge augmentation, at the day of the implant placement (6months after augmentation) and on the follow-up visits at 12months (6months after implant placement).[15]

IX- Prosthetic procedure

6 months later, under local anesthesia, the surgical covering screw was exposed and removed then healing cap was then placed for 2 weeks. After that, Impression was made with the aid of impression post and laboratory analogue using silicone rubber base material to fabricate working cast then the final restoration of porcelain fused to metal was fabricated and cemented on the abutment.

XII- Statistical analysis:

The data collected, tabulated, computed, and statically analyzed. Statistical analysis was performed with SPSS software version 24 (SPSS).

RESULTS

Twenty patients having narrow alveolar ridge were selected to participate in this study. No abnormal reactions or complications were observed post surgically during the observational period of the study.

By measuring alveolar ridge width there were no statistically significant difference at pre-operative ridge augmentation when comparing between groups while there were statistically significant difference at post-operative (6months) of ridge augmentation when comparing between groups. Also, there were statistically significant differences at different periods within groups.

In statistically checking to both modified plaque index and modified sulcus bleeding index; this study recorded no statistically significant differences between both groups at any observation period checkpoint and there were statistically significant differences within the groups in different observation periods. (chart no.1)

By measuring peri-implant pocket depth and clinical attachment loss, there were statistically significant difference at 6 and 9 months when comparing between groups. Also, there were statistically significant differences at different periods within groups.

By measuring implant stability quotient (ISQ) there were statistically significant difference at baseline and 6 months when comparing between groups. Also, there were statistically significant differences at different periods within groups.

By measuring change in marginal bone loss there was statistically significant difference at 6 and 9 months when comparing between groups. Also, there were statistically significant differences at different periods within groups.

By measuring bone density there was no statistically significant difference at baseline (before ridge augmentation), there was statistically significant difference at 6 and 12 months after ridge augmentation when comparing between groups. Also, there were statistically significant differences at different periods within groups.

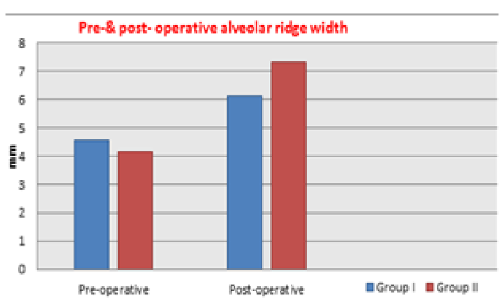

Fig (5): Histogram representing changes in the means Pre-& post- operative alveolar ridge width between groups.

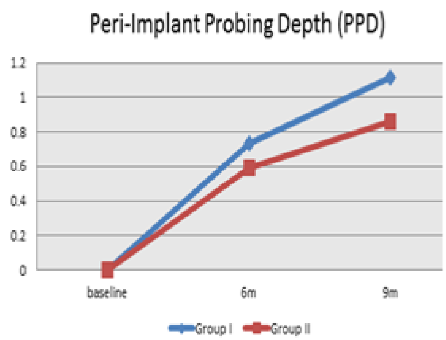

Fig (6): Diagram showing means of peri-implant probing depth in all groups in each baseline,6and9 months.

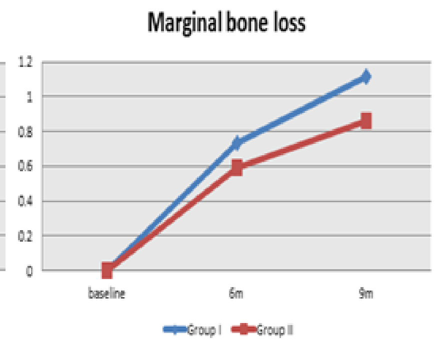

Fig (7): Diagram showing means of marginal bone loss in all groups in each baseline,6and9 months.

Table (1): *Illustrating mean ± SD values of* modified plaque index, modified bleeding index and peri-implant probing depth *along with significance level using paired & unpaired t-test.*

Clinical parameters	**Clinical ridge width**				**mPI**					mBI					PPD				
	Baseline		6months		Base line	6 months		9 months		Base line	6 Months		9 months		Base line	6 months		9 months	
G 1	4.2±0.537		6.1±0.337		0.00	0.44 ±0.26		0.489±0.18		0.00	0.49±0.28		0.61±0.33		0.00	2.12±029		2.72±0.18	
G 2	4.1±0.394		7.0 ±0.895		0.00	0.36 ±0.27		0.40±0.19		0.00	0.42±0.31		0.53±0.26		0.00	1.77±0.32		2.35±0.29	
Unpaired t test	t	P	t	P	P	P	t	P	T	P	P	t	P	t	P	P	t	P	t
G I Vs G II	1.47	0.16	2.8	0.04*	1ns	0.52	0.64	0.33	0.98	1ns	0.2	1.21	0.54	6.2	1ns	0.02*	2.53	0.003*	3.4

Table (2): *Illustrating mean ± SD values of* implant stability, alveolar ridge width implant stability, Changes in marginal bone loss and bone density measurements *along with significance level using paired & unpaired t-test.*

<table>
<tr><td rowspan="2">Clinical parameters</td><td colspan="4">ISQ</td><td colspan="4">Alveolar ridge width</td><td colspan="5">MBL</td><td colspan="8">BD</td></tr>
<tr><td colspan="2">Base line</td><td colspan="2">6 months</td><td colspan="2">Base line</td><td colspan="2">6 months</td><td>Base line</td><td colspan="2">6 months</td><td colspan="2">9 months</td><td colspan="3">Base line before augmentation</td><td colspan="2">6 months After augmentation</td><td colspan="3">9 months After augmentation</td></tr>
<tr><td>G 1</td><td colspan="2">65.3±2.45</td><td colspan="2">68.1 ±1.49</td><td colspan="2">4.56±0.4</td><td colspan="2">6. 1±0.36</td><td>0.00</td><td colspan="2">0.731±0.1</td><td colspan="2">1.111±0.15</td><td colspan="3">556.5±45.4</td><td colspan="2">559.8±63.4</td><td colspan="3">612.6±60.4</td></tr>
<tr><td>G 2</td><td colspan="2">68.6±1.26</td><td colspan="2">71.5 ±1.95</td><td colspan="2">4.17±0.49</td><td colspan="2">7.3±0.81</td><td>0.00</td><td colspan="2">0.59±0.14</td><td colspan="2">0.85±0.19</td><td colspan="3">565.7±49.1</td><td colspan="2">660.3±58.5</td><td colspan="3">670.7±56.1</td></tr>
<tr><td>Unpaired t test</td><td>P</td><td>T</td><td>P</td><td>T</td><td>T</td><td>p</td><td>P</td><td>T</td><td>P</td><td>T</td><td>P</td><td>T</td><td>P</td><td>T</td><td></td><td>P</td><td>T</td><td>P</td><td>T</td><td></td><td>P</td></tr>
<tr><td>G I Vs G II</td><td>0.001*</td><td>3.78</td><td>0.00*</td><td>4.49</td><td>1.91</td><td>0.07</td><td>1ns</td><td>3.88</td><td>1ns</td><td>3.88</td><td>0.001*</td><td>3.88</td><td>0.001*</td><td>0.45</td><td>0.66</td><td></td><td>2.21</td><td>0.04*</td><td>2.22</td><td></td><td>0.039*</td></tr>
</table>

DISCUSSION

Horizontal bone augmentation is necessary to achieve adequate bone volume especially when placing dental implants in partial or complete edentulous patients. Several bone grafting techniques and materials have been advised to reconstruct adequate bone volume in deficient areas of the alveolar bone. These techniques include horizontal alveolar ridge augmentation using bone grafting materials and guided bone regeneration.[16]

Patients in this study experienced no adverse reactions, discomfort, or complications. This procedure is considered safe, effective, and less invasive than other methods, reducing the risk of accidentally damaging adjacent soft tissues and resulting in minimal patient morbidity and easier handling. Clinically, no implant mobility was observed, and radiographic results confirmed proper osseointegration. These findings meet the criteria for implant success reported in other studies, including the absence of persistent symptoms like pain, infection, or paresthesia; implant immobility; no continuous peri-implant radiolucency; minimal progressive bone loss (less than 1.5 mm in the first year); patient and dentist satisfaction with the implant-supported restoration.[17]

It was found that a healing period of six months allowed for significant bone regeneration and maturation following ridge augmentation procedures. This six-month period also reduced the risk of complications such as infection and graft failure. Additionally, it allowed for accurate assessment of bone graft success and ensured optimal conditions for implant placement. Therefore, in this study, implants were placed six months after ridge augmentation for all patients.[18]

Branemark et al.[19] stressed that implant techniques need a 6-month submerged healing period for implants in regenerated bone and 3-4 months for those in native bone. Therefore, in this study involving patients with atrophic maxillary anterior regions, a 6-month submerged healing period was used for all cases.

Separating ridge augmentation and implant placement into two stages allows for significant bone regeneration and maturation. This staged approach ensures the grafted bone achieves sufficient density and volume to support the implant. Performing these procedures separately reduces the risk of complications such as infection and graft failure. The healing period between stages allows the bone graft to stabilize and integrate before being subjected to the stresses of implant placement.[20]

A two-stage approach results in better implant stability. The initial stage focuses on creating a solid bone foundation, which is crucial for the long-term success of the implant. By separating the procedures, optimal conditions for osseointegration are provided, allowing the bone graft to fully heal and integrate before the implant is placed. This creates a more favorable environment for the implant to fuse with the bone.[21] So in this study, ridge augmentation was performed in the first stage, followed by implant placement in the second stage.

It has been postulated that; in the anterior and premolar area of the maxilla, the direction of bone loss was horizontal, with progressive loss of bone on the labial aspect of the ridge, leaving a thin atrophic ridge with usually adequate height, while the dimension of available bone height of the posterior maxilla is greatly reduced as a result of resorption from the crest of the ridge and pneumatization of the maxillary sinus after the loss of teeth. Hence, anterior region of maxilla was selected to perform alveolar ridge. [22]

The width of the ridge in the study ranged from 3-5 mm, aligning with established guidelines for implant placement. [194] The study reported positive outcomes in terms of oral hygiene, soft tissue health, and clinical indicators such as the modified plaque index and modified sulcus bleeding index.

The study aimed to compare the tunnel with sub periosteal bag and buccal flap techniques for ridge augmentation in terms of various parameters related to implant treatment outcomes. The findings contribute valuable information to the understanding of these surgical techniques and their impact on oral health and implant success.

The evaluation period showed favorable results, with no suppuration detected, and the absence of bleeding on probing serving as a predictor for stable peri-implant conditions. Peri-implant probing depth (PPD) was assessed, and the study found no significant difference in PPD between the two groups.

Primary implant stability, which denotes the biomechanical stability upon implant insertion, is influenced by various factors such as bone quantity and quality, implant design, surgical technique, and insertion torque. This initial stability sets the stage for the development of new bone around the implant, forming a biological fixation known as secondary implant stability.[23]

Clinical assessment of implant stability can be achieved through the recording of insertion torque values or by using resonance frequency analysis. While insertion torque measurement is a well-established method, it primarily evaluates primary stability during implant placement. Resonance frequency analysis can be employed at any point during the implant's lifespan.[24]

The Osstell™ transducer serves as a device to evaluate the initial stability of a dental implant. It continuously monitors implant stability and can distinguish between clinical success and failures. Osstell™ also allows the assessment of implant stability through resonance frequency, measured as the Implant Stability Quotient (ISQ) on a scale of 1 to 100. ISQ values above 65 are considered most favorable, indicating good implant stability, while values below 45 suggest poor primary stability. Furthermore, the ISQ number correlates with the lateral stability of the implant, influenced by the rigidity of the bond between bone and implant surface.[25]

Throughout the study's observation periods, all groups exhibited a gradual increase in bone density. This study demonstrates a significant change in bone density measurements around the implant over the evaluation period across all groups, indicating successful integration .[26]

This study identified a correlation between bone density and implant stability, which aligns with earlier research. Cone beam computed tomography is a straightforward way to assess bone density around dental implants and examine bone condition prior to implantation. Resonance frequency analysis is a dependable technique for forecasting bone healing around implants and assessing stability during follow-up. Although Hounsfield units hold promise as a diagnostic tool for predicting implant stability.[27]

Marginal bone loss (MBL) surrounding dental implants constitutes a significant concern, as substantial bone loss has been identified as a key factor contributing to implant failure. The factors influencing MBL during bone

healing encompass both biological and biomechanical aspects. Host-related factors, including plaque control, smoking, and wound-healing capacity, are associated with MBL. Additionally, implant design characteristics such as platform switching, implant surface, and microthreads in the neck may contribute to MBL. Moreover, factors like surgical trauma and variations in restorative protocols could also play a role in this process.[28, 29]
Peri-implant probing depth (PPD) is closely tied to the condition of the peri-implant tissue. In healthy sites, the probe tip halts approximately at the level of the most coronal aspect of connective tissue adhesion to the implant neck, reaching around 3mm. In contrast, at inflamed sites, the probe consistently reaches close to or makes contact with the bone level.[30]
Throughout the current investigation, the average probing depth did not surpass 2.75 mm at any observation period within all groups. This finding aligns with study which concluded that successful implants typically permit probe penetration of approximately 3 mm after implant loading, measured from the crown margin to the base of the sulcus.[31]
Various thresholds are considered for peri-implantitis by different authors, such as PD, ≥ 4 mm for initial peri-implantitis, ≥ 6 mm for moderate peri-implantitis, and ≥ 8 mm for severe peri-implantitis. Pockets below 4 mm generally indicate soft-tissue inflammation, while those above 4 mm indicate soft-tissue pockets.[32]
Koldsland et al. utilized two PD thresholds, ≥ 4 mm and ≥ 6 mm, to distinguish different levels of peri-implantitis severity. Peri-implant probing is crucial for diagnosing peri-implant disease. A microbiological study highlighted a marked difference in peri-implant microflora composition between implants with deep and shallow pockets, suggesting that pockets 5 mm or more deep may serve as protected habitats for potential pathogens and indicate peri-implantitis.[33]
The study utilized the modified plaque index (mPI) for a quantitative assessment of oral hygiene. In our investigation, the mean modified plaque index (mPI) across all groups during the observation period indicated minimal plaque accumulation around the implants, reflecting commendable oral hygiene practices by the patients. No statistically significant differences ($p>0.05$) were observed between groups at any time point, In agreement with another study, a meaningful relationship exists between oral hygiene and bone resorption .[34]
Traditional GBR techniques include flap elevation and placement of a block or particulate graft in conjunction with space maintaining devices and cell occlusive membranes. This approach often results in complications that may increase morbidity and negatively affect the outcome of the augmentation procedure as well as the peri-implant soft tissue esthetics.[35]
The predictability of horizontal GBR has been well established in the literature, as well as the risk of membrane exposure as a main complication related to this procedure; flap design and management are believed to be crucial for obtaining healing by primary closure of the surgical site following GBR.[36]
Therefore, it is not surprising that Deeb et al found that GBR with tunnel technique with injection of particulate bone graft into a subperiosteal pocket was associated with less wound dehiscence membrane exposure and lower morbidity than GBR with an open approach. Another advantage of the tunnel technique was the lower number of postoperative visits and surgical procedures, leading them to conclude that tunnel technique was a more costeffective approach with similar clinical outcomes compared to “traditional” GBR.[37]
The tunneling technique is believed to become one of the foremost vital methods for enhancing bone formation. additionlly, the subperiosteal tunneling procedure is attractive because it’s minimally invasive. The technique offers the advantages of a more conservative surgical entry and little postoperative morbidity than the flap procedure, thereby shortening surgical time and minimizing the extent of postoperative pain, edema, and infection.[38]
This agreed our results as all the grafts healed successfully with no rejection of any case. No signs of infection or wound dehiscence were reported through the follow-up period. The bone graft material might have less movement when the subperiosteal tunnel technique is used because the graft is stabilized in its sub periosteal bag than with the open approach.[38]

The primary outcomes of the present study revealed that, bone formation in the grafted site is significantly greater when a tunnelling procedure with sub periosteal bag is used to place allogeneic bone for horizontal alveolar augmentation than when we use the buccal flap technique.
In the present study, we proved that new bone formation was more in the tunnel technique with sub periosteal bag than bucall flap technique. Therefore, it is likely that the greater bone formation in the tunnelling group would have been influenced by the graft stabilization.These results coincided with the results of Feng Xuan et al who stated that bone formation within the graft site is significantly greater when a tunnelling procedure is used to place bone blocks for ridge augmentation than when we use the flap technique.[39]
Commonly, full flap is raised (open approach) and bone graft is delivered to the deficient areas that are candidates for future implant insertion. Lateral ridge augmentation using the sub periosteal tunnelling dissection with sub periosteal bag is a closed and partially blind procedure, because it doesn't permit viewing the deficient ridge, but it enables access to the recipient area with minimal tissue dissection and handling.[40]
Although others have performed augmentation of the lateral ridge without use of tissue barriers, we believe that usage of membrane to create a tent effect will keep the dissected tissue raised, permitting insertion of the bone graft material, allowing an increase in volume of the deficient area and preventing the ingress of unwanted tissues such as fibroblasts into the grafted bone is a reliable source for bone grafting.[41, 42]
Osteoinductive and osteoconductive properties of allogeneic bone promote new bone formation, allogeneic bone is also easy to handle and is easily packed under the elevated and dissected pocket. Although different kinds of bone grafting materials from other areas of the body (such as iliac crest, calvaria, tibia, chin, or external oblique line from the mandible) are available and are commonly used . Patients are usually more receptive to a procedure that's minimally invasive and doesn't require a secondary surgical site. Because the pocket technique is indeed a minimally invasive procedure that doesn't require a secondary site for bone harvesting, patients benefit from less pain and rapid recovery.[43]
When considering ridge width augmentation with a buccal flap, statistical variances were observed between pre- and post-operative stages. This aligns well with findings from other studies where patients underwent treatment involving a collagen membrane along with particulate autogenous and anorganic bovine bone-derived mineral, showcasing comparable outcomes.[44, 45]
A key advantage of tunneling technique with sub periosteal bag (TTSB) is the preservation of an intact periosteum layer in the flap that can also contribute to the bone regeneration with its osteoinductive properties. The rationale for the varied outcomes of the two procedures is presumably explained by the effect of the periosteum. Within the flap procedure, an incision is made through the periosteum to advance the flap over the graft and to achieve primary closure without tension, which results that the graft material not completely covered with the periosteum. In contrast, with the tunnelling procedure, the periosteum is lifted without flap elevation or a releasing incision of the periosteum. The periosteum is the source of mesenchymal cells and osteoblasts that are important in osteogenesis; the preservation of the periosteum optimizes bone formation.[46, 47]
The role of the periosteum as a potential source of osteoprogenitor cells in growth factor–mediated bone-regenerative procedures must be considered. Current knowledge suggests that the periosteum contains a population of progenitor cells that mediate the repair of bone defects. The osteoinductive potential of the periosteum as a source of undifferentiated mesenchymal cells in bone repair also has been reported.[48]
The level of horizontal augmentation attained depended on how well the boundaries of the subperiosteal pouch were defined, ensuring most of the graft material remained inside. This caused the mucosa to stretch outward as the graft particles were placed and compacted. There was a worry that too much tension on the mucosa could result in the graft being exposed due to dehiscence. Controlling the dispersion of the graft particles is technique sensitive and may result in irregular augmentation patterns. However, although the particles were visible radiographically they were not associated with any negative biologic or clinical effects.[49]

Based on these findings, **Giulio and Karmon** showed that using TTSB for ridge augmentation before implant placement can result in minimal complications and patient discomfort. By employing a tunneling approach and a subperiosteal bag filled with xenogeneic bone graft, sufficient horizontal ridge dimension can be achieved. There's a possibility that placing particulate bone graft material within a folded bioresorbable collagen membrane, with the perforated side facing the alveolar ridge and the non-perforated side facing the flap, could offer additional advantages by preventing the infiltration of non-osteogenic cells into the defects and horizontal bone width gained was 3.7 ± 1.8 mm which in agreement with this study where horizontal bone width gained was 3.13± 0.315mm.[50]

CONCLUSIONS

Within the limitations of this trial, there was significant post-operative ridge width gained, less peri-implant probing depth, more primary and secondary implant stability and less marginal bone loss in the Tunnel technique with subperiosteal bag.

Tunnel technique with subperiosteal bag combined with allogeneic bone was an effective technique in increasing ridge width with less marginal bone loss than buccal flap technique, the pre-implant site condition was improved with the tunnel technique compared to the buccal flap technique.

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