CLINICAL AND RADIOGRAPHIC EVALUATION OF THE EFFECT OF SOCKET PRESERVATION USING ROLL PEDICLE CONNECTIVE TISSUE GRAFT WITH BOVINE BONE

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Abstract

Aim: This study aimed to evaluate the clinical and radiographic effect of roll pedicle connective tissue as a barrier membrane together with bovine bone in alveolar ridge preservation after tooth extraction regarding the width and height of alveolar bone and gingival thickness.

Subjects and methods: This case series trialincludedeight patients with eight non-restorable single or double-rooted teeth, having alveolar socket defect (type I & II). Patients were assigned into the single test procedure, which included atraumatic extraction where sites were grafted with bovine bone and covered with roll pedicle connective tissue graft as a barrier membrane. Bone caliper and periodontal probe were used to assess the width of alveolar crest and gingival thickness respectively on the fabricated acrylic stent for each patient at baseline, 3 and 6 months. Assessments of height of alveolar bone crestby Digora system software were performed at baseline, 3and 6 months.

Results: The widthof alveolar crest and gingival thickness were measured at two points 3 and 5mm.Results showed that width of the alveolar crest at 3 and 5mm showed significant increase of 1.56(1.09-2.03), 1.50(0.79-2.21) respectively in comparison with the baseline. The gingival thickness at 3mm after 6 months showed an increase of 0.88mm(0.58-1.71) when compared to baseline.While at 5mm, it showed a statistically increase of median of(1.63-2.88).Moreover, the height of alveolar crest after 6 months showed a median of(2.09-3.89) in comparison to the baseline.

Conclusion: Socket preservation in type I and II socket defect withtherollpedicleconnectivetissuegraft with bovine boneresultedinastatisticallysignificantincreaseinthe width and height of the alveolar bone and the soft tissue thicknessfrom baselineto 3 and 6 months.

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INTRODUCTION

It was approved that the degree of residual ridge resorption is closely related to the time of tooth extraction in both maxilla and mandible. The loss of tissue contour is usually the greatest in the early post-extraction period

within six months. Apparently, healing of sockets in the maxilla occurred faster because of the greater vascular supply than those in the mandible, which could lead to a faster resorption pattern **(Irinakis, 2007).**

The main reason behind that reabsorption is greater at the buccal side could be connected to the initiation of catabolic changes that result in reabsorption of the bundle bone lining the socket **(Balli et al. 2018)**. The fibroblasts within the periodontal ligament, the distinctly oriented collagen fibers, the vascular elements and inflammatory cells reside lateral to the bundle bone **(Araújo and Lindhe 2009).** When a tooth is extracted, the osteoclastic activity is activated due to disturbance of the blood supply from the severed periodontal ligaments. As most of the buccal plate is composed of bundle bone compared with the lingual plate, so it resorbs faster **(Balli et al. 2018).** This could be due to the limited thickness of the facial bone wall in comparison with the lingual side of the socket **(Chappuis, Araújo and Buser, 2017).**

When the bone topography in maxilla and mandible were assessed using cone beam computed tomography (CBCT), it was found that the thickness of buccal plate was anatomically less than 2mm in over 80% of the anterior and posterior teeth. In addition, the most critical areas in the maxilla were laterals incisors, canines and first premolars**(López-Jarana et al., 2018)**.

Therefore, atraumatic extraction was considered as the first modality in ridge preservation **(Bartee, 2001).** A variety of techniques are available for minimally invasive atraumatic tooth extraction such as easy X-trac system, or extraction using physical forceps, ultrasonic,rubber band extraction, implant drill and periotomes**.** However, the main conservative modality to avoid the extraction site defects is socket preservation procedure where the main target of these procedure is conservation of the vertical and horizontal dimensions **(Jain et al., 2017).**

The process of socket preservation includes grafting (filling and augmenting) an intact socket. Bone grafting could be done using different materials, such as autografts (the patient's own bone, which requires multiple painful procedures), allografts (human bone, not from the patient), andxenografts (animal bone) or Alloplasts (synthetic bone). Autografts are osteogenic and contain bone-forming cells; allografts could be osteoconductive and osteoinductive, attracting bone-forming cells. While the xenografts and Alloplasts are osteoconductive acting as scaffolds for other bone-forming cells **(Keith & Salama, 2007).**

Bovine-derived bone grafts were found to have the advantage of a higher osteoconductive potential compared with synthetically derived materials. Consequentially bovine grafts (particulate and blocks) were successfully used for the treatment of human intrabony defects and ridge augmentation **(Glogauer et al., 2015).** Also, the use of xenograft has proven its effect in alveolar ridge preservation **(Llanos et al., 2019).**

Different types of barrier membranes were used in various studies over the years, such as expanded polytetrafluoroethylene (e-PTFE), collagen, polyglycolic acid and polyglactin. These were grouped into two major types: non-resorbable and resorbable membranes **(Irinakis, 2007).** It was critical to consider the benefits of socket or ridge preservation and the use of barrier membranes when treating and planning tooth extractions. The clinician’s choice of barrier membrane was determined by the type of procedure and the desired outcome, which is necessitated by the state of the socket following tooth extraction **(Rodriguez et al., 2018).**

Connective tissue grafts were a common intervention in periodontal plastic surgery and peri-implant soft tissue plastic surgery. This was contributed to their ease of handling and achieving minimally traumatic harvesting techniques aimed at maximizing tissue volume that promoted their multi-usage **(Böhm et al., 2018).**

One of the developed techniques of

alveolar ridge preservation is using the rolled pedicle connective tissue graft technique that was introduced by **(Abrams, 1980).** This technique includedde-epithelization of a palatal pedicle flap and exposure of palatal bone to be rolled under the buccal mucosa to increase the buccolingual dimensions of the edentulous ridge for further fabrication of fixed prosthesis. Moreover, it was described by **Sclar (2003)** who used tunnel approach to reposition a connective tissue pedicle from palate and the technique was called Vascularized inter-positional periosteal connective tissue flap to conduct massive volumes of augmentation in the aesthetic zone with the least post-operative tissue loss.

Hence, the subepithelial CT pedicle techniques were proved to provide great amount of tissue, achieved closure of soft tissue at donor and recipient sites, and could cause minimal postoperative morbidity **(Romanos et al., 2013)**.

Materialsandmethods:

1. Studysettings:

This case series included 8 sites in 4 males and 4 females with age ranging between 26-45 years; with maxillary, single or double-rooted teeth that required extraction showing a buccal bony defect (type I & II) socket defect. Patients were assigned into the single test procedure, which included atraumatic extraction and sites were grafted with bovine bone and covered with roll pedicle connective tissue graft as a barrier membrane.

Subjects were selected from the outpatient clinic, Department of Oral Medicine and Periodontology, Faculty of Dentistry, Cairo University between September 2019 and January 2021. Screening of patients was continued until the target sample was achieved. Identifying and recruiting potential subjects was achieved through patients' database.

2. Ethical Procedures:

The study protocol was approved by the Ethics Committee of Scientific Research, Faculty of Dentistry, CairoUniversity(28-7-2019).ThisclinicaltrialwasregisteredinU.S.NationalInstitutesofHealthClinicalTrials Registry, ClinicalTrials.gov Identifier: ID: NCT05255341. The detailed operation and follow up periods were clearlydescribedindetailtoallpatientsselectedinthisclinicaltrial.Allsubjectsparticipatedinthistrial,signed a written consent, and fully agreed to participate in this work.

3. Eligibilitycriteria:

- Sites included in the study were maxillarysingle or double rooted teeth indicated for extraction with the presenceofaalveolar socket defect grade I and II**(Elian and Smith, 2007).** Patients included wereadults >18 years old with healthy systemic condition and normal platelet counts according to complete blood count (CBC) test done in the screening stage **(lee, et al 2018).** While patients with acute infection at the extraction socket(**Darby, et al 2008)**orwithhistory of treatment with bisphosphonate**(Shudo et al. 2018)**or under any medications that may interfere with wound healing were excluded from this study**(Busti et al. 2005).**

4. Powerandsamplesize calculation:

Based on the study design, as it is a case series study, the medical biostatistics unit (MBU) reviewed the protocol and referred to determine the sample size with the supervisor and to be reviewed by the department of evidence-based committee. A similar technique was first observed in (**2015)**, termed as "Long palatal connective tissue rolled pedicle graft with demineralized freeze dried bone allograft plus platelet-rich fibrin combination: A novel technique for ridge augmentation", and was published as a methodological case report study with three patients as sample size **(Reddy et al. 2015).** However, the sample size was raised to 8 cases.

5. Randomization:

Randomization and allocation were not required, as it is a single arm study, thus all the

patients were assigned to the procedure of socket preservation using bovine bone graft and roll pedicle connective tissue graft from the palate was used as a barrier membrane.

6. Clinical outcomes:

The primary outcome in this clinical trial was thechange in width of the alveolar ridgemeasured via an acrylic stent which was fabricated for each patient to act as a guide and assist in standardization of all clinical measurements.Two holes were made in the acrylic stent (3mm and 5 mm below the alveolar crest) on the buccal and palatal extensions within the midline of the tooth to be extracted. While the secondary outcomes were the change in the gingival thickness and the height of the alveolar ridge. The gingival thickness was evaluated by William's graduated periodontal probeinserted horizontally perpendicular to the alveolar bone at the two assigned holes labially/buccally at baseline, 3- and 6-months post extraction(**Langlois, Emidio, & Silva, 2018)**. All the outcomes were measuredpreoperative, then at 3and 6 months postoperatively.

7. Radiographicassessment:

Radiographic evaluation of each tooth assigned for extraction was done using standardized periapical radiograph with paralleling technique and radiographic stentaccording to **Schropp et al., (2003)**at baseline (immediately after preserving the socket), then 3- and 6-months post extraction to evaluate the crestal bone level at the lowest point of the socket defect.

Digital periapical radiographs were taken by VARIO x-ray machine set at 1.75mAs and a Phosphor storage plate [1](PSP) size 2**.** The paralleling technique was taken by Rinn XCP[2] holder and a bite block made for each patient with heavy silicone impression material in order to standardize the technique.

After taking the radiograph, the PSP was removed from its plastic wrapping and inserted into the vista scanner**.** Linear measurements were performed according to**(Nisar et al., 2020).** Using the image software of Digora system[3] as shown in (**figure 1)**. Crestal bone height was measured to determine the amount of bone at (baseline, 3 and 6 months).

Before taking the required measurements, each radiograph was calibrated**.** After that, a line connecting the CEJs of the two adjacent teeth to the extraction socket was drawn. Next, a line was drawn perpendicular to the first line to the alveolar crest (lowest point of the alveolar ridge defect). The perpendicular measured distance between the two lines represented the height of alveolar crest. These steps were repeated for each patient at baseline, 3- and 6-months follow-up visits as shown in(**figure 2)**.

[1]Durr Dental Co, Psp, Germany
[2]Easy Mix Putty Aquasil Dentsply Caulk®)
[3]Digora for Windows 2.8™, SOREDEX Inc., Tuusula, Finland

Figure 1: Photograph showing vista scan device

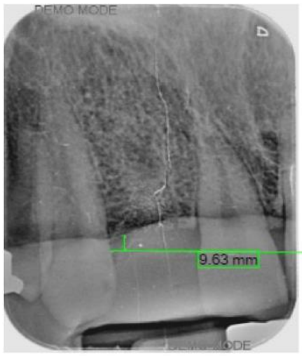

Figure 2: Radiograph showing the height of alveolar crest.

8. TreatmentProtocol:

8.1 Pre-surgicalphase:

Instructions for oral hygiene measures were provided as modified circular brushing technique, and interdental cleansing devices. Participants received phase I therapy by supragingival scaling and subgingival debridement using ultrasonic scalers[4] for supragingival deposits and Gracey curettes[5] (3-4 or 5-6) for subgingival debridement. A 0.12% chlorhexidine mouthwash[6]was prescribed and the oral hygiene wasrechecked after 7 days for gingival index and plaque index **(Haydari et al. 2017).** Primary impression was taken for the jaw containing the tooth or root to be extracted for construction of an acrylic stent.

8.2 Surgicalphase:

8.2.1 ***Atraumatictooth extraction:***

Patients were prepared for tooth extraction by rinsing their mouth with antiseptic mouth wash chlorhexidine gluconate 0.12% for about 1 minute before extraction.Local anesthesia was given by infiltration using Articaine Hydrochloride 4%[7].The surgical procedure was done under complete asepsis and infection control.After induction of local anesthesia, sulcular incisions were performed on the buccal and lingual aspects of the teeth to be removed with minimal flap reflection to minimize crestal bone loss.Every attempt was made to minimize trauma to the alveolus during extraction, where surgical blade #15 was used to severe the periodontal ligament fibers at the mesial and distal aspect of the root.The periodontal ligament fibers were further separated with the use of Periotome[8] inserted within the gingival sulcus and moved circumferentially all around the tooth or root to rupture the supracrestal, attachment apparatus**(figure 3A)**.The tooth was carefully extracted with small elevators used when required, but luxation was performed in the mesio-distal direction with extreme care to avoid fracture of the buccal or lingual alveolar walls**(Shilpa *et al.*, 2017)(figure 3B).**

8.2.2. Preparation of roll pedicle connective tissue graft:

- Immediately after tooth extractionas shown in **(figure 3C)**, After administration of local anesthesia, partial thickness single horizontal incision was made on the palatal aspect of the ridge at the mesial line angle of the tooth to the mesial line angle of first molar. From the horizontal incision line, an oblique incision was placed from mesial line angle to the lateral tooth (**figure 3D).**Care was taken to maintain at least 3 mm distance from the gingival margin of teeth to the oblique incision.The soft tissue was reflected at least 4 mm beyond the

[4]Guilin Woodpecker Medical Instrument Co, China
[5]Hu-Friedy, LLC Co., USA
[6]Hexitol M.W. The Arab Drug Company (ADCO)
[7]Septocaine with epinephrine 1:100000, Setodont,canada
[8]H. ZEPF, DR Hildebrand, Germany

alveolar crest margin as shown in(figure 3d). Rollpedicle connective tissue graft technique was performed as proposed by **(Abrams, 1980**) that comprised de-epithelization of a palatal pedicle flap and exposure of palatal bone as shown in **(figure 3E).** The extraction socket was filled with bovine derived xenograft[9] to be covered with roll pedicle connective tissue graft as a barrier membrane as shown in **(figures3F&G)**. This pedicle was rolled under the buccal mucosa to increase the buccolingual dimension of the edentulous ridge.as shown in**(figure 3H)**. An anteroposterior subperiosteal tunnel was performed on the palate near the extraction site for preparing a gate for the pedicle graft to pass from the donor to recipient sites**.**The length of the palatal connective tissue pedicle graft was approximately 2 times more than the apicocoronal length of the ridge defect. This Anterior extension of the tunnel was done under the margin of the extraction socket as shown in **(figure 3I).** Then the flap was advanced over the jumping distance through the tunnel into the extracted socket **(figure 3I).** The pedicle connective tissue graft was rolled from the apical end beneath the tunnel and secured with 5–0 vicryl suture[10] to the labial flap to be secured in the buccal pouch (**figure 3J).** Then the donor palatal site was sutured with the same suture **(figure 3K).**

[9]ovis xeno, DENTIS, Australia
[10]ETHICON LLC, San Lorenzo, Puerto Rico

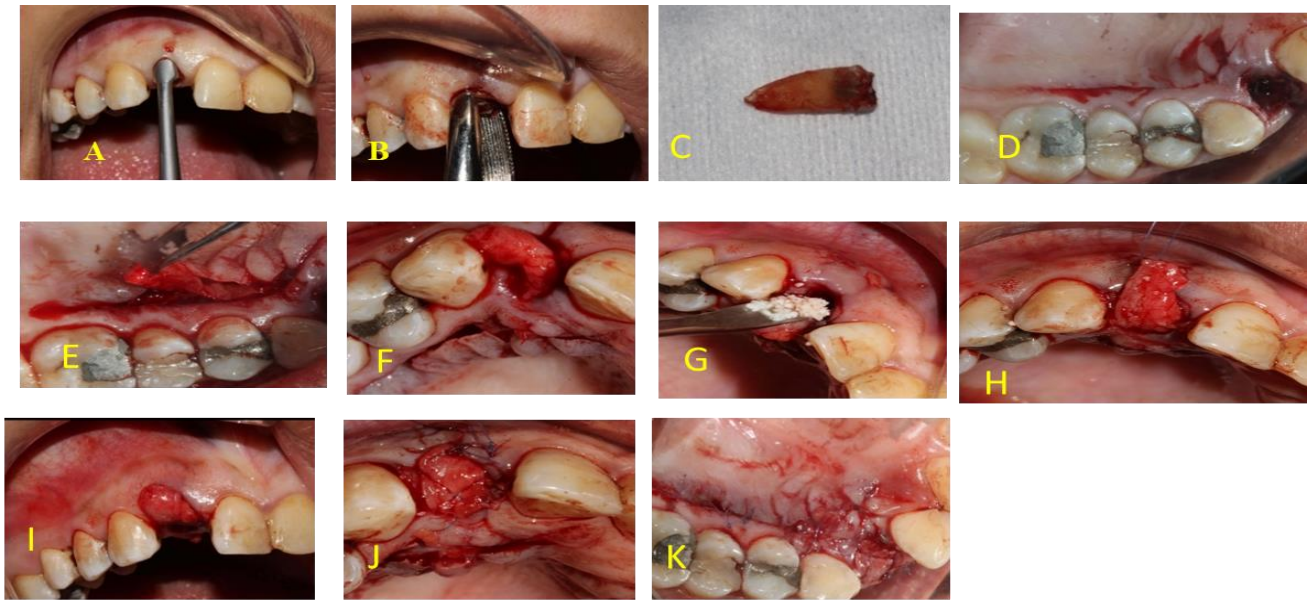

Figure3:A:Clinicalphotographsshowinginsertion of periotome to severe periodontal ligaments around the tooth to be extracted.B: showing handling of forceps for removal of the remaining root.C:showing the extracted remaining root.D: showing the single horizontal incision of the palate for harvesting the pedicle connective tissue graft.E:showing handling of the pedicle connective tissue graft.F:clinical phtograph showing rotation of the pedicle connective tissue graft via the lingual tunnel to the recipient site.G:clinical photograph showing bovine bone applied into the socket.H: clinical photograph showing handling of the graft into the buccal pouch with suture 5-0.I:Clinical photograph of the graft rolled inside the buccal pouch.J:clinical photograph showing suturing of the graft into the buccal pouch. K:Clinical photograph of suturing the palatal donor site.

8.3 Post-surgicalphase:

The patient was followed up weekly for the first month.The operator motivated and ensured the importance of continuing the oral hygiene measures and follow-up appointments. Reminding calls were used to the patient to ensure for follow-up.Antibiotics were prescribed (Amoxicillin 500 mg)[11]capsules t.i.d for 3 days post-operatively **(Reddy et al. 2015)**.Analgesics were prescribed, Ibuprofen 400 mg[12]b.i.d for 2 days post-operatively**(Reddy et al. 2015).**Patients were instructed to rinse with mouth wash including 0.12% chlorhexidine rinse Hexitol®[13] twice daily for 2 weeks then after 2 weeks the sutures were removed. Three weeks post surgically the patients were instructed to gently brush the operated area with a soft toothbrush using roll technique.

9. StatisticalMethods

Statistics were presented as frequency and percentages for qualitative data. For quantitative data, normality was checked using Kolmogorov-Smirnov and Shapiro-Wilk tests. For normally distributed data, summary statistics were presented as mean ± standard deviation (SD)[14]. The comparisons between

[11]ETHICON LLC, San Lorenzo, Puerto Rico
[12]Ibuprofen 400 mg, Kahira Pharm. & Chem. Ind. Co. Egypt, Under license from: Abbott Laboratories
[13]Hexitol, Chlorhexidine HCL 0.125%.The Arab Drug Company (ADCO) - A.R.E
[14]amoxicillin 500mg, Egyptian international Pharmaceutical Industries Company.E.I.P.I.CO.

different time points were done using paired t-test and the mean difference along with 95% confidence interval (CI) were reported. For non-normally distributed data, summary statistics were presented as mean ± SD, median and range and comparisons between different time points were done using Wilcoxon signed-rank test. All testes were two-tailed and significance level was set at level of $P \leq 0.05$. Statistical analysis was performed using IBM (NY: IBM Corp. USA)[15] statistics for windows.

Results:

1. DemographicData:

This case series study included 8 hopeless teeth in the upper esthetic zone that needed extraction. The study sample included 4 male participants who accounted for 50% of the total sample and 4 female participants representing the remaining 50% as shown in **table (1).**The mean age (±SD) corresponded to 36.38 (± 6.39) years with a minimum age 26 years and maximum age 45 years. All of the patients, who were enrolled in this study, met the inclusion criteria. No dropouts were recorded during the follow ups with no complications noticed after the surgical procedures during the follow ups and proper healing was presented in all of the surgical sites.

[15]IBM SPSS Statistics for Win1dows, Version 23.0. Armonk, NY: IBM Corp

Table (1): Descriptive statistics for age and gender

	Mean (±SD)		Min	Max
Age (years)	36.38 (±6.39)		26.00	45.00
Gender		**Number**	**Percentage**	
	Male	4	50%	
	Female	4	50%	

2. Width of the alveolar bone:

The alveolar bone width at 3 mm level had mean (±SD) value at baseline, 3 and 6 months 7.00 (±1.63) mm, 8.56 (±1.50)mm and 7.88 (± 1.66)mm respectively. There was a statistically significant increase in width from baselineto6 months(P-value <0.001) with 0.88(±0.23) mm change from baseline to 6 monthsand 13.02 (±4.47) %percentage change. While the mean (±SD) width at 5 mm level at baseline, 3 and 6 months were 7.31 (±1.53) mm, 8.81 (±1.60)mm and 8.13 (± 1.55) mm respectively. The mm change from baseline to 6 month was 0.88(±0.23) and the percentage change% from baseline to 6 months was 11.46 (±3.91) as shown in **table (2)**.

3. Gingival thickness:

In this case series clinical trial, the mean (±SD) of gingival thickness at 3 mm level was 1.56 (±0.50), 2.13 (±0.58) and 2.44(±0.56)mm at baseline,3 and 6 months respectively. After 3 months there was a statistically significant increase of0.56 [0.41, 0.71] mm in comparison with the baseline (*P*<0.001) while after 6 months there was a statistically significant increase (*P*<0.001) of 0.88 mm, with 95%CI [0.58, 1.17] as shown in **table (3)**.At 5 mm level,the mean (±SD) of gingival thickness was 1.63 (±0.52), 2.13 (±0.52)and 2.38 (±0.69)mm at baseline,3 and 6 months respectively. After 3 months there was a statistically significant increase (*P*=0.005). Also, after 6 months there was a statistically significant increase to 2.38 (±0.69) mm when compared to baseline (*P*=0.010) as represented in **table (3).**

4. Radiographicoutcomes:

The mean (±SD) height of the alveolar bone was 4.01 (±0.89), 3.28 (±1.18) and 2.78 (±1.25) mm at baseline,3 and 6 months respectively. The gain change in mm from baseline to 6 monthswas1.23 (±0.62) mm which corresponded to a percentage change 32.48 (±16.02)%as shown in **table (4)**.

Table 2: Descriptive statisticsandresultsofpaired t-test for comparison between bonewidth at baseline, 3 and 6 months

period	**3 mm level**			**5 mm level**		
	Mean (±SD)	Difference vs. baseline Mean difference [95% confidence interval]	**P-value vs. baseline**	**Mean (±SD)**	Difference vs. baseline Meandifference [95% confidence interval]	**P-value vs. baseline**
BL	7.00 (±1.63)		N.A	7.31(±1.53)		N.A
3 M	8.56 (±1.50)	1.56 [1.09,2.03]	<0.001*	8.81(±1.60)	1.50[0.79, 2.21]	0.002*

6 M	7.88 (±1.66)	0.88[0.68,1.07]	<0.001*	8.13(±1.55)	0.82 [0.60,1.03]	<0.001
mm change in alveolar bone width						
BL-3 M	1.56 (±0.56)	1.09, 2.03		1.50(±0.85)	0.79, 2.21	
3 M-6 M	-0.69(±0.46)	[-0.30, -1.07]	0.004*	-0.69(±0.70)	-0.10, -1.28	0.028*
BL-6 M	0.88(±0.23)	0.68, 1.07		0.82(±0.26)	0.60, 1.03	
% Change in alveolar bonewidth						
BL-3M	24.13(±12.49)	13.69, 34.57		21.49(±14.31)	9.53, 33.46	
3M-6M	-9.67 (±7.86)	-3.10,- 16.25	0.004*	-8.82 (±9.88	-0.56, -17.08	0.028*
BL-6M	13.02 (±4.47)	9.29, 16.76		11.46 (±3.91)	8.19, 14.72	

**Statistically significant P <0.05.BL: baseline, M:month.*

Table 3:Descriptive statisticsandresultsofPaired t-test& Wilcoxon signed-rank test for comparison betweengingival thickness at baseline, 3 and 6 months.

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period	**3 mm level**			**5 mm level**			
	Mean (±SD)	Difference vs. baseline Mean difference [95% confidence interval]	**P-value vs. baseline**	**Mean (±SD)**	**Median**	**Range (25^{th}, 75^{th} percentile)**	**P-value vs. baseline**
BL	1.56(±0.50)		N.A	1.63(±0.52)	2.00	(1.00- 2.00)	N.A
3M	2.13(±0.58)	0.56[0.41,0.71]	<0.001*	2.13(±0.52)	2.50	(1.50- 2.50)	0.005*
6M	2.44(±0.56)	0.88[0.58,1.17]	<0.001*	2.38(±0.69)	2.50	(1.63-2.88)	0.010*

**Statistically significant P <0.05.BL:baseline.M:month.*

Table 4: Descriptive statisticsandresultsof Wilcoxon signed-rank test used for comparing alveolar bone height at baseline, 3 and 6 months

period	**Mean (±SD)**	**Gain in mm 95% confidence interval of change**	**Median**	**Range**	**P-value vs. baseline**	**Gain inpercentage (%) Mean (±SD)**	**95% confidence interval of change**
BL	4.01(±0.89)		3.91	(3.20- 4.81)	N.A		
3 M	3.28(±1.18)		2.69	(2.57-4.45)	0.012*		
6 M	2.78(±1.25)		2.19	(2.09-3.89)	0.012*		
BL- 3M	0.73 (±0.59)	0.24, 1.23				19.37 (±14.16)	7.53, 31.21

3M- 6M	0.49 (±0.29)	0.25, 0.74		16.38 (±10.34)	7.74, 25.02
BL- 6M	1.23 (±0.62)	0.71, 1.74		32.48 (±16.02)	19.10, 45.87

**Statistically significant P <0.05.BL: baseline, M: month.*

Discussion:

Periodontal disease is the cause behind loss of alveolar bone before tooth extraction. Any periapical pathology or trauma to teeth and bone might cause further loss of bone. After tooth extraction, the size of the residual ridge gets reduced most rapidly in the first 6 months, while bone resorption activity in the residual ridge continues throughout life at a slower rate resulting in the removal of large amounts of alveolar bone**(Jahangiriet al., 1998).**

Post-extraction wound healing is related to molecular and cellular sequences which occursimultaneously. Healthy patients were included in this study since it is logical to assume that the final healing outcome after tooth extraction could be affected by factors that caused such events such as systemic conditionas the patient's general health and habits as smoking**(Bartee, 2001)**.Also, local factors as the number and proximity of teeth to be extracted, the condition of the socket and tissue biotype could affect the final healing outcome**(Hung *et al.*, 2005).**Smokers were excluded since it is a contraindication for protocols, such as bone regeneration and bone grafting (**F. Renouard, 2008)**. Also, the predictability and extent of periodontal regeneration were associated with cigarette smoking as stated by **(Reynolds and Bowers, 1996).** It was proved that smoking might accelerate the dimensional reductions with 0.5mm more bone crest reduction observed following tooth extraction in smokers than non-smokers **(Saldanha et al., 2006).**

The exclusion of patients with history of bisphosphonate intakewas based on the fact that bisphosphonate treatment was strongly associated with a pathological condition called bisphosphonate-related osteonecrosis of the jaw (BRONJ),as reported by**(Ebetino, Rogers and Russell, 1998)**. However, recent literature and general guidelines assumed that dental surgery for patients under oral bisphosphonate were not completely contraindicated, although uncertainties and clinical issues still remain to be addressed **(Nancollaset al., 2006).**

Supragingival scaling and subgingival debridement were performed for the patients involved in the current study in order to diminish the inflammation and the bacterial load that could delay the healing process as suggested by **Gottsegen (1961**). While atraumatic extraction was performed byperiotomes as recommended by**(Garber, Salama and Salama, 2001)**to severe the fibers that run from the cementum to the surrounding osseous tissues and to eliminate the need for raising a mucoperiosteal flap. This method of atraumatic extraction allows removal of the root without traumatizing the walls of the socket in addition to root separation that was performed in some cases of first premolars extraction to avoid traumatizing the buccal bone plate. This avoided gingival lacerations and helped in removing firm teeth and retained roots without causing damage to the surrounding thin alveolar plates of bone maintaining the shape of the extracted socket undisturbed with an intact alveolus **(Sharma et al., 2015; Horowitz, 2005).**

The amount of horizontal bone loss is generally the greatest and occurs more frequently on the buccal or facial side than on the lingual or palatal side of the ridge. Moreover, a subsequent reduction of vertical ridge height was found to be more pronounced on the buccal aspect **(Araújo *et al.*, 2005)**. This could be due to the limited thickness of the facial bone wall in comparison with the lingual side the socket **(Chappuis, Araújo, and Buser 2017).** Consequently, in a systematic review by

(Vittorini Orgeas et al. 2013) it was observed that socket preservation procedures were effective in limiting horizontal and vertical ridge alterations in post extraction sites. Therefore, in this study types I and II socket defects were selected for the procedure of preservation.

The recipient site forthe vascularized interpositional connective tissue (VIP-CT) flap was performed according to **Sclar (2003)**, who utilized a tunnel approach to reposition a connective tissue pedicle by the elevation of the flap. The latter began at the distal aspect and was carried out anteriorly towards but short of the incisive foramen to avoid traumatizing the neurovascular structure in this area. The graft and the flap were secured deep in the recipient site by vertical interrupted sutures and properly adapted without inducing dead space between the graft and the vascular bed to enhance the revascularization of the graft. Moreover, this technique of VIP-CT flap was used in the present study as **Akcali et al. (2014)** claimed that it could provide an intact blood supply with good ability in conducting larger volume of soft tissue augmentation with less postoperative shrinkage.

The donor site was confined to the palatal premolars area which had the greatest volume of subepithelial donor tissue and the least incidence of complications **(Reiser et al., 1996)**. Therefore, as advised by **(Ioannouet al., 2015)** it is necessary that the clinician should be aware of the anatomy of the palate to minimize the possibility of hemorrhage accompanied with traumatizing the major palatine artery while harvesting the graft. The arterial vascular trunk is typically located approximately 12-17 mm from the CEJ of the posterior teeth in patients with an average or high palatal vault**.** Also, it was necessary to leave 3-4 mm between the edges of the extraction socket and the beginning of the pedicle flap as this distance permitted harvesting of the graft from the advised area with attaining a large base with constant blood supply to the pedicle graft as recommended by**(Mörmann and Ciancio, 1977).**

The use of xenograft had proven its beneficial influence in alveolar ridge preservation **(Llanos et al., 2019).** Therefore, in the current study, a bovine xenograft was used inside the socket based on the results of the systematic review done by **(Horváth et al., 2013)** who stated that although ridge preservation procedure did not totally prevent bone loss, but the presence of a bone graft material could actually limit the vertical bone loss significantly.

The primary and secondary outcomes in this clinical trial were chosen based on the systematic review done by **(García-González et al., 2020).** However, there is a contradiction with studies regarding the volumetric changes after soft tissue augmentation as **Studer et al. (2000)** noted that most of the volumetric changes happened in the initial phase of healing while others demonstrated that the high degree of volume stability was observed between 1 and 3 months postoperatively and the graft shrinkage happened only between 3 and 6 months postoperatively as recorded by (**Akcali et al., 2014).**

The clinical measurements were done using bone caliper and periodontal probe based on a randomized clinical trial done by **(Cardaropoliet al., 2014)**where a clinical measurement of the bone plate width and buccal bone thickness with calipers and a periodontal probe were done on a clinical acrylic stent. The measurements were done at two fixed points on a fabricated acrylic stent for each patient for standardization of measurements and identification of the predetermined points on the ridge **(Agarwal et al., 2015).**

Moreover, it has been revealed that when the distance from the CEJ to the facial bone crest was augmented, thinner thickness of facial alveolar bone thickness was expected. The prevalence to find a facial alveolar bone thicker than one mm decreased as the distance from the facial bone crest to the CEJ increased as noticed by**(Rojo-Sanchiset al., 2019).**Hence,in this study the CEJ was used as a

reference point for estimation of the clinical parameter in regard to width and height of alveolar crest and gingival thickness.

In this case series, the width of alveolar bone increased from 7.00 (±1.63) at baseline to 8.56 (±1.50) after 3 months and decreased to 7.88 (±1.66) after 6 months. This agreed with the systematic review done by **(Avila-Ortizet al., 2014)** which concluded that alveolar ridge preservation could be effective in limiting physiologic ridge reduction when compared to tooth extraction alone. It was also reported in this systematic review that socket grafting for ridge preservation showed a socket preservation effect in buccolingual dimension of 1.89 with 95% CI: (1.41, 2.36) after a minimum healing time of 12 weeks.

The buccolingual width findings in this study at 3 months agreed with another meta-analyses of**(Vignolettiet al., 2011)** who reported a mean difference of bone width of 1.84(2.974,0.732) for alveolar ridge preservation versus unassisted healing. However, it should be mentioned that their analysis was obtained from 10 different studies that followed different clinical protocols with different clinical scenarios and different methods of measurements which might have a significant influence in the results. Furthermore,the resultsof this case series wereconsistent with**(Vittorini Orgeas et al., 2013)**who performed a meta-analysis on multiple clinical ridge preservation approaches. They found that in sites having bone grafting and a barrier membrane when compared to extraction alone showed mean difference of 1.99mm (0.086, 2.485, *P* > .001) regarding the width of bone crest.

On the other hand, the results of this trial were superior to the results of a case series obtained by **(Stimmelmayr et al., 2012)**who used a combined epithelialized and subepithelialized connective tissue graft with autogenous and bovine bone for socket preservation before implant insertion. They found out that the width of the crest immediately after augmentation was 6.80 (±1.2) mm and at the time of implant insertion, which was 5 months after socket preservation, it was 5.65 (±1.5) with a mean resorption of bone graft 1.2 (±1.1) mm. Although their results were considered acceptable, yet the high liability for graft necrosis caused early exposure of the bone graft and hence graft resorption.

Concerning the width of the alveolar bone at the level of 5 mm, the results of this case series were 7.31(±1.53) at baseline then increased to 8.81 (±1.6) after 3 months, however the width decreased to 8.13 (±1.55) after 6 months. These results were superior to a randomized clinical trial done by **(Segnini et al., 2021)**, where the authors evaluated the effect of free gingival graft on the preservation of socket with facial wall defect combined with deproteinized bovine bone graft. The width of alveolar crest in their study at baseline was 9.41(±1.65) then decreased to 8.78 (±0.93) after 4 months. This could be explained that the compression of bone graft within the socket in addition to the pedicle connective tissue graft led to the initial increase in width at 3 months, however after 6 months the socket started to collapse due to the heavy occlusal forces and the gradual graft resorption. Moreover, in their study the same authors reported no increase in the gingival thickness since the free gingival graft was only used as a socket seal without any attempt to increase the labial soft tissue volume.

In this case series, the gingival thickness at the level of 3 mm at baseline was 1.56 (±0.50) then increased to 2.13 (0.58) after 3 months then became 2.44 (± 0.56) after 6 months. These values were superior to those obtained by **(Akcaliet al., 2015)** who utilized the VIP connective tissue graft to augment soft tissue in the maxillary arch. They reported that the values at baseline were 1.21 (0.74, 2.47) mm then mildly increased to 1.26 (0.50, 1.71) mm after 3 months explaining that graft shrinkage occurred between 3 and 6 months postoperatively. However, the VIP connective tissue graft group showed less shrinkage than the free subepithelial connective tissue graft.

The variability in the results could be due to the different measurement methods of the keratinized tissue thickness gain between the two studies; the present study used two-dimensional (linear measurement) method by periodontal probe while the comparative study used three dimensional methods (volumetric measurement) by optical scanning of the casts and carrying out a volumetric analysis using a specific software.

Moreover, the results of this case series were inferiorto a randomized clinical trial by **(Barakatet al., 2015)** who measured the efficacy of the modified roll flap (MRF) technique for augmenting the labial peri-implant soft tissue during stage-two implant surgery. The outcome measures included the measurement of the labial soft tissue thickness where it increased from 1.2 (±0.2) to 3.0 (±0.5) mm after 3 months supporting the validity of the MRF in converting the thin gingival biotype to a thick one and hence improving the peri-implant environment.

This inferiority in results could be due to differences in the method of measurement as they measured soft tissue thickness only at one fixed points or could be due to presence of implant which supported the ridge from collapse.

Furthermore, the results of this study regarding gingival thickness were superior to a randomized clinical trial done by**(Papaceet al., 2021)** who evaluated anorganicxenogenic bone graft with a combined epithelialized-subepithelialized connective tissue graft (CECG) versus porcine collagen matrix (CM) placed in labial and palatal tunnels for socket preservation. They reported an increase of soft tissue thickness in the CECG from 1.24 mm (±0.50) at baseline to 1.29(±0.26) after 3 months reaching 1.2 (±0.32) mm at 6 months with an overall increase in gingival thickness from of 0.02 (±0.66) mm. The superiority of the results of this case series could be attributed to the use of a pedicle connective tissue graft with better blood supply rather than the free graft which is completely cut from its source of vascularity. This might have enhanced the longevity of the graft and thus enhanced its ability to increase the soft tissue thickness.

Periapical radiograph could give information on interproximal bone level, thusradiographic osseous changes had been calibrated with periapical radiographas statedby **(Schropp et al, 2003 and Crespi et al, 2009)**. Bone formation in the alveolar socket and quantified contour changes of the alveolar ridge was evaluated following extraction of single tooth using study casts and standardized periapical radiographs. However, such type of analysis had specific limitations as an assessment tool, starting from the fact that periapical radiographs provided only two-dimensional images of three-dimensional structures. Therefore, it was important for images to be taken under standardized conditions (film type, time of exposure, film processing) at a standardized projection geometry (**Wenzel &Sewerin 1991).**Accordingly, in this study the radiographs were done using paralleling technique with occlusal template and baseline radiographs recording the apico-coronal height. Patients were recalled after 14 days for suture removal and evaluation of wound healing. While radiographic parameters were re-evaluated at three and six months postoperatively.

In terms of alveolar height changes, the results of this study agreed with a systematic review done by **(Vignolettiet al., 2011).** The authors observed a mean difference of bone height of 1.47 mm (1.98,0.95) when alveolar ridge preservation was performed in comparison to unassisted healing. Also, the results of this study agreed with another systematic review done by **(Vittorini Orgeaset al., 2013)** who reported a mean difference in bone height of 0.962 (–1.177 to 3.101) through combination of grafts and barrier membranes when compared to natural socket healing.

Moreover, the results of this study were in agreement with a systematic review by **(Iocca et al., 2017)** who reported that socket grafting appeared to be more effective when compared

to no grafting as it showed a statistically significant mean difference of height of 1.02 (0.44–1.59). Despite the different surgical approaches and the effect of primary releasing incision on healing of hard and soft tissue, yet it could be concluded that socket preservation with bone grafts and membranes are more effective and give statistically significant ridge enhancement values than the natural socket healing.

In the present study it was noticed that the vascular bed of the recipient site had to be wide enough to allow revascularization of the graft. Also, the integrity of the covering flap, the proper adaptation of the graft without inducing dead space and its proper securing to be stabilized during the healing phasewere mandatory. All these elements were also recommended by **Taylor et al. (2010)** to preserve the alveolar ridge and augment it after tooth extraction.

Conclusions:

Fromthisstudy,itcanbeconcludedthat:

- The roll pedicle connective tissue graft resulted in a statistically significant increase in the soft tissue thickness from baseline to 3 and 6 months and enhancement of the esthetics.
- Socket preservation using bovine bone together with pedicle connective tissue graft provided a statistically significant increase in width of alveolar bone 3 and 6 months after tooth extraction.
- Socket preservation using bovine bone together with pedicle connective tissue graft provided a statistically significant increase in height of alveolar bone.

Recommendations:

- Future randomized controlled clinical trials need to be carried out to compare the combined clinical and radiographic effect of pedicle connective tissue grafts and bone grafts in alveolar ridge preservation after tooth extraction with other techniques.
- The effect of pedicle connective tissue graft with bovine bone in socket preservation should be further inspected with larger sample sizes and longer follow-up periods besides their effect on class III socket defects.

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