Soft Tissue Dimensional Changes Following Extraction and Ridge Preservation Using Three Different Techniques: A Randomized Controlled Clinical Trial

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Abstract

Background: Though the effects of ridge preservation with allograft and membrane have been widely researched, outcomes for using a non-resorbable membrane alone have not been as thoroughly investigated. The purpose of this study was to compare the effects of three different ridge preservation modalities on hard tissue dimensions including one group using only a non-resorbable membrane with no bone grafting performed.

Methods: Thirty-four patients requiring tooth extractions with ridge preservation were distributed randomly between three groups: bone graft alone, bone graft with e-PTFE membrane, or e-PTFE membrane alone with no bone graft. Cone beam computer tomography (CBCT) was taken at baseline and 3-4 months post-extraction. Buccal-lingual socket width was measured on the CBCT at fixed points at the crest of bone and 2 mm below the crest.

Results: Twenty-two patients and 27 teeth were included in the analysis. When comparing the three treatment groups, there was no statistically significant difference between the three groups in buccal-lingual socket width change at the crest of bone or at 2 mm apical to the crest as measured on the CBCT scans ($P \leq 0.05$, confidence interval 95%). No differences were seen between the three groups total or for pair-wise comparisons, or for age, gender identity, or arch.

Conclusion: Similar results were achieved in all three groups, even without simultaneous bone graft placement. e-PTFE membrane alone may be a viable treatment modality for patients who are unable to undergo bone graft placement at time of extraction, though more research is needed.

Introduction

One of the biggest challenges when treatment planning the restoration of an edentulous space is retaining a maximum amount of alveolar bone. Socket preservation is historically a straightforward, cost-effective, and predictable method of maintaining bone height and width after extraction of a tooth. The purpose of socket preservation is to retain bone volume in all dimensions using grafting materials. Without socket preservation, the alveolar ridge will recede over time, with most changes occurring within six months of extraction (Irinakis 2006). According

to Shropp 2003, alveolar ridge width will reduce by 50% (5-7 mm) twelve months after extraction with no ridge preservation performed, with two-thirds of this reduction occurring in the first three months after extraction. Additionally, the bone level at extraction sites dictate the level of the bone crest remodeling, not the crest level at adjacent teeth.

Lekovic et al (1998) found an average loss of 1.50 mm in height and 4.56 mm in width at six-month re-entry post-extraction, showing the great extent of bone loss occurring in this time frame. This loss of volume can pose difficulties when attempting to restore the edentulous site, either with an implant, a fixed partial denture, or a removable appliance. Extracting single teeth without socket preservation results in a triangularly shaped ridge with 60% of bone loss around the marginal portion of the edentulous site (Misawa 2016). According to an Araujo study on extractions in dogs, after extraction, the bone heals in two phases. For the first phase, bundle bone is resorbed and replaced with woven bone, resulting in substantial vertical reduction of the buccal crest. For the second phase, resorption happens from the outer surfaces of both bone walls. After extraction, new bone is rapildy formed between 4-8 weeks post extraction, and then bone matures and increases in volume with fewer osteoblasts from 8-12 weeks (Evian 1982). This new bone can even be used to provide vital osseous grafting material for infrabony defects (Soehren 1979). If socket preservation is not performed at the time of extraction, additional methods of soft and hard tissue augmentation may be performed at a later date depending on the restorative plan (Newman 2011). These guided bone regeneration methods are generally much more invasive and costly to the patient; therefore socket preservation should be recommended to nearly all patients wanting to replace the tooth being extracted. This is especially important for patients with thin bone phenotypes (≤ 1 mm) as they tend to experience more progressive vertical bone loss and remodeling after extractions than patients with thicker bone (Chappuis 2017).

Regarding the socket preservation technique, after the tooth is extracted, the socket is curetted and cleansed with saline solution. The gingival tissue is reflected by a few millimeters via a full-thickness flap away from the bone, creating a pocket around the socket. Flapless extraction is preferred as it results in less bone loss and more attachment on the buccal aspect of the socket (Arajuo 2009). The socket is then filled with bone grafting material which is loosely packed into the space (Newman 2011). he graft material can be autogenous bone, harvested from the ramus or another site; allograft from cadaver bone; or xenograft from other animals, such as bovine or porcine bone. Autogenous bone has the best healing results as it is both osteogenic and osteoinductive, though harvesting bone requires an additional surgical site for the patient (Newman 2011). Allograft and xenograft also are very successful; in particular, demineralized freeze-dried bone allograft (DFDBA) is thought to potentially be osteoinductive due to the presence of BMPs (Newman 2011). Alloplastic grafts, such as hydroxyapatite and bioglass, often have a much longer healing time for bone to be incorporated into the graft and are not osteoinductive or osteogenic (Newman 2011). The graft material can also be mixed with growth

factors such as PRP, PRF, or PGRF. Extracting and placing bone graft results in significantly less loss of crestal height, allowing for more optimal implant placement (Nevins 2006).

Next, a membrane is placed over the site and tucked into the pocket created between the bone and gingival tissues. Ideal membranes are biocompatible, allow for space maintenance, are occlusive with cells, are easy to manipulate, and are resorbable or easy to remove if nonresorbable (Newman 2011). Resorbable membranes include bovine or porcine collagen membranes, as well as CollaTape, another resorbable collagen wound dressing that can help heal minor wounds and cover extraction sites. Non-resorbable membranes include expanded polytetrafluoroethylene (ePTFE). The soft tissue is then closed over the membrane and sutured without disturbing the membrane placement, with primary closure attempted. The patient will return for an evaluation one to two weeks after the surgery, at which point sutures will be removed if they are still present and healing will be evaluated. Six to twelve months after surgery, non-resorbable membranes can be removed and an implant placed at the site, though the non-resorbable membrane should be removed earlier if it becomes exposed (Newman 2011).

Though many studies have detailed socket preservation with bone graft and membrane, there is unsubstantial research regarding using membrane alone without a graft, or using collatape with bone graft. Since the main goal of the procedure is to retain bone by preventing epithelialization of the graft within the socket, theoretically the use of a membrane alone would also prevent epithelialization of the socket without a bone graft needed to maintain the space. If using a membrane without a bone graft achieves a similar hard tissue result as a non-resorbable membrane or bone graft covered with Collatape and no true membrane, this would provide an economic benefit to the patient and thus make socket preservation accessible to more people while reducing redundancy regarding materials and streamlining the procedure itself.

The aim of the present study was to evaluate hard tissue outcomes measured radiographically following ridge preservation procedures comparing three distinct surgical protocols: bone graft and collatape, bone graft and e-PTFE membrane, and e-PTFE membrane alone.

Materials and Methods

This study was a prospective single center randomized control trial of 14 months duration conducted at the Periodontics Department at Louisiana State University Dental School from October 2021 to December 2022. The study protocol was approved by the Institutional Review Board of Louisiana State University (IRB 00000177), registered by the U.S. National Institutes of Health Clinical Trials Registry and fulfilled the requirements of the Helsinki Declaration of 1975, as revised in 2013. The study was explained to all patients both orally and written including the

purpose and procedures involved. A signed informed consent was obtained from each patient prior to study initiation.

Thirty four systemically healthy adult patients (24 females and 10 males) with age ranging from 27 to 73 years (mean 54.75 years) requiring extraction of at least one tooth were included. Inclusion criteria for patients and sites were: 1) greater than 18 years of age; 2) systemically healthy or with well controlled disease (ASA I or II); 3) requiring extraction of a tooth with intact bony walls, buccal plate, and no history of periodontal disease; 4) willing to participate in the study and sign informed consent; 5) requiring extraction of one or more of the following teeth: maxillary and mandibular premolars, maxillary and mandibular canines, maxillary incisors, or mandibular molars; and 6) willing to receive clinical exams, radiographs, surgery, and post-operative exams.

Exclusion criteria included: 1) systemic conditions that could alter wound healing, such as uncontrolled diabetes or history of past or current bisphosphonate therapy; 2) smoking more than 10 cigarettes per day; 3) absence of buccal or lingual plate at study tooth; 4) all maxillary molars and mandibular incisors and third molars.

Patients and teeth were randomized prior to surgery with a computer generated table. If a patient had more than one tooth included in the study, each tooth was assigned to a different group. The three groups were BC (bone graft + collatape), BP (bone graft + PTFE), and P (PTFE alone). Collatape was used to cover the bone graft and was not considered a membrane itself. All surgical procedures were performed by residents in the postgraduate periodontal department. Measurements were recorded by one investigator.

Clinical measurements

CBCTs and intraoral scans were taken of all patients at baseline and 13-18 weeks after surgery. The center of the apex of the root of each single rooted tooth or furcation of two-rooted teeth was determined. The crest of the ridge was measured buccal-lingually at that point on the preoperative CBCT. A fixed point was determined for each scan (generally a point on the sinus floor for maxillary teeth or the lower bound of the mandible for mandibular teeth). The distance from the fixed point to the buccal-lingual line was measured, as well as an additional measurement 2 mm apical to that point.

Surgical Procedures

Teeth were extracted with minimal clinical trauma using a flapless approach if possible. Teeth were sectioned as needed with high speed handpieces. Teeth were only included in the study if

the buccal plate remained intact after extraction. Granulation tissue was removed and sockets were irrigated with sterile saline. Sites were grafted with: solvent-dehydrated bone allograft (SDBA, Puros) plus Collatape (BC), SDBA plus e-PTFE membrane (BP), or e-PTFE membrane alone without bone graft (P). The e-PTFE membranes were trimmed to fit closely over the socket. To place the e-PTFE membranes, a full-thickness pocket was created between the gingiva and bone circumferentially and the membrane placed within. All sites were sutured with resolon 4-0 sutures with some attempt for primary closure without elevating a flap.

Postoperatively, patients received amoxicillin 500 mg three times a day for 7 days and Ibuprofen 600 mg to take as needed alternating with acetaminophen 500 mg. All patients were instructed to rinse twice daily with 0.12% chlorhexidine gluconate for seven days 30 min after brushing their teeth. Sutures were removed at two weeks and sites wiped with 0.12% chlorhexidine gluconate. e-PTFE membranes were removed at six weeks, or earlier if the membrane started to extrude from the socket. Patients were asked to report if the membrane came out on its own. Patients were followed up at two weeks, six weeks, and 13-18 weeks postoperatively with the final CBCT and intraoral scan taken at the last appointment.

Statistical Analysis

A sample of 7-10 patients were included in each of the three groups (7 BC, 10 BP, 10 P). Categorical variables were summarized within groups by reporting counts and percentages, while means and standard deviations were reported for continuous variables. When present, the number of missing values was reported within parentheses. Categorical variables were tested for associations with group using Fisher exact tests, while Kruskal-Wallace tests were used for continuous variables. Pairwise comparisons between groups were made using Fisher exact tests with categorical variables and Wilcoxon rank-sum tests with continuous variables. Independence assumptions of these tests were ignored, as 1 person had 2 teeth included in the analysis, 2 people had 3 teeth included, and 1 person had 4 teeth included. Each of these people had more than 1 treatment applied to their teeth. Descriptive statistics were presented using a nonparametric Wilcoxon rank sum test due to the small sample size. Significance level was set at $P \leq 0.05$ with a 95% confidence level.

Results

A total of 48 patients were initially screened, and 34 were enrolled in the study (24 females and 10 males). Patient ages ranged from 27 to 73. No patients were current smokers. Twelve patients did not return for the final CBCT and intraoral scan, resulting in 22 patients (27 teeth included) completing the study and included in the final analysis. Two patients had two teeth included, one patient had three teeth included, and one had four teeth. For patients with

multiple teeth included, randomization was performed for each individual tooth but separate treatment groups.

At baseline, there were no significant differences between any of the three groups for male vs female identity (*P* = 0.856), maxillary vs mandibular teeth (*P* = 0.394), or age (*P* = 0.139). No statistically significant difference was seen for buccal-lingual socket dimension prior to surgery (BC 9.53 mm +/- 2.36 at crest and 9.91 mm +/- 2.79 mm 2 mm below crest; BP 8.38 mm +/- 1.76 vs 9.15 mm +/- 2.03l P 9.02 mm +/- 1.57 vs 9.87 mm +/- 1.85; *P* = 0.462 and 0.774 respectively). CBCT measurements showed the buccal-lingual width of the ridge in all three groups was not statistically significantly reduced for any of the groups post-operatively (BC 7.2 mm +/- 2.8 at crest and 8.91 mm +/- 2.62 mm 2 mm below crest; BP 6.58 mm +/- 1.91 vs 8.32 +/ 1.54; P 6.9 mm +/- 1.94 (missing 2 data points) vs 8.31 mm +/- 2.87; *P* =0.812 and 0.735 respectively). There was no statistically significant reduction in width for individual groups or when comparing pairs of groups to each other (crestal bone difference *P* = 0.740, 0.694, 0.408 vs 2 mm below crestal bone *P* = 0.887, 0.660, 0.791 for BC vs BP, BC vs P, and BP vs P respectively).

Variable Name	Bone graft + collatape (BC) (7)	Bone graft + PTFE (BP) (10)	PTFE alone (P) (10)	PVALS	BC vs BP, BC vs P, BP vs P
Mandibular	4 (57.1)	3 (30)	6 (60)	0.394	0.35, 1, 0.37
Maxillary	3 (42.9)	7 (70)	4 (40)		0.35, 1, 0.37
Male Identity	1 (14.3)	3 (30)	2 (20)	0.856	0.603, 1, 1
Female Identity	6 (85.7)	7 (70)	8 (80)		0.603, 1, 1
Continuous Variables					
Age	57.14 (7.03)	56.1 (11.03)	47.9 (13.54)	0.139	0.845, 0.186, 0.063
Crestal Bone (2mm) Before	9.91 (2.79)	9.15 (2.03)	9.87 (1.85)	0.774	0.536, 0.962, 0.631
Crestal Bone (2mm) After	8.91 (2.62)	8.32 (1.54)	8.31 (2.87)	0.735	0.601, 0.887, 0.496

Crestal Bone (2mm) Difference	-1 (0.92)	-0.83 (1.15)	-1.56 (2.07)	0.902	0.887, 0.66, 0.791
Crestal Bone Before	9.53 (2.36)	8.38 (1.76)	9.02 (1.57)	0.462	0.315, 0.407, 0.52
Crestal Bone After	7.2 (2.8)	6.58 (1.91)	6.9 (1.94, 2)	0.812	0.813, 0.955, 0.477
Crestal Bone Difference	-2.33 (2.26)	-1.79 (2.3)	-2.18 (1.14, 2)	0.666	0.74, 0.694, 0.408

Table 1: Descriptive characteristics by group. Counts (%) are reported for each categorical variable while means (sd) are reported for continuous variables. When present, missing values are listed in parentheses. ff

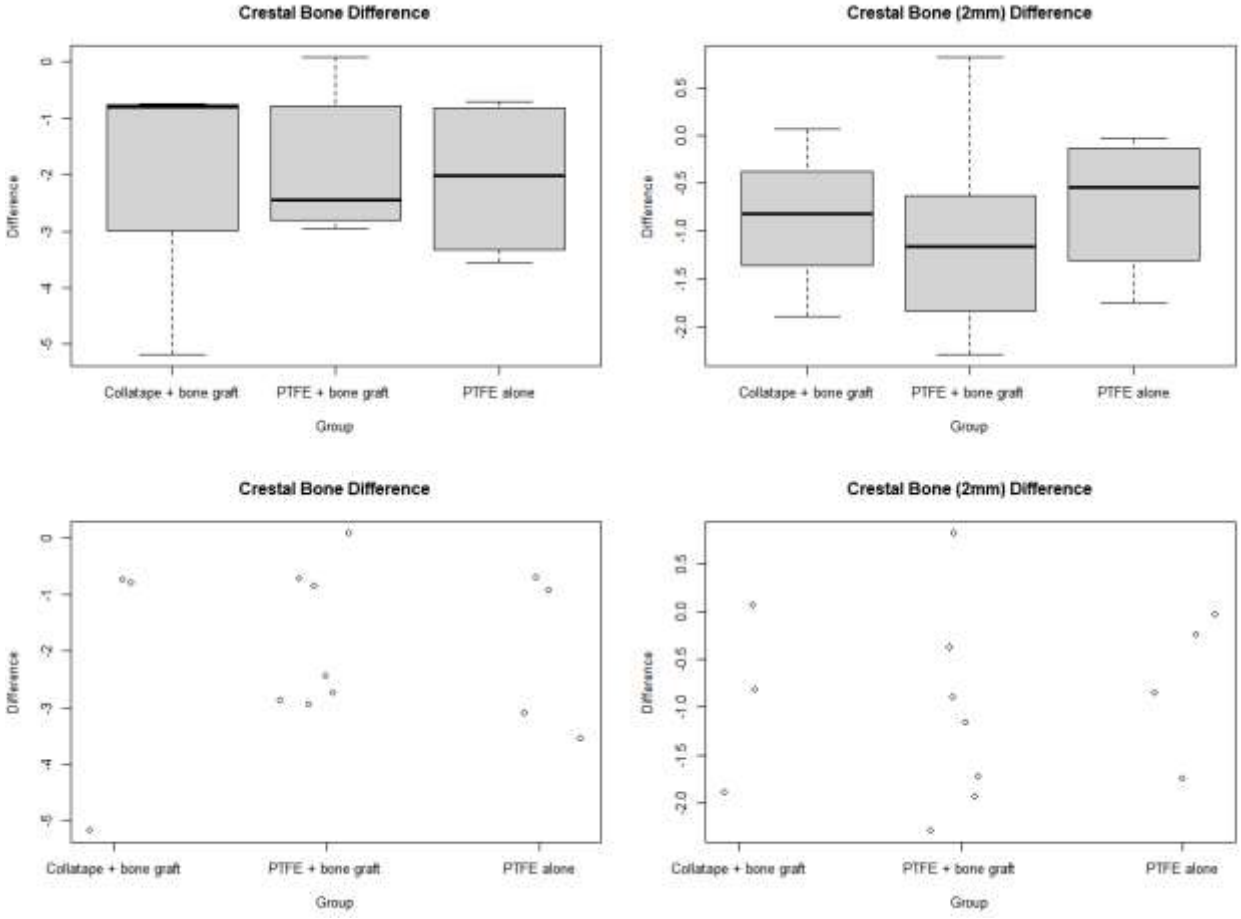

Figure 1: Graph of the spread of the difference variables (top = boxplots, bottom = raw data).

	Bone graft + collatape (BC) (4)	Bone graft + PTFE (BP) (3)	PTFE alone (P) (6)	PVALS	BC vs BP, BC vs P, BP vs P
Male Identity	0 (0)	0 (0)	0 (0)	1	30.8, 23.1, 46.2
Female Identity	4 (100)	3 (100)	6 (100)		30.8, 23.1, 46.2
Age	58.25 (6.65)	52.33 (17.79)	45 (16.32)	0.318	1, 0.238, 0.3
Crestal Bone (2mm) Before	11.95 (1.08)	9.55 (2.58)	10.71 (1.91)	0.29	0.229, 0.257, 0.905
Crestal Bone (2mm) After	10.87 (0.56)	9.3 (1.68)	8.59 (3.62)	0.453	0.229, 0.476, 1
Crestal Bone (2mm) Difference	-1.09 (1.02)	-0.25 (1.34)	-2.12 (2.53)	0.407	0.4, 0.476, 0.381
Crestal Bone Before	11.15 (0.88)	8.83 (2.39)	9.67 (1.6)	0.133	0.114, 0.114, 0.905
Crestal Bone After	8.75 (2.6)	7.02 (3.46)	7.82 (1.18, 2)	0.719	0.629, 0.686, 0.857
Crestal Bone Difference	-2.4 (2.42)	-1.81 (4.38)	-2.28 (0.92, 2)	0.654	0.629, 0.686, 0.629

Table 2: Descriptive characteristics by group in Mandibles. Counts (%) are reported for each categorical variable while means (sd) are reported for continuous variables. When present, missing values are listed in parentheses.

Discussion

All three groups performed equally well regardless of the presence of bone graft. Radiographically measured hard tissue changes were not statistically significant for any group or when comparing the groups together or pair-wise. These results are comparable to those reported by Cheon et al (2017) and Mandarino et al (2018). Cheon compared dPTFE membranes with freeze-dried bone allografts in damaged sockets, while Mandarino compared d-PTFE alne versus no biomaterial. Both studies showed successful preservation of bone height,

width, and volume radiographically in the test groups, as well as an increase in keratinized tissue for the Mandarino test group. Results after ridge preservation in current literature are varied, with many studies reporting similar results with multiple types of ridge preservation materials including cross-linked vs non-crosslinked membranes, allografts from various sources, and biomaterials such as PRF. The results of this study were promising for the use of e-PTFE alone, but more study participants are required to truly verify the results. CBCT measurements showed consistent maintenance of the height and bucco-lingual width of the sockets after ridge preservation. Maintenance of ridge width is important for having adequate bone for implant placement without additional ridge augmentation. Lee 2018 reported that primary intention did not have any positive effects on ridge preservation, nor did it preserve KT as well as secondary intention. This study showed that flapless procedures appeared to be more successful in preserving bone width and height as well as keratinized tissue width.

The results of this study suggest that e-PTFE membranes alone without bone grafting may be adequate for ridge preservation. In a systematic review by Jung 2018, no ridge preservation is indicated if the implant is placed 0-2 months after extraction except in cases with soft tissue defects. Using ePTFE alone may help prolong the amount of time patients can wait after extraction prior to implant placement. This may be helpful for treating patients who are unable to have bone grafting due to finances, religious or social concerns, or other issues. More research is needed to determine the true outcomes of ridge preservation with and without bone graft and non-resorbable membranes.

Conclusion

The use of e-PTFE membrane without bone graft showed similar results post-operatively to bone graft with collatape or e-PTFE membrane regarding dimensional ridge changes. This may be beneficial for patients who are unwilling or unable to undergo bone grafting after extraction, while also reducing cost for patients and practitioners. More research is needed with larger sample sizes to distinguish the effects of the three protocols.

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Citations:

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