Ridge Preservation Using Dense Polytetrafluoroethylene Membrane Alone Versus Dense PTFE Membrane with Particulate Bone Graft and Bone Graft with Collagen Dressing: A CBCT-Based Comparative Analysis of Linear and Volumetric Dimensional Changes

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Abstract

Purpose: This retrospective study evaluated linear and volumetric alveolar ridge changes following three alveolar ridge preservation (ARP) approaches—dense PTFE (dPTFE) membrane alone, dPTFE with particulate bone grafting, and bone grafting with collagen dressing—and assessed the modifying influence of buccal plate thickness on treatment outcomes.

Materials and Methods: Twenty seven extraction sites from 20 patients were analyzed using pre and post operative CBCT scans superimposed in Planmeca Romexis. Horizontal ridge width was measured at 1, 3, and 5 mm apical to the crest; vertical height and volumetric changes were also quantified. Sites were stratified by buccal plate thickness (<1 mm vs ≥1 mm). Statistical analyses included paired tests, ANOVA, two way ANOVA for interaction effects, effect size calculations, and responder analysis (≤2 mm crestal loss).

Results: All groups exhibited post extraction dimensional reduction. dPTFE with bone grafting showed the smallest horizontal and vertical losses, while membrane only sites demonstrated the greatest reduction. The collagen dressing group produced intermediate outcomes. Although differences were not statistically significant, effect sizes were moderate to large in favor of grafted approaches. Buccal plate thickness strongly influenced outcomes in membrane only sites, with thin plates showing >3 mm greater crestal loss; this effect was largely mitigated in grafted groups. Responder analysis indicated that grafted sites were approximately three times more likely to achieve acceptable ridge preservation than membrane only sites.

Conclusion: dPTFE combined with bone grafting provided the most consistent and favorable ridge preservation, while grafting with collagen dressing offered partial benefit. Membrane only treatment was highly dependent on buccal plate thickness, with thin plates exhibiting substantial resorption. Bone grafting appears to enhance dimensional stability and reduce biologic vulnerability associated with thin buccal plates. Larger, adequately powered studies are needed to confirm these findings and refine clinical protocols.

Introduction

Following tooth extraction, the alveolar process undergoes a cascade of remodeling events resulting in predictable dimensional reductions of the ridge. Early studies by Araújo demonstrated that the most pronounced changes occur at the buccal plate, which is often composed of bundle bone and undergoes rapid resorption following extraction. This physiologic remodeling may result in horizontal ridge reduction exceeding 3–5 mm within the first few months of healing, often compromising implant placement and necessitating additional augmentation procedures. The clinical implications of these changes have been emphasized in more recent systematic reviews, which demonstrate that ridge resorption may negatively affect implant feasibility, esthetics, and long-term outcomes (Avila-Ortiz 2020; Couso 2021; Couso 2022).

Alveolar ridge preservation techniques have been proposed to mitigate post-extraction bone loss. Traditional approaches have involved placement of bone graft materials within the socket, often combined with barrier membranes to promote guided bone regeneration. While numerous biomaterials and techniques have been evaluated, no gold-standard ARP protocol has been universally accepted. Additionally, conventional guided bone regeneration (GBR) principles typically advocate for membrane coverage with primary closure; however, this approach is associated with reduced keratinized tissue width and increased morbidity due to flap advancement and periosteal releasing incisions (Barone 2014).

Dense PTFE membranes offer a unique advantage due to their submicron pore size, which prevents bacterial infiltration and allows healing without primary closure while maintaining barrier function. Clinical studies have demonstrated that dPTFE membranes can attenuate ridge dimensional changes when used in combination with bone grafting, even when left exposed (Avila-Ortiz 2020). Despite this, the necessity of bone grafting in conjunction with these membranes remains controversial. Cost-effectiveness analyses have suggested that membrane use may correlate more strongly with ridge preservation than graft material itself, further questioning the need for grafting (Barootchi 2022).

A significant limitation of existing literature is the lack of control for biologically relevant variables, particularly buccal plate thickness. Prior studies have demonstrated that thinner buccal bone (<1 mm) undergoes greater resorption following extraction, yet this factor has not been consistently incorporated into study designs (Chappuis et al.). Furthermore, systematic reviews assessing dPTFE outcomes have highlighted heterogeneity due to inclusion of compromised extraction sockets and inconsistent baseline characteristics.

Additionally, limited investigations have evaluated alternative approaches such as bone grafting covered by collagen wound dressings, which do not follow classical GBR principles but remain commonly used in clinical practice.

Therefore, the purpose of this study was to evaluate linear and volumetric changes in ridge dimensions following ARP with dPTFE membrane alone compared to dPTFE combined with bone grafting and bone grafting with collagen dressing, and to assess the modifying effect of buccal plate thickness on these outcomes.

Materials and Methods

This retrospective analysis was conducted on data collected from a previously initiated clinical study involving 27 extraction sites across 20 patients. Study groups included sites treated with dPTFE membrane alone (n = 10), dPTFE membrane combined with particulate bone graft (n = 10), and bone graft with collagen dressing (n = 7).

CBCT scans were obtained prior to extraction and at 3–4 months postoperatively. Pre- and post-operative DICOM files were imported into Planmeca Romexis software and superimposed using multiple anatomical landmarks to ensure reproducible alignment of baseline and follow-up images.
Linear measurements were recorded at standardized reference points located 1-, 3-, and 5-mm apical to the midfacial crest. Vertical ridge height changes were also recorded using consistent anatomical reference points and superimposition. Volumetric changes were assessed using defined volumes of interest based on reproducible landmarks. All measurements were recorded to a precision of 0.01 mm.

Sites were stratified based on pre-extraction buccal plate thickness, categorized as thin (<1 mm) or thick (≥1 mm). Additional exploratory stratification included tooth type and presence of adjacent teeth.

Statistical analyses included parametric and non-parametric tests for between-group comparisons among all three treatment groups, paired analyses for within-group changes, and one-way ANOVA for global comparisons. Two-way ANOVA was used to assess interaction between treatment modality and buccal plate thickness. Effect sizes were calculated using Cohen’s d. A responder analysis defined acceptable ridge preservation as ≤2 mm crestal width loss. Odds ratios were calculated to compare likelihood of achieving acceptable outcomes between groups. Statistical significance was set at $\alpha = 0.05$.

All groups, including the collagen dressing cohort, were included in quantitative analyses.

Results

All treatment groups exhibited measurable reductions in ridge dimensions following extraction.
Sites treated with dPTFE membrane combined with bone grafting demonstrated consistently smaller reductions in ridge width at 1-, 3-, and 5-mm levels, as well as smaller decreases in ridge height, compared to sites treated with membrane alone. The bone graft with collagen dressing group

demonstrated intermediate outcomes, with ridge loss greater than the dPTFE with graft group but less than membrane alone.

Although these differences followed a consistent directional pattern, no statistically significant differences were detected among the three groups using ANOVA or non-parametric testing.
Effect size analysis revealed moderate to large effects favoring grafted approaches, particularly for horizontal ridge dimensions, with the greatest effects observed at the 1-mm and 3-mm levels. The collagen dressing group demonstrated smaller effect sizes relative to dPTFE with grafting, indicating a reduction in ridge loss but less predictable outcomes.

Buccal plate thickness significantly influenced treatment outcomes in membrane-only sites. Thin-plate sites exhibited markedly greater ridge reduction, particularly at the crestal level, with differences exceeding 3 mm compared to thick-plate sites. In contrast, this dependence on plate thickness was largely mitigated in both grafted groups, where differences between thin and thick plates were minimal.

Responder analysis demonstrated that sites treated with dPTFE and bone grafting were approximately three times more likely to achieve acceptable crestal ridge preservation compared to membrane-only sites, with the collagen dressing group demonstrating intermediate success rates.

Discussion

The findings of this study are consistent with established literature demonstrating that extraction sockets undergo significant dimensional changes, particularly in the horizontal dimension. As previously described by Araújo, the buccal aspect of the ridge is particularly susceptible to resorption due to its composition of bundle bone. The magnitude of ridge loss observed in membrane-only sites in the present study is comparable to reported outcomes of unassisted socket healing, reinforcing the concept that barrier membranes alone may not sufficiently counteract physiologic bone remodeling.

In contrast, the addition of bone grafting resulted in reductions in ridge loss that align with outcomes reported in systematic reviews of ridge preservation techniques, where horizontal loss is typically reduced to approximately 2–3 mm (Avila-Ortiz et al.). Although statistical significance was not achieved in this study, effect size analysis demonstrated moderate to large differences favoring grafting, suggesting clinically meaningful improvements that were likely underpowered.
The incorporation of the collagen dressing group provides additional clinical insight. While grafting combined with a collagen dressing resulted in reduced ridge loss compared to membrane-only treatment, outcomes were less consistent than those observed with dPTFE combined with bone grafting. This suggests that while graft placement provides a structural scaffold for bone regeneration, the choice of barrier material plays a critical role in maintaining space and reducing variability in healing outcomes.

A key finding of this study is the role of buccal plate thickness as a determinant of ridge preservation outcomes. Consistent with findings from Chappuis et al., thin buccal plates exhibited substantially greater ridge loss in membrane-only sites. Importantly, this effect was attenuated in both grafted groups, suggesting that bone grafting mitigates the biologic disadvantage associated with thin buccal plates. This observation provides mechanistic insight into how graft materials function within the socket, acting as a scaffold that maintains space and reduces collapse during healing.

Responder analysis further supports these findings by demonstrating increased likelihood of achieving clinically acceptable outcomes with grafting. This aligns with contemporary emphasis on treatment predictability rather than mean dimensional change alone.

The primary limitation of this study is its relatively small sample size, which limits statistical power. Power analysis indicates that approximately 30–45 sites per group would be required to detect statistically significant differences for the observed effect sizes. Nevertheless, the consistency of directional findings across all three groups, combined with moderate effect sizes and biologic plausibility, strengthens the validity of the conclusions.

Conclusion

All alveolar ridge preservation techniques evaluated resulted in measurable post-extraction ridge reduction. The use of dPTFE membrane combined with bone grafting demonstrated the greatest preservation of ridge dimensions and the most consistent outcomes. Bone grafting with collagen dressing provided intermediate results, reducing ridge loss compared to membrane alone but with greater variability. Buccal plate thickness significantly influenced outcomes in membrane-only sites, whereas this dependence was reduced in grafted sites.

These findings suggest that bone grafting enhances dimensional stability and predictability of ridge preservation, particularly in anatomically compromised sites. Further studies with larger sample sizes are required to confirm these findings and establish definitive clinical protocols.

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