ALVEOLAR RIDGE PRESERVATION USING DENSE POLYTETRAFLUOROETHYLENE MEMBRANES. A REVIEW ARTICLE

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ABSTRACT

INTRODUCTION: Alveolar ridge preservation is a widespread term, which describes the methods of reducing hard and soft tissue loss following tooth extraction and thus preserving optimal tissue volume for future implant placement and prosthodontic rehabilitation. Various techniques give promising, long-term results. Some of them utilize the use of barrier membranes. Their function is to isolate the intrabony defect from rapidly growing tissues. There are two main types of barrier membranes—resorbable and non-resorbable, both having their characteristics, advantages, and disadvantages.

AIM: The present review aims to observe the use of non-resorbable dense polytetrafluoroethylene (dPTFE) membranes for ridge preservation and evaluate its advantages, limitations, and success rate according to the literature. The collected data was carefully systematized in a comparative, concise, and unbiased review of the application of dPTFE membranes.

MATERIALS AND METHODS: This review is based on 56 articles, researches, case reports, retrospective studies, and controlled clinical trials. It provides a meticulous analysis of the existing electronic database.

RESULTS: There is growing evidence that the utilization of dPTFE membranes successfully preserves the dimensions of the alveolar ridge, increases the width of the keratinized tissues, and preserves the place of the mucogingival junction. When using them, primary wound closure is not mandatory and the membrane can be easily removed after four weeks.

CONCLUSION: The use of dPTFE for ridge preservation should be considered a reliable and successful method. Although they have some limitations, most of the studies report in favor of their utilization.

Keywords: *alveolar ridge preservation, barrier membranes, guided bone regeneration, dense polytetrafluoroethylene membrane*

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INTRODUCTION

The term "ridge preservation" (RP) refers to the procedures performed during or following tooth extraction, aiming to reduce alveolar ridge resorption and stimulate bone regeneration within the alveoli (1).

Ridge preservation is guided bone regeneration (GBR) in post-extraction sockets that provides an appropriate environment for implant insertion (2).

The American Academy of Periodontology defines RP as a method of "preventing ridge collapse and preserving ridge dimension" following tooth removal, usually performed "for purposes of implant site development," while GBR is "the surgical augmentation" of a resorbed alveolar bone (3).

Ridge preservation techniques involve the application of bone grafts, bone substitutes, and barriers, which prevent the downgrowth of epithelium in the defect (4) and promotes the migration of osteoprogenitor cells (5). Membranes can be broadly classified into two groups—non-resorbable and resorbable (6). The first group provides better space maintenance and the second less postoperative complications (7).

There is a risk of esthetic and functional problems following tooth removal if RP techniques are not performed. Guided bone regeneration using polytetrafluoroethylene (PTFE) membranes is a simple alternative method that gives promising long-term results in tissue maintenance and allows implant placement (8).

AIM

This review aims to observe the use of non-resorbable dense polytetrafluoroethylene (dPTFE) membranes for RP and evaluate its features, indications, advantages, limitations, and success rate according to the literature. It points out some research gaps to which to pay attention.

MATERIALS AND METHODS

The present review is based on the scientific electronic database, including 56 articles and books. The information was carefully analyzed, compared, and summarized to identify the qualities and possible drawbacks of dPTFE as a biomaterial used for GBR and RP.

RESULTS

Since the introduction of GBR (9,10), various types of resorbable and non-resorbable membranes have been utilized as a tool for tissue regeneration. Resorbable membranes can either be of natural or synthetic origins. Their representatives are collagen membranes (CM), barriers made of polylactic or polyglycolic acid, human placental tissues, human pericardium, fascia, or dermal tissue. Non-resorbable membranes are those made of expanded or high-density polytetrafluoroethylene, titanium mesh, and cellulose acetate. Their applications include: coverage of intrabony defects (11,12,13), root coverage (14,15,16), and other GBR procedures (10,17).

Resorbable membranes have to be submerged and isolated from the oral environment. Otherwise they will resorb in approximately 2 weeks (18) and will not provide the necessary amount of time for progenitor cells to migrate, differentiate, and create osteoid tissue. Even if a non-resorbable membrane, such as expanded polytetrafluoroethylene (ePTFE), is used and soft-tissue dehiscence occurs, the membrane becomes susceptible to contamination and infection within 4 weeks (19,20). This is due to their high surface roughness, which facilitates bacterial adhesion when the membrane is exposed to the oral environment. Therefore, a primary closure over the membrane is necessary to avoid such complications (21,22). Another drawback is that their removal usually necessitates a second surgical intervention.

These limitations can be avoided by the application of dPTFE membranes. Their successful application was reported in animal and clinical studies (23,24,25).

The first to report clinical and histologic results of dPTFE utilization for RP were Bartee et al. (23,26). Their research showed newly formed, well-vascularized lamellar osseous tissue within the graft. There was no inflammatory response and the residual graft was in a state of degradation, remodeling, and resorption (23,27).

Hoffmann et al. conducted a retrospective non-randomized study whose aim was to observe the clinical outcomes of RP with dPTFE alone (28). All 276 extraction sites received dPTFE. One year later, 10 hard tissue specimens were obtained. A significant regeneration of the extraction sites was observed histologically. The newly formed tissue was regular cancellous bone predominantly with several zones of bone marrow and cells (28). It resembled the osseous tissue observed in sites with spontaneous healing (29). The surface of dPTFE barriers is impenetrable for bacteria, which is their major advantage. Primary

wound closure was not achieved in any of the cases, however, all of them showed positive outcomes. The authors concluded that dPTFE membranes successfully preserve soft and hard tissue volume (28).

In 2019 Mohammed Sabe-Alarab et al. (30) published a research article on a randomized controlled trial, which evaluated the changes in height of the alveolar process when using dPTFE membrane for RP in comparison with a control group. Both RP and control groups showed a reduction in bone height but it was significantly less when dPTFE membranes were used.

Barboza et al. (31) published a randomized controlled clinical trial on the use of dPTFE membranes as a method for increasing the volume of keratinized tissues. Dense polytetrafluoroethylene membranes were used in 15 sockets and the control group received none. The authors reported that dPTFE barriers facilitated the formation of keratinized tissues.

Sun et al. carried out a study, which assessed the outcomes of RP with dPTFE and freeze-dried allogenic bone, used in post-extraction alveoli with bone deficiency. This technique led to considerably less bone loss at the most coronal portion of the ridge and reduced the need for GBR during implant insertion (32).

In 2019 Formiga et al. published a randomized clinical trial, comparing the effect of RP with the dPTFE alone versus dPTFE in conjunction with xenograft material. The use of xenograft and dPTFE proved to be superior only in the middle and cervical thirds of the sockets as well as the socket height maintenance when compared with spontaneous healing or healing with dPTFE alone (8).

After a histomorphometric analysis, Fotek et al. (2009) (33) reported a higher amount of vital bone in the group with dPTFE than the one with allogenic material. The difference, however, was not of statistical significance.

Arbab et al. conducted a clinical and histologic study to compare the results of RP with resorbable CM versus non-resorbable dPTFE membranes. All sockets received a cancellous allograft material and a buccal overlay xenograft. No statistically significant difference in height and width reduction among the groups was reported. The utilization of resorbable versus non-resorbable membranes did not affect the clinical or the histologic outcome of the RP procedure (34).

In 2014 Ronda et al. (35) also reported similar results considering bone quality when dense and expanded PTFE membranes were used.

Yamashita et al. (36) used a combination of bone grafts and Emdogain® or plasma-rich protein (PRP) and covered them with dPTFE barriers. The sockets were overbuilt with material around 0.8 mm. No bone loss was observed.

Walker et al. used cone-beam computed tomography to evaluate the outcomes of dPTFE utilization. They reported that the membranes were beneficial for the preservation of the buccal height but without a significant difference in the width (37).

A study, conducted by Borg and Mealey (38), assessed the efficacy of RP with dPTFE in conjunction with a combined mineralized/demineralized allograft versus 100% mineralized freeze-dried bone allograft (FDBA). The barriers were removed 4 weeks after placement. It was histologically evident that a bone allograft in conjunction with dPTFE leads to increased vital bone formation (36%) compared to defects grafted with FDBA alone. Furthermore, this combination reduced the number of residual graft particles (18% vs. 27%). These findings validated the successful utilization of this material for RP and confirmed that 4 weeks is a sufficient amount of time for membranes to be effective.

Membrane exposure can lead to detrimental results as bacterial infection disturbs bone formation (39). Early exposure leads to bacterial contamination and membrane disintegration by hydrolysis (40). If non- or low-cross-linked membranes become exposed, they lose their barrier function and become ineffective to protect the defect from epithelial downgrowth (41).

In 2003 Oh et al. reported that membrane coverage is a key factor for GBR success. They noticed less linear bone fill and bone to implant contact in sites that experience membrane exposure (42). Surface roughness from 10 to 100 μm facilitates bacterial adhesion. The use of dPTFE membranes, which have nanoporous surfaces (with a pore size < 0.3 μm), avoids this limitation. (43). If exposed, this type of barrier is usually removed in 4–6 weeks. In cases of

bone dehiscence and severe bone deficiency, primary wound closure is mandatory (2).

Kaidou et al. introduced a novel approach for RP—the so-called "combo technique". It employs a CM over the osseous defect and a dPTFE at the place of soft tissue dehiscence in post-extraction alveoli from Type I, II, and III. Primary closure is not necessary since the CM remains intact during the entire regenerating period. This technique provides excellent tissue preservation (2).

In terms of bone formation after RP with allografts and dPTFE membranes, Cheon et al. observed histologically the following results: 28% new bone formation, 27% residual graft, and 43% fibrous tissues (44).

Bakhshalian and colleagues used anorganic bovine bone material and reported 40.1% bone and 12% residual graft after 21 weeks (45). No correlation was found between the healing time and the amount of newly formed bone and residual graft particles.

Min et al. performed RP with anorganic bovine bone and dPTFE. The results showed 37% vital bone and 12% residual graft (46). Similar to what Bakhshalian et al. stated, there was no correlation between the healing time and the percentage of bone formation.

The combination of hydroxyapatite and dPTFE histomorphometrically showed the following: 25% new bone, 28% soft tissue, and 15% graft particles (47).

In 2020 Wen et al. histologically evaluated the fractions of residual graft particles and connective tissue at 2, 4, and 6 months following RP with cancellous allograft and dPTFE. Extraction sockets that healed for 6 months produced the greatest amount of vital bone with a reduction of graft particles from the 2nd to 6th month (48).

Laurito et al. investigated histologically the newly formed tissues beneath exposed dPTFE membranes to assess their efficacy. The extraction sites received nanocrystalline hydroxyapatite and dPTFE membranes. The stability of the membranes was ensured by creating subperiosteal pockets. Membranes were left exposed and removed after 28 days when a soft-tissue biopsy was obtained. All samples showed dense connective tissue without epithelial migration and foreign body reaction. The results indicated that exposed dPTFE membranes serve successfully as barriers without negative effects on periodontal health (49).

In a follow-up study, the authors presented the results after 6 months of healing. They repeated the clinical measurements and took bone specimens for histologic and histomorphometric analysis. An overall bone reduction was observed. The results showed 25.92% ±18.78% newly formed bone, 28.55% ±9.73% soft tissues, and 15.43% ±11.08% residual graft particles. This study suggests that the combination of nanocrystalline hydroxyapatite (nc-HA) with dPTFE gives promising results as a method for RP. Membrane exposure did not impair the healing process, as observed clinically and histologically (47).

The application of a dPTFE barrier over a CM in post-extraction alveoli prevents the early disintegration of CM. Thus, this is an alternative technique to healing by primary intention. Furthermore, dPTFE prevents the translocation of the mucogingival junction (MGJ) and the distortion of the surrounding soft tissues, caused by flap advancement. Moreover, its utilization preserves and even increases the volume of keratinized tissues (2).

Several studies (28,47,49) have reported a significant increase of keratinized mucosa width when using dPTFE membranes. Since there is no need for vertical releasing incisions, the MGJ remains in place. The membrane preserved the blood clot, with no need for bone grafting in the socket (50).

Mandarino et al. evaluated the efficacy of dPTFE membranes as a method for RP by comparing the dimensional changes with a control group. The results showed that the utilization of dPTFE led to an increased zone of keratinized tissues. In both groups, there was a reduction in width and mild reduction or gain in height of the ridge. The membrane did not influence the healing process (51).

A previous study by the same authors showed that intentionally exposed dPTFE increases the amount of keratinized tissues before the placement of dental implants (31).

However, it is not clear yet how long the barriers should be kept in place. It seems that a formation of dense osteoid tissue can be observed in 4 weeks. It subsequently mineralizes and forms bone tissue. In cases of larger defects and bone deficiencies, it may be necessary to keep the membrane longer. However,

no data is supporting this concept with dPTFE (52). Further research is needed to define the correlation between the size of the defect and the time dPTFE membranes are kept to protect and isolate.

A dual-layer RP technique has been proposed with dPTFE, covering CM membranes to enhance bone formation (53,54). The dual-layer technique was performed in an animal study. A significant increase in ridge volume, height, and width was observed after a 4-month interval (53). However, there is a pilot randomized control trial, whose authors compared both single and dual-layer techniques and concluded that none of them was superior in terms of clinical and volumetric outcomes (34).

DISCUSSION

Resorbable and non-resorbable barriers are broadly used for GBR and RP purposes, but they require primary closure for optimal results. Dense polytetrafluoroethylene membranes are an exception. They don't need to be fully submerged, thus reducing patient morbidity (52). These membranes have numerous advantages. They are biocompatible and allow cell adhesion without tissue ingrowth. Since there is no need for releasing incisions and additional freeing of the flap, the MGJ remains in place. Because of their relatively smooth surface, dPTFE barriers can be easily removed without additional surgeries (27,55). Moreover, they successfully preserve hard and soft tissue volumes and even increase the amount of keratinized gingiva. Likewise, the presence of a wide zone of keratinized gingiva will facilitate the management of peri-implant tissues (56).

However, dPTFE has some disadvantages. Some authors don't find its use in terms of bone preservation statistically significant compared to other RP methods (8,34,42). This requires further assessment of whether the method is cost-effective. Another limitation is the need for removal. For this reason, dPTFE membranes should not be placed near adjacent teeth due to the risk of attachment loss (17). Further research is needed to define the correlation between the size of the defect and the time the barrier should be kept in place and the possible need for additional fixation.

CONCLUSION

In conclusion, dPTFE membranes can be considered a successful and reliable method for RP. Although they have some limitations, it is becoming evident that they can increase the amount of keratinized tissues and preserve the place of MGJ since primary closure is not necessary. Dense polytetrafluoroethylene membranes are biocompatible and impenetrable for bacteria. Further research is needed to determine whether their utilization is cost-effective, whether and when to combine them with bone grafts, and what treatment protocol is most suitable depending on the size of the defect.

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