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Collagen vs expanded polytetrafluorethylene membranes during guided-bone regeneration simultaneous with implant placement – a systematic review

Membranas de colágeno vs politetrafluoretileno expandido para regeneração óssea guiada simultânea à colocação de implante - uma revisão sistemática

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Abstract

Purpose: This systematic review evaluated the influence of the membrane type (resorbable collagen or non-resorbable expanded polytetrafluorethylene; e-PTFE) on the guided-bone regeneration associated to implant placement. **Methods**: Any type of clinical study or literature review was searched at MEDLINE/PubMed and Cochrane databases. Two independent reviewers screened titles/abstracts of articles and the full-text of potentially eligible studies. When data was available, pairwise meta-analysis was performed using random statistical model. **Results**: Nine studies met the inclusion criteria, considering 685 implants in 360 patients. Vertical bone regeneration did not differ with the use of the two membranes in 8 of the 9 studies included. Meta-analysis did not show either greater vertical bone gain or vertical bone loss after regeneration with any of the membranes. The results have shown a tendency of higher bone gain in horizontal guided-bone regeneration with non-resorbable e-PTFE membranes (reported by 2 of 3 studies). All studies clearly showed that both membranes were effective in increase bone volume. There was no clear tendency of any of the two membranes in cause more complications. **Conclusion**: resorbable collagen and non-resorbable e-PTFE membranes are similarly effective in vertical guided-bone regeneration; however, horizontal guided-bone regeneration seems to benefit with the use of non-resorbable ones. Both membranes showed to be effective in guided-bone regeneration and similar in regards to complications.

Keywords: dental implants; vertical bone gain; horizontal bone gain.

Resumo

Objetivo: Esta revisão sistemática avaliou a influência do tipo de membrana (colágeno reabsorvível ou politetrafluoretileno expandido não reabsorvível; e-PTFE) na regeneração óssea guia associada à colocação do implante. **Métodos:** Qualquer tipo de estudo clínico ou revisão de literatura foi pesquisada nas bases de dados MEDLINE / PubMed e Cochrane. Dois revisores independentes examinaram títulos / resumos de artigos e o texto completo de estudos potencialmente elegíveis. Quando os dados estavam disponíveis, a meta-análise pareada foi realizada usando modelo estatístico aleatório. **Resultados:** Nove estudos preencheram os critérios de inclusão, considerando 685 implantes em 360 pacientes. A regeneração óssea vertical não diferiu com o uso das duas membranas em 8 dos 9 estudos incluídos. Meta-análise não mostrou maior ganho ósseo vertical ou perda óssea vertical após a regeneração com qualquer uma das membranas. Os resultados mostraram uma tendência de maior ganho ósseo na regeneração óssea guiada horizontal com membranas de e-PTFE não reabsorvíveis (relatadas por 2 de 3 estudos). Todos os estudos mostraram claramente que ambas as membranas foram eficazes no aumento do volume ósseo. Não houve uma tendência clara de qualquer uma das duas membranas em causar mais complicações. **Conclusão:** o colágeno reabsorvível e as membranas não-reabsorvíveis de PTFE-e são igualmente eficazes na regeneração óssea guiada vertical; no entanto, a regeneração óssea guiada horizontal parece se beneficiar com o uso das membranas não reabsorvíveis. Ambas as membranas mostraram-se eficazes na regeneração óssea guiada e similares em relação às complicações.

Palavras-chave: implantes dentários; ganho ósseo vertical; ganho ósseo horizontal.

Introduction

The difficulty to place dental implants in sites with insufficient bone quantity has been a concern in dental implantology. Although the use of implant in treatments is very predictable, some defects in the alveolar bone may represent an obstacle to the dental implant therapy, resulting in an aesthetic and functional commitment (1). Different techniques have been established over the years to reconstruct deficient alveolar ridges and facilitate the dental implant placement (2). Bone grafts are used for recovery of areas with bone deficiency arising from various etiologies. This graft tissue newly inserted in the receptor site provides support while native bone grows (3). The main purpose of these regeneration processes is to provide stability and protection for the dental implants (4).

In the processes of the new bone formation, three factors are considered - osteogenesis, osteoinduction, and osteoconduction (5). Osteogenesis occurs when osteoprogenitor cells in the graft material can survive transplantation and can differentiate into osteoblasts and later osteocytes (6). Osteoconduction is defined as a material encouraging bone formation from already existing bone or differentiated mesenchymal cells via scaffolding. Osteoinduction is when undifferentiated mesenchymal cells in the native bone are differentiated into osteoblasts to grow new bone (4).

Therefore, as important as the type of the graft used in the regeneration processes is the material that protect them on the receptor site. This safety zone provided by membranes could guarantees bone formation without a cellular competition with the soft tissues surrounding the site to be regenerated (7). The successful use of non-resorbable and resorbable membrane materials for guided-bone regeneration (GBR) has been documented in the literature (8).

The expanded polytetrafluoroethylene (e-PTFE) membranes were considered for years as the standard for GBR due to its successful application (9,10). However, despite the high predictability of bone regeneration using e-PTFE membranes, it has some drawbacks such as the need of a second surgical intervention for removal. Moreover, the common membrane exposure can cause bacterial contamination (11). Subsequently, the inflammatory reaction surrounding of the soft tissues may require early removal of the membrane. In this context, the use of resorbable membranes has been investigated.

More recently, collagen resorbable membranes become an alternative for many clinical situations. With this material, the second surgery stage is not necessary. However, besides some clinical studies are available, literature reviews collecting and comparing data of studies that evaluated resorbable and non-resorbable membranes have not been performed (12). Therefore, the aim of this study was to systematically review human studies of vertical and horizontal alveolar ridge augmentation

comparing two different types of membranes (resorbable collagen and non-resorbable e-PTFE) for the purposes of dental implant placement associated to guided-bone regeneration.

Methods

This systematic review followed the 4-phase flow based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement and the reporting of the review was based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement checklist (13).

Eligibility criteria

Inclusion criteria

The search's inclusion criteria were articles that investigated the treatment of guided-bone regenerations with resorbable and non-resorbable membranes associated with immediate implant placement. The studies should have directly compared by quantitative analysis two (or more) different membranes (resorbable collagen and non-resorbable e-PTFE) on immediate implant placement with bone filling. There were no search limitations on follow-up period, publication date, and sample size.

Exclusion criteria

Exclusion criteria eliminated studies with absence of quantitative data, which did not compare resorbable with non-resorbable membranes, which did not perform guided-bone regeneration, and non-simultaneous implant placement. Case reports, small case series papers, and animal studies were excluded.

Information sources and literature search

Studies were identified by searching two electronic databases (PubMed and Cochrane). The search strategy was drafted based on free-text terms for both databases, considering the focused question: "does the membrane type (resorbable collagen or non-resorbable e-PTFE) influence the bone volume around immediately-placed implants simultaneous to guided-bone regeneration?".

The search identified papers that were tagged under (1) immediate implant placement, (2) guided-bone regeneration, (3) resorbable collagen membrane, (4) non-resorbable e-PTFE membrane. The articles were included from earliest inception until June 13, 2019.

Key search words applied in the research in the PubMed and Cochrane were: (alveolar regeneration OR alveolar preservation OR alveolar augmentation OR ridge regeneration OR ridge preservation OR ridge augmentation OR socket regeneration OR socket preservation OR socket augmentation OR bone graft OR guided bone regeneration) AND (resorbable membrane OR non-resorbable membrane OR bioresorbable membrane OR collagen membrane OR e-PTFE membrane) AND (dental implant OR implant OR oral implant dentistry).

Hand-search was conducted in the following journals (last five years): British Journal of Oral and Maxillofacial Surgery, Clinical Implant Dentistry and Related Research, Clinical Oral Implants Research, European Journal of Oral Implantology, Implant Dentistry, International Journal of Oral and Maxillofacial Implants, International Journal of Oral and Maxillofacial Surgery, International Journal of Periodontics and Restorative Dentistry, Journal of Clinical Periodontology, Journal of Oral Implantology, Journal of Craniofacial Surgery, Journal of Cranio-Maxillofacial Surgery, Journal of Maxillofacial and Oral Surgery, Journal of Oral and Maxillofacial Surgery, Journal of Periodontology, Periodontology 2000.

The articles selected were those written in Spanish, English or Portuguese.

Study selection

Two independent reviewers screened all titles/abstracts of articles and the full text of potentially eligible studies was retrieved and reviewed for eligibility. Articles that fulfilled the eligibility criteria were included in the study. The reviewers hand-searched the reference lists of included articles for additional papers. Any disagreement between the two reviewers was resolved after additional discussion. If a possible divergence persisted, a third reviewer was consulted. Papers that fulfilled the selection criteria were processed for data extraction.

Data extraction

Data was recorded on a spreadsheet including authorship, compared materials, complications (in soft tissue or loss of implant), and main results.

Data synthesis (meta-analysis)

Descriptive presentation of the results was used to summarize the findings.

When sufficient data were available, comparisons among the membrane types were estimated using pairwise meta-analysis to calculated pooled mean differences.

All summary estimates were reported with point estimates and corresponding 95% confidence intervals (CIs). Statistical heterogeneity was evaluated using the Cochrane Q

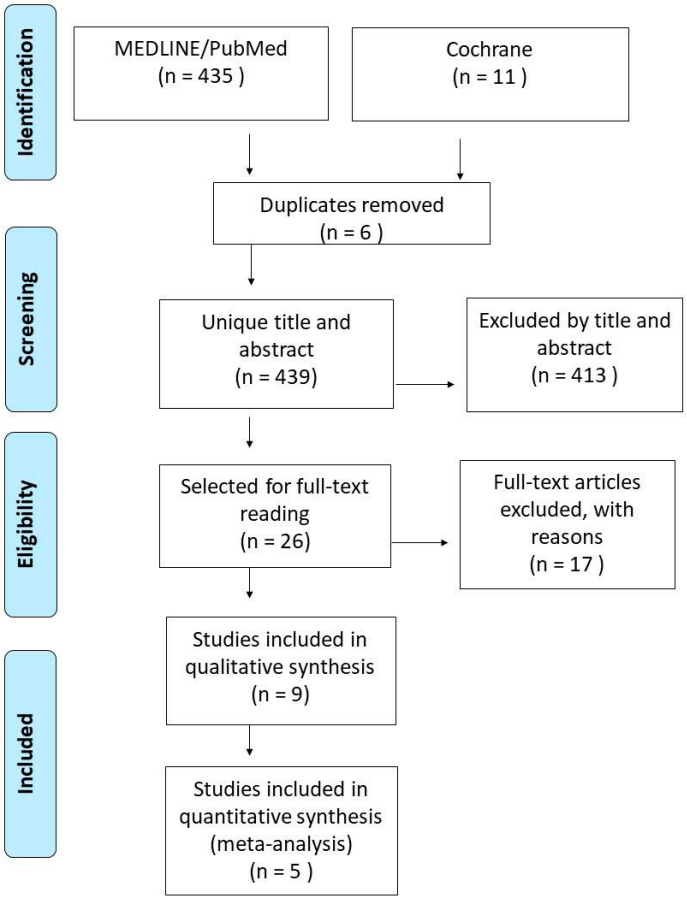
statistic and I2 (>75% indicates high heterogeneity). All analyses were performed using the random effects model and conducted in Review Manager 5.3 software (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014).

Results

Literature search

The results of the search procedure are presented in the flow diagram (Figure 1). The search initially identified 435 papers in Medline/PubMed and 11 in Cochrane database. Following title and abstract-based search 26 papers were selected for full-text review. Upon full review of these papers, only 9 publications were included for data extraction and descriptive analysis in accordance with the inclusion criteria (14-22). Five studies were included in the meta-analysis (15,17,18,21,22).

Figure 1. Flow diagram of study selection representing information from the number of studies identified in each database until the number of studied included in the qualitative and quantitative analyses



Study characteristics

In the included papers, 685 implants in 360 patients underwent alveolar ridge augmentation with simultaneous implant placement. Demineralized bovine bone mineral and/or autogenous particulate bone were used for guided-bone regeneration. The two types of membrane used were non-resorbed (e-PTFE) or resorbable collagen ones. All information is present in Table 1.

Vertical bone gain/loss or defect reduction

The nine included studies evaluated the effect of the membrane type on vertical bone regeneration. Only one study observed values that favored one of the membranes, as significant higher bone gain occurred with e-PTFE after 6 months (15). The other eight studies did not find differences with the use of resorbable collagen or non-resorbable membranes in the vertical bone regeneration (14,16-22). Meta-analysis of studies with 1 to 6 years follow-up evaluating the influence of membrane type on the bone loss after guided-bone regeneration failed to show difference among the membrane type (p=0.67) (Figure 2). The same was observed in the meta-analysis for bone gain after vertical guided-bone regeneration (p=0.66) (Figure 2).

Figure 2. Meta-analysis comparing data for bone loss after vertical guided-bone regeneration and bone gain with vertical guided-bone regeneration. Note that differences between resorbable and non-resorbable membranes were not observed in both analyses

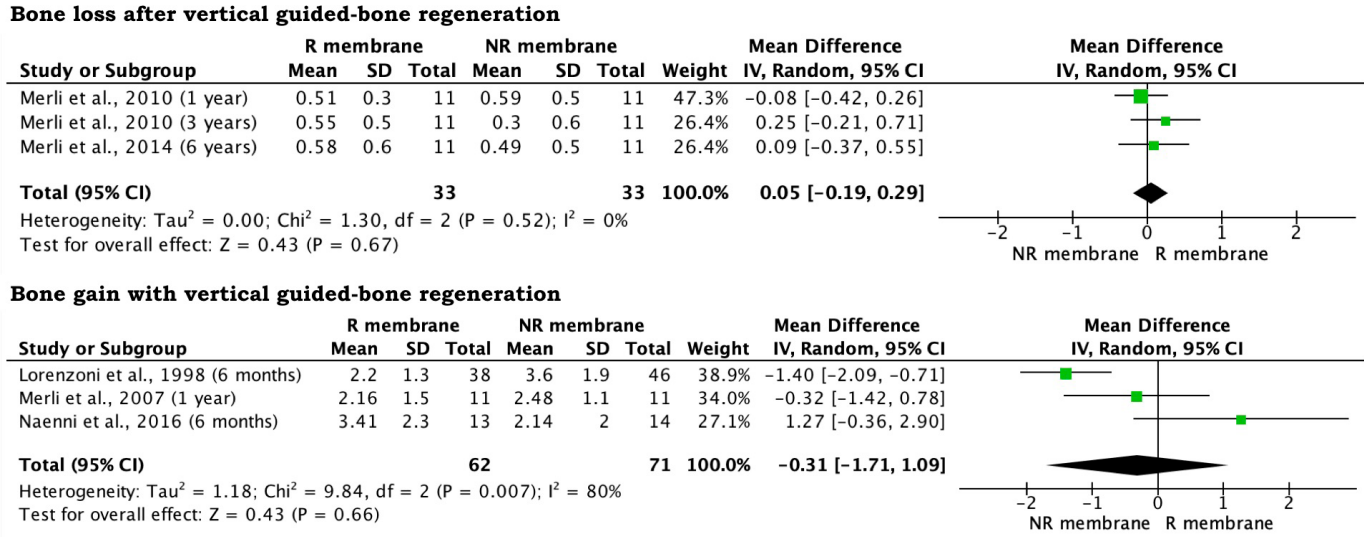


Table 1. Characteristics of included studies and summary of main findings including the number of patients and implants for each study, the procedures performed for the guided-bone regeneration (including type of bone substitute used), the membranes compared, the complications observed – in the guided-bone regeneration (GBR) and the number of implants lost, and the results for vertical and horizontal bone gain

Author	Sample (Patients / implants)	Procedure	Comparison	Complications		Result for bone gain/loss or defect reduction
				GBR	Implant lost (implant per group)	
Naenni et al. 2016	27 / 27	Implant + deproteinized bovine bone mineral	**G1**: e-PTFE membrane; **G2**: resorbable collagen membrane;	**G1**: 14% dehiscence **G2**: 30 % dehiscence	None	***Vertical***: no differences in bone gain or defect reduction after 6 months. ***Horizontal***: significant lower bone thickness loss with e-PTFE after 6 months of surgery.
Merli et al. 2014	22 / 22	Implant + particulate autogenous bone	**G1**: e-PTFE membrane; **G2**: resorbable collagen membrane;	**G1**: 45% **G2**: 36% *type of complication not specified*	None	***Vertical***: no significant differences in marginal bone level after 6 years or bone loss between baseline and 6 years. ***Horizontal***: -
Scheneider et al. 2014	40 / 40	Implant + Demineralized bovine bone mineral	**G1**: e-PTFE membrane **G2**: Collagen membrane	**G1**: 9.5% membrane dehiscence or fenestration; **G2**: 26% membrane dehiscence or fenestration;	None	***Vertical***: no differences in vertical bone defect reduction at 6 months. ***Horizontal***: significant higher bone gain with e-PTFE at 6 months.
Jung et al. 2013	58 / 222	Implant + Demineralized bovine bone mineral	**G1**: e-PTFE membrane **G2**: Collagen membrane	UNCLEAR	**G1**: 3 (41) **G2**: 9 (112) *No significant different*	***Vertical***: no difference in bone loss after 12 years in function. ***Horizontal***: -

Author	Sample (Patients / implants)	Procedure	Comparison	Complications		Result for bone gain/loss or defect reduction
				GBR	Implant lost (implant per group)	
Merli et al. 2010	22 / 22	Implant + particulate autogenous bone	**G1**: e-PTFE membrane; **G2**: resorbable collagen membrane;	None	None	***Vertical***: no differences in bone loss after 3 years. ***Horizontal***: -
Merli et al. 2007	22 / 77	Implant + particulate autogenous bone	**G1**: e-PTFE membrane; **G2**: resorbable collagen membrane;	**G1**: 5/ 11 (3 dehiscence, 1 fistula, 1 swelling) **G2**: 4/ 11 (2 abscesses, 1 dehiscence, 1 swelling)	None	***Vertical***: no difference in bone gain. ***Horizontal***: -
Chen et al. 2005	62 / 62	Implant + particulate autogenous bone	**G1**: e-PTFE membrane; **G2**: resorbable collagen membrane.	**G1**: none **G2**: failure of two connective tissue grafts.	None	***Vertical***: no difference in the % of reduction in vertical defect height. ***Horizontal***: no difference in the % of reduction in horizontal defect depth and horizontal defect width.
Lorenzoni et al. 1998	82 / 129	Implant + deproteinized bovine bone mineral	**G1**: e-PTFE membrane; **G2**: resorbable collagen membrane;	**G1**: 22% dehiscence **G2**: 50% dehiscence	None	***Vertical***: significant higher bone gain with e-PTFE after 6 months. ***Horizontal***: -
Zitzmann et al. 1997	25 / 84	Implant + Demineralized bovine bone mineral	**G1**: e-PTFE membrane **G2**: Collagen membrane	**G1**: 44 % **G2**: 9% *type of complication not specified*	**G1**: 0 (41) **G2**: 2 (43) *Not statistically assessed*	***Vertical***: no differences in bone gain or defect reduction. ***Horizontal***: -

e-PTFE: expanded polytetrafluoroethylene.

Horizontal bone gain/loss or defect reduction

Three studies evaluated the effect of the membrane type on the horizontal bone volume. One study found no difference in the percentage of reduction in the horizontal defect depth and horizontal defect width (16). The other two studies showed results favorable to the use of non-resorbable membranes. The first observed significant lower bone thickness loss with e-PTFE after 6 months of surgery (22). The second observed significant higher bone gain with e-PTFE at 6 months (20). All studies observed significant bone increase with both membranes. Meta-analysis was not possible due to the heterogeneity of data analysis and presentation.

Complications

Two of the nine studies reported implant loses. One study found no significant influence of the membrane type on the implant loss (19) and the other did not report statistical comparison (14), although the percentage of loses suggest no difference (Table 1).

Complications with GBR was reported by seven studies. Membrane dehiscence or fenestration was mentioned by 04 studies (15,17,20,22), being more frequent reported in resorbable membranes than non-resorbable ones in three studies (15,20,22). Other two studies reported greater number of complications in site treated with non-resorbable membranes (14,18), without specify the type of complication. Another study reported loss of two connective tissue grafts in the group with resorbable membrane and no complication with non-resorbable ones (16).

Discussion

This systematic review evaluated the influence of use resorbable or non-resorbable membranes for guided-bone regeneration simultaneous to dental implant placement. The use of the different membranes for vertical bone regeneration did not differ in most studies, which was confirmed by the meta-analysis. However, a tendency for better horizontal bone-gain with non-resorbable membranes was observed.

According to Merli et al. (21) over of 6 years the average loss difference of peri-implant vertical bone was 0.09 mm comparing non-resorbable to resorbable membranes and no statistical differences were observed. It is suggested also by the meta-analysis performed that the bone stability after healing is not different in the sites treated with resorbable membrane in comparison to non-resorbable ones. Scheneider et al. (20) also had corroboration findings to Merli et al. (17), Merli et al. (18), Merli et al. (21), with no significant differences between the two membranes tested. In contrast to this observation, a study reported that the resorbable membranes demonstrated more sites with incomplete vertical bone fill (20). In that study, the mean relative

defect resolution was 81% with resorbable and 96% with non-resorbable membranes. These results corroborate with data from Zitzmann et al. (14), in which sites treated with non-resorbable membranes showed higher vertical bone gain compared to resorbable membranes. The characteristic of regeneration procedures using membranes is related to high rates of success because the membrane coverage creates a suitable environment for bone regeneration (15,16,19,20). These coverage membranes beget the maintenance space of the regeneration sites and let the bone cells proliferate without intervention of soft tissue cells invading the site. After that, the bone matrix is formed and the soft-tissue cells cannot make interference into those regeneration sites (19,22). The histomorphometric analysis showed in previous studies that reinforced e-PTFE membranes maintained a larger space than standard membranes (15,20,22). However, it might be speculated that the period in which resorbable membranes are active is enough to ensure proliferation of bone cells and form bone matrix (14,16-22).

Therefore, it is worth to mention that most studies had efficient vertical results with both kind of membranes, principally when the regeneration site had sufficient walls, which aid the regeneration process (14,16,20,22). One limitation presented by some studies that might influence on the results lay on the variety of initial vertical defect size (14,19,20). As clinical analysis was adopted, it is clear (and expected) that some variation in the sites of regeneration. Other aspect related is the shape of the site to be regenerated, where one- or two-wall defects seems to be harder to regenerate than three walls (14). Moreover, there is the possibility that the extraction sockets have a limited potential for regeneration, amounting to about 75% of the initial defect height because of the loss of crestal bone as part of physiological remodeling (16).

In case of results comparing the two membranes when considered horizontal guided-bone regeneration, the main explanation for the differences (favorable to non-resorbable membranes) may be related to resorption of resorbable membranes before complete bone ingrowth, or a partial collapse of membranes after applications (20). As reported by Naenni et al. (22) a loss of horizontal thickness was observed, and the loss in non-resorbable group was significant lower, which demonstrate that the collagen membrane is more susceptible to collapse, even being supported by the bone substitute material. According to data for the improvement of the horizontal bone volume, a stable positioning and a stable-form of the membrane is required, therefore the space maintenance can be obtained (22). However, in addition to this information, both membranes have provided positive results, especially when associated with demineralized bovine bone matrix (DBBM) filling the bone defects (15,19,22).

Most of studies (7/9) included in this literature review did not show implant loss (15-18,20-22). Moreover, no differences in implant loses were observed with the use of both membranes, showing that the membrane type does not interference in long-term of implants survival, with low rates of failure (7% or 18 of 265 implants) (19). These small amount of implant loses are related to dehiscence caused during the procedures, which might cause infections of the regenerated sites (14,16,19).

Complications were observed with both types of membranes, without a clear tendency on what type of membrane would provide greater intercurrences. The most frequent were fenestration or dehiscence that seems to be related with the removal of e-PTFE material at second-stage surgery, which can cause extensive flap procedure, because the membrane may be firmly adhered to the bone and at times requiring dissection of soft tissues (14,19). Even though both techniques were able to achieve good results, in some cases they are related to the presence of complications, but with very few serious complications (17). Among the main problems reported in the studies are the abscesses or tissue defects with exposures of bone grafts and implants (17,18,21). Soft tissue complications leading to exposures are observed with both kind of membranes. Although the resorbable membrane revealed more exposures, the overall incidence of soft tissue dehiscence for both was lower than that reported in previous studies including e-PTFE membranes (14). Other aspect to be mentioned is the local that occurred the complications, as most cases were observed in the posterior region of the jaw (17,22).

The treatment for membrane exposure can range from simple interventions (medication and disinfection) to periodontal surgeries (open-flap debridement). In all the cases, the patients received a course of prophylactic antibiotics (amoxicillin) for about 8 days. It is suspected that penicillin-resistant bacteria can survive in the patient's mouth; this might explain why abscesses developed in some cases (16,17). When occurred bacterial colonization in sites regenerated by non-resorbable membranes, it was performed debridement of soft tissues to remove the membrane, followed by new suture (17,22). For the dehiscence in the sites regenerated by resorbable membranes, the patient was advised to apply local disinfecting agents and was recalled once a week for 4 weeks and later on once a month. When the dehiscence persisted, new surgical intervention was made (20,22).

Conclusions

Based on the data present in literature, the studies suggest that during guided-bone regeneration simultaneous to dental implant placement:

- There is no difference in the use of resorbable collagen and non-resorbable e-PTFE membranes for the vertical bone improvement;
- Data for horizontal bone gain suggest a tendency for better results with non-resorbable e-PTFE membranes;
- Both membranes were considered effective for increasing the vertical and horizontal bone levels.
- No distinct predominance of complications was observed with one of the two membranes.

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