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Review Article

Management of Non-Resorbable Membrane Exposure: A Systematic Review

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Abstract

Introduction: Guided Bone Regeneration (GBR) is used to treat bone loss prior to implant placement, employing non-resorbable membranes such as d-PTFE or titanium due to their strength and biocompatibility. However, membrane exposure (either premature or delayed) can affect treatment success, with an incidence ranging from 11% to 23%. This often occurs due to soft tissue dehiscence. To reduce the risk of exposure, it is recommended to assess factors such as the amount of keratinized gingiva and the size of the bone defect.

Objective: To review and analyze the different strategies and approaches used to manage the exposure of non-resorbable membranes in GBR procedures.

Materials and Method: A search was conducted for scientific articles published between 2015 and 2025, retrieved from the Scopus, Pubmed, Wiley Online Library and Science Direct databases. Clinical studies evaluating the management of non-resorbable membrane exposure were selected.

Results: A total of 526 articles were identified from the selected databases: PubMed (504 articles), Science Direct (2 articles), Wiley Online Library (17 articles) and Scopus Preview (3 articles). After applying the inclusion and exclusion criteria, 14 articles were included for review.

Conclusion: GBR is effective for rehabilitating patients with bone loss and non-resorbable membranes have proven effective. However, membrane exposure remains a challenge. Proper soft tissue management and the use of chlorhexidine can reduce the incidence of exposures and improve outcomes.

Keywords: Guided Bone Regeneration (GBR); Exposure; Non-Resorbable Membrane

Introduction

Guided Bone Regeneration (GBR) represents a therapeutic approach for managing significant alveolar bone loss, commonly resulting from tooth loss and the consequent progressive resorption. This technique is indicated either prior to or concurrently with dental implant placement and is also employed to provide adequate soft tissue support for the rehabilitation with complete dentures [1]. This technique, involving the use of non-resorbable membranes such as dense Polytetrafluoroethylene (d-PTFE) and titanium meshes, is widely employed due to their mechanical strength, biocompatibility and long-term stability [2]. However, premature or delayed exposure of these membranes may compromise the outcomes of the procedure and, in some cases, lead to treatment failure [3]. In a 2023 study, Mizraji D, reported that membrane exposure has an incidence ranging from 11% to 23% [4]. Soft tissue dehiscence leads to membrane exposure and may occur more frequently in patients with systemic diseases, smokers or those with abnormal anatomical conditions [5]. To reduce the rates of premature exposure, it is recommended to assess the soft tissues, including the amount of keratinized gingiva, flap mobility, the dimensions of the bone

defect and the biomaterials used [6]. Several studies have attempted to classify and address the complications arising from the use of these membranes. In 2011 Fontana M, proposed a clinical classification of complications associated with the use of PTFE membranes exclusively in GBR procedures [3]. This classification aims to identify the problem as a treatment modality. In 2022, Vroom G, proposed a new classification specifically for complications related to d-PTFE membranes reinforced with titanium, which entails a management strategy for exposures based on the severity of each type of membrane [7]. Class I represents exposure without active infection, Class II refers to exposure combined with purulent exudate and Class III involves the presence of an abscess without membrane exposure [7].

Given the clinical relevance of these complications and the variety of therapeutic approaches proposed in the literature, this article aims to conduct a systematic review of the available scientific evidence on the management of non-resorbable membrane exposure in GBR procedures. The review seeks to identify and analyze the different reported intervention methods, as well as their success rates, in order to provide clinical recommendations based on the best available evidence.

Materials and Methods

PICO Question (Problem, Intervention, Comparison, Outcome)

- P: Patient with bone defect
- I: GBR with non-resorbable membrane
- C: Management of membrane exposure
- O: Membrane exposure does not affect guided bone regeneration

Search Protocol

The first step in the systematic process of this review involved the use of the PICO methodology to formulate a clinical or research question. Articles were included from PUBMED, SCIENCE DIRECT, SCOPUS PREVIEW and WILEY ONLINE LIBRARY.

Research Question

Does exposure of non-resorbable membranes lead to failure in bone grafting?

Literature Search Plan Formulation

Considering the proposed research question, scientific articles published between 2015 and 2025 were analyzed. These articles were retrieved from the SCOPUS, PUBMED, WILEY ONLINE LIBRARY and SCIENCE DIRECT databases, written in English.
A rigorous search of scientific articles was conducted across the mentioned databases, using MeSH terms such as: “non-resorbable membrane AND exposure,” “titanium mesh AND exposure,” “e-PTFE AND exposure,” “Guided Bone Regeneration AND non-resorbable membrane exposure,” “d-PTFE AND exposure,” and “Guided Bone Regeneration AND titanium mesh exposure”.

Inclusion Criteria

- Studies involving human subjects
- Patients with bone loss
- Articles published from 2015 onwards
- Articles written in English

Exclusion Criteria

- Letters to the editor
- Animal studies
- Clinical opinions
- *In-vitro* studies
- Literature reviews

Elimination Criteria

- Studies where ethical codes were not respected

Results

During the bibliographic search, a total of 526 articles were identified in the selected databases, including PubMed (504), Wiley Online Library (17) and ScienceDirect [2]. Of these, 496 duplicate articles were removed. After applying the inclusion criteria, 14 articles that did not meet the criteria were also excluded. Finally, 14 articles were selected for a thorough reading, as illustrated in Fig. 1. In the analysis, only human studies were considered. The characteristics of the included studies were categorized by author, year, study design, sample size in each group, treatment and results, as presented in Table 1.

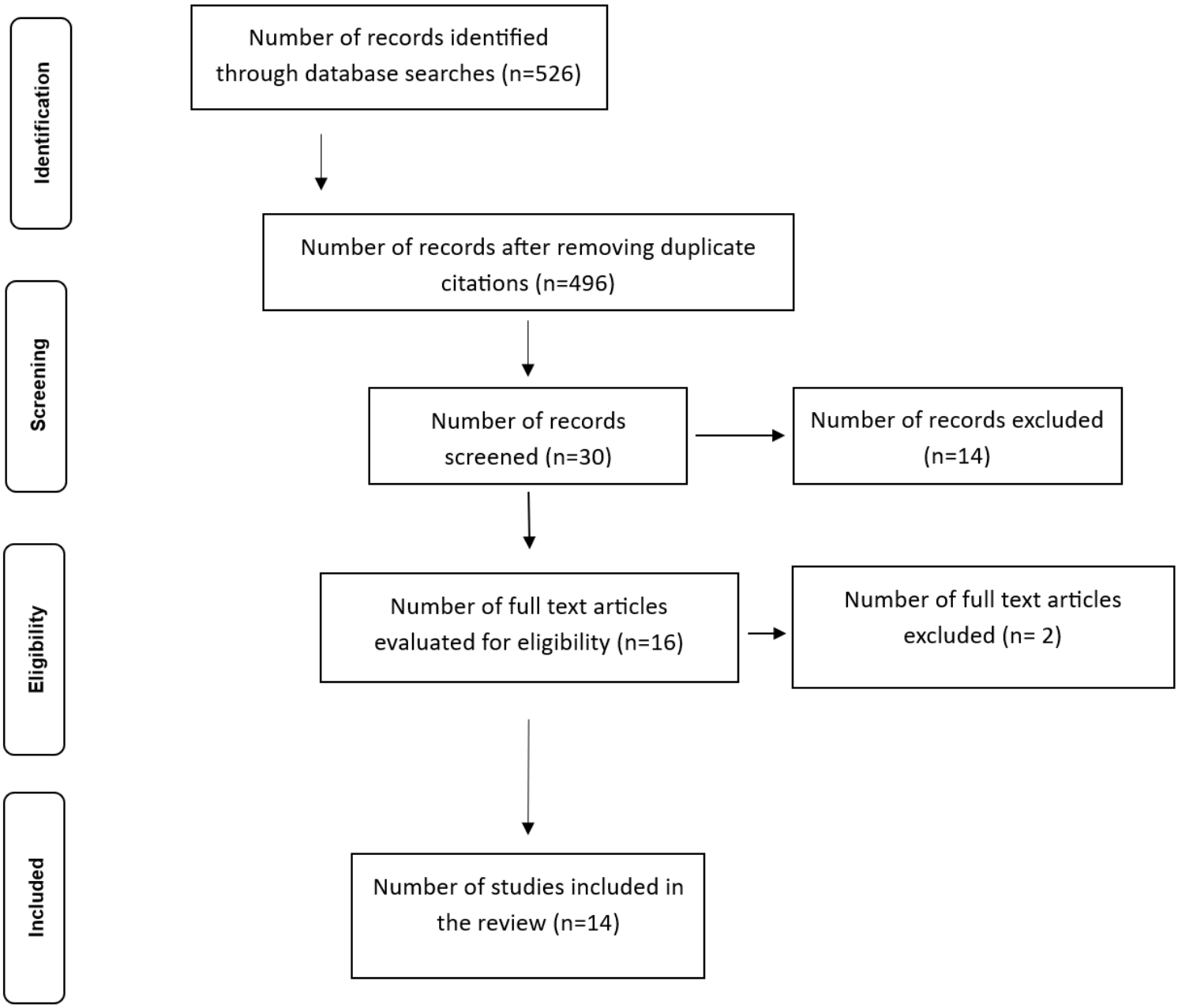

Figure 1: Inclusion and exclusion strategy.

Discussion

GBR is a predictable surgical procedure aimed at promoting bone formation; however, membrane exposure is a critical complication as it can directly interfere with the treatment's objectives. In this regard, Vroom's classification provides a useful guide for managing complications effectively, tailoring treatment according to the severity of the exposure. In cases of small exposure (≤ 3 mm), the membrane may be preserved with the use of antiseptics (such as chlorhexidine) to reduce bacterial load in the exposed area and protect the membrane [7]. In cases of larger exposures (> 3 mm) or active infection, immediate membrane removal may be required [7]. Lim L, identified an average complication rate of 16.8% in GBR procedures, regardless of the type

of membrane used [5]. However, the study emphasizes that careful soft tissue management is crucial to minimize membrane exposure and improve long-term clinical outcomes. Cucchi B, compared the use of custom titanium-reinforced meshes with d-PTFE meshes in vertical ridge augmentation procedures [8]. The results showed similar rates of surgical and healing complications between the techniques, with no significant differences in vertical bone gain or postoperative volumetric changes. Zeller S, analyzed complication rates associated with GBR procedures using d-PTFE membranes reinforced with titanium [9]. Their study revealed a higher prevalence of early membrane exposure, leading to a decreased treatment success. Ghensi S, Stablum J, Masmoudi, Belleggia indicated the use of chlorhexidine mouthwash as the antiseptic of choice, effective against bacteria, yeasts and both gram-positive and gram-negative viruses for its effectiveness in reducing dental plaque formation by 30-80% by penetrating the biofilms, altering plaque formation and acting bactericidally, which helps patients achieve a plaque-free oral environment for optimal postoperative healing when mechanical cleaning is not possible in the treated areas [10-14]. In this way, patients were kept under control until the exposed membrane was removed. No active infection was present, which did not affect the outcomes, Jegham M, Cucchi V, Alauddin demonstrated that membrane exposure, regardless of the timing of the exposure, as well as in cases of small dehiscences or when an adjunctive factor was applied during the removal of the exposed membrane, did not affect the outcomes of guided bone regeneration [11,15,16]. However, in a randomized clinical trial by Atef T, where non-resorbable membranes were used, membrane exposure occurred due to early exposure and premature membrane removal, which led to graft resorption at six months postoperatively [17].

Year	Author	Study type	Sample Size	Type of Exposure	Treatment	Outcome
2018	Almutairi [18]	Case report	1 patient	Exposure at 4 weeks, 4-8 mm	Surgical management by making two small vertical incisions and repositioning the tissue coronally to cover the membrane. The patient was instructed to use chlorhexidine mouthwash.	One week after the surgical attempt to cover the membrane exposure, the size had increased. Two weeks later, intraoral examination revealed pus discharge between the membrane and tissue. The membrane had to be removed due to infection.
2017	Ghensi, Stablum [10]	Case report	1 patient	Exposure at 14 days	Chlorhexidine (0.12%) mouth rinses for 30 days, 1% chlorhexidine gel twice a day until reentry procedure and weekly plaque removal at the clinic. Follow-up was done and the membrane was removed at 4 months.	This case shows that membrane exposure can be managed with deep knowledge of the materials used and proper oral hygiene.
2024	Cucchi, Bettini [8]	Randomized clinical trial	50 patients (25 with titanium-reinforced pTFE, 25 with customized titanium mesh)	2 cases of pTFE membrane exposure, 1 case of titanium mesh exposure	Non-resorbable membranes were removed, the area was cleaned with solutions, IV antibiotics (ceftriaxone) were administered and flaps were closed without membranes or adjunct devices.	After healing time, implants were placed with additional bone augmentation if needed.

2017	Jegham, Masmoudi [11]	Case report	1 pacient	Small circular flap dehiscence and titanium mesh exposure visible at 1 month during healing phase	No clinical signs of inflammation or infection. The patient used chlorhexidine gel until mesh removal.	The exposure did not affect the successful regenerative outcome.
2020	Alauddin and Ramli [16]	Case report	1 pacient	14 days after surgery: wound dehiscence with exposed membrane (4 mm x 9 mm), loose and detached sutures	The membrane was removed and replaced with Concentrated Growth Factor (CGF) as a barrier.	The exposure did not affect the successful regenerative outcome.
2020	Hartmann and Seiler [19]	Retrospective analysis	55 patients	Exposure in 25% of cases		The graft outcome was not affected.
2019	Atef, Tarek [17]	Randomized clinical trial	20 pacients	Exposure in 4 patients	Amoxicillin/clavulanic acid 1 g every 12 h orally, chlorhexidine irrigation for 7 days, mesh removal in cases 2 and 9. Case 10 retained the mesh due to good oral hygiene. Case 2 had late exposure and was managed with chlorhexidine irrigation and secondary intention healing.	Case 6: horizontal bone gain of 5 mm post-surgery, 1 mm after 6 months (80% volume loss). Case 9: 4.7 mm initially, 1.7 mm after 6 months (64% loss). Case 10: 18% graft resorption at 6 months.
2019	Hartmann, Hildebrandt [20]	Clinical study	65 patients	Mesh exposure in 37.1% of cases	Topical chlorhexidine gel applied to most exposed areas	Small dehiscences can be managed with anti-infective agents. Larger dehiscences may require early mesh removal and soft tissue healing to facilitate further treatment.
2017	Cucchi, Vignudelli [15]	Randomized clinical trial	20 patients with titanium-reinforced d-PTFE membrane, 20 with titanium mesh and	Group A: 2 exposures with d-PTFE membrane; Group B: 3 exposures with collagen membrane	Membrane removal	Exposure occurred within the first 4 postoperative weeks in both groups, leading to incomplete or failed bone regeneration. Late exposure did not affect bone regeneration in either group.

			cross-linked collagen membrane			
2015	Maridati, Cremonesi [21]	Case report	1 patient	Wound dehiscence observed after suture removal. >3 mm membrane exposure without infection. Membrane left in place for 2 more weeks to ensure bone regeneration. A full-thickness flap was raised 4 weeks post-regeneration to remove PTFE membrane and fixation screws.	Membrane was left in place for 4 weeks to ensure adequate space maintenance.	The underlying bone graft was clinically healthy and left undisturbed to allow regeneration.
2024	Zeller, Schenk [9]	Retrospective analysis	84 patients	Early membrane removal due to complications in 14 sites	Immediate membrane removal	
2023	Bahaa, Diab [22]	Randomized clinical trial	40 patients	15 cases of titanium mesh exposure	Irrigation with 0.12% chlorhexidine during follow-ups, mouth rinses for 2 weeks and weekly checkups. If infection occurred, amoxicillin-clavulanic acid for 7-10 days.	An inverse correlation was observed between the percentage of mesh exposure and clinical bone gain, highlighting the harmful effect of titanium mesh exposure.

2025	Poomprakobsri, Kan [23]	Retrospective analysis	232 patients	100 membranes exposed: 63 early (<1 month), 37 late (>1 month)	83 received chlorhexidine and antibiotics; 17 received no treatment. 16 of 100 exposed and 3 of 171 unexposed developed infections. Membranes and grafts were removed as needed.	A higher exposure rate was associated with the type of barrier used. Dimensional bone loss was significantly different between the total exposed group (58.3%) and unexposed (44.1%), with no significant differences among barrier types in exposed cases.
2021	Belleggia [12]	Case report	1 patient	At 4-month follow-up, a 4 mm exposure without infection occurred	Chlorhexidine 0.2% mouthwash three times daily and manual cleaning with gauze soaked in 3% hydrogen peroxide	One month later, the clinical condition remained unchanged. CBCT showed sufficient bone maturation for re-entry. Membrane was removed.

Table 1: Characteristics of the included studies.

Conclusion

The use of non-resorbable membranes has proven to be a reliable option due to their mechanical properties and biocompatibility. However, complications arising from premature or delayed exposure of these membranes remain a significant challenge. Nonetheless, careful management of soft tissues and the evaluation of risk factors can significantly reduce the incidence of exposures. The use of an antiseptic, such as chlorhexidine, helps to maintain the exposed membrane for a longer period, reducing bacterial load, thus allowing the progression of GBR. As new approaches and technologies continue to evolve, it is essential to further refine GBR techniques to maximize the long-term success of these procedures and ensure optimal patient rehabilitation.

Conflict of Interest

The authors declare that they have no conflicts of interest with the contents of the article.

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Author Contributions

All authors contributed equally for this paper.

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