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CASE REPORT

Alveolar Ridge Preservation Using Clot and Dense Polytetrafluoroethylene Membrane (PTFE-d): A Novel Surgical Protocol and Clinical Case Report

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Abstract

This study presents a biologically driven, minimally invasive protocol for alveolar ridge preservation (ARP) using autologous blood clot and dense polytetrafluoroethylene (PTFE-d) membranes. After tooth extraction, alveolar bone undergoes significant resorption, particularly in the first three months. The ARP/PTFE-d technique aims to stabilize the blood clot three-dimensionally, protect the healing socket from soft tissue invasion, and promote targeted osteogenesis through a biologically active and vascularized environment. A classification system is proposed to guide the indication of this protocol in sockets with preserved bony walls, avoiding its use in cases with major defects (type Vb).

The clinical technique is described step-by-step, from atraumatic extraction to membrane placement and removal at 21 days, followed by CBCT evaluation at 12 weeks. A clinical case illustrates the efficacy of this approach, with minimal vertical bone loss and preservation of soft tissue contours. Biological mechanisms, such as the M1-M2 macrophage activation, mesenchymal stem cell activity, and osteoblast-mediated signaling, are highlighted as key components of successful bone regeneration.

The results suggest that the ARP/PTFE-d protocol is a cost-effective and clinically efficient alternative to bone grafting, supporting implant planning without delaying treatment. Further controlled studies are recommended to validate its long-term outcomes.

2. Keywords: Alveolar ridge preservation, PTFE-d membrane, Tooth extraction, Autologous clot

Introduction

After tooth extraction, a physiological process of bone remodeling begins in the post-extraction socket, characterized by a significant reduction in the dimensions of the alveolar ridge. Recent studies have shown that, in the first six months, alveolar volume loss can reach between 29% and 63% horizontally, and between 11% and 22% vertically, with the most notable and accelerated changes occurring during the first three months after tooth extraction [1]. This phenomenon is largely due to the resorption of the bundle bone, a laminar bone structure that surrounds the tooth and contains Sharpey's fibers [2]. With an average thickness of 0.2 to 0.4 mm, the bundle bone depends entirely on the presence of the tooth, as its irrigation comes from the periodontal ligament. After extraction, a catabolic process is triggered that stimulates osteoclastic activity, causing gradual resorption of the residual bone. This resorption is more pronounced in the vestibular plate due to its thinner thickness and the loss of bundle bone, which contributes to the reduction in height and thickness of the alveolar ridge [3]. Given the magnitude of these changes, it is essential to implement alveolar ridge preservation strategies (ARP) immediately after extraction. These techniques seek to minimize bone loss and maintain the dimensions of the alveolar ridge.

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Alveolar ridge atrophy is an irreversible process, so numerous ARP techniques have been proposed to counteract post-extraction bone loss, which may or may not include the use of autologous bone grafts or bone substitutes with or without barrier membranes. Among the available techniques, alveolar preservation with autogenous clot and dense polytetrafluoroethylene membranes (ARP/PTFE-d) stands out as a simple, economical alternative with optimal results for future implant placement. Despite its usefulness, emerging trends question the routine use of ARP, pointing out that it could be overtreatment, given that studies indicate similar levels of bone loss with or without its post-extraction use [4].

Given this context, a detailed understanding of the physiology of the post-extraction tooth socket becomes critically important. Following tooth extraction, a sequence of biological and physiological events essential for socket repair is triggered. Initially, a blood clot forms, acting as a scaffold and source of biochemical signals. Subsequently, an inflamatory phase develops, characterized by the migration and proliferation of inflammatory cells, fibroblasts, and other connective cells [5]. These cells, together with the release of growth factors such as bone morphogenetic proteins (BMPs) and platelet-derived growth factor (PDGF), activate various intracellular signaling pathways that promote cell differentiation and the transition to the bone remodeling phase. This integrated process results in the structural reorganization of the alveolar socket, marking the beginning of bone tissue formation [6-8].

Araujo, et al. define wound stability as the degree of displacement of healing tissues as a function of pressure [5]. The fundamental aim of the ARP/PTFE-d technique is to achieve three-dimensional stabilization of the blood clot, a key element in the initial bone repair cascade. Correct positioning of the membrane acts as a selective barrier that protects the healing microenvironment, allowing the entry of angiogenic and osteogenic factors from the medullary compartment of the alveolar walls. This highly vascularized and biologically active environment promotes targeted and predictable osteogenesis, optimizing the quality and volume of newly formed bone tissue.

The PTFE-d membrane, characterized by its high density and non-resorbable microporous structure, acts as a non bioactive, biocompatible mechanical barrier that prevents the invasion of epithelial and soft connective tissue cells into the healing socket, allowing a crucial cell exclusion effect to preserve space and allow the proliferation of osteoprogenitor cells from the surrounding medullary bone [9]. Moreover, the chemical nature of PTFE-d confers hydrophobic properties that reduce the risk of bacterial contamination, favoring a sterile and protected environment. In this context, the blood clot stabilized under the membrane becomes a reservoir of growth factors, such as transforming growth factor beta (TGF-β) and bone morphogenetic proteins (BMPs), which stimulate osteogenesis and bone remodeling [10].

The present study aims to propose an ARP/PTFE-d surgical protocol. This approach would be presented as an effective, economical and practically applicable clinical alternative designed to preserve the bone dimensions of the socket after tooth extraction.

Description of the Technique

A modification of the classification of postextraction sockets proposed by Cardaropoli, et al. [9] was made for decision-making in alveolar preservation with the exclusive use of autologous clot and PTFE-d membrane (Figure 1). The modified classification includes classes I to V, with subdivision into Va and Vb according to the severity and extension of the defect. In this context, we propose the indication of the ARP/PTFE-d protocol for type I, II, III, IV and Va alveoli. This indication is based on the presence of remaining native basal bone, which allows passive stabilization of the PTFE-d membrane during the healing period.

In these cases, the remaining bone contour acts as a biological container that favors the formation and organization of the clot, protecting it from soft tissue collapse and allowing bone repair. In contrast, sockets classified as Vb are not considered suitable for this approach, due to the absence of a bony continent that prevents membrane displacement or collapse. In these cases, the primary stability of the clot is not guaranteed, which significantly compromises the predictability of the treatment and makes it advisable to use more complex approaches involving particulate grafts and advanced guided bone regeneration techniques.

Methodology

Local infiltrative anesthesia (peri-focal)

- Use 2% lidocaine with vasoconstrictor (epinephrine 1:100,000) to ensure effective analgesia during the surgical procedure.

Syndesmotomy

- Liberate the junctional epithelium, surrounding gingival fibers and interdental papilla.

Mucoperiosteal flap

- Create a full-thickness pocket in the vestibular and palatal areas, the apical extension of which should be individualized to the anatomy of the socket.

Atraumatic extraction

- Perform tooth extraction using conservative techniques that maximize preservation of the bony walls of the socket.

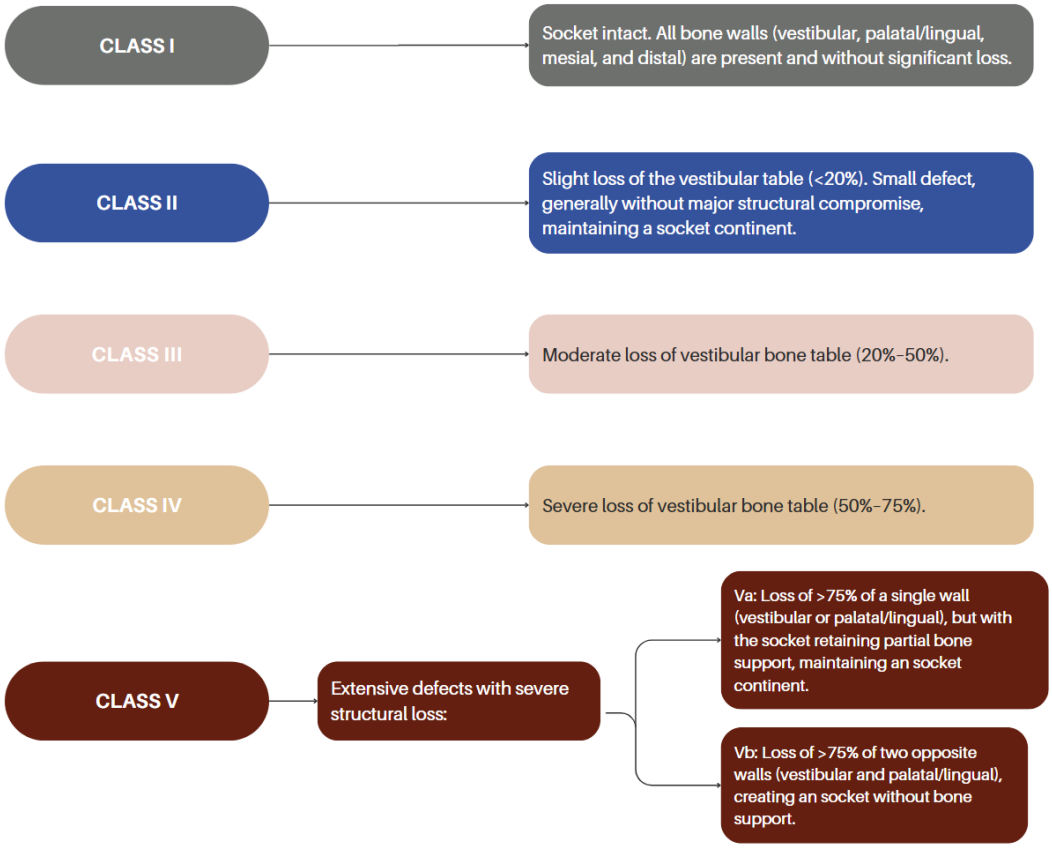

Figure 1: Modified cardapoli socket classification.

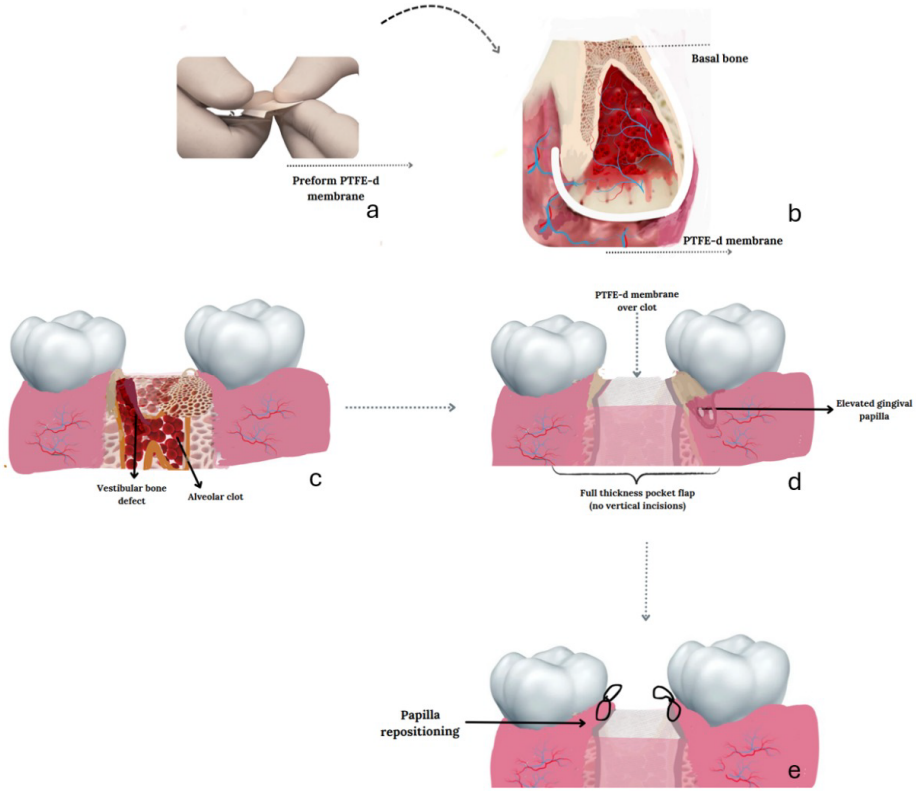

Figure 2: Trim and adapt the PTFE-d membrane: (a) Pre-shaping the d-PTFE membrane, ensuring the formation of a dome and maintaining the dimensions of the socket; (b) Positioning the membrane over the socket, resting on the bony papillae without contact with adjacent teeth; (c) Visualization of blood clot formation within the socket; (d) Placement of the d-PTFE membrane into the full-thickness vestibular and palatal pouch flap; (e) Repositioning of soft tissues and the gingival papilla.

Prepare the socket

- Perform thorough Lucas Curette curettage to debridate and remove residual granulation tissue and irrigate with saline (0.9% sodium chloride) to promote clot formation.

Evaluate the socket

- Analyze the conditions of the alveolus, verifying the preservation of the bone walls.

Trim and adapt the PTFE-d membrane (Figure 2)

- Apicocoronal extension: Position the membrane over at least 2 mm thick vestibular and palatal/lingual basal bone adjacent to the alveolar process.

- Mesiodistal extension: Ensure that the membrane rests on the alveolar bone ridges, ensuring a minimum distance of 1 mm to adjacent teeth.

- Occlusal Conformation: Preform the membrane in a dome shape to avoid its collapse in the socket and to favor clot stabilization.

Repositioning and soft tissue synthesis

- Reposition the gingival papillae in their original anatomic position over the PTFE-d membrane.

- Nylon 5.0 in interrupted sutures to stabilize the membrane and ensure adequate soft tissue closure.

Post exodontic indications and medical prescription

- Individualize pharmacological prescription according to the patient's characteristics and needs.

Postoperative control after 7 days

- Clinically evaluate membrane stability and soft tissue evolution.

Remove membrane and sutures after 21 days.

- Remove PTFE-d membrane and sutures. No need for anesthesia.

Take CBCT at 12-16 weeks post-extraction.

- Take a new CBCT to evaluate the dimensional changes of the alveolus and plan the installation of the dental implant.

Clinical Case

A clinical case was conducted at the Universidad del Desarrollo, Chile, where the patient signed informed consent forms approving both the proposed treatment plan and their participation in academic research. A comprehensive diagnostic process was initiated, including a clinical examination, a cone-beam computed tomography (CBCT) scan, and an intraoral scan using a Medit i600 scanner (Figure 3). Dimensional analysis of the surgical site revealed vestibulo-palatine measurements of 8.70 mm at the cervical level, 8.16 mm at the middle third, and 7.88 mm at the apical level. Additionally, the vertical height from the sinus floor to the vestibular cortical plate measured 11.40 mm.

The surgical procedure began with an atraumatic tooth extraction. The site was diagnosed as an alveolus type 1, indicating that both the vestibular and palatal cortices were intact, though thin and lacking a trabecular component. The socket was irrigated with saline to promote clean clot formation. A dense polytetrafluoroethylene (PTFE-d) membrane (Lumina, Criteria®) was then carefully adapted to the site. A three-dimensional STL file of the surgical area was captured post-operatively using the Medit i600 scanner.

Postoperative management included a prescription of meloxicam 15 mg every 24 hours and acetaminophen 1 g every 8 hours for three days. Antibiotics were not prescribed, as this decision was individualized to reduce unnecessary exposure and prevent bacterial resistance. The patient attended follow-up appointments at 7, 14, and 21 days, during which no complications were observed. Pain was reported with a visual analog scale (VAS) score of 3 during the first three days, decreasing to VAS 1 afterward. The PTFE-d membrane was removed at 21 days without requiring local anesthesia.

At 12 weeks evaluation, the site showed complete healing, an increase in the band of keratinized gingiva, and preservation of the vestibular contour. Follow-up imaging included a new CBCT and intraoral scan, which confirmed the dimensional stability of the surgical site (as presented in Table 1), supporting the successful outcome of the intervention.

Table 1: Measurements of the socket before and after alveolar ridge preservation.

	Initial	12 Weeks	Discrepancy
Cervical	8,70	7,75	-1
Medium	8,16	7,43	-0,68
Apical	7,88	7,71	-0,13
Vertical	11,40	10,73	-0,63

Table 1 presents the dimensional changes of the alveolar socket before and 12 weeks after ridge preservation. Measurements were taken at the cervical, middle, apical, and vertical levels. A reduction was observed across all dimensions: the cervical width decreased from 8.70 mm to 7.75 mm (-1.00 mm), the middle from 8.16 mm to 7.43 mm (-0.68 mm), the apical from 7.88 mm to 7.71 mm (-0.13 mm), and the vertical height from 11.40 mm to 10.73 mm (-0.63 mm). These results indicate a moderate dimensional change, with minimal apical and vertical bone loss, supporting the effectiveness of the preservation technique in maintaining socket integrity.

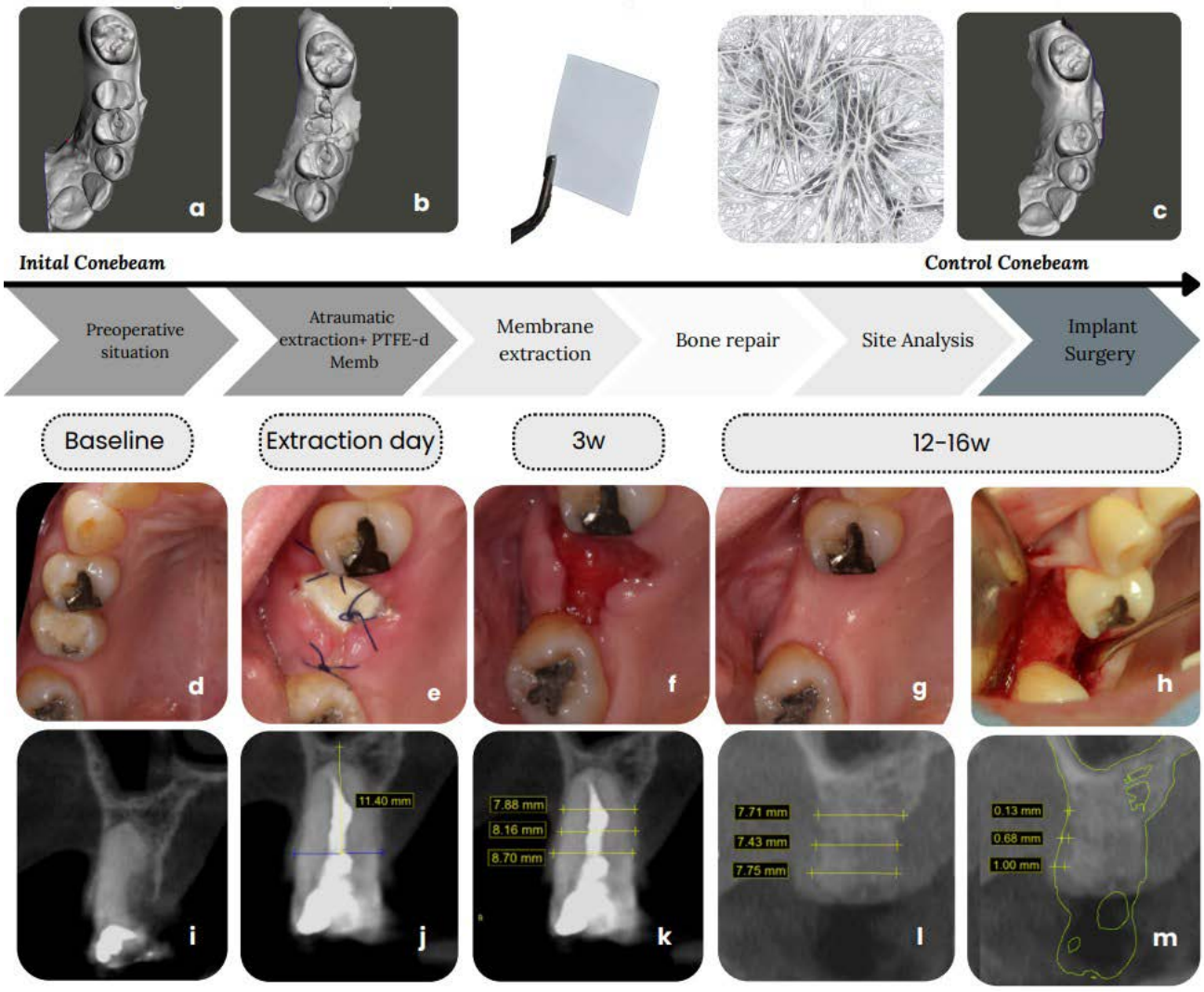

Figure 3: Clinical case follow up: (a) Initial STL scan; (b) STL scan showing placement of PTFE-d membrane; (c) STL scan at 12-week follow-up; (d) Initial intraoral photograph; (e) PTFE-d membrane placement; (f) Membrane removal at 21 days; (g) 12-week follow-up evaluation; (h) Alveolar ridge preserved at 12 weeks; (i) Initial CBCT showing cervical bone wall perforation; (j) Initial vertical bone dimensions on CBCT scan; (k) Initial horizontal bone dimensions on CBCT scan l) and m) CBCT at 12-week follow-up post-preservation.

Discussion

This article presents a conservative approach with a ARP-PTFE-d technique, avoiding bone grafts and reducing biological and clinical times. A clinical case is presented that demonstrates the efficacy of this technique in preserving alveolar dimensions and optimizing the site for future rehabilitation. Chatzopoulos, et al. carried out a systematic review on the use of PTFE-d membranes in alveolar preservation. The meta-analysis showed an average horizontal bone loss of 3.23 mm at 3 months post-extraction without intervention, suggesting the importance of effective strategies to preserve bone dimensions [6]. Studies indicate that a vestibular table with less than 1 mm thickness is usually associated with a vertical bone resorption of approximately 7.5 mm, while with more than 1 mm the average loss is 1.1 mm [5,10]. In the case reported, although there was a thin bone table (< 1 mm), the ARP-PTFE-d limited the vertical loss to only 0.63 mm at 3 months. This highlights the importance of detailed diagnostic planning and demonstrates that this conservative technique does not represent overtreatment or delay rehabilitation, but instead reduces treatment times. The effectiveness is based on the physiological function of the clot, which acts as a matrix for tissue regeneration and a source of growth factors (PDGF and TGF-β), promoting bone and connective tissue formation to optimize alveolar remodeling.

This coordinated interaction between immune, mesenchymal and osteoblastic cells underlines the complexity and efficiency of the biological processes involved in bone healing and regeneration. In this context, macrophages play an essential role in the regulation of the inflammatory response and tissue regeneration, with two main functional phenotypes: M1 and M2 [11]. M1 macrophages, activated by signals such as IFN-γ and LPS, secrete proinflammatory cytokines (TNF-α, IL-1β, IL-6) and mediate the initial

defense against pathogens, however their prolonged activation can inhibit tissue repair. In contrast, M2 macrophages, induced by IL-4, IL-10 and IL-13, exhibit an anti-inflammatory and pro-regenerative profile, releasing factors such as TGF-β and VEGF that promote decreased inflammation, angiogenesis and tissue remodeling. In the context of bone regeneration, M2s favor the migration and differentiation of mesenchymal stem cells toward osteoblastic lineages, generating an environment conducive to new bone formation. This phenotypic transition from M1 to M2 is essential for effective healing and can be promoted by strategies such as alveolar preservation with autologous clot and bioinert membranes, which optimize the immunobiological environment of the post-extraction site [12].

On the other hand, mesenchymal stem cells, derived from bone marrow and other tissues, have been described to play a crucial role in bone regeneration through their immunomodulatory and osteogenic capacity. These cells not only differentiate towards osteoblastic lineages, but also induce the polarization of macrophages towards the M2 phenotype, characterized by their anti-inflammatory and pro-regenerative profile. In parallel, osteoblasts, in addition to their main function in bone matrix formation, secrete paracrine signals that promote the proliferation and differentiation of new mesenchymal cells, generating a positive cellular feedback loop that enhances alveolar site remodeling. This coordinated interaction between immune, mesenchymal and osteoblastic cells emphasizes the complexity and efficiency of the biological processes involved in bone healing and regeneration after properly planned ARP-PTFE-d [12].

A CBCT at 12 weeks after ARP is essential to accurately assess bone maturation and plan implant placement. Histologically, at this stage a mostly mineralized bone matrix is observed, with organized trabeculae, active osteoblasts and ongoing osteoclastic remodeling, indicating a dynamic process favorable for osseointegration. Performing CBCT before 12 weeks would be premature, since between 4 and 8 weeks the neoformed bone still lacks mineral maturity, which may distort the interpretation of bone volume and available bone quality. In addition, CBCT allows comparison with the preoperative study and determination of the need for additional procedures [13].

In the early stages of post-extraction healing, the bone regeneration process follows an established sequence of histological events. Initially, the blood clot that forms after tooth extraction acts as a provisional matrix that promotes cell migration and angiogenesis. During the first 1 to 2 weeks, the clot is replaced by lax connective tissue, in which fibroblasts predominate, and the proliferation of mesenchymal cells from various sources, such as bone marrow and periodontal tissue, begins. These mesenchymal cells have the ability to differentiate into various cell lineages, including osteoblasts, chondrocytes and adipocytes, depending on microenvironmental signals and extracellular matrix proteins [14]. Between weeks 4 and 8, the first immature bone trabeculae develop, initially being bone tissue that is in the process of mineralization. This process is mediated by osteoblasts, which secrete extracellular matrix composed of type I collagen, followed by the deposition of minerals, mainly hydroxyapatite. During this phase, bone remodeling also begins, with the activity of osteoclasts resorbing primitive bone and allowing the formation of denser and more organized bone. By 12 weeks, the neoformed bone has reached a sufficient degree of maturity to support mechanical loading, although it is still in the process of maturing into lamellar bone, which contributes to the long-term stability of the alveolar site and osseointegration of implants. This process of bone regeneration is tightly regulated by the interaction between mesenchymal cells, osteoblasts and the biochemical environment, which includes growth factors such as TGF-β and VEGF, essential for angiogenesis, bone remodeling and resolution of inflammation [15].

The decision to remove the PTFE-d membrane at 21 days is based on the physiological principles of bone regeneration and the dynamics of the blood clot in the post-exodontic healing process. During this time, the clot, which initially acts as a biological scaffold, has been largely replaced by an osteoid matrix, the result of cell proliferation and differentiation activated by growth factors, cytokines, inflammatory mediators and cellular mechanisms released at the surgical site [16]. The PTFE-d membrane plays a key role in the early stages by excluding epithelial and soft connective tissue cells, preventing their invasion into the alveolar space and ensuring an osteogenic environment. However, after three weeks, this risk is significantly reduced, as the forming osteoid matrix establishes a natural biological barrier against colonization by unwanted tissues.

Leaving the PTFE-d membrane exposed for a period longer than 21 days is not recommended due to multiple biological and clinical reasons supported in the literature. First, PTFE-d is a non-resorbable and impermeable membrane, which prevents the passage of fluids, nutrients and cells through it. While this property prevents epithelial and bacterial infiltration at the regenerative site, it also limits irrigation of the underlying clot from the oral environment. Vascularization is a critical component in the processes of bone healing and regeneration, as it allows for the transport of oxygen, immune cells, progenitor cells and growth factors necessary for osteogenesis. Prolonged membrane residence may compromise this balance by maintaining a hypoxic microenvironment, which may result in less predictable or slower bone regeneration.

Conclusion

Alveolar preservation is a fundamental strategy in modern implant dentistry, aimed at minimizing the loss of bone and soft tissue following tooth extraction. Among the various techniques available, the use of autologous blood clot in combination with dense polytetrafluoroethylene membranes has emerged as an effective, cost-efficient, and minimally invasive option that also contributes to reducing overall treatment time. Current evidence from systematic reviews and meta-analyses supports the efficacy of this approach, demonstrating a significant reduction in both vertical and horizontal bone resorption-particularly in high-risk areas, such as sites with vestibular bone plates thinner than 1 mm. Although further validation through randomized clinical trials with larger sample sizes is warranted, the available data are promising. The clinical protocol described is straightforward, practical, and accessible for routine use, promoting a biologically driven approach to alveolar ridge preservation that aligns with the natural healing dynamics of the tissues involved.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Author Contribution Statement

All authors contributed equally to the conception, design, execution, and writing of this work. They were jointly involved in data collection and analysis, as well as in the interpretation of the results. Furthermore, all authors critically reviewed the manuscript, approved the final version, and agree to take full responsibility for its content on equal terms.

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