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ORIGINAL

# Preservation of the alveolar ridge after tooth extraction. Havana. 2024-2026

## Preservación de la cresta alveolar post-extracción dentaria. La Habana. 2024-2026

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**ABSTRACT**

Introduction: After an extraction, bone resorption occurs with a decrease in the height and width of the available bone. Alveolar preservation is intended to preserve the architecture or volume of the alveolar ridge and provide maximum bone availability for implant placement. Objective: To determine the use of high-density polytetrafluoroethylene (d-PTFE) membrane in the preservation of the alveolar ridge after tooth extraction. Material and Method: A parallel randomised controlled trial was conducted. The sample consisted of 11 randomly selected subjects. The variables studied were: dental arch and operated sector, variations in width and height of the alveolar ridge, plaque index, bleeding on probing and depth of the pocket. Results: 81.2% of the operated teeth belonged to the maxilla, with 50% of them being anterior teeth with greater effectiveness in the use of the membrane. The horizontal dimension of the alveolar ridge showed a significant mean reduction of 1.19 ± 1.55 mm, compared to the group without biomaterial (2.27 ± 1.52mm) and the vertical variation was also lower (0.14 ± 184mm vs 0.98 ± 1.49mm). Conclusions: The most surgically operated on sector is the anterosuperior. The total dimensional changes in the vertical direction in both groups were greater than in the horizontal direction. Variations in the alveolar ridge were less noticeable at 6 months.

Keywords: Bone resorption, alveolar crest preservation, non-resorbable membranes, d-PTFE.

**RESUMEN**

Introducción: Tras una exodoncia se produce una resorción ósea con disminución de la altura y ancho del hueso disponible. La preservación alveolar está destinada a preservar la arquitectura o volumen de la cresta alveolar y proporcionar la máxima disponibilidad ósea para la colocación de implante. Objetivo: Determinar el uso de la membrana politetrafluoroetileno de alta densidad (d-PTFE) en la preservación de la cresta alveolar post-extracción dentaria. Material y Método: Se realizó un ensayo controlado aleatorio paralelo. La muestra quedó conformada por 11 sujetos seleccionados al azar. Las variables que se estudiaron fueron: arcada dentaria y sector intervenido, variaciones en anchura y altura de la cresta alveolar, índice de placa, sangramiento al sondaje y profundidad de la bolsa. Resultados: El 81,2% de los dientes intervenidos pertenecieron al maxilar, siendo el 50% de ellos dientes anteriores con mayor efectividad en el uso de la membrana. La dimensión horizontal del reborde alveolar mostró una significativa reducción media de 1,19 ± 1.55 mm, comparada con el grupo sin biomaterial (2,27 ± 1,52mm) y la variación vertical fue también menor (0,14 ± 184mm vs 0,98 ± 1,49mm). Conclusiones: El sector más intervenido quirúrgicamente es el anterosuperior. Los cambios dimensionales totales en dirección vertical en ambos grupos fueron mayores que en dirección horizontal. Las variaciones de la cresta alveolar fueron menos notables a los 6 meses.

Palabras clave: Resorción ósea, preservación de cresta alveolar, membranas no reabsorbibles, d-PTFE.

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## INTRODUCTION

After a tooth extraction, bone resorption occurs with a decrease in the height and width of the available bone, in addition to significant changes in bone quality. To ensure the placement of dental implants, it is crucial to have adequate bone dimensions, maintaining a safety margin of 1.5 mm on the buccal plate and 1 mm on the lingual/palatal plate. 1

Alveolar preservation according to Vignoletti et al. in 2012 (as cited by Encalada Abad2) is defined as any therapeutic approach carried out immediately after tooth extraction intended to preserve the architecture or volume of the alveolus or intracapsular alveolar crest and provide the maximum bone availability for implant placement.

The need to optimize bone regeneration has driven the development of various methods, including guided bone regeneration and the application of bone substitutes.3 The first guided bone regeneration (GBR) experiments were applied in the early 1990s in atrophic jaws.3

The selection of regenerative materials depends largely on the morphology of the alveolar bone defect; the larger the defect, the more critical it is for the material to replace and maintain space, as with bone grafts and membranes. Various materials have been used, including autogenous and non-autogenous particulate bone grafts, such as allografts (mineralized or demineralized), xenografts, and alloplastic materials (hydroxyapatite (HA), bioactive crystals).3

The development of barrier membranes for the regeneration of bone defects has been of great importance in dental implantology over the past 30 years. Since that time, a wide variety of membranes have been introduced.4

Depending on their resorption capacity or degradability, they are classified as resorbable and non-resorbable, with the non-resorbable ones being of interest in this study, specifically the d-PTFE membrane. There are 4 polytetrafluoroethylene membranes for GBR procedures: expanded (e-PTFE), dense (d-PTFE), titanium mesh, and PTFE with titanium reinforcement. 4

### Scientific problem

How was the d-PTFE membrane used in preserving the alveolar ridge after tooth extraction for implant placement?

### General objective

To determine the usefulness of the d-PTFE membrane in the preservation of the alveolar ridge after tooth extraction.

### Specific objectives

1. To identify the treated sites according to sector and dental arch.
2. To determine the variation in alveolar ridge dimensions according to width and height.

## METHODS

### Study type

One parallel randomized controlled trial was conducted to determine the use of d-PTFE membrane in alveolar ridge preservation after tooth extraction for implant placement.

### Study Universe

It consisted of all patients who were rehabilitated with implants in the Prosthetics Clinic at the Faculty of Stomatology in the period from 2024 to 2026. Patient recruitment, surgeries, and follow-ups were carried out in collaboration with the Cojímar Convention School.

The inclusion criteria were: patients aged 21 years or older, with the presence of a single tooth to three teeth to be extracted (anterior teeth and premolars of both jaws with adjacent natural teeth, good general health without contraindications for oral surgical procedures (good integrity of the bone walls), diagnosis and indications for dental extraction: endodontic failures or traumatic complications (e.g., root fracture), teeth irrecoverable due to severe caries or complicated crown/root fracture, patients with controlled periodontal status, no history of allergy or hypersensitivity to any of the products used in the study, such as polyethylene, and who agree to participate in the study and sign informed consent.

The exclusion criteria were: presence of relevant medical conditions: such as bone diseases,

diabetes mellitus, unstable or life-threatening diseases, or those requiring antibiotic prophylaxis, history of past or ongoing chemotherapeutic or radiotherapeutic treatments, patients who smoke with a declared consumption of > 10 cigarettes per day, signs of local inflammation; pregnancy or lactation, history of malignant neoplasia, radiotherapy or chemotherapy for malignant neoplasia in the last 5 years, history of autoimmune disease or prolonged use of steroids, previous bone regeneration procedures in the area of interest, patients who do not wish to continue participating in the project.

**Sample size**

The sample consisted of randomly selected subjects from whom between a single extraction and three extractions were performed to determine which sites belonged to the experimental case group and others for control cases, making a total of 10 patients.

**Randomization and allocation concealment**

Randomization was performed electronically by an author who did not participate in the surgical procedures. The assignments were sealed in opaque envelopes that were opened after the surgery was completed.

**Information Collection Methods:**

**Randomization and allocation concealment**

Randomization was performed electronically by an author who did not participate in the surgical procedures. The assignments were sealed in opaque envelopes and opened after the surgery was completed.

**Data collection:**

**Examinations: clinical and radiographic evaluations.**

Each participant underwent clinical and radiological examinations. The latter included a preoperative radiograph (orthopantomogram or periapical radiograph) or an intraoral scanning impression of the alveolar socket wound area and the alveolar ridge contour, and 2 postoperative CBCT (Cone Beam Computed Tomography, and in Spanish Tomografía Computarizada de Haz Cónico) scans; the first was performed on the day of extraction with subsequent membrane placement, another at 3 months after surgery to evaluate the dimensional change of the alveolar bone and before implant placement, and then annually for at least 2 years.

**CBCT scanning and measurement procedures**

All measurements were performed by a single examiner.

Soft tissue dimensional changes were obtained from intraoral scanner data. 3D model files (STL files) were created, and occlusal planes were measured at the midpoint of the alveolus; these measurements were compared as vertical dimensional changes. A perpendicular line was created in the middle part of the alveolus at intervals of 1 mm.

For hard tissue dimensional changes, alveolar bone changes were measured using two consecutive CBCT radiographs in DICOM files (Digital Imaging and Communications in Medicine) obtained at baseline and at 3 months, and subsequently processed using 3D Slicer software.

Measurements on the first CBCT scan included the height and width of the buccal plate and the oral plate. Measurements were performed on a paraxial section at the center of the alveolus (a vertical line drawn at the midpoint of the horizontal line connecting the mesial and distal bony margins of the alveolus). The heights of the vestibular and palatal bony walls were measured vertically by drawing two straight lines from the most superior point of each bone plate to the most superior point of the mandibular canal (for mandibular teeth) or the most inferior point of the maxillary sinus (for maxillary teeth), respectively, that is, to a line connecting the cementoenamel junctions (UEC) of adjacent teeth at the mesiodistal midpoint between those adjacent teeth.

These points were selected as stable reference points instead of the lower part of the socket due to the rapid resorption of the bundle bone that covers its inner aspect. The plate widths were measured 3 mm apically from the superior points of the bone plates.

CBCT images were superimposed, and the dimensional variation in width and height be-

tween treated and untreated sites was evaluated, as well as the variation over time.

After selecting the region of interest (ROI) that included only hard tissues, it was converted into 3D models. The horizontal dimensional changes of the alveolar bone were analyzed with GOM software, as previously described.

### Peri-implant clinical parameters

For each implant, the following clinical measurements were made: dental plaque index, bleeding on probing, and pocket depth. For the latter two, a periodontal probe was used with light force, without anesthesia, by the same previously trained examiner.

### Surgical procedures

### Implant placement procedure and histological process

The allocation of test and control sites was randomized, and the assignments were placed in sealed envelopes that were opened after the surgery was completed. Both the experimental and control sites in the same patient were treated during the same surgical phase. The atraumatic extraction of teeth was performed under infiltration anesthesia with articaine 40 mg/0,005 mg/ml.

- For implant placement, the implant position was marked with a small round surgical bur through the surgical stent (acrylic guide). During preparation of the implant bed, a trephine bur with an inner diameter of 2 mm and a length of 6 mm was used to extract the bone from the preserved bed. The bone core (a cylindrical bone core of 2 x 6 mm from the central part of the anterior socket) was immersed in a fixative (10% formaldehyde).

- The implant osteotomy was continued according to the company's protocol.

Implant stability at the time of insertion (IST1) and before prosthetic placement (IST2) was recorded using a modified damping capacity analysis device.

Subsequently, the teeth were extracted, and the sockets were debrided and rinsed with saline solution. In the control group, the socket was sutured with crossed mattress sutures or simple interrupted sutures with non-resorbable polyamide 5/0. In the experimental group, a small full-thickness flap was made without releasing incisions to create subperiosteal pockets for insertion of the membrane between the buccal bone and the flap. The wounds were sutured to allow non-submerged healing with crossed mattress sutures and/or single interrupted sutures with polyamide 5/0.

Postoperative instructions and medication were given: amoxicillin 500 mg orally (2 capsules, 2 times a day) for 5 days, ibuprofen 400 mg orally (1 tablet, 3 times a day), and chlorhexidine mouth rinse (2 times a day). Subjects were evaluated at 2 weeks after suture removal.

Afterward, the teeth were extracted and the sockets were debrided and rinsed with saline solution. In the control group, the sockets were sutured with crossed mattress or simple interrupted sutures using non-resorbable polyamide 5/0. In the experimental group, a small full-thickness flap was made without releasing incisions to create subperiosteal pouches for insertion of the membrane between the buccal bone and the flap. The wounds were sutured to allow non-submerged healing with crossed mattress sutures and/or single interrupted sutures using polyamide 5/0.

Antibiotic prophylaxis was prescribed: amoxicillin with clavulanic acid 1000 mg (twice daily for seven days) or 500 mg orally (2 capsules, 2 times daily for 5 days) or azithromycin 500 mg (one daily for five days) in case of allergy to beta-lactams, analgesics such as ibuprofen 400 mg orally (1 tablet, 3 times daily) Postoperative instructions were given for personal oral hygiene and a gentle diet. Analgesics and mouthwash with 0.12% chlorhexidine were also prescribed. Suture removal was performed after one week in the control group and two weeks in the experimental group.

On day 14, all sutures were removed, and on day 28, the membrane was removed using hemostatic forceps. Wound epithelialization after membrane removal took 2 to 4 weeks. Subsequently, all subjects were recalled at 3 months postoperatively. 3 months later, before readmission, cone-beam computed tomography (CBCT2) was performed with a surgical stent (acrylic guide), the scores of the aforementioned measurements were recorded: plaque index, bleeding index, gingival recession, and pocket depth, and implants were placed in both groups. After 3 more months, the crown was delivered to the patient.

### Calibration for measurements and blinding procedures

The analysis of the radiographic images was performed by an experienced evaluator, who was unaware of the treatment group assignment, although the implant types were recognized in the

images. For the tridimensional image analyses, the evaluator was blinded to treatment assignment.

### Analysis and Processing of Information

### Statistical Analysis

Data were analyzed using descriptive statistics, including the mean and standard deviation. All variables were examined using the Shapiro-Wilk test to assess data normality. The obtained results were processed manually and entered into an automated database using Excel and Microsoft Word 2013 for the statistical processing of the information. As summary measures for qualitative and quantitative data, a descriptive analysis was performed using absolute numbers and percentages.

### Discussion and Synthesis

The results were presented in tables to facilitate interpretation. The research findings were compared with those of similar studies. The researcher's and tutor's criteria were considered, together with information from the scientific literature consulted during the study, which allowed conclusions to be reached.

### Ethical Considerations

This research was carried out with prior informed consent from the patient, obtained after a clear explanation of the procedures and possible complications, and with authorization from the directors of the Faculty of Stomatology. All individuals were treated equally, regardless of their physical condition or cultural level. The study was conducted exclusively for scientific and academic purposes, safeguarding the identity and the physical and moral integrity of the participants.

## RESULTS

**Table 1. Distribution of surgically treated sites according to sector and treated arch.**

| Intervened sites | Sector and Dental Arch | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Superior | | | | Inferior | | | | Total | | | |
| | Anterior | | Posterior | | Anterior | | Posterior | | Anterior | | Posterior | |
| | N | % | N | % | N | % | N | % | N | % | N | % |
| dPTFE membrane | 5 | 31,2 | 4 | 25 | 1 | 6,2 | - | - | 6 | 37,4 | 4 | 25 |
| Control | 3 | 18,8 | 1 | 6,2 | 1 | 6,2 | 1 | 6,2 | 4 | 25 | 2 | 12,5 |
| Total | 8 | 50 | 5 | 31,2 | 2 | 12,5 | 1 | 6,2 | 10 | 62,5 | 6 | 37,4 |

Of the 16 surgically treated sites, 81.2% were located in the maxilla and in the anterior-superior dental sector; 37.4% were in the experimental group.

Changes in ridge height were measured on both the vestibular and lingual aspects. In the experimental group, the mean reduction was 1.91 ± 1.43 mm on the vestibular aspect and 1.83 ± 1.27 mm on the lingual aspect.

**Table 2. Variation of the alveolar ridge of the surgically treated sites according to the (vertical) height of the bone.**

| Treated sites according to dental sector | Alveolar ridge variation | | | |
|---|---|---|---|---|
| | Experimental | | Control | |
| | Vestibular-palatal/lingual wall | | Vestibular-palatal/lingual wall | |
| | 3 months | 6 months | 3 months | 6 months |
| Anterosuperior | 1.95 ± 1.46 mm | 1.87 ± 1.40 mm | 2.84 ± 2.24 | 1.79 ± 1.23 mm |
| Anteroinferior | 1.71 ± 1.32 mm | 1.64 ± 1.27 mm | 2.54 ± 2.31 | 1.85 ± 1.68 mm |
| Posterosuperior | 1.85 ± 1.34 mm | 1.82 ± 1.30 mm | 2.69 ± 2.33 | 1.92 ± 1.25 mm |

In the control group, the corresponding values were 2.73 ± 2.19 mm and 1.72 ± 1.12 mm, respectively. Although a lower vertical reduction was observed in the dPFTE membrane group, the vestibular aspect was the most affected in both groups.

**Table 3. Variation of the alveolar ridge of the surgically treated sites according to the width (horizontal) of the bone.**

| Intervention sites according to dental sector | Alveolar ridge variation | | | |
|---|---|---|---|---|
| | Experimental | | Control | |
| | Mesiodistal wall | | Mesiodistal wall | |
| | 3 months | 6 months | 3 months | 6 months |
| Anterosuperior | 7.72 ± 2.95 mm | 6.88 ± 2.88 mm | -6.74 ± 3.32 mm | -6.67 ± 3.228 mm |
| Anteroinferior | 6.84 ± 2.55 mm | -6.84 ± 2.5 mm | 6.43 ± 3.42 mm | 6.19 ± 3.19 mm |
| Posterosuperior | 7.45 ± 2.95 mm | 7.37 ± 2.95 mm | 6.87 ± 3.18 mm | 6.78 ± 2.88 mm |

Changes in ridge width were measured both mesially and distally. In the experimental group, the mean reduction was 6.37 ± 2.95 mm, and in the control group, 6.67 ± 3.13 mm.

## DISCUSSION

In general, bone resorption after tooth loss is an inevitable phenomenon that leads to resorption of the alveolar bone and to clinically visible dimensional alterations, negatively affecting both oral health and social complications. An edentulous site can be rehabilitated with dental prostheses, bridges, or dental implants; however, the quantity and quality of the soft and hard tissues are essential.

Table 1 shows the distribution of surgically treated teeth, with predominance of the maxilla in the anterior-superior dental sector.

This information is important when considering the anatomy and structure of the anterior teeth for alveolar ridge preservation and implant placement. The alveolar bone in this area is usually narrower and thinner, especially in the vestibular (external) region, and presents a thicker cortical layer in the mandible, which provides greater resistance to vertical masticatory forces. The alveoli are simpler, adapted to the single conical roots of incisors and canines. Hence, the anterior region has a higher success rate because bone loss is slower (in width) due to bone quality, and it requires fewer regeneration techniques, except in cases of severe trauma. Unlike posterior teeth, where the bone is wider and bulkier, with a greater presence of cancellous bone to absorb lateral forces during mastication, and the alveoli are compound and partitioned, designed to house multiple roots, the success rate is lower because these areas frequently require bone grafts or maxillary sinus lifting due to height loss. The placement of zygomatic implants is an alternative in cases of advanced atrophy. 5

Table 2 showed the vertical (height) variation of the alveolar bone. The least significant changes occurred at the sites where the experimental membranes were placed, although the vestibular surface was the most affected in both groups.

These data are consistent with those observed by Araújo et al. in 2015, as cited by Encalada2, who indicated that ridge reduction is greater in posterior sites but is more critical in the anterior area due to aesthetic demands. The anterior area also presents thinner vestibular cortical plates, composed of bundle bone that is gradually resorbed because it is tooth-dependent; therefore, changes can be more pronounced, as observed in the present investigation, where a greater loss of vestibular volume was seen in incisors.

The Dpfte membrane, upon contact with the alveolar bone, induces significant effects, since it acts as a selective physical barrier allowing bone regeneration while blocking the invasion of soft tissues into the healing site. In extractions with dehiscences or thin alveolar walls (<1 mm), it maintains bone architecture during the initial healing phase, prevents epithelial and connective tissue cells from migrating into the empty socket, and reserves space for bone regeneration. It favors osteogenesis (new bone formation) by allowing osteoprogenitor cells and growth factors to act without interference. Its structural stability prevents soft tissue collapse into the socket, maintaining the bone volume necessary for future implants and prostheses. It does not generate immunological rejection because it is an inert and highly biocompatible material, which reduces the risk of inflammation or infection at the surgical site, but it requires a second surgical interven-

tion for its removal (usually 4 to 6 weeks). Furthermore, it has pores of a specific size (25 to 30 µm) that allow the entry of nutrients and blood cells, favoring angiogenesis (blood vessel formation) and bone tissue formation. 6

Furthermore, changes in the coronal part and the vestibular aspect of the alveolar ridge were greater than those in the apical part and the lingual aspect. However, the mean vertical and horizontal dimensional changes at all locations of the alveolar ridge contour did not show significant differences between the two groups (P > 0.05).

Table 3 showed the variation in alveolar bone width (horizontal length), which was similar to the changes observed in height.

This coincided with the study conducted by Chatzopoulos 7, who used the same extraction treatment protocol for the test and control groups (with or without flap). A significant difference was observed (p = 0.042), supporting a better gain of keratinized tissue after placement of a dPTFE membrane (3.49 mm [95% CI: 0.16; 6.83]) compared with extraction alone, at 3-4 months after treatment (I2 = 89%, p < 0.001). It also coincided regarding the radiographic vertical dimensional change, since a significant reduction in alveolar bone loss was observed with a dPTFE membrane + allograft (-0.70 mm [95% CI: -1.35, -0.06]) compared with extraction alone (-2.17 mm [95% CI: -2.84, 1.51]).

Tan et al., cited by Elizalde8, reported the percentage of dimensional changes in a systematic review after tooth extraction without intervening in the healing process. In the vertical direction, the changes ranged between 11% and 22%, and in the horizontal direction, between 29% and 63%, after only 6-7 months of healing. In contrast, when using xenograft for alveolar preservation with the Bartee or Bio-col technique, the present study observed dimensional stability of the socket, with a vertical range between 13.58% and 20.76% and a horizontal range between 13.45% and 15.72% at 6 months of healing.

The preservation of this space is attributed to the combination of the dPTFE membrane with a xenograft. This xenograft is a deproteinized bovine bone mineral (DBBM) used as a bone substitute. It is obtained from a donor of another species (the cow) and has been deprived of all organic components through high-temperature processes to minimize the immune response. It maintains a crystalline, porous structure and a carbonate content similar to human bone minerals. Due to its similarity to native bone structure, it is claimed to provide a favorable osteoconductive environment during bone regeneration. This combination reduces post-extraction bone loss, especially in critical areas such as the vestibular wall; favors early vascularization; minimizes fibrosis; and accelerates the formation of vital bone. It also allows the formation of vital bone because Bio-Oss induces the formation of mature lamellar bone, with 30-35% mineralized tissue at 4 months. It has a high porosity of 70-80% of the total volume, with interconnected pores that facilitate angiogenesis (formation of blood vessels) and the migration of osteoprogenitor cells. It also favors osteoconductivity, acting as a scaffold that guides the formation of new bone and integrates its particles into the regenerated bone matrix. 7

## CONCLUSIONS

The sector that received the most interventions was the anterosuperior. In both groups, the total dimensional changes were greater in the vertical direction than in the horizontal direction. Alveolar ridge variations were less pronounced at 6 months. The use of dPTFE membranes helped maintain the dimensions of the alveolar bone.

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## CONFLICT OF INTEREST

None

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