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Comparative evaluation of sticky bone with guided tissue regeneration and platelet-rich fibrin membranes in healing of apicomarginal defects with periapical pathology: An in-vivo study

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Abstract

AIM. The objective of this study is to comparatively evaluate the effectiveness of sticky bone alone, sticky bone with a PRF membrane, as well as sticky bone having a GTR membrane in healing apicomarginal defects.
MATERIALS AND METHODS. Twenty-seven patients with apicomarginal defects were randomly divided into three groups: Group I (sticky bone alone), Group II (sticky bone with GTR membrane), and Group III (sticky bone with PRF membrane). Clinical and radiographic assessments, including probing depth, bone density, and lesion size, were conducted. Statistical analyses included paired t-tests and ANOVA with a remarkable level of $p < 0.05$.
RESULTS. Notable improvements in all parameters were observed across groups ($p < 0.05$). Group III showed the most notable reductions in probing depth and lesion size and the highest increase in bone density. Group II exhibited moderate improvements, while Group I had the least favorable outcomes.
CONCLUSION. Combining sticky bone with PRF or GTR enhances bone healing in apicomarginal defects, with PRF yielding the best results.

Keywords: apicomarginal defect, bone regeneration, guided tissue regeneration, platelet-rich fibrin, sticky bone, wound healing

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Сравнительная оценка липкой кости с направленной регенерацией тканей и фибриновых мембран с высоким содержанием тромбоцитов при заживлении апикомаргинальных дефектов с периапикальной патологией: исследование in-vivo

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Резюме

ЦЕЛЬ. Целью данного исследования является сравнительная оценка эффективности применения Sticky Bone (костного материала), Sticky Bone с мембраной PRF (обогащенной тромбоцитами) и Sticky Bone с мембраной для направленной тканевой регенерации (GTR) при заживлении апикомаргинальных дефектов.

МАТЕРИАЛЫ И МЕТОДЫ.В исследовании участвовали 27 пациентов с апикомаргинальными дефектами, которые были случайным образом разделены на три группы: Группа I: только Sticky Bone. Группа II: Sticky Bone с мембраной GTR. Группа III: Sticky Bone с мембраной PRF.Проводились клинические и рентгенологические оценки, включая измерение глубины зондирования, плотности кости и размера поражения. Статистический анализ включал парные t-тесты и ANOVA с уровнем значимости $p < 0,05$.
РЕЗУЛЬТАТЫ. Во всех группах наблюдались значительные улучшения по всем параметрам ($p < 0,05$). Группа III показала наибольшее снижение глубины зондирования и размера поражения, а также наибольшее увеличение плотности кости. Группа II продемонстрировала умеренные улучшения. Группа I показала наименее благоприятные результаты.
ЗАКЛЮЧЕНИЕ. Комбинированное использование Sticky Bone с PRF или GTR улучшает процесс заживления кости при апикомаргинальных дефектах, причём применение PRF дает наилучшие результаты.

Ключевые слова: апикомаргинальный дефект, регенерация кости, направленная тканевая регенерация, мембрана PRF, Sticky Bone, заживление тканей

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INTRODUCTION

Apicomarginal defects, characterized by localized bone loss around the root apex, represent a significant challenge in periradicular surgery. These defects can arise from various etiologies, including endodontic infections, periodontal disease, or a combination [1]. The successful treatment of apicomarginal defects requires a comprehensive approach that addresses both the underlying pathology and the bony defect [2]. PRF and GTR membranes have emerged as promising therapeutic options for promoting bone regeneration and soft tissue healing in dental procedures. An advanced form of platelet concentrate from the second generation, pioneered by Choukroun et al., contains a rich array of growth factors along with cytokines that have the ability to stimulate stem cell proliferation, angiogenesis, and matrix remodelling [3–5]. On the other hand, GTR membranes act as physical barriers that prevent the ingrowth of non-periodontal tissues, allowing for the regeneration of lost periodontal structures.

“Sticky bone” is a novel bone graft material, introduced by Sohn DS et al. in 2010, that offers an additional option for enhancing bone healing and tissue regeneration [6]. Sticky bone combines PRF with bone graft particles to create a biologically solid scaffold that promotes cell proliferation, matrix remodelling, and angiogenesis. Its enhanced stability and reduced particle scattering make it ideal for treating apicomarginal defects [7]. The objective of this current research is to evaluate the radiological outcomes of bone healing in apicomarginal and periapical defects following endodontic surgery, comparing the sticky bone’s effectiveness as a graft material in conjunction with either PRF or GTR membranes as barrier membranes under the null hypothesis that no significant differences exist between the three study groups.

MATERIALS AND METHODS

This prospective *in-vivo* research was conducted between 2021 and 2024 at the Department of Conservative Dentistry and Endodontics of the Dental College & Hospital after receiving approval from the Institutional Ethics Committee.

Study Population

A total of 27 patients with nonvital teeth and apicomarginal defects were included. Selection criteria included recurrent purulent discharge, probing pocket depths of 6–10 mm, and negative vitality test results. Patients with satisfactory general health and willingness for follow-up were included, while those with systemic diseases or known allergies were excluded. Written consent had been delivered by each participants, according to the Helsinki Declaration.

Participants were randomly divided into 3 groups:
- Group I: Sticky bone alone
- Group II: Sticky bone with a GTR membrane
- Group III: Sticky bone with a PRF membrane

Surgical Procedure

Following the completion of non-surgical endodontic treatment, periapical surgery was planned for the study participants. After local anesthesia with 2 percent lidocaine with 1:80,000 epinephrine (Xylocaine, Astra Zeneca Pharma, Bengaluru, India), a mucoperiosteal flap with full-thickness had been elevated to expose the apicomarginal defect. Following osteotomy, the lesion was enucleated and sent for histopathological assessment. Ultrasonic instruments were used for thorough root planing. Apicectomy was carried out, and retrograde cavities were prepared with an E10D ultrasonic tip (Guilin Woodpecker, China). MTA (Mineral trioxide aggregate) (MTA Angelus, Brazil) was used to fill the retrograde cavities, which were confirmed by intraoral periapical radiographs (IOPAR).

Preparation of Sticky Bone and PRF

According to protocol by Sohn DS et al., 10 ml of venous blood was drawn from the patient's antecubital vein and then centrifuged (Remi R8-C, India) without an anti-coagulant for 2 minutes at 2700 RPM, manufacturing autologous fibrin glue (AFG) and red blood cells to prepare sticky bone [6]. To form sticky bone, the AFG was collected and mixed with HA (hydroxyapatite) crystals (SYBOGRAF-Plus, Eucare Pharmaceuticals) and polymerized for 5 to 10 minutes.

In Group I patients, Sticky bone was placed in the bony cavity (Fig. 1, I).

In Group II patients, after packing the bony cavity with Sticky bone, the wound was covered with a resorbable GTR membrane (Healiguide, Advanced Biotechnologies, Inc., USA) (Fig. 1, II).

For Group III, after filling the bony cavity with sticky bone, the wound was covered with a PRF membrane. PRF was prepared following Choukroun's protocol [8] by centrifuging blood at 2114 RPM for 10 minutes, separating the PRF layer, and compressing it in a PRF box to form the membrane (Fig. 1, III).

Postoperative Evaluation

Radiographic evaluations and clinical examination were performed at baseline and 12 months. The decrease in probing depth was assessed clinically using a manual periodontal [University of North Carolina (UNC-15), Hu Freidy, Chicago] probe. An elevation in bone density and a reduction in lesion size were assessed using iRYS Viewer CBCT software (My-Ray Dental Imaging, Imola, Italy). The software's polygonal tracing tool was employed to manually define the region of interest (ROI) for both area and bone density evaluations. It provided gray-level values to estimate bone density, allowing for a detailed assessment of the healing process by comparing measurements from both time points. Preoperative and postoperative values were compared to assess the effectiveness of the treatments (Fig. 2–4).

Statistical analysis

Data was tabulated and assessed by IBM SPSS Statistics for Windows, Version 27.0. (Armonk, NY: IBM Corp). To evaluate the demographic variables the chi-square test had been applied. Statistical evaluation included one-way ANOVA (analysis of variance) with *post-hoc* Tukey's test and a Paired t-test, following confirmation of data normality by the Shapiro-Wilk's test. An alpha level of 5% was considered as the level of statistical significance.

RESULTS

This investigation included a majority of participants aged 20–29 years, accounting for 62.96%, with 24.07 ± 4.43 years as the mean age. The age distribution across the three groups did not show any statistically significant differences ($p = 0.32$), indicating no

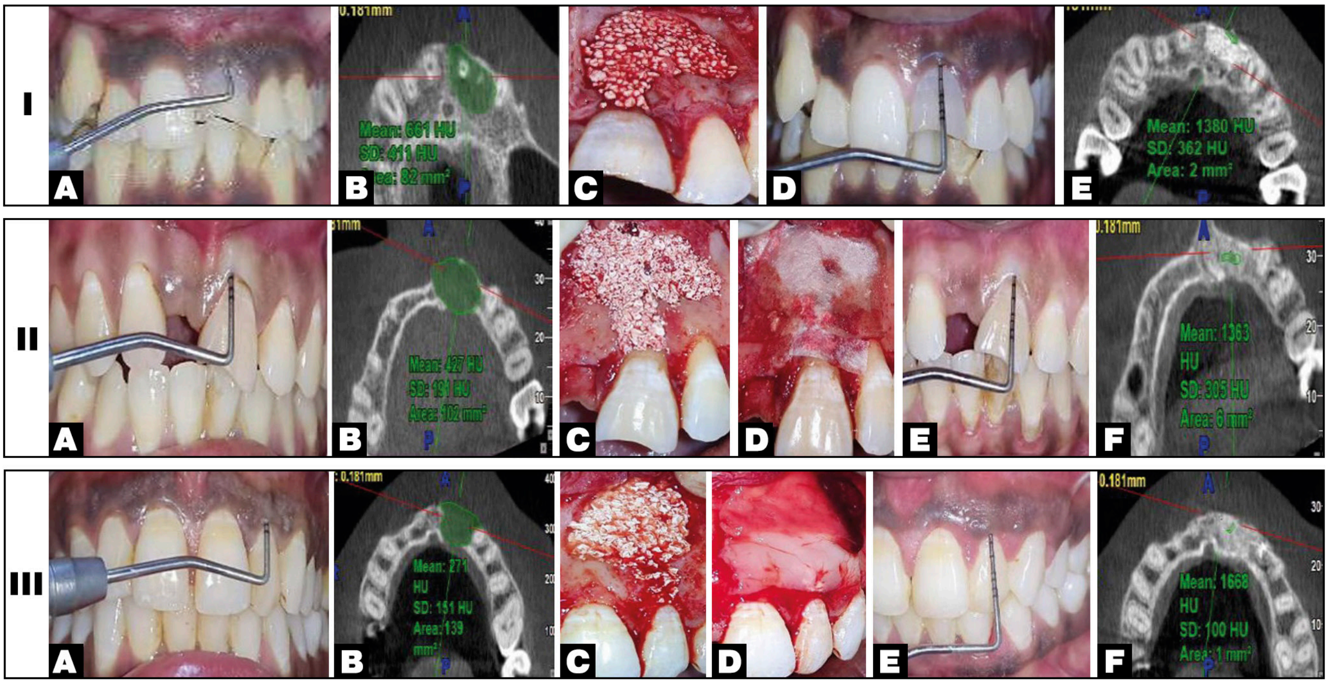

Fig. 1. I: Group I – (*A*) pre-operative clinical view, (*B*) baseline CBCT, (*C*) Sticky Bone placement, (*D*) post-operative clinical view, (*E*) 12-month follow-up CBCT; **II:** Group II – (*A*) pre-operative view, (*B*) baseline CBCT, (*C*) Sticky Bone placement, (*D*) GTR membrane placement, (*E*) post-operative view, (*F*) 12-month follow-up CBCT; **III:** Group III – (*A*) pre-operative view, (*B*) baseline CBCT, (*C*) Sticky Bone placement, (*D*) PRF membrane placement, (*E*) post-operative view, (*F*) 12-month follow-up CBCT

Рис. 1. I: Группа I – (*A*) предоперационный клинический вид, (*B*) исходное CBCT, (*C*) размещение Sticky Bone, (*D*) постоперационный клинический вид, (*E*) CBCT через 12 месяцев; **II:** Группа II – (*A*) предоперационный вид, (*B*) исходное CBCT, (*C*) размещение Sticky Bone, (*D*) размещение мембраны GTR, (*E*) постоперационный вид, (*F*) CBCT через 12 месяцев; **III:** Группа III – (*A*) предоперационный вид, (*B*) исходное CBCT, (*C*) размещение Sticky Bone, (*D*) размещение мембраны PRF, (*E*) постоперационный вид, (*F*) CBCT через 12 месяцев confounding effect of age. Regarding gender, males represented 59.26% of the participants, but no significant association was found between gender distribution and the groups ($p = 0.14$). Thus, both age and gender were evenly distributed across the groups, ensuring balanced demographics in the study.

In terms of pocket depth, all three groups demonstrated significant reductions from the pre-operative (T0) to the post-operative (T1) measurements. Group I exhibited a reduction from 6.67±0.5 mm at T0 to 4.22±0.83 mm at T1 ($p < 0.001$), Group II from 7.0±0.707 mm at T0 to 3.22±0.44 mm at T1 ($p < 0.001$), and Group III from 6.44±1.13 mm at T0 to 2.22±0.44 mm at T1 ($p < 0.001$) (Table 1).

The mean change in pocket depth was as follows: Group I: 2.44±0.726 mm, Group II: 3.78±0.667 mm, and Group III: 4.22±0.972 mm. The one-way ANOVA test indicated a difference in the statistical significant value between the groups ($p < 0.001$), with Groups II & III showing significantly greater reductions in pocket depth compared to Group I (Table 2).

In terms of lesion size, all three groups exhibited a significant reduction from the pre-operative to the post-operative 12-month follow-up. Group I showed a reduction from 76.72±23.01 mm^2 to 5.33±2.37 mm^2, Group II from 128.3±36.11 mm^2 to 5.49±1.57 mm^2, and Group III from 126.6±18.65 mm^2 to 2.23±1.12 mm^2 ($p < 0.0001$ for all groups) (Table 1). According to the analysis of one-way ANOVA indicates a statistically significant difference among the groups with $p = 0.0003$, with Group I exhibiting a notably smaller reduction in lesion size compared to Groups II and III. However, there is no statistically significant difference between Groups III and Group II (Table 2).

All groups demonstrated a significant increase in bone density from pre-operative to post-operative levels. Group I showed an increase from 539.7±81.27 HU to 1122±158.9 HU, Group II from 547.5±90.45 HU to 1350±160.8 HU, and Group III from 440.2±146.7 HU to 1565±242.7 HU ($p < 0.0001$ for all groups) (Table 1). According to the one-way ANOVA indication a statistically significant difference has been found in bone density between the groups ($p < 0.0001$), with Group III showing the greatest increase, followed by Group II, and finally, Group I. According to the *Post-hoc* analysis exposed notable distinction between Groups I and Group III ($p < 0.0001$) and between Groups II as well as Group III ($p = 0.0025$), with Group II also showing a significantly higher increase compared to Group I ($p = 0.04$) (Table 2).

Figure 5 depicts the percentage decrease in probing depth and lesion size, respectively, alongside the increase in bone density.

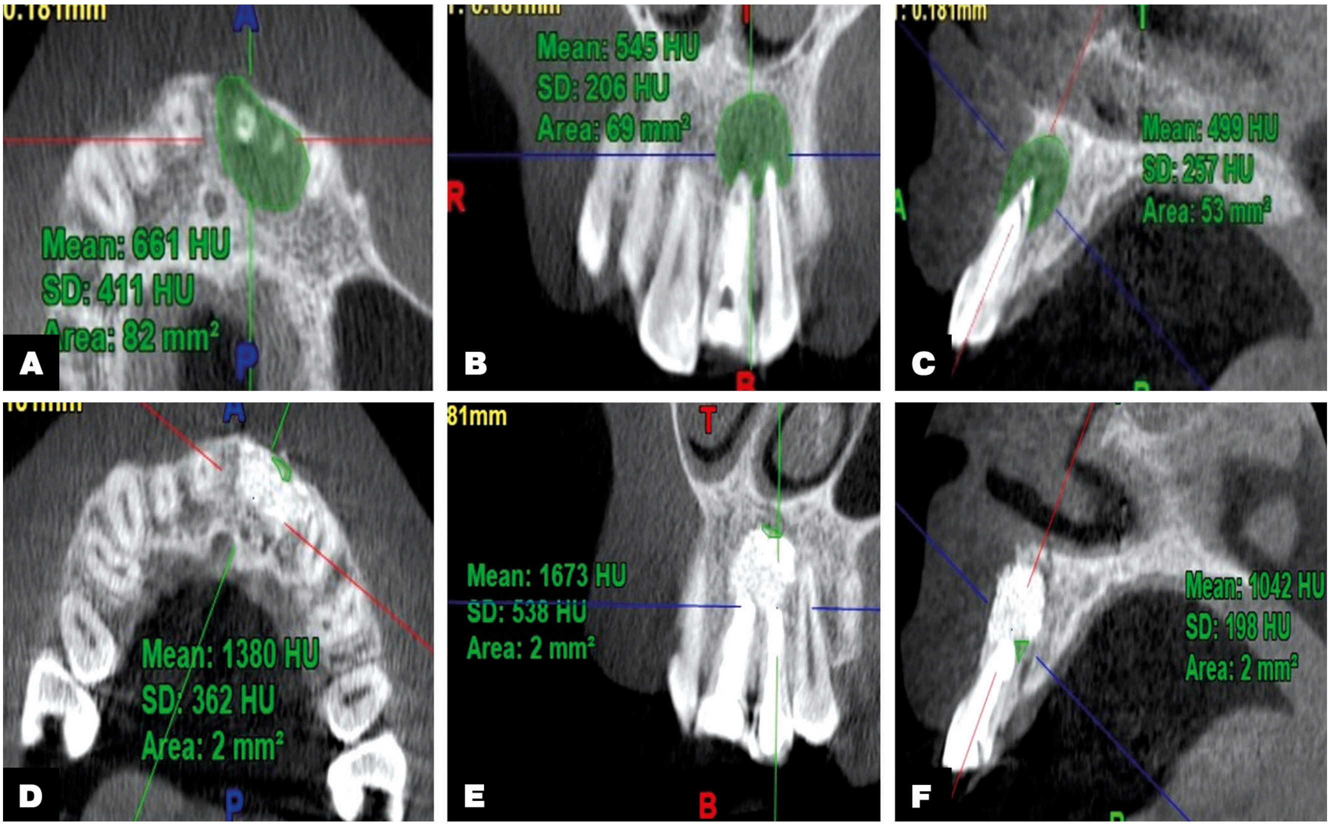

Fig. 2. Cone Beam Computed Tomography (CBCT) Scans for Group I: (*A*) pre-operatively in axial section, (*B*) pre-operatively in coronal section, (*C*) pre-operatively in sagittal section, (*D*) post-operatively in axial section, (*E*) post-operatively in coronal section, and (*F*) post-operatively in sagittal section

Рис. 2. Конусно-лучевая компьютерная томография (CBCT) для группы I: (*A*) предоперационный аксиальный срез, (*B*) предоперационный коронарный срез, (*C*) предоперационный сагиттальный срез, (*D*) постоперационный аксиальный срез, (*E*) постоперационный коронарный срез, (*F*) постоперационный сагиттальный срез

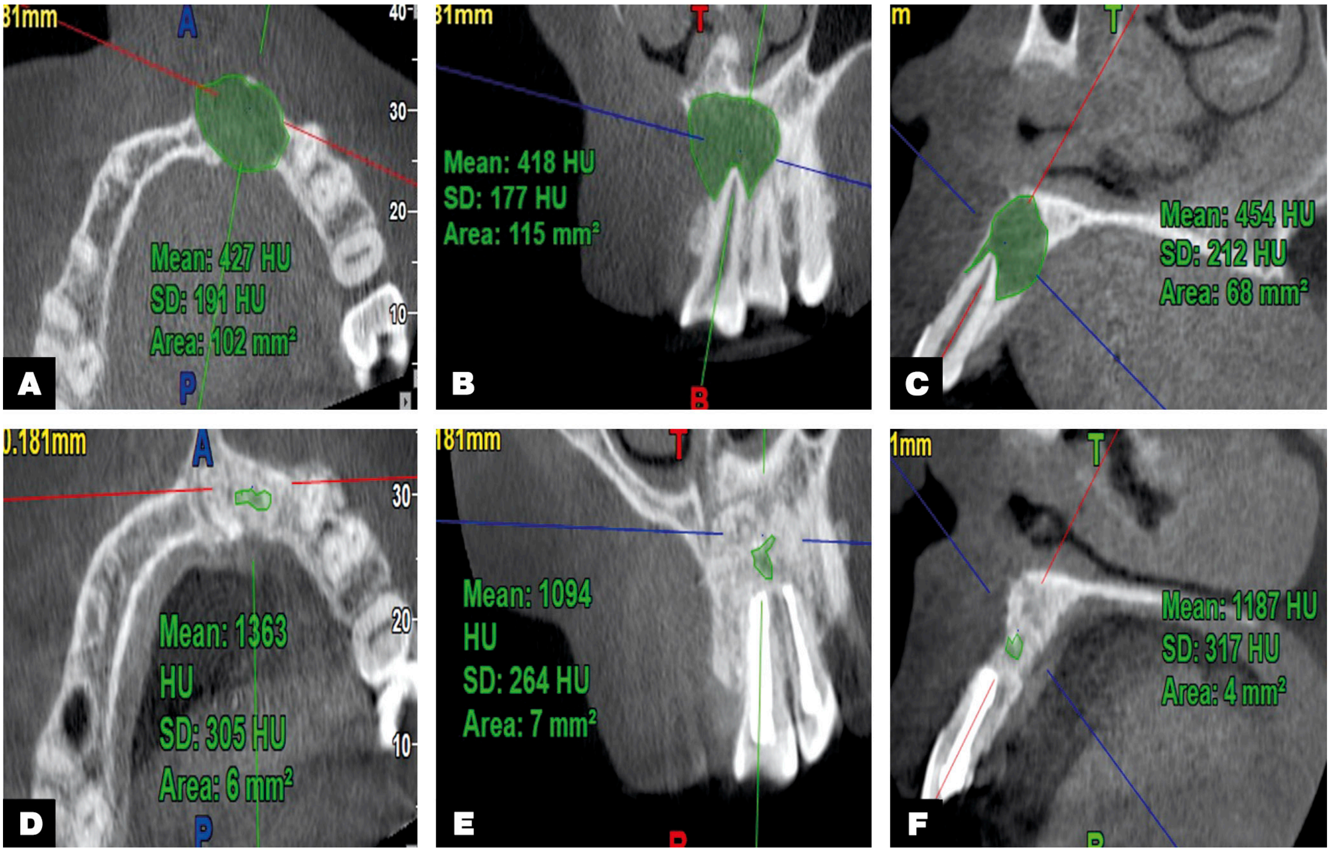

Fig. 3. Cone Beam Computed Tomography (CBCT) Scans for Group II: (*A*) pre-operatively in axial section, (*B*) pre-operatively in coronal section, (*C*) pre-operatively in sagittal section, (*D*) post-operatively in axial section, (*E*) post-operatively in coronal section, and (*F*) post-operatively in sagittal section

Рис. 3. Конусно-лучевая компьютерная томография (CBCT) для группы II: (*A*) предоперационный аксиальный срез, (*B*) предоперационный коронарный срез, (*C*) предоперационный сагиттальный срез, (*D*) постоперационный аксиальный срез, (*E*) постоперационный коронарный срез, (F) постоперационный сагиттальный срез

Table 1. Clinical and radiographic parameters at baseline, and 12-month follow-up

Таблица 1. Клинические и рентгенологические параметры на начальном этапе (T0) и через 12 месяцев (T1)

Parameters	Group I (*n*=9)		Group II (*n*=9)		Group III (*n*=9)	
	Mean±SD	*p*-values	Mean±SD	*p*-values	Mean±SD	*p*-values
Clinical						
PD(T0) [mm]	6.67±0.5	<0.001*	7±0.707	<0.001*	6.44±1.13	<0.001*
PD(T1) [mm]	4.22±0.83		3.22±0.44		2.22±0.44	
Radiographic						
Area (T0) [mm^2]	76.72±23.01	<0.001*	128.3±36.11	<0.001*	126.6±18.65	<0.001*
Area (T1) [mm^2]	5.333±2.367		5.489±1.57		2.233±1.12	
BDU(T0) [HU]	539.7±81.27	<0.001*	547.5±90.45	<0.001*	440.2±146.7	<0.001*
BDU(T1) [HU]	1122±158.9		1350±160.8		1565±242.7	

Note: n – number of samples per group, T0 – baseline; T1 – 12 months follow-up, SD – standard deviation, PD – probing depth, BDU – bone density units, HU – Hounsfield units; * statistically significant.

Примечания: n – количество образцов в группе; T0 – исходный уровень (начальное обследование); T1 – обследование через 12 месяцев; SD – стандартное отклонение; PD – глубина зондирования; BDU – единицы плотности кости; HU – единицы Хаунсфилда; * – статистически значимо.

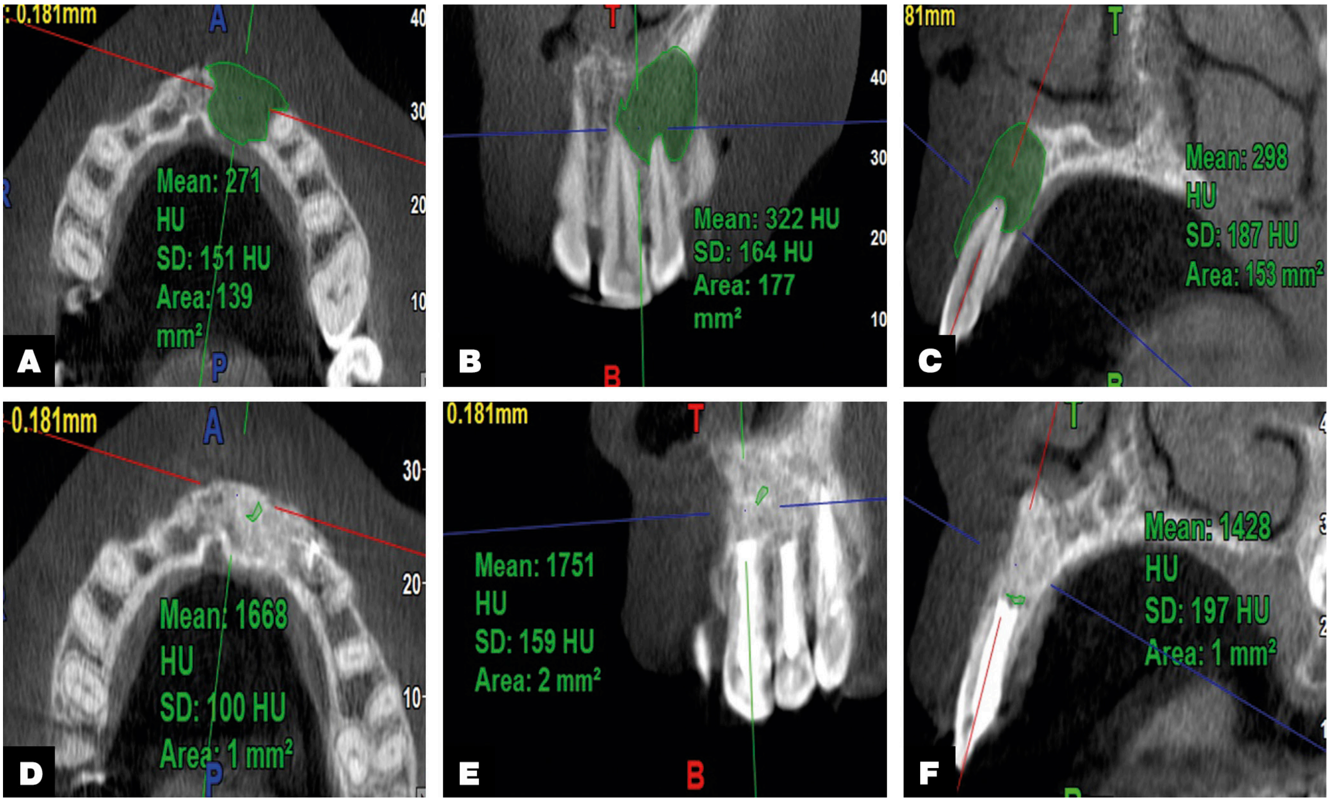

Fig. 4. Cone Beam Computed Tomography (CBCT) Scans for Group III: (*A*) pre-operatively in axial section, (*B*) pre-operatively in coronal section, (*C*) pre-operatively in sagittal section, (*D*) post-operatively in axial section, (*E*) post-operatively in coronal section, and (*F*) post-operatively in sagittal section

Рис. 4. Конусно-лучевая компьютерная томография (CBCT) для группы III: ((*A*) предоперационный аксиальный срез, (*B*) предоперационный коронарный срез, (*C*) предоперационный сагиттальный срез, (*D*) постоперационный аксиальный срез, (*E*) постоперационный коронарный срез, (*F*) постоперационный сагиттальный срез

Table 2. Inter-group comparisons of the clinical and radiographic parameters over 12 months relative to the baseline

Таблица 2. Межгрупповые сравнения клинических и рентгенологических параметров за 12 месяцев относительно исходного уровня

Parameters	Group I ($n = 9$)	Group II ($n = 9$)	Group III ($n = 9$)	*p*-values
Mean PD change (mm)	2.44±0.726[a]	3.78±0.667[b]	4.22±0.972[b]	<0.001*
Mean Area reduction (mm^2)	71.39±23.11[a]	122.8±34.85[b]	124.4±18.54[b]	0.0003*
Mean Gain in Bone Density (HU)	582.3±116.1[a]	802.8±141.6[b]	1125±253.2[c]	<0.001*

Note: Different superscript letters indicate a statistically significant difference between the corresponding groups; *n* – number of samples per group, T0 – baseline; T1 – 12 months follow-up, SD – standard deviation, PD – probing depth, BDU – bone density units, HU – Hounsfield units; * statistically significant.

Примечания: Различные надстрочные буквы указывают на статистически значимую разницу между соответствующими группами; *n* – количество образцов в группе; T0 – исходный уровень (начальное обследование); T1 – обследование через 12 месяцев; SD – стандартное отклонение; PD – глубина зондирования; BDU – единицы плотности кости; HU – единицы Хаунсфилда; * – статистически значимо.

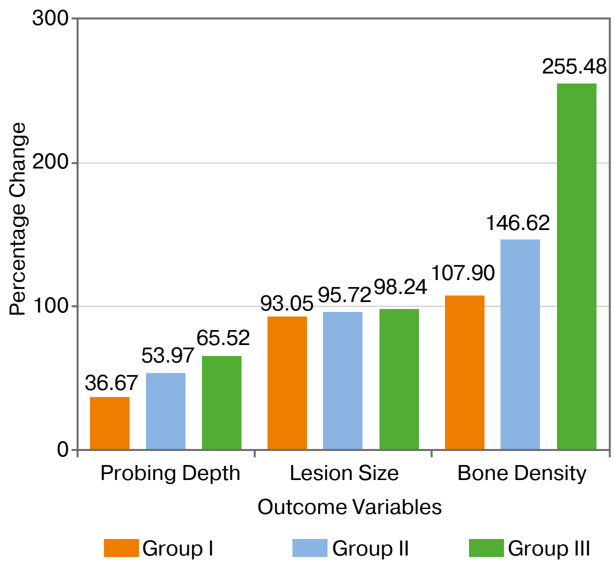

Fig. 5. Bar graph illustrating the percentage reduction in probing depth and lesion size, alongside the increase in bone density

Рис. 5. Гистограмма, иллюстрирующая процентное снижение глубины зондирования и размера поражения, а также увеличение плотности кости

DISCUSSION

The objective of this current investigation is to assess the effectiveness of different materials as well as techniques in endodontic surgery, focusing on their impact on bone regeneration in apicomarginal defects. According to the indication of the findings of the current research, the application of sticky bone in combination with PRF or GTR membranes significantly enhances bone healing compared to sticky bone alone.

Endodontic surgery is typically considered when nonsurgical retreatment fails, or when a biopsy is required. Although non-surgical endodontic treatment remains the preferred approach due to its high success rate of approximately 94%, endodontic surgery has become more effective due to advancements such as improved magnification, minimal root resection, ultrasonic root-end preparation, and the use of biocompatible materials [9]. The prognosis of endodontic surgery, however, can be influenced by factors like the amount and location of bone adjacent to the root apex. Apicomarginal defects, characterized by localized destruction of marginal bone, can severely impact the success rate of surgery, which may drop to as low as 27–37% in cases associated with such defects [10]. The main objectives of periapical surgery are the removal of pathological tissue, thorough cleaning, and shaping of the apical portion of the root canal, along with achieving complete wound healing. Healing can occur through repair or regeneration, based on the size and characteristics of the defect. Minor defects typically heal by regeneration, whereas more significant defects tend to heal by repair, involving connective tissue proliferation [11]. The study highlighted the importance of grafting materials and barrier membranes in addressing bony defects. HA, known for its osteoconductive properties, was used as a graft material. Our results were consistent with previous studies, such as those by Sreedevi et al. [12] and Panday et al. [13], which demonstrated the efficacy of HA in filling osseous defects. Additionally, autologous sticky bone, a graft material with osteoconductive and osteoinductive properties, proved effective [14]. Sticky bone, composed of HA crystals and growth factors within a fibrin matrix, offers advantages such as adaptability to defect shapes, stability during healing, and accelerated bone regeneration [6].

PRF, was also used as a barrier membrane in our study. PRF contains growth factors that enhance wound healing and bone regeneration, similar to findings by Meharwade et al. [10] and Sharma et al. [2] Compared to GTR membranes, PRF membranes offer several benefits, including a lower risk of infection and no cytotoxic effects. However, the limitations of PRF include rapid biodegradation and lower rigidity, which may affect its application in certain procedures.

The present study showed significant improvements in bone density and a reduction in lesion size in all groups, along with a reduction in pocket depth. Notably, the sticky bone with the PRF membrane group demonstrated the greatest decrease in lesion size, increase in bone density, and a reduction in pocket depth. However, no notable difference was found in the GTR membrane group, aligning with the outcomes of Ustaoğlu et al. [15]. In support of these findings, Thorat et al. [16] observed that PRF treatment led to more significant reductions in probing depth, increased level of clinical attachment, and improved defect fill compared. Pradeep et al. [17] similarly found PRF and PRP (Platelet Rich Plasma) to be equally effective in these parameters, with PRF being less time-consuming and less technique-sensitive.

The primary strength of this research lies in its application of both clinical and radiographic assessments to evaluate the healing of apicomarginal defects. Including three treatment groups allows for a comprehensive comparison of sticky bone alone and in combination with PRF and GTR membranes. Nonetheless, the limited sample size may restrict the generalisability of the findings. Additionally, the shorter follow-up period of 12 months may not be sufficient to assess long-term outcomes, particularly in bone stability.

Future studies should involve larger sample sizes and extended follow-up durations – and histological evaluations to better assess bone regeneration and the sustainability of outcomes.

CONCLUSION

In summary, our study confirms that combining sticky bone with either PRF or GTR membranes significantly enhances bone regeneration in apicomarginal defects, with PRF providing slightly superior results compared to GTR. These findings align with recent advances in regenerative techniques, highlighting the importance of barrier membranes in improving surgical outcomes.

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