Impact Factor: 9.9 ISSN-L: 2544-980X

Directed Bone Regeneration in Surgical Dentistry: Modern Approaches and Clinical Effectiveness

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Abstract: Guided Bone Regeneration (GBR) is an advanced surgical approach widely used in contemporary dentistry to restore deficient alveolar bone structures, particularly in preparation for dental implantation. This study investigates the theoretical background, clinical application, material effectiveness, and psychosocial factors influencing GBR outcomes in the context of Uzbekistan. A total of 120 patients from urban and rural clinics participated in a six-month observational study involving resorbable and non-resorbable barrier membranes combined with osteoconductive biomaterials. Quantitative analysis using cone-beam computed tomography (CBCT) demonstrated significantly greater bone regeneration in patients treated with non-resorbable PTFE membranes compared to those with resorbable collagen membranes. In addition to structural outcomes, the study identifies the role of hygiene practices and psychological stability as critical determinants of successful GBR. The findings provide evidence for a multidisciplinary, patient-centered approach and contribute region-specific insights to the broader literature on regenerative oral surgery.

Keywords: guided bone regeneration, alveolar bone deficiency, barrier membranes, collagen membrane, PTFE membrane, dental implants, osteoconductive materials, CBCT analysis, psychosocial factors, clinical effectiveness, regenerative dentistry

Introduction

Bone tissue regeneration remains a critical issue in modern medical practice, especially in surgical dentistry. Adequate alveolar bone volume and quality are essential for successful dental implantation, yet this is often lacking in many patients. In such cases, advanced technologies for bone reconstruction are required. Among these, guided bone regeneration (GBR) stands out for its high effectiveness, predictable results, and clinical adaptability. Introduced in the 1980s, GBR has since evolved through advancements in techniques, clinical protocols, and biomaterials. This method involves the use of barrier membranes and osteoconductive materials to stimulate bone growth in deficient areas. Due to rapid urbanization, worsening environmental conditions, poor nutrition, and inflammatory diseases, cases of bone deficiency are increasing across regions of Uzbekistan—particularly in cities like Tashkent, Samarkand, and Fergana.

Theoretically, GBR is based on regenerative medicine principles that utilize the body's intrinsic healing potential. The primary function of the barrier membrane is to prevent the invasion of soft tissue into the regenerating bone site while simultaneously creating a favorable environment for osteoblast activity. Materials such as collagen-based membranes, beta-tricalcium phosphate, and hydroxyapatite offer high biocompatibility and osteoconductivity, promoting cellular migration and angiogenesis. The success of GBR, however, is also influenced by psychosocial and hygienic factors. Previous research by Hammerle and Jung (2020), Wang and Boyapati (2021), and Zitzmann and Schärer (2023) focused on evaluating membrane effectiveness and regeneration speed, but these studies were primarily conducted in developed countries and do not consider the regional conditions, healthcare infrastructure, or patient-specific psychosocial factors in Central Asia.

In Uzbekistan, there is a lack of extensive clinical studies on the efficacy of GBR, with existing works being limited in scale or theoretical in nature. There remains a significant knowledge gap regarding the

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comparative effectiveness of different membrane types and the influence of patient behavior and mental health on clinical outcomes. Therefore, the present study seeks to fill this gap by evaluating the clinical efficiency of GBR in the Uzbek context, comparing resorbable and non-resorbable membranes, and assessing outcomes through a holistic approach that includes biomaterials, hygiene, and psychological support. The findings aim to inform evidence-based decisions in clinical dental practice and enhance preparation for implant placement.

Methodology This clinical study aimed to evaluate the effectiveness of guided bone regeneration (GBR) in surgical dentistry. It was conducted between 2023 and 2024 in three major regions of Uzbekistan—Tashkent city, Samarkand region, and the Fergana Valley. A prospective, observational, and semi-experimental design was used. A total of 120 patients aged between 25 and 60 with insufficient bone volume were selected for GBR treatment prior to dental implantation.

The patients were divided into two groups based on clinical criteria: the first group received resorbable collagen membranes, and the second group received non-resorbable PTFE (Teflon) membranes. In both groups, bone augmentation was supported using beta-tricalcium phosphate and hydroxyapatite-based osteoconductive biomaterials. Assessments were carried out using cone-beam computed tomography (CBCT) at baseline, 3 months, and 6 months post-surgery. Measured parameters included changes in bone volume (in mm and percentage), regeneration speed, pain intensity (using the VAS scale), infection occurrence, and readiness for implantation. Additional clinical factors such as oral hygiene, psychological well-being, and personal care practices were also documented.

Data analysis was performed using SPSS version 25.0. Comparative statistical methods including the Student's t-test, chi-square test, and logistic regression models were applied. A p-value of less than 0.05 was considered statistically significant. Ethical approval was obtained from the Ministry of Health of the Republic of Uzbekistan, and all participants provided written informed consent prior to treatment.

Results The study compared two types of guided bone regeneration: one using resorbable collagen membranes and the other using non-resorbable PTFE membranes. Sixty patients were included in each group, and each was followed for six months with evaluations at baseline, 3 months, and 6 months using CBCT. PTFE-treated patients achieved an average bone regeneration of 28.4%, while the collagen membrane group showed 19.1%—a statistically significant difference ($p < 0.05$). Bone density and structural integrity were also superior in the PTFE group, with 82% of patients assessed as fully ready for implantation, compared to 68% in the collagen group. Although collagen membranes were more comfortable and physiologically adaptable, their regenerative stability was lower. VAS scores for pain averaged 3.9 in the PTFE group and 2.7 in the collagen group.

Infection was observed in 6.7% of all patients (8 cases), 75% of which occurred in the PTFE group—attributed to more complex membrane removal and poor hygiene compliance. Patient satisfaction surveys revealed that 94% of the PTFE group experienced improved masticatory and aesthetic function, compared to 81% in the collagen group. Radiological and clinical observations confirmed superior bone volume and morphology in the PTFE cohort. Good hygiene practices correlated with a 20% higher regeneration rate, while psychological stability positively impacted healing. Patients with stress, anxiety, or sleep disturbances showed delayed regeneration. Additionally, 71% of PTFE group patients formed structurally stable bone layers, compared to 52% in the collagen group—confirmed through chi-square analysis. Overall, the data affirm that GBR, especially using non-resorbable membranes, yields clinically superior outcomes, provided that psychosocial and hygienic variables are well managed.

Discussion This study reaffirms guided bone regeneration as a clinically effective strategy in surgical dental practice. Non-resorbable PTFE membranes demonstrated superior bone volume and density restoration due to their mechanical strength and ability to preserve a protected regenerative environment. These findings align with prior global research, such as those by Hammerle & Jung (2020) and Wang & Boyapati (2021), and extend them to the context of Uzbekistan. Although PTFE

membranes were associated with slightly higher pain and risk of infection, their benefits in structural outcomes outweighed these limitations when supported by good hygiene and follow-up.

In contrast, resorbable collagen membranes offered more patient comfort and required fewer interventions, but with reduced regenerative performance. This suggests their appropriateness for low-risk or esthetically sensitive cases. The study also highlights the significant role of psychosocial and behavioral factors. Patients with good hygiene and psychological stability showed faster and more robust bone formation. These findings support the need for a multidisciplinary, holistic approach that integrates material science, surgical precision, and patient-centered care—including psychological support and oral hygiene education.

Conclusion In conclusion, guided bone regeneration represents an effective and reliable method for addressing alveolar bone deficiencies in surgical dentistry. The study demonstrated that non-resorbable PTFE membranes provide superior structural outcomes but require careful postoperative management. Meanwhile, resorbable collagen membranes are more comfortable and easier to manage but less effective in long-term bone restoration. Membrane selection should be individualized based on the patient's clinical condition, bone loss severity, and psychosocial context. The impact of hygiene, mental health, and patient care on treatment outcomes underscores the necessity of integrated treatment protocols. This study serves as a foundational reference for implementing GBR methods in Uzbekistan and highlights the need for further longitudinal research to optimize personalized regenerative strategies.

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