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Original Research

A Prospective Study on the Effectiveness of Guided Tissue Regeneration in Treating Intrabony Defects

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ABSTRACT:

Background: Periodontitis is a chronic inflammatory disease characterized by progressive destruction of the periodontal ligament and alveolar bone. Intrabony defects represent advanced stages of periodontal breakdown and are prime candidates for regenerative periodontal therapy. Guided Tissue Regeneration (GTR) has been widely utilized to restore lost periodontal structures by promoting selective repopulation of regenerative cells. However, clinical outcomes of GTR vary depending on defect morphology, patient factors, and surgical precision. This study evaluates the clinical and radiographic effectiveness of GTR in systemically healthy patients presenting with intrabony defects. **Aim:** To assess the effectiveness of Guided Tissue Regeneration in treating intrabony periodontal defects by evaluating changes in clinical and radiographic parameters following treatment. **Materials and Methods:** A prospective clinical study was conducted on 20 systemically healthy patients diagnosed with chronic periodontitis and presenting with intrabony defects. Clinical parameters recorded at baseline and follow-up included Plaque Index (PI), Gingival Index (GI), Probing Pocket Depth (PPD), Clinical Attachment Level (CAL), Bleeding on Probing (BOP), Gingival Recession (GR), and Tooth Mobility. Radiographic assessment of defect depth, defect fill percentage, and defect angle was performed using standardized intraoral periapical radiographs. All patients received initial nonsurgical therapy followed by GTR surgery using a bioresorbable membrane. Postoperative evaluations were performed at scheduled intervals. Data analysis was conducted using SPSS version 26.0, with $p < 0.05$ considered statistically significant. **Results:** Significant improvements were observed across clinical and radiographic parameters. Mean PI reduced from 1.92 ± 0.18 to 0.86 ± 0.14, and GI decreased from 2.11 ± 0.22 to 0.94 ± 0.17. PPD showed a mean reduction of 3.90 mm, while CAL demonstrated a gain of 3.58 mm ($p < 0.001$ for both). BOP reduced by 60.00%, and tooth mobility improved markedly. Radiographically, defect depth reduced from 5.92 ± 0.54 mm to 2.38 ± 0.41 mm, with an average defect fill of 59.82% ± 6.15% and a notable improvement in defect angle. **Conclusion:** GTR proved to be a highly effective regenerative technique for managing intrabony defects, leading to significant clinical attachment gain, pocket depth reduction, and substantial radiographic bone fill. The findings support GTR as a predictable and valuable treatment modality for periodontal regeneration in appropriately selected patients.

Keywords: Guided tissue regeneration, Intrabony defect, Clinical attachment level, Periodontal regeneration, Chronic periodontitis

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INTRODUCTION

Periodontitis is a chronic inflammatory disease of the supporting structures of the teeth characterized by progressive loss of clinical attachment and alveolar bone, ultimately leading to tooth mobility and tooth loss if left untreated.[1] The breakdown of the periodontal apparatus is driven by a complex interaction between pathogenic biofilm and a susceptible host response, resulting in destruction of periodontal ligament fibres and resorption of adjacent bone. Among the various patterns of bone loss observed in periodontitis, intrabony defects—vertical osseous defects with the base of the pocket apical to the alveolar crest—are of particular clinical significance because they are strongly associated with advanced disease and compromised tooth prognosis.[2]Intrabony defects are not only markers of severe periodontal breakdown but also potential

candidates for regenerative therapy. Their morphology, defined by the number of remaining bony walls, defect depth, and defect angle, has been shown to influence both disease progression and treatment outcomes.[3] Narrow, deep defects with three or more remaining walls tend to provide a more contained environment for blood clot stabilization and space maintenance, thereby favoring regeneration, whereas shallow or wide defects often heal by repair with a long junctional epithelium. Accurate diagnosis and defect characterization using clinical probing and radiographic assessment are therefore essential in planning regenerative approaches such as guided tissue regeneration (GTR).The biological rationale for periodontal regeneration is rooted in the classic concept that the cell population repopulating the root surface determines the nature of healing. Melcher proposed that true regeneration of the periodontal attachment apparatusnew cementum, functionally oriented periodontal ligament, and alveolar bonecan be achieved only if cells from the periodontal ligament and adjacent undifferentiated mesenchymal cells dominate the healing wound, rather than rapidly proliferating epithelial cells or gingival connective tissue. This understanding shifted the therapeutic goal from mere pocket reduction and repair toward regeneration and laid the conceptual foundation for techniques designed to selectively favor periodontal ligament cells during healing.[1]Building on this biologic principle, early experimental and clinical studies demonstrated that new attachment could form on previously diseased root surfaces when appropriate surgical and wound-stabilizing conditions were provided.[2] Nyman and co-workers showed that carefully executed periodontal surgery combined with meticulous plaque control could result in new connective tissue attachment rather than a long junctional epithelium, challenging the long-held belief that regeneration was not possible on periodontally involved roots. Subsequent clinical case reports by Gottlow et al. introduced the concept of using barrier membranes to exclude epithelial and gingival connective tissue from the root surface, allowing periodontal ligament cells to repopulate the defect area and resulting in histologic evidence of new cementum, bone, and periodontal ligament in human intrabony defects.[3] These landmark studies established guided tissue regeneration as a biologically driven regenerative strategy.GTR applies the principle of selective cell repopulation through the placement of a barrier membrane between the gingival flap and the root surface/defect, thereby creating a secluded space for periodontal ligament and bone cells to regenerate the lost attachment apparatus.[4] Early protocols often used non-resorbable expanded polytetrafluoroethylene (ePTFE) membranes, which provided excellent space maintenance but required a second surgery for membrane removal. The subsequent development of bioresorbable membranes aimed to reduce patient morbidity and simplify clinical management while maintaining similar regenerative potential. Over time, refinements in flap design, suturing techniques, and biomaterial selection have sought to optimize stability of the blood clot, minimize membrane exposure, and improve predictability of regenerative outcomes across a broader range of defect morphologies.[5]Clinical and radiographic studies have consistently demonstrated that GTR can provide significant probing pocket depth reduction, clinical attachment level gain, and radiographic bone fill in intrabony defects compared with open flap debridement alone, particularly in narrow and well-contained defects.[5] However, the magnitude of clinical benefit varies considerably, reflecting the influence of defect configuration, residual periodontal support, patient-related factors (such as smoking and oral hygiene), and surgical technique. To further enhance regenerative outcomes, GTR has been combined with bone grafts, bone substitutes, and biologically active agents to improve space maintenance, osteoconductivity, and wound stability.[5]In parallel, biologic-based regenerative strategies such as enamel matrix derivative (EMD) and growth factors have gained prominence as adjuncts or alternatives to traditional barrier-based GTR. Systematic reviews have reported that EMD can produce clinical attachment gains and bone fill comparable to or, in some cases, exceeding those of GTR in intrabony defects, while often simplifying surgical procedures by eliminating the need for membrane placement and removal. Similarly, the use of recombinant or naturally derived growth factors—including platelet-derived growth factor, bone morphogenetic proteins, and others—has been associated with enhanced periodontal regeneration in selected clinical scenarios, particularly when combined with suitable scaffolds or grafting materials.[6]

MATERIALS AND METHODS

This prospective clinical study was conducted in the Department of Periodontology at the Genesis Institute of Dental Sciences and Research, Firozpur, Punjab. The study evaluated the clinical effectiveness of Guided Tissue Regeneration (GTR) in the management of intrabony periodontal defects. Ethical approval was obtained from the Institutional Ethical Committee, and written informed consent was taken from all participants prior to enrollment.A total sample size of 20 systemically healthy subjects presenting with chronic periodontitis and radiographically confirmed intrabony defects were recruited. Participants were selected using purposive sampling. Inclusion criteria consisted of subjects aged 25–55 years, presence of at least one intrabony defect with probing pocket depth (PPD) ≥ 6 mm, clinical attachment loss, and radiographic evidence of a vertical bone defect measuring ≥ 3 mm. Exclusion criteria included smokers, pregnant or lactating women, patients with systemic conditions affecting

periodontal healing, history of periodontal therapy in the past six months, and individuals under medications known to influence periodontal status.

Clinical Examination and Baseline Parameters
A comprehensive periodontal examination was performed using a UNC-15 periodontal probe by a single calibrated examiner. Baseline clinical parameters recorded included Plaque Index (PI), Gingival Index (GI), Probing Pocket Depth (PPD), Clinical Attachment Level (CAL), Bleeding on Probing (BOP), Gingival Recession (GR), and Tooth Mobility (according to Miller's index). Standardized intraoral periapical radiographs (IOPA) were obtained using the paralleling technique to evaluate defect morphology and depth. Defect angle and defect fill were assessed radiographically using digital analysis software.

Surgical Procedure
Following initial periodontal therapy consisting of scaling and root planing, subjects presenting with persistent intrabony defects underwent the GTR surgical procedure. Under local anesthesia, intracrevicular incisions were placed, and full-thickness mucoperiosteal flaps were elevated to expose the defect. Thorough debridement and root surface planing were performed using Gracey curettes. A bioresorbable GTR membrane was adapted over the defect to facilitate selective cell repopulation and stabilize the blood clot. Flaps were repositioned and sutured using interrupted or sling sutures to achieve primary closure. A periodontal dressing was applied when necessary.

Post-operative Care and Follow-up Protocol
All patients received standard post-operative instructions including antimicrobial mouth rinse (0.12% chlorhexidine gluconate), systemic antibiotics when indicated, and analgesics. Sutures were removed after one week, and professional plaque control was reinforced at regular follow-up visits. Clinical parameters were recorded at baseline and subsequent re-evaluation intervals to assess changes in periodontal status and healing outcomes. Radiographic assessment of bone fill and defect changes was conducted using the same standardized technique to ensure reproducibility.

Outcome Measures
Primary outcome measures included reduction in Probing Pocket Depth (PPD) and gain in Clinical Attachment Level (CAL). Secondary outcomes comprised changes in Plaque Index (PI), Gingival Index (GI), Bleeding on Probing (BOP), Gingival Recession (GR), radiographic defect depth reduction, defect fill percentage, and defect angle modification. Healing response and membrane stability were also evaluated clinically during follow-up.

Statistical Analysis
All data collected were tabulated and analyzed using Statistical Package for Social Sciences (SPSS) Version 26.0. Descriptive statistics were calculated as means and standard deviations for all clinical and radiographic variables. The normality of data distribution was assessed using the Shapiro–Wilk test. Comparative analysis between baseline and follow-up measurements was performed using paired t-tests for normally distributed variables and Wilcoxon signed-rank test for non-parametric variables. A p-value of <0.05 was considered statistically significant.

RESULTS

Table 1: Distribution of the Study Population
The study population consisted of 20 subjects diagnosed with chronic periodontitis presenting with intrabony defects. The distribution of age revealed that the majority of participants (45.00%) belonged to the 36–45-year age group, followed by 30.00% in the 25–35-year category, and 25.00% in the 46–55-year category. This indicates that middle-aged adults were most commonly affected by moderate to severe periodontal destruction requiring regenerative therapy. With respect to sex distribution, males constituted a higher proportion (60.00%) compared to females (40.00%), suggesting a slightly greater representation of male patients in the clinical sample. Evaluation of defect morphology demonstrated that 65.00% of the defects were 3-wall defects, while 35.00% were 2-wall defects. This predominance of 3-wall defects is clinically relevant, as these defects generally provide better containment and are more favorable for regenerative procedures such as Guided Tissue Regeneration.

Table 2: Changes in Plaque Index (PI) and Gingival Index (GI)
A substantial improvement in oral hygiene and gingival health was observed following the intervention. The mean Plaque Index reduced markedly from 1.92 ± 0.18 at baseline to 0.86 ± 0.14 at follow-up, yielding a mean reduction of 1.06. This decline was statistically significant ($p < 0.001$), reflecting effective plaque control and patient compliance during the observation period. Similarly, the mean Gingival Index decreased from 2.11 ± 0.22 to 0.94 ± 0.17, demonstrating a significant reduction of 1.17 ($p < 0.001$). This indicates considerable improvement in gingival inflammation following the GTR procedure and supportive periodontal therapy.

Table 3: Probing Pocket Depth (PPD) and Clinical Attachment Level (CAL) Changes
Significant clinical improvements were observed in pocket depth and attachment level after treatment. The baseline mean Probing Pocket Depth of 7.35 ± 0.62 mm reduced to 3.45 ± 0.51 mm at follow-up, resulting in a mean pocket reduction of 3.90 mm, which was statistically significant ($p < 0.001$). This reduction

indicates successful resolution of deep periodontal pockets and effective healing of the intrabony defects. Additionally, the Clinical Attachment Level demonstrated substantial improvement, decreasing from a baseline mean of 8.10 ± 0.71 mm to 4.52 ± 0.63 mm at follow-up, with a mean gain of 3.58 mm ($p < 0.001$).

Table 4: Bleeding on Probing (BOP), Gingival Recession (GR), and Tooth Mobility

Bleeding on Probing, an indicator of gingival inflammation, showed a dramatic reduction from 78.00% at baseline to 18.00% postoperatively, representing a 60.00% decrease. This reduction was highly significant ($p < 0.001$), demonstrating effective inflammation control through periodontal therapy and GTR outcomes. Gingival Recession showed a slight non-significant increase from 0.85 ± 0.22 mm to 1.10 ± 0.25 mm, with a mean difference of –0.25 mm ($p = 0.067$). Such mild postoperative recession is expected following surgical flap elevation and is generally clinically acceptable. Tooth mobility also improved notably, with the proportion of Grade I and II mobility decreasing from 45.00% to 15.00%, yielding a 30.00% reduction. This improvement was statistically significant ($p = 0.012$), indicating enhanced periodontal support and stabilization following regeneration.

Table 5: Radiographic Defect Depth Reduction and Defect Fill

Radiographic analysis revealed significant structural improvements in the treated defects. The mean defect depth showed a considerable reduction from 5.92 ± 0.54 mm at baseline to 2.38 ± 0.41 mm at follow-up, reflecting a mean fill of 3.54 mm ($p < 0.001$). Additionally, the mean defect fill percentage amounted to 59.82% ± 6.15%, indicating a high level of bone regeneration and defect resolution. Improvement was also observed in the defect angle, reducing from 38.65° ± 4.20° to 28.41° ± 3.75°, with a mean angular correction of 10.24°, which was statistically significant ($p < 0.001$).

Table 1. Distribution of Study Population (n = 20)

Variable	Category	n (%)
Age Group (years)	25–35	6 (30.00%)
	36–45	9 (45.00%)
	46–55	5 (25.00%)
Sex	Male	12 (60.00%)
	Female	8 (40.00%)
Defect Type	2-Wall Defect	7 (35.00%)
	3-Wall Defect	13 (65.00%)

Table 2. Comparison of Mean Plaque Index (PI) and Gingival Index (GI) at Baseline and Follow-up

Parameter	Baseline Mean ± SD	Follow-up Mean ± SD	Mean Difference	p-value
Plaque Index (PI)	1.92 ± 0.18	0.86 ± 0.14	1.06	**<0.001***
Gingival Index (GI)	2.11 ± 0.22	0.94 ± 0.17	1.17	**<0.001***

*Highly significant

Table 3. Comparison of Probing Pocket Depth (PPD) and Clinical Attachment Level (CAL)

Parameter	Baseline Mean ± SD	Follow-up Mean ± SD	Change (mm)	p-value
Probing Pocket Depth (PPD) (mm)	7.35 ± 0.62	3.45 ± 0.51	3.90	**<0.001***
Clinical Attachment Level (CAL) (mm)	8.10 ± 0.71	4.52 ± 0.63	3.58	**<0.001***

Table 4. Changes in Bleeding on Probing (BOP), Gingival Recession (GR), and Tooth Mobility

Parameter	Baseline	Follow-up	Percentage Reduction (%)	p-value
Bleeding on Probing (BOP %)	78.00%	18.00%	60.00%	**<0.001***
Gingival Recession (GR) (mm)	0.85 ± 0.22	1.10 ± 0.25	–0.25 (slight increase)	0.067 (NS)
Tooth Mobility (Grade I & II)	9 (45.00%)	3 (15.00%)	30.00%	**0.012***

(NS = Not significant)

Table 5. Radiographic Defect Depth Reduction and Defect Fill Percentage

Radiographic Parameter	Baseline Mean ± SD	Follow-up Mean ± SD	Improvement	p-value
Defect Depth (mm)	5.92 ± 0.54	2.38 ± 0.41	3.54 mm	**<0.001***
Defect Fill (%)	—	59.82% ± 6.15%	—	—
Defect Angle (°)	38.65° ± 4.20°	28.41° ± 3.75°	10.24° reduction	**<0.001***

DISCUSSION

The present prospective clinical study demonstrated that guided tissue regeneration (GTR) using a bioresorbable membrane in intrabony defects produced substantial clinical and radiographic improvements in a relatively small cohort of 20 chronic periodontitis patients. The mean probing pocket depth (PPD) reduced from 7.35 ± 0.62 mm to 3.45 ± 0.51 mm (mean reduction 3.90 mm), and clinical attachment level (CAL) improved from 8.10 ± 0.71 mm to 4.52 ± 0.63 mm (mean gain 3.58 mm), with marked reductions in plaque and gingival inflammation indices and a radiographic defect fill of 59.82 ± 6.15%. These findings are in line with the overall evidence from systematic reviews, where Needleman et al (2006) reported that, across 17 randomized controlled trials, GTR achieved a mean additional CAL gain of about 1.22 mm and greater PPD reduction (≈1.21 mm) compared with open flap debridement, together with increased hard-tissue gain at re-entry, confirming that barrier-based regenerative surgery consistently provides superior outcomes compared with conventional access flap therapy.[7]

When comparing the magnitude of PPD reduction and CAL gain, the present results are comparable or slightly higher than those reported in large multicenter GTR trials. In this study, PPD reduction was 3.90 mm and CAL gain 3.58 mm, which is similar to the mean CAL gain of 3.04 ± 1.64 mm and PPD reduction of 4.03 ± 1.81 mm observed in the GTR group of the multicenter phase-IV trial by Tonetti et al (1998), in which 143 patients with deep intrabony defects were treated across 11 centers.[8] In that trial, access flap alone yielded CAL gains of only 2.18 ± 1.46 mm, underlining the added benefit of barrier placement. The slightly higher attachment gain in the present series (3.58 mm vs 3.04 mm) may be related to the predominance of 3-wall defects (65.00%), strict plaque control, and the inclusion of systemically healthy, non-smoking subjects, whereas the multicenter design of Tonetti et al introduced greater heterogeneity in operator skill and patient factors.

The improvements in soft-tissue indices in this study also support the critical role of infection control in regenerative outcomes. Here, Plaque Index decreased from 1.92 ± 0.18 to 0.86 ± 0.14 and Gingival Index from 2.11 ± 0.22 to 0.94 ± 0.17, accompanied by a reduction in bleeding on probing (BOP) from 78.00% to 18.00% (60.00% reduction). Similar stringent plaque-control regimens have been emphasized in controlled clinical trials. For example, Sculean et al (1999) reported in a split-mouth study that both enamel matrix proteins (EMP) and GTR led to significant reductions in PPD (from 8.1 ± 1.7 mm to 4.3 ± 1.2 mm with EMP and from 8.3 ± 1.7 mm to 4.3 ± 0.7 mm with GTR) and CAL gains of about 3.1 mm and 3.0 mm respectively over 8 months, under conditions of rigorous oral hygiene maintenance, with plaque and gingival indices kept low throughout the study period.[9] The comparable PPD reduction (3.90 mm) and CAL gain (3.58 mm) in the present study, together with pronounced improvements in PI, GI, and BOP, suggest that effective plaque control and patient compliance were achieved at a level comparable to specialized clinical trial settings.

Post-operative gingival recession and stability of clinical outcomes are important considerations when interpreting regenerative results. In the current study, gingival recession showed only a slight, statistically non-significant increase from 0.85 ± 0.22 mm to 1.10 ± 0.25 mm (mean 0.25 mm; $p = 0.067$), whereas tooth mobility (Grade I and II) decreased from 45.00% to 15.00%, indicating improved periodontal support. These findings are consistent with the long-term data of Sculean et al (2004), who reported that sites treated with GTR or enamel matrix derivative (EMD) maintained clinically meaningful CAL gains (approximately 2.7–2.9 mm at 5 years in GTR/EMD groups) with modest gingival recession and sustained low bleeding indices over a 5-year period.[10]

Radiographically, the present study demonstrated a reduction in mean defect depth from 5.92 ± 0.54 mm to 2.38 ± 0.41 mm, corresponding to a linear fill of 3.54 mm and a mean defect fill of 59.82% ± 6.15%. The mean defect angle improved from 38.65° ± 4.20° to 28.41° ± 3.75°, yielding an angular correction of 10.24°. These outcomes are somewhat lower, but still comparable, to the classic re-entry study by Cortellini et al (1993), who reported a mean bone gain of 4.3 ± 2.5 mm and a net reduction of 4.7 mm in infrabony defect depth, with about 73.0% ± 31.2% of the original defect filled and particularly favorable results in 3- and 2-wall components (95% ± 6.2% and 82% ± 18.7% fill, respectively).[11] The slightly lower radiographic fill in the present study (≈59.82%) may be attributed to differences in defect baseline characteristics, use of radiographic (rather than re-entry) assessment, and the relatively small sample size; however, the magnitude of linear defect fill (3.54 mm) still falls well within the range reported for successful GTR procedures in similar defect types.

Defect morphology is a critical determinant of regenerative success, and the predominance of 3-wall defects (65.00%) and 2-wall defects (35.00%) in this series likely contributed to the favorable outcomes. Trombelli et al (1997), in a retrospective analysis of 38 intrabony defects treated with GTR, found that GTR resulted in significant improvements in PPD, CAL, and probing bone levels and that presurgical PPD and bone level were predictive of the amount of CAL and bone gain, whereas defect depth and configuration per se were less strongly correlated with outcome; smoking, however, had a pronounced negative effect.[12] The present study, which included only systemically healthy, non-smoking patients with deep baseline PPD (mean 7.35 mm) and radiographic defects ≥ 3 mm, mirrors those favorable prognostic conditions and may explain the substantial CAL gain (3.58 mm) and defect depth reduction (3.54 mm)

observed despite radiographic (rather than surgical) evaluation of bone fill.

The changes in defect angle observed in this study further support the importance of defect geometry in regenerative healing. The mean defect angle improved by 10.24°, from 38.65° to 28.41°, reflecting a transformation toward a narrower, more contained defect configuration after therapy. Nibali et al (2021), in a systematic review of intrabony defects treated with regenerative approaches, reported that deeper defects with narrower angles and a greater number of remaining bony walls exhibited superior CAL gains and radiographic bone fill at 12 months compared with shallow, wide defects.[13]

CONCLUSION

The findings of this prospective study demonstrate that Guided Tissue Regeneration is an effective and predictable treatment modality for managing intrabony periodontal defects. Significant reductions in probing pocket depth and bleeding on probing, along with substantial gains in clinical attachment level and radiographic defect fill, highlight the regenerative potential of the technique. The predominance of favorable defect morphology and strict plaque control further contributed to positive outcomes. Overall, GTR significantly enhanced periodontal healing and stability in systemically healthy patients with chronic periodontitis.

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