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Short Communication

Comparative evaluation of osseous bone splitting by piezosurgery and intramarrow penetration in localized intra-bony defects in patients with chronic periodontitis: a clinico-radiographical pilot study

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ABSTRACT

Chronic periodontitis leads to intrabony defects that compromise tooth stability. Conventional treatments often show limited bone regeneration. Techniques like bone splitting by piezosurgery and intra marrow penetration (IMP) have emerged to enhance bone healing. This study aimed to explore their comparative effectiveness in promoting osseous regeneration and improving clinical outcomes in affected patients. 16 patients with probing depth ≥6 mm were selected and randomly underwent open flap debridement (OFD), followed by osseous bone splitting of the defect using piezosurgery (group A) and IMP (group B), with subsequent bone graft placement in the defect. Full mouth gingival index, plaque index, pocket probing depth and relative attachment level were assessed at baseline and 6 month visits. Defect base level (DBL), crestal bone level (CBL), intrabony defect depth (INTRA) and defect angle (ANG) were also analysed. Intragroup comparison shows statistically significant results in all clinical and radiological parameters in group A and group B ($p<0.05$). Intergroup comparison shows similar results in both the groups at 6 months interval. Both techniques of bone splitting using piezosurgery and IMP have shown promising results in the management of localized intra-bony defects in patients with chronic periodontitis.

Keywords: Periodontitis, Intra-bony defects, Piezo-surgery, Osseous bone splitting, Intra-marrow penetration

INTRODUCTION

Chronic periodontitis is an inflammatory illness of the supporting tissues of the teeth results in destruction of periodontal ligament and alveolar bone, damaging periodontal tissues, causing intrabony defects (IBD) to occur and ultimately causing tooth loss.[1,2] Mechanical debridement and, if necessary, systemic or local pharmaceutical treatment are used to lessen the bacterial burden on the tooth.[3] However, deep IBD poses a major challenge because disease progression risk is high. Thus, periodontal therapy requires more surgery to fix these flaws to best allow conditions for new attachment.[4] Open flap debridement or OFD was among some of the earliest practices that were used to achieve an ideal set of biological conditions, provided high tooth retention together with the improvement of periodontal clinical parameters.[5]

In addition to OFD, a variety of regenerative techniques are tried to replace the lost or damaged tissues that include the periodontal ligament, cementum and bone. Materials for bone grafting create a framework which is structural that supports regeneration of bone. Within this framework, clot development, maturation, and remodeling occur. They generally can be put into categories of autogenous grafts, allografts, xenograft and alloplastic synthetic materials like tricalcium phosphate and hydroxyapatite products.

Recently, periodontics has undergone the introduction of a xenograft that is bovine derived. Bio-Oss® has an unlimited supply with proven safety. This is the material that doesn't require any additional donor site. By eliminating all organic components using a low-heat chemical extraction process, Bio Oss® preserves the natural architecture of bone.

Bio-Oss® is commonly used in dental procedures such as ridge augmentation, sinus elevation, and the repair of furcation and vertical bone defects. Healing after periodontal therapy—whether by debridement, flap surgery, or grafting—occurs through limited true regeneration, typically at the coronal defect area.[6,7]

Also, total periodontal regeneration is an infrequent discovery, especially when using regenerative materials, such as membranes.[8] The apical and middle portions of periodontal defects typically have narrower angulations than the coronal third, which may contribute to the limited healing often seen in wider defects or in the coronal aspect of intrabony defects, even with current regenerative techniques.[9] Cortellini and Tonetti classified defects with angulations ≤25° as narrow and ≥37° as wide, noting that narrow defects showed lower recurrence rates over long-term follow-up.[10]

Intra marrow penetration (IMP), also known as decortication, is the deliberate drilling of holes from the cortical bone straight into the cancellous bone. IMP has been shown to significantly enhance regeneration in intrabony periodontal defects.[11] This technique used in regenerative periodontal procedures to remove cortical bone and expose the underlying cancellous bone. This induces localized bleeding, leading to clot formation rich in cytokines and growth factors. These biochemical signals attract mesenchymal progenitor cells, osteoblasts, and endothelial cells, facilitating rapid revascularization and enhancing osteogenesis at the defect site.[12]

Piezosurgery is a cutting-edge method for performing safe and accurate osteotomies using piezoelectric ultrasonic vibrations. Tomaso Vercelotti created it to get over the drawbacks of conventional tools in oral bone surgery.[13] Piezosurgery treats intrabony defects via bone splitting techniques that can be accompanied with bone swaging, which repositions bone from adjacent edentulous areas to contact the root without fracturing its base. Due to limited access, this is mainly suited for defects with nearby edentulous spaces or interdental gaps >4 mm.[14]

Piezoelectric surgical instruments, featuring miniaturized tips and advanced cutting precision, allow for fine, controlled osteotomies that may broaden the application of periodontal osseous wall swaging. Despite advantages such as minimal invasiveness and preservation of the osteogenic potential of vital bone, the technique remains limited by a lack of extensive clinical research, clearly defined indications, and standardized procedural protocols.[9]

There are no such studies conducted in the past that compare these treatment options for intrabony defects. So, the goal of this research was to compare bone splitting by piezosurgery with the intra marrow penetration at localized defect site in chronic periodontitis patients clinically as well as radiographically.

METHODS

This randomized controlled clinical trial was conducted from November-2024 to August-2025 on patients visiting outpatient clinic of Department of Periodontology and Oral Implantology, ITS Center for Dental Studies and Research, Ghaziabad (Uttar Pradesh). Ethical clearance was obtained from Institutional Ethics Committee. This study was also registered under Clinical Trial Registry India with registration number CTRI/2024/10/075932.

Prior to treatment, each participant gave written informed consent after being fully told about the study's possible hazards and benefits. Patients aged 30–60 years with chronic periodontitis and probing pocket depths ≥6.0 mm were included. Eligible cases presented with 2- or 3-wall intrabony interproximal defects without furcation involvement, a defect depth of ≥3 mm (as measured from the alveolar crest to the base of the defect on periapical radiographs), a width of ≥3 mm at the coronal aspect, and a defect angulation of ≥45 degrees. Exclusion criteria included a history of periodontal treatment within the past year, presence of non-vital or mobile teeth at the defect site, pregnancy or lactation, systemic diseases, and any history of smoking, alcohol consumption, or substance abuse.

Subject population

The subjects were chosen from among those who were scheduled for a standard oral examination. A total of 16 patients were divided with equal distribution of sites using opaque, sealed, sequentially numbered envelopes in both the groups. Patient and investigator were blinded throughout the study. Group A included 8 patients in which OFD followed by osseous bone splitting of the defect by piezo-surgery and bone grafting whereas group B included 8 patients in which OFD followed by IMP in the defect and bone grafting was carried out. At baseline and after 6 months, full mouth plaque index and gingival index, relative pocket probing depth (PPD) and relative attachment level (RAL) were recorded in both the groups. Defect base level (DBL) measured from CEJ to bottom of defect (BD), crestal bone level (CBL) measured from CEJ to alveolar bone crest (AC), intrabony defect depth (INTRA) measured by subtracting CBL from DBL, defect angle (ANG) measured between the line tangential to the root surface and the second line connecting BD to AC were also recorded using dental imaging software (Cruxcan, Cruxell corp.) through intra oral peri-apical radiograph (IOPAR) with grid by paralleling cone technique (specification: tube voltage=70KvP, tube current=8 mA and exposure time=0.63 sec).

Surgical procedure

Pre surgical phase

All patients with intrabony defects first underwent comprehensive supragingival and subgingival scaling and root planing (SRP). Oral hygiene instructions were provided and reinforced. After a 4-week healing period, patients demonstrating satisfactory plaque control were scheduled for the surgical intervention. All clinical and radiological parameters were assessed as shown in Figure 1(a), 1(b), 2(a) and 2(b). Routine blood investigations were also conducted before the surgery.

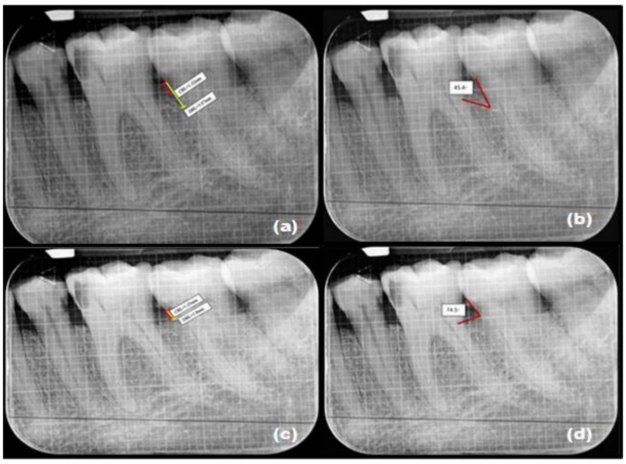

Figure 1: Group A pre-operative (a) DBL=3.87 mm and CBL=1.32 mm, (b) ANG=45.4◦, post-operative (c) DBL=1.8 mm and CBL=1.25 mm, and (d) ANG=74.5.

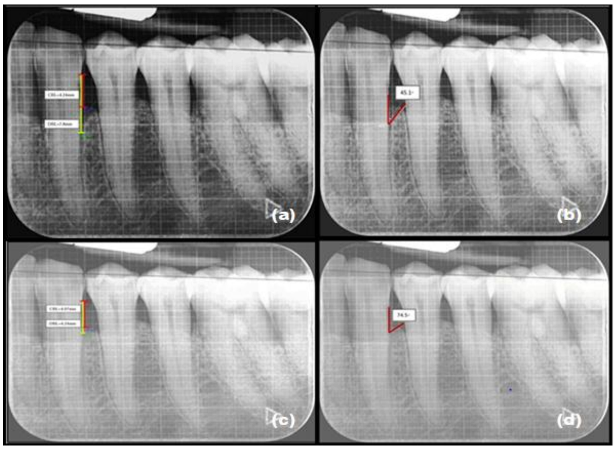

Figure 2: Group B pre-operative (a) DBL=7.8 mm and CBL=4.24 mm, (b) ANG=45.1◦, post-operative, (c) DBL=4.24 mm and CBL=4.07 mm, and (d) ANG=74.5◦.

Surgical phase

Prior to the procedure, patients were told to rinse with 0.12% chlorhexidine for 30 seconds. After local anesthetic has been administered, buccal and lingual (or palatal) crevicular incisions were made, and full-thickness mucoperiosteal flaps were carefully reflected on both the facial and lingual/palatal aspects of each involved tooth or segment. Flap reflection extended to include one tooth mesial and distal to the defect. Granulation tissue within the defect was meticulously removed using Gracey curettes (Hu-Friedy, Chicago, IL, USA). The exposed root surfaces were then thoroughly scaled and planed using a combination of hand instruments and ultrasonic scalers, followed by copious irrigation with sterile water.

For group A, the proximal osseous walls were carefully divided using piezoelectric inserts (UC1, US3) while being heavily irrigated with sterile water. Apically, the split was prolonged to the intrabony defect's base. The split bone wall was carefully moved toward the exposed, periodontally afflicted root surface using a periosteal elevator, keeping the ultimate position around 1 mm from the root. Particularly at mandibular sites, where the coronal third usually consists of dense cortical bone, extra care was given to prevent excessive force that could fracture the base of the split wall. Bone graft (GEISTLICH, Bio-oss) was used to fill the V-shaped gap that resulted between the swaged bone and the osseous wall (Figure 3).

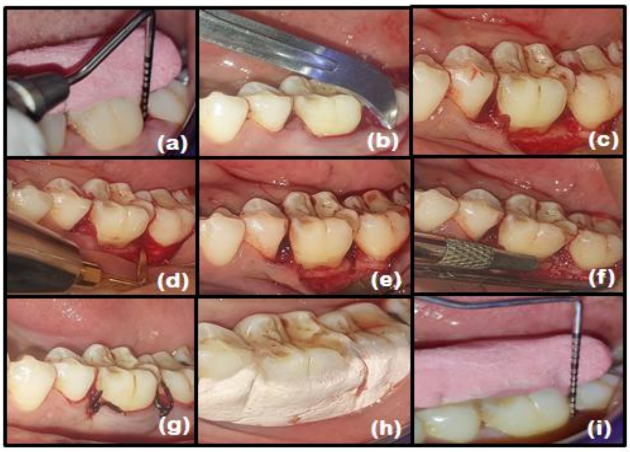

Figure 3: Group A (a) PPD=6 mm, (b) incision, (c) flap reflection, (d) bone splitting using piezo-electric inserts, (e) bone splitting and swaging, (f) bone grafting, (g) suture placement, (h) placement of periodontal dressing, and (i) PPD=2 mm.

For Group B, intra-marrow penetration was performed at the defect site using a 1-mm diameter round carbide bur under copious sterile saline irrigation. A series of 2 to 4 perforations were created within the osseous defect, with approximately 1 mm of spacing between each. Bone graft (GEISTLICH, Bio-oss) was then incrementally placed and each increment was carefully condensed to ensure adaptation to the defect walls and filled up to the level of the bone crest (Figure 4).

Post-surgical phase

The surgical flap was closed using either simple interrupted or figure-of-eight sutures, followed by the application of periodontal dressing. Postoperatively, all participants were prescribed amoxicillin 500 mg thrice a day and Zerodol SP twice a day for five days. Patients were advised to refrain from using mechanical plaque control in the surgical area until the sutures were removed, and to rinse twice a day with 0.12% chlorhexidine. Sutures and periodontal dressings were removed one week after surgery. Follow-up visits were scheduled weekly for the first month post-surgery and subsequently. All clinical and radiological parameters were assessed as shown in Figures 1c and d, and 2c and d at 6 month intervals.

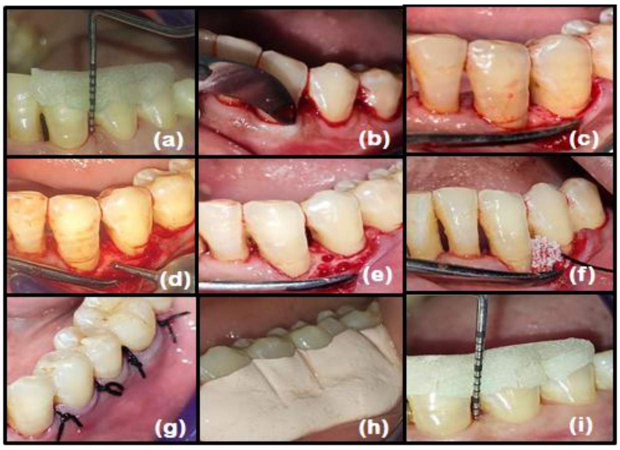

Figure 4: Group B (a) PPD=6 mm, (b) incision, (c) flap reflection, (d) bone splitting using piezo-electric inserts, (e) bone splitting and swaging, (f) bone grafting, (g) suture placement, (h) placement of periodontal dressing, and (i) PPD=2 mm.

Statistical analysis

The statistical package for the social sciences software program (SPSS 16 Inc., Chicago, IL, USA) was used to do the statistical analysis. Shapiro-Wilk's test was used to determine whether the data was normal. The descriptive statistics mean, S.D. were calculated. The values obtained were statistically analysed and to compare significance of means of parameters between groups, it was tested by parametric test i.e. Independent t-test and Paired t-test for intra group comparison for normally distributed data. P value ≤0.05 was considered to be statistically significant. Power analysis calculation was done using software G* Power version 3.1.9.7. β error and power of study was 5% and 95% respectively.

RESULTS

16 participants were recruited for this study and divided into two groups at random. All of the enrolled patients' data were available for statistical analysis, and neither group's patients were lost to follow-up. No adverse events were reported. The CONSORT flow chart, which explains the study procedure, is shown in Figure 5.

Table 1 shows the demographic data of individuals participated in this study that was homogenous to both the groups.

The baseline evaluation of clinical and radiographic data is summarized in Table 2, and did not show any statistically significant differences between group A and group B (p≥0.05).

Table 3 depicts the comparison of improvements at the 6-months follow-ups in both treatment modalities.

Table 4 highlights intragroup comparison of group A and group B between baseline and 6-month. At the 6-month follow-up following surgery, both therapy groups showed statistically significant improvements in all clinical and radiographic measures (p≤0.05).

Table 1: Demographic characteristics of study population.

Parameters	Group A (n=8)	Group B (n=8)	P value
Age (years), mean±SD (range)	48.25±9.82 (30-60)	53.25±10.76 (30-60)	0.34
Gender, N (%)			
Female	5 (62.5)	4 (50.0)	0.61
Male	3 (37.5)	4 (50.0)	

Table 2: Comparison of clinical and radiological parameters between group A and group B at baseline.

Parameters	Group A (n=8)	Group B (n=8)	P value
GI	0.40±0.32	0.56±0.32	0.35
PI	0.56±0.39	0.66±0.42	0.65
PPD (mm)	2.38±0.51	2.38±0.74	1.0
RAL (mm)	2.62±0.91	2.75±0.70	0.76
DBL (mm)	3.89±1.64	3.93±1.27	0.95
CBL (mm)	2.22±1.25	2.50±1.21	0.65
INTRA (mm)	1.60±1.42	1.42±0.89	0.76
ANG (◦)	69.82±12.53	70.32±10.76	0.93

Table 3: Intergroup comparison of clinical and radiological parameters between group A and group B from baseline to 6 months.

Parameters	Group A (n=8)	Group B (n=8)	P value
GI	1.42±0.43	1.26±0.44	0.48
PI	1.64±0.55	1.50±0.51	0.60
PPD (mm)	6.62±1.40	6.00±0.92	0.31
RAL (mm)	6.88±1.72	6.38±0.91	0.48
DBL (mm)	6.20±1.93	5.94±1.65	0.77
CBL (mm)	2.50±1.51	2.93±1.28	0.55
INTRA (mm)	3.69±1.86	3.01±0.64	0.34
ANG (◦)	49.02±6.87	52.21±7.41	0.38

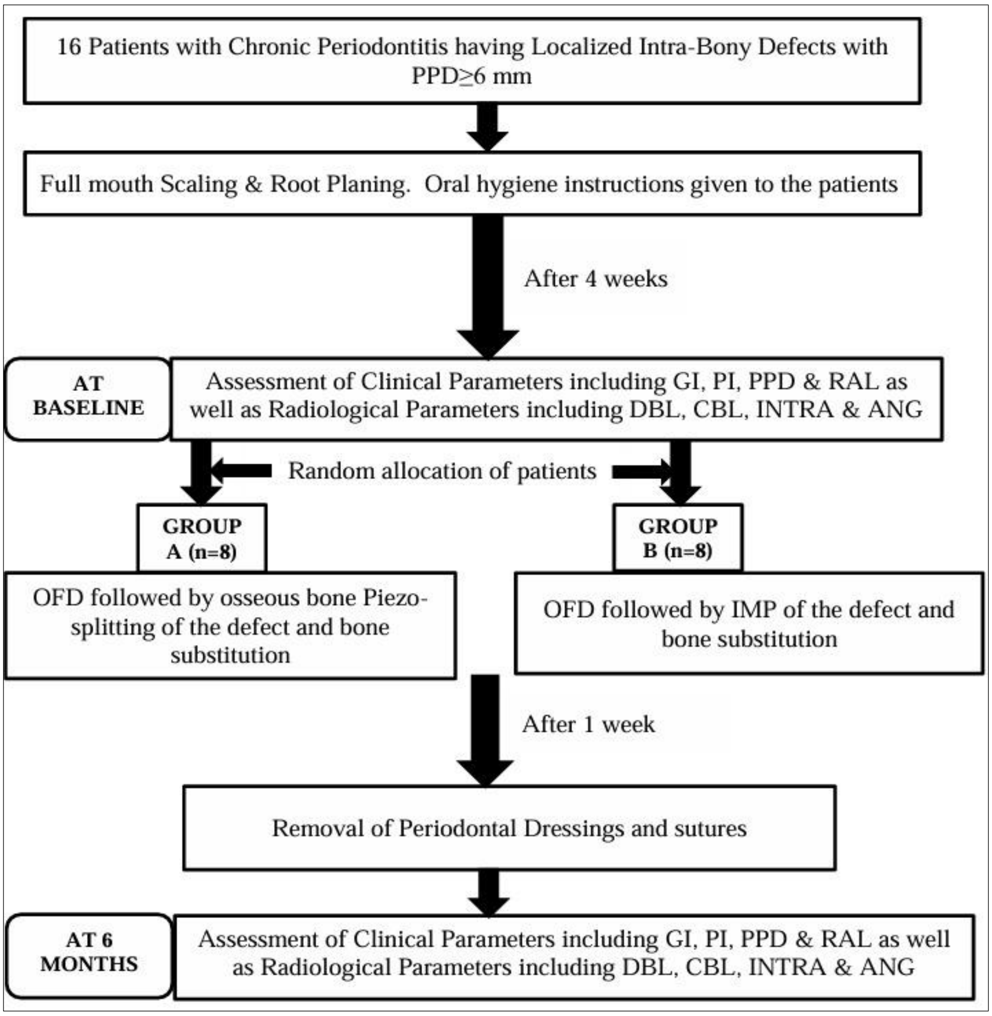

Figure 5: CONSORT flow chart.

Table 4: Intragroup comparison of clinical and radiological parameters in group A and group B from baseline to 6 months.

Parameters	Group A (n=8)		P value	Group B (n=8)		P value
	Baseline	6 months		Baseline	6 months	
GI	1.42±0.43	0.40±0.32	0.00	1.26±0.44	0.56±0.32	0.00
PI	1.64±0.55	0.56±0.39	0.00	1.50±0.51	0.66±0.42	0.00
PPD (mm)	6.62±1.40	2.38±0.51	0.00	6.00±0.92	2.38±0.74	0.00
RAL (mm)	6.88±1.72	2.62±0.91	0.00	6.38±0.91	2.75±0.70	0.00
DBL (mm)	6.20±1.93	3.89±1.64	0.00	5.94±1.65	3.93±1.27	0.001

Continued.

Parameters	Group A (n=8)		P value	Group B (n=8)		P value
	Baseline	6 months		Baseline	6 months	
CBL (mm)	2.50±1.51	2.22±1.25	0.02	2.93±1.28	2.50±1.21	0.06
INTRA (mm)	3.69±1.86	1.60±1.42	0.00	3.01±0.64	1.42±0.89	0.001
ANG(◦)	49.02±6.87	69.82±12.53	0.007	52.21±7.41	70.32±10.76	0.008

DISCUSSION

The regeneration of intra-osseous defects focuses on restoring damaged periodontal support through a coordinated biological process involving the recolonization of progenitor cells at the healing site. Periodontal surgery using regenerative techniques generally achieves better healing outcomes compared to access flap surgery alone. Previous studies have explored various methods for regenerating intrabony defects, including guided tissue regeneration, different graft materials, and combinations of these approaches.[15]

Important principles in repair using bone grafts include angiogenesis as well as stimulation, proliferation, and differentiation of osteoblast precursors.[16] Based on these principles, different strategies have been tested to speed up healing in bony defects. Two-wall and three-wall defects, unlike one-wall defects, benefit from the tissue supply of the lateral walls and apical area, which provide structural support and help stabilize the blood clot. This leads to a higher potential for bone regeneration in these defects after conventional or regenerative treatments.[17]

Bovine-derived xenograft was chosen for this study because it serves as a scaffold for new bone growth and has been shown to achieve true histologic regeneration in humans when used alone.[18] Intra marrow penetration creates a pathway for blood from the highly vascular cancellous bone to reach the recipient site, delivering more progenitor cells and cytokines. Crea et al shown that after open flap debridement, decortication promotes periodontal repair in intrabony defects.[15]

In previously available limited studies, periodontal osseous wall splitting required an adjacent edentulous area, restricting its applicability and making it relatively uncommon.[14] In the current study, a piezoelectric unit with various specialized inserts was used, allowing for safe and precise osteotomies. This technique was successfully applied in areas with tight interproximal contacts and narrow bony walls, with no reported cases of osteonecrosis.

To the best of our knowledge, this was the first clinical trial that compared osseous bone splitting by piezo surgery with the intra marrow penetrations in the treatment of intra-bony defects. At baseline, the evaluation of clinical and radiological parameters in the current study revealed statistically non- significant differences between group A and group B indicating that there were no biases or confounding factors at the outset of the study.

In the present study, on intragroup comparisons, gingival index and plaque index showed statistically significant reduction in both group A and group B from baseline to 6 months. On intergroup comparison, both groups demonstrated similar reduction in plaque and gingival inflammation from baseline to 6 months follow up. These results are similar to the study carried by Saini et al and Debnath et al in defects treated with or without IMP.[16,19] However, Ugale et al found non-significant results on intragroup comparison in defect groups treated with OFD alone, OFD+ decortication or combined with platelet rich fibrin.[20] The improvement in gingival index and plaque index scores in our study could be attributed to patient education initiatives taken at follow up visits.

In our study, both group A and group B showed significant mean reduction in pocket probing depth and gain in relative attachment level from baseline to 6 months. But on intergroup comparison both the techniques showed statistically similar improvements after 3 months indicating that they are equally efficient in the treatment of intrabony defects. Similar to our study, Destawy et al (2023) found significant results on intragroup comparisons from baseline to 6 months in the group I (OFD + bone graft) and group II (OFD + osseous bone swaging).[9] Ghaysh et al (2017) reported similar reduction in PPD and CAL gain after 3 and 6 months in the defects treating with OFD + IMP and OFD + bone graft.[12] Also, Destawy et al concluded that there were significant improvement in PPD and CAL after 6 months in defects treated with bone grafting alone or osseous wall swaging with bone grafting.[9] Both soft- and hard-tissue improvements after inflammation resolution, attachment gain with long junctional epithelium formation, and/or soft-tissue healing at the base of the pocket, in addition to the osteogenic potential of the bone graft material used in the study, can be responsible for this overall decrease in PPD and relative attachment level (RAL) gain.

On intragroup comparison, both groups showed significant improvement in DBL from baseline to 6 months. On intergroup comparison, mean reduction in DBL was higher in group A compared to group B at 6 months. However, the difference between the groups was statistically insignificant. Destawy et al showed similar reduction in DBL from baseline to 6 months in defects treated with bone grafting alone or osseous wall swaging with bone grafting.[9] Saini et al (2020) reported higher reduction in DBL from baseline to 6 months and 9 months in group treated with OFD + IMP + DFDBA when compared with OFD + DFDBA alone.[16] Similarly, on intragroup comparison, both groups showed significant improvement in CBL from baseline to 6 months. The mean reduction in

CBL was higher in group B than group A at 6 months. However, the difference in reduction of CBL was statistically non-significant. Similar to our study, Saini et al (2020) and Destawy et al reported statistically significant reduction in CBL on intragroup comparisons in test as well as control groups from baseline to 6 and 9 months.[9,16] Saini et al reported higher reduction in CBL from baseline to 6 months and 9 months in group treated with OFD + IMP + DFDBA when compared with OFD + DFDBA alone.[16]

Another factor that influences healing is the defect depth. Narrow and deep periodontal defects show better regenerative outcomes than wide, shallow ones.[21] The defect depth or INTRA values in this study showed statistically significant improvement in both group A and B from baseline to 6 months on intragroup comparison. On intergroup comparison, the mean reduction in INTRA values was higher in group A than group B at 6 months. However, the difference between the groups was statistically insignificant. Similar results were reported by Saini et al (2020) where statistically significant reduction in INTRA were found on intragroup comparisons in test as well as control groups from baseline to 9 months.[16]

Steffensen and Webert reported a significant relation between defect angle and bone fill after flap surgery.[22] On intragroup comparison, mean gain in defect angle was statistically significant in both group A and group B from baseline to 6 months indicating that both the techniques are almost equally effective in converting the defect angle from narrow to wide. The mean gain in ANG was more in group A than group B at 6 months on intergroup comparison. However, the difference between the two groups was statistically non-significant. These results are supported by Saini et al where they also found non-significant results on intergroup comparison of defect angle after 6 and 9 months in defects treated with or without IMP and found significant results when compared from baseline to 9 months in both groups.[16]

Piezocision preserves the surrounding soft tissues and their vascular supply while specifically targeting mineralized areas. During the healing phase, the V-shaped area generated by tilting the osseous wall toward the root surface undergoes a similar regenerative pattern. This area is initially bounded on one side by the osseous wall of the pocket and on the other by an avascular, smear-coated root surface. Later, it is surrounded by two cellular and well-vascularized osseous walls. This change promotes osteogenesis from the nearby critical bone and helps maintain blood flow. By reducing micromovements that could normally hasten graft resorption after transplantation, the use of xenogeneic grafts has been demonstrated to improve graft stability in these regions.[9]

Decortications at the graft recipient site have been proposed as a way to encourage physical interlocking between the bone graft material and the native bone. Additionally, evidence from animal studies indicates that marrow penetration can stimulate localized anabolic remodeling of the alveolar spongiosa and enhance the activity of the periodontal ligament, thereby potentially supporting improved regenerative outcomes.[23]

The present study showed that both treatment modalities led to notable improvements after a 6-months follow-up. Clinically, there was a reduction in PPD and a gain in RAL, indicating improved soft tissue healing. Radiographically, both techniques also resulted in greater bone fill and a reduction in defect depth. Overall, the outcomes suggest that both approaches were effective and yielded similar results in promoting periodontal healing. However, this study has several drawbacks. Firstly, 6 months follow up was short for assessing bone regeneration, and sample size was less. Also, the radiographic assessment was performed using the paralleling cone technique, which may not accurately identify anatomical landmarks or provide precise measurements of intra-bony defects. The absence of histologic analysis makes it difficult to determine the biological mechanisms responsible for the observed reduction in probing pocket depth (PPD). Lastly, there is a need to develop specialized piezoelectric tips designed for cutting interdental bone with tight contacts and thin dimensions, which would enhance the efficiency of osseous wall swaging procedures.

CONCLUSION

Based on the study's limitations, both intramarrow penetration and osseous bone splitting using piezosurgery are useful in treating localized intra-bony abnormalities in individuals with chronic periodontitis. The findings demonstrate that both methods are appropriate and equally effective for correcting intra-bony abnormalities in periodontitis. This enables medical professionals to think about using either approach as a form of treatment. To validate these results and more accurately evaluate the long-term efficacy and potential benefits of each strategy, more research with bigger sample numbers and longer follow-up is required.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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