Effect of Ascorbic Acid-Loaded Injectable Platelet-Rich Fibrin Combined with Partially Demineralized Dentin Graft on Alveolar Ridge Preservation: A Randomized Controlled Clinical Trial

Research Proposal
Submitted to the Department of Periodontics of Oral and Dental Medicine, Nahda University
In partial fulfillment of the requirements of Masters' degree in …(periodontics)…

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I. Abstract

Statement of the Problem:

Following tooth extraction, physiological remodeling causes progressive horizontal and vertical alveolar ridge resorption, potentially compromising subsequent implant placement. Alveolar ridge preservation (ARP) is therefore used to minimize post-extraction dimensional changes and facilitate delayed implant rehabilitation. Partially demineralized dentin graft (PDDG) is a promising autogenous graft material because of its structural and biochemical similarity to bone and its potential osteoconductive and osteoinductive properties. Combining PDDG with injectable platelet-rich fibrin (I-PRF) produces a cohesive "Sticky Dentin" graft that may enhance graft stability and regeneration. Ascorbic acid (AA) has important roles in collagen synthesis, angiogenesis, cellular activity, and osteogenesis; however, its additional regenerative benefit when incorporated into PDDG–I-PRF for ARP remains insufficiently investigated.

Aim:

This study aims to compare the ridge-preservation and regenerative outcomes of AA-Sticky Dentin (PDDG + AA-loaded I-PRF), Sticky Dentin (PDDG + I-PRF), and PDDG alone in post-extraction sockets planned for delayed implant placement.

Materials and Methods:

This prospective, three-arm, parallel-group randomized controlled trial will enroll patients requiring extraction, ARP, and delayed implant placement. Participants will be randomized 1:1:1 to **PDDG, Sticky Dentin, or AA-Sticky Dentin**. The **primary outcome** will be CBCT-assessed horizontal ridge dimensional change. **Secondary outcomes** will include histomorphometric assessment of new bone, residual graft, and connective tissue, vertical ridge change by CBCT at 4 months and bone-core biopsy during implant osteotomy will be performed.

II. Background

Tooth extraction initiates a sequence of physiological remodeling events that results in substantial dimensional changes of the alveolar ridge. The most pronounced reduction occurs during the early healing period and involves both horizontal and vertical bone loss, which may compromise the available hard-tissue volume and adversely affect subsequent implant placement.[1,2,3]

Alveolar Ridge Preservation (ARP) has been introduced as a safe and predictable procedure to minimize post-extraction ridge resorption by placing grafting materials, with or without barrier membranes or soft tissue sealing techniques.[4,5] The principal objective of ARP is to preserve ridge dimensions and maintain a favorable alveolar contour to facilitate future prosthetic or implant rehabilitation and reduce the need for subsequent bone augmentation.[6,7]

A variety of grafting materials and biological approaches have been investigated for ARP.[8] Among these, autogenous dentin has attracted increasing interest because dentin shares considerable structural and chemical similarities with alveolar bone. .[9,10]

Moreover, dentin grafts offer a cost-effective approach by recycling biological waste and providing an alternative to other autogenous graft materials.[8-10]

Consequently, demineralization exposes the organic matrix and associated bioactive components of dentin, potentially enhancing its osteoconductive and osteoinductive properties.[11,12]

Partially Demineralized Dentin Graft (PDDG) performance depends on its biological properties and processing protocol.[13] However, variations in demineralizing agents and application times may affect graft bioactivity and contribute to inconsistent outcomes. [14,15 16]

EDTA preserves the collagen matrix and facilitates controlled release of bioactive components, while sodium hydroxide provides effective disinfection without compromising dentin bioactivity.[16,17] Treatment with 10% EDTA for 17–20 minutes can achieve approximately 70% calcium removal and produce a non-cytotoxic graft suitable for autogenous use.[18]

Recent clinical evidence supports the use of autogenous particulate dentin (APD) and autogenous partially demineralized dentin matrix (PDDM) for ridge preservation, demonstrating favorable radiographic and histomorphometric outcomes compared with spontaneous healing and established grafting materials[19, 20]. A recent randomized clinical trial further demonstrated that demineralized dentin grafts can provide clinically relevant dimensional stability and new bone formation during ARP.[21,22]

Despite these advantages, particulate dentin grafts may lack cohesion and stability within the extraction socket, particularly during the early healing period. [23,24] Injectable platelet-rich fibrin (I-PRF) has consequently been investigated as a biological adjunct.[25,26] I-PRF provides a fibrin-based matrix enriched with platelets and bioactive mediators and can be combined with particulate graft materials to produce a cohesive graft mass known as "Sticky Dentin." This approach may improve graft handling and stability while providing a biologically favorable environment for tissue healing[23,24]. Importantly, recent randomized clinical evidence has directly evaluated demineralized dentin graft alone and in combination with I-PRF for ridge preservation, supporting continued investigation of I-PRF-based dentin grafting strategies. [27–30]

Nevertheless, the regenerative potential of the PDDG–I-PRF combination may be further influenced by additional biological mediators. Ascorbic acid (AA) is a potent water-soluble antioxidant with beneficial effects on periodontal health and wound healing[31–34], and an essential cofactor for collagen synthesis and has recognized roles in extracellular matrix formation, cellular function, angiogenesis, and osteogenic activity[35–39]. These biological functions provide a plausible rationale for investigating AA as an adjunct to a PDDG–I-PRF graft. However, while PDDG and I-PRF have individually or jointly been investigated in ARP[27–30], recent randomized clinical trial further demonstrated that vitamin C incorporated into I-PRF showed promising regenerative effects in the treatment of intraosseous periodontal defects and allover periodontal regeneration and may also enhance soft-tissue healing[40,41].

However, evidence on the use of ascorbic acid (AA) in ARP remains limited, and its additional benefit when combined with PDDG and I-PRF has not been clearly established

This knowledge gap provides the rationale for the present randomized controlled clinical trial. The study will compare AA-Sticky Dentin (PDDG + AA-loaded I-PRF), Sticky Dentin (PDDG + I-PRF), and PDDG alone for alveolar ridge preservation following tooth extraction. The primary objective is to determine whether the addition of AA to the PDDG–I-PRF combination provides superior preservation of alveolar ridge horizontal width preoperatively and 4 months postoperatively. Additionally, core bone biopsies obtained at 4 months were histomorphometrically analyzed for newly formed bone, mature bone, and residual graft material as secondary outcomes. This three-arm design will allow the specific contribution of I-PRF and the potential additional effect of AA to be evaluated against PDDG alone.

III. Research Question

In patients with non-restorable teeth, does adding vitamin C to partial demineralized dentin graft combined with I-PRF affect the radiographic ridge width of post-extraction sockets?

PICOTS Element	Description
P (Patient/Problem)	Patients requiring alveolar ridge preservation following tooth extraction with ST IB contained extraction sockets planned for delayed implant placement.
I (Intervention)	(AA-stick dentin): (AA-loaded I-PRF) combined with (PDDG)
C (Comparator)	(P-Sticky Dentin): (PDDG) combined with (I-PRF); and (PDDG) alone (control).
O (Primary Outcome)	Comparing radiographic horizontal alveolar ridge width between groups using CBCT preoperatively and 4 months postoperatively
T (Time)	Four months after alveolar ridge preservation (core biopsy obtained at implant placement). Total follow-up until implant placement: 4 months.
S (Setting)	Department of Periodontics, Faculty of Oral and Dental Medicine, Nahda University, Beni Suef, Egypt.

IV. Study (Research) Objectives

General Objective

To evaluate whether the addition of ascorbic acid (AA) to the PDDG–I-PRF combination enhances alveolar ridge preservation following tooth extraction, compared with PDDG alone.in post-extraction ST IB contained sockets.

Primary Objective

Comparing radiographic horizontal alveolar ridge width between groups using CBCT preoperatively and 4 months postoperatively.

Secondary Objectives

1. Assess alveolar bone density in the three study groups at 4 months postoperatively using CBCT-derived grayscale values (GVs).
2. Evaluate the histomorphometric characteristics of core bone biopsy specimens collected during implant osteotomy 4 months after alveolar ridge preservation.

Clinical Relevance

The clinical relevance of this study is to determine whether combining (PDDG) with (I-PRF), with or without ascorbic acid (AA), can enhance alveolar ridge preservation compared with PDDG alone. The three-arm design will assess the individual and additional effects of I-PRF and AA by comparing PDDG, Sticky Dentin (PDDG + I-PRF), and AA-Sticky Dentin (PDDG + AA-loaded I-PRF). Improved ridge stability or bone regeneration could support this biologically enhanced autogenous approach for socket preservation before delayed implant placement. The findings may also help clinicians determine whether the additional use of I-PRF or AA provides a clinically meaningful benefit beyond PDDG alone.

V. Study Design

Study Design Checklist

Randomized Controlled Trial (RCT)

This study will be designed as a prospective, three-arm, parallel-group randomized controlled clinical trial.

Group (1) Graft PDDG alone.

Group (2) (PDDG) combined with(I-PRF); (Sticky Dentin).

Group (3) Ascorbic Acid-loaded I-PRF combined with (PDDG); (AA-stick dentin).

in patients requiring delayed implant placement following tooth extraction.

- The primary outcome will be to compare horizontal alveolar ridge width between groups using CBCT preoperatively and 4 months postoperatively.

- Secondary outcomes histomorphometric bone regeneration assessed from bone core biopsy specimens harvested during implant placement after a four-month healing period.

Study Population

The study population will comprise patients requiring tooth extraction followed by alveolar ridge preservation prior to delayed implant placement who attend the Department of Periodontics, Faculty of Oral and Dental Medicine, Nahda University, Beni Suef, Egypt. Eligible participants will be limited to individuals presenting with ST IB contained extraction sockets that are considered unsuitable for immediate implant placement according to established socket classification systems and current clinical recommendations.[42-44]

Study Duration

The study duration will be approximately 4 months, encompassing patient recruitment, surgical intervention, a 4-month healing period, radiographic and histomorphometric assessment at the time of implant placement, and completion of data collection.[45,46]

Participation Criteria

Inclusion Criteria

- Patients aged 18:60 years. [47]
- ASA Type I medically healthy patients with no significant medical history. [47]
- Non- restorable teeth indicated for extraction followed by delayed implant placement. [48]
- Patients eligible for immediate implant placement but facing factors that prevent implant placement at the time of extraction. [48]
- Patients requiring alveolar ridge preservation before planned dental implant placement.
- Presence of ST IB sockets after extraction. [42–44]
- periodontally healthy adjacent teeth . [48]
- Adequate oral hygiene plaque index ≤15%, and willingness to comply with the study protocol and follow-up visits. [47]
- Cooperative patients willing to comply with the 4-month follow-up period. [47]
- Ability to understand and sign the informed consent form. [47]

Exclusion Criteria [47,48]

- Uncontrolled systemic diseases affecting bone healing (e.g., uncontrolled diabetes mellitus).
- History of radiotherapy or chemotherapy involving the head and neck region.
- Current use of medications known to influence bone metabolism (e.g., bisphosphonates, denosumab, long-term corticosteroids).
- Smokers or tobacco users.
- Pregnancy or lactation.
- Acute uncontrolled infection requiring extensive debridement or preventing ridge preservation.
- Patients with poor oral hygiene or untreated active periodontal disease.

- Psychiatric patients, or with a learning disability, or those unable to give consent
- Patients unable or unwilling to attend follow-up visits.

Withdrawal Criteria

Participants will be withdrawn from the study if any of the following occur:

- Withdrawal of informed consent at any stage of the study.
- Failure to attend scheduled follow-up appointments.
- Development of medical conditions contraindicating continuation of the study.
- Protocol violations that may influence study outcomes.
- Occurrence of serious adverse events requiring alternative treatment.

Null Hypothesis (H0)

There will be no statistically significant difference among PDDG alone, PDDG + I-PRF (Sticky Dentin), and PDDG + AA-loaded I-PRF (AA-Sticky Dentin) in terms of CBCT-assessed horizontal and vertical alveolar ridge dimensional changes following alveolar ridge preservation.

Alternative Hypothesis (H_1)

Alveolar ridge preservation using AA-Sticky Dentin results in significantly greater alveolar ridge dimensional preservation assessed by CBCT and histomorphometric bone regeneration compared with Sticky Dentin and PDDG alone after a three-month healing period.

VI. Materials and Methods

Study Setting

This prospective, parallel-arm randomized controlled clinical trial will be conducted at the Department of Periodontics, Faculty of Oral and Dental Medicine, Nahda University (NUB), Beni Suef, Egypt. Patient recruitment, clinical examinations, tooth extraction, alveolar ridge preservation, postoperative follow-up, implant placement, and bone core biopsy collection will all be carried out at the same department. Cone-beam computed tomography (CBCT) scans will be obtained preoperatively to confirm the indication for alveolar ridge preservation and after a three-month healing period to assess dimensional ridge changes and support implant treatment planning. Histological and histomorphometric evaluation of bone core biopsy specimens will be performed in a specialized oral pathology laboratory.

Sample Size Calculation[49]

The sample size was calculated based on the changes in radiographic horizontal alveolar ridge width from baseline to 4 months following alveolar ridge preservation reported by **Abaza et al. (2024).** The reported mean changes in radiographic bone width were −0.63 ± 0.90 mm, −0.18 ± 0.28 mm, and −1.27 ± 0.90 mm in the I-PRF, hyaluronic acid, and control groups, respectively. Based on these data, the estimated effect size (Cohen's f) was approximately 0.594. Using G*Power software (version 3.1.9.4), with a one-way ANOVA, three groups, an alpha level of $\alpha = 0.05$, and 95% statistical power, the required sample size was approximately 48 participants (16 participants per group).

Randomization and Allocation Concealment[49]

Following confirmation of eligibility and completion of the baseline clinical and CBCT assessments, eligible participants will be randomly allocated in a 1:1:1 ratio to one of the three study groups. A computer-generated randomization sequence will be prepared using **Randomizer.org (www.randomizer.org)**.

Allocation concealment will be maintained using sequentially numbered, coded, opaque, sealed envelopes, each containing the treatment assignment for the corresponding participant. The envelopes will be prepared according to the computer-generated randomization sequence and securely maintained until the time of treatment allocation.

Following administration of local anesthesia and immediately before the surgical intervention, the corresponding envelope will be opened by the **study supervisor**, who will reveal the assigned treatment to the operator. Participants will then be allocated to one of the following groups:

- **Group I:** (PDDG) alone. - **Group II:** (PDDG) combined with (I-PRF).

- **Group III:** (PDDG) combined with (AA-I-PRF).

Blinding[49]

Due to the distinct nature and preparation of the three interventions, blinding of the operator performing the surgical procedures will not be feasible. The participants will also not be considered blinded because the interventions differ in their preparation and application.

However, **blinding will be maintained for outcome assessment**. The examiner responsible for CBCT measurements will be blinded to the treatment allocation. Similarly, the histopathologist/histomorphometric examiner will be blinded to the treatment groups during processing and quantitative analysis of the bone biopsy specimens.

Treatment groups will be coded using numerical or alphabetical identifiers, and the group codes will remain concealed from the outcome assessors until completion of the corresponding measurements and analyses

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Preoperative Phase

Following informed consent, all participants will undergo clinical examination and baseline CBCT evaluation.

After confirming eligibility, each participant will undergo comprehensive medical history assessment, clinical examination of the tooth indicated for extraction, and preoperative periapical radiographic evaluation. Participants will receive a detailed explanation of the study objectives, potential benefits, surgical procedures, possible risks, and study timeline before providing written informed consent.

Initial periodontal therapy (Phase I) will include professional mechanical plaque removal (PMPR) before surgery, comprising supragingival scaling, subgingival debridement when indicated, correction of defective restorations, and polishing. Patients will receive individualized instructions on toothbrushing and interdental cleaning, which will be reinforced as needed throughout the study period to maintain optimal plaque control. [28]

Surgical Procedures

In all groups

Surgical Extraction and Preparation of Autogenous Partially Demineralized Dentin Graft (PDDG)

1. **Preoperative preparation:**
   Patients will be instructed to rinse with 0.12% chlorhexidine mouthwash (Hexitol, Adco Pharma Co., Egypt) before the surgical procedure. [22,28,47,48]

2. **Local anesthesia:**
   Local anesthesia will be administered using 2% mepivacaine hydrochloride combined with 1:1000 levonordefrin (Alexandria Company for Pharmaceuticals). [22,28,47,48]

3. **Atraumatic tooth extraction:**
   The non-restorable tooth will be extracted using a minimally traumatic, flapless technique. A supracrestal fiberotomy will initially be performed to sever the supracrestal periodontal fibers. The tooth will then be gently loosened using periotomes (Nordent Manufacturing Inc., IL, USA) and straight, thin elevators (Nordent Manufacturing Inc., IL, USA), followed by extraction with extraction forceps (Nordent Manufacturing Inc., IL, USA). [22,28,29,47,48]

4. **Socket inspection:**
   Following extraction, the socket will be carefully inspected with a periodontal probe to confirm the integrity of the socket walls and identify any defects. [22,28,29,47,48]

5. **Tooth cleaning:**
   The extracted tooth will be thoroughly cleaned to remove residual periodontal ligament fibers, cementum, soft-tissue attachments, carious lesions, and existing restorations. Cleaning will be performed using a high-speed fine finishing stone under continuous saline irrigation. The pulp chamber will subsequently be thoroughly debrided using sterile endodontic files. [22,28,29,50]

6. **Grinding of the tooth:**
   The cleaned tooth will be processed using an autoclavable stainless-steel grinder (capacity: 100 g; 220 V/50 Hz; 750 W; speed: 25,000 rpm; particle size: 20–100 µm; manufactured in China). The tooth will be ground to produce particulate dentin. [30]

7. **Particle-size selection:**
   The resulting dentin particles will be transferred to stainless-steel wire sieves with mesh sizes of **300 µm and 1200 µm**.[30] The sieve assembly will be vibrated to obtain particles

within the desired size range of **300–1200 µm**, while particles smaller than 300 µm will be discarded. [29,30,50]

8. **Chemical cleansing and disinfection:**
   The selected particulate dentin will be placed in a sterile container and immersed in a solution of **0.5 M sodium hydroxide (NaOH) and 30% ethanol** for **10 minutes** to facilitate defatting, removal of organic contaminants, and disinfection. [29,50]

9. **First PBS washing:**
   Following chemical cleansing, the dentin particles will be rinsed **2 minutes twice with phosphate-buffered saline (PBS)** to remove residual chemical agents. [29,50]

10. **Partial demineralization:**
    The dentin particles will subsequently undergo partial demineralization by immersion in **10% ethylenediaminetetraacetic acid (EDTA) for 10 minutes**. This step is intended to partially remove the mineral component while preserving the dentinal collagenous matrix and exposing potentially bioactive components. [18,29]

11. **Final washing:**
    After partial demineralization, the particles will be rinsed **twice with PBS** to remove residual EDTA. [29]

12. **Drying:**
    The processed PDDG particles will be dried using sterile gauze and subsequently prepared for placement into the extraction socket. [22,28]

13. **Graft placement:**
    The prepared PDDG will then be transferred to the extraction socket according to the assigned treatment protocol.

Group (1) will receive (PDDG) only.
Group (2) will receive (PDDG) combined with Plain(I-PRF); (P-Sticky Dentin).
Group (3) will receive (AA-loaded I-PRF) combined with (PDDG); (AA-stick Dentin).

*All chemical reagents will be supplied by **Alpha Chemical Co.®, India.** The PDDG processing protocol is based on the chairside approach described by **Binderman et al. (2014).*** [29,50]

For I-PRF

For preparation of injectable platelet-rich fibrin (I-PRF), 10 mL of venous blood will be collected into sterile polyethylene terephthalate (PET) tubes without anticoagulants and immediately centrifuged at 60 × g (700 rpm) for 3 minutes at room temperature using a centrifuge with a 45° rotor. The upper yellowish I-PRF fraction will be carefully aspirated with a sterile syringe, avoiding contamination with the underlying red blood cell fraction.[25–30]

In Group 2, freshly prepared I-PRF will be mixed thoroughly with the PDDG particles to obtain P-Sticky Dentin.[28–30]

In Group 3, 2,500 µg (2.5 mg) of pure L-ascorbic acid will be added to 10 mL of freshly collected blood to achieve a final concentration of 250 µg/mL. The blood will then undergo the same centrifugation protocol, and the resulting AA-containing I-PRF will be aspirated and mixed with the PDDG particles.[40,41] The mixture will stand for approximately 10 minutes to allow fibrin polymerization and formation of a cohesive, moldable AA-Sticky Dentin graft.

The assigned graft material will be gently placed into the contained extraction socket without excessive compression. An absorbable gelatin/collagen sponge will be placed over the graft for protection and stabilization. As only contained ST IB sockets will be included, no barrier membrane will be used. The graft will be stabilized by its cohesive consistency and the socket walls, then secured with an internal crisscross suturing technique using 5-0 monofilament polypropylene sutures to provide stable soft-tissue coverage during initial healing. [22,51]

Post-Operative Care and Follow Up

Postoperative Care and Medication

- Participants were advised to avoid trauma to the surgical site, manipulation of the sutures, hot food, and vigorous rinsing during the first 24 hours. [22,52]
- Brushing of the surgical area was avoided, with gentle brushing resumed after 2 weeks.[22,52,53]
- **Antibiotic therapy:** Amoxicillin 875 mg + clavulanic acid 125 mg (Augmentin 1 g; GSK) was prescribed twice daily for 7 days. [54,55]

- For patients allergic to penicillin, doxycycline 100 mg (Doxymycin; Nile Co., Egypt) was prescribed twice daily. [56]
- **Analgesic therapy:** Diclofenac potassium 50 mg (Cataflam; Novartis) was prescribed three times daily for 5 days as needed for postoperative pain. [57]
- **Mouthwash:** Gentle rinsing with 0.12% chlorhexidine was recommended twice daily for 2 weeks. [58]

Postoperative Instructions and Follow-up[22,28,47,48]

- Patients will be instructed to strictly follow all postoperative recommendations.
- Patients will be advised not to touch or disturb the surgical site with their tongue or fingers.
- Patients will be instructed to avoid wearing any dental appliance that contacts or exerts pressure on the surgical area.
- Sutures will be removed 2 weeks after surgery.
- Face-to-face adherence reminders will be provided during follow-up visits.
- **3 days postoperatively:** Clinical assessment of swelling, wound healing, dehiscence, and adverse events.
- **7 days postoperatively:** Clinical reassessment and reinforcement of postoperative instructions.
- **2 weeks postoperatively:** Follow-up examination and suture removal.
- **4 months postoperatively:** Final clinical assessment and CBCT scan before planned implant placement.

Patients will receive standardized postoperative instructions and medications and participants were recalled after a 4-month healing period for final clinical evaluation, CBCT assessment, implant placement, and bone core biopsy harvesting.

During implant osteotomy preparation, a trephine bur will be used to harvest a bone core biopsy for histological and histomorphometric analysis before implant placement.

VII. Ethical Considerations

The study will be conducted in accordance with the Declaration of Helsinki, ICH-GCP E6(R3), and the ethical regulations of the Faculty of Oral and Dental Medicine, Nahda University. Ethical approval will be obtained from the Institutional Research Ethics Committee before starting the study.

All eligible participants will receive clear verbal and written information about the study, including its purpose, procedures, potential risks and benefits, and their right to withdraw at any time without affecting their dental care. Written informed consent will be obtained before any study-related procedure.

Potential risks include discomfort from blood collection, tooth extraction, surgical procedures, CBCT examination, and bone-core biopsy. These risks will be minimized using standard clinical and aseptic procedures, appropriate local anesthesia, and postoperative care.

Participant confidentiality will be maintained using coded study records, and personal information will be accessible only to authorized members of the research team. Any adverse events will be documented and appropriately managed.

VIII. Data Management and Statistical Analysis

All clinical, radiographic, and histomorphometric data will be recorded using standardized case report forms. Each participant will be assigned a unique identification code, and personal identifiers will be stored separately from the study database. Data will be entered into a password-protected electronic database and checked for completeness and accuracy before analysis.

Descriptive statistics will be presented as mean ± standard deviation for quantitative variables and frequencies and percentages for categorical variables. Data normality will be assessed using the Shapiro–Wilk test.

For comparison of the three study groups, one-way ANOVA will be used for normally distributed continuous data, while the Kruskal–Wallis test will be used for non-normally distributed data. Within-group changes between baseline and 3 months will be analyzed using the paired t-test or Wilcoxon signed-rank test, as appropriate. Categorical data will be analyzed using the Chi-square test or Fisher's exact test. Statistical significance will be set at $P < 0.05$.

To reduce the risk of bias, participants will be randomly allocated in a 1:1:1 ratio using a computer-generated randomization sequence, with allocation concealment through sequentially numbered, opaque, sealed envelopes. Outcome assessment and statistical analysis will be performed by investigators blinded to treatment allocation. Blinding of the operator and participants will not be feasible because of the nature of the interventions.

No qualitative data will be collected in this study; therefore, qualitative data analysis will not be applicable.

IX. Dissemination of Results and Publication Policy

The study findings will be submitted as part of the requirements for the Master's degree in Periodontology, Faculty of Oral and Dental Medicine, Nahda University. The results will also be presented at national and international scientific meetings and submitted for publication in peer-reviewed journals.

Authorship will follow the recommendations of the **International Committee of Medical Journal Editors (ICMJE)**. Individuals meeting authorship criteria will be listed as authors, while contributors who do not fulfill authorship requirements will be acknowledged appropriately.

Participants may receive a summary of the study findings upon request after completion of the study.

X. Funding of the Study

This study is **self-funded** by the principal investigator. All expenses related to clinical procedures, laboratory investigations, radiographic examinations, histological analysis, graft preparation, and study materials will be covered by the investigator. No external financial support or commercial sponsorship will be received, and no conflicts of interest are declared.

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