



## ORIGINAL RESEARCH

## PATIENT SATISFACTION AND PINK ESTHETICS FOLLOWING MANAGEMENT OF POST-EXTRACTION RIDGE ALTERATIONS WITH DIFFERENT TYPES OF DENTIN GRAFTS: A RANDOMIZED CONTROLLED CLINICAL TRIAL

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## ABSTRACT

**Objective:** This study aimed to compare postoperative patient satisfaction and soft tissue esthetics following alveolar ridge preservation (ARP) using three different forms of autogenous tooth-derived grafts (ATDGs): undemineralized dentin (UDD), incompletely demineralized dentin matrix (IDDM), and fully demineralized dentin matrix (FDDM) in the esthetic zone.

**Materials and Methods:** Thirty participants who require single tooth extraction in the esthetic zone were randomly allocated into three equal groups (n=10) to receive ARP with UDD, IDDM, or FDDM. Patient satisfaction using a questionnaire was assessed on the day of tooth extraction. While, esthetic outcomes were evaluated using the Pink Esthetic Score (PES), six months after final crown delivery.

**Results:** High satisfaction was reported in all three groups: UDD (80%), IDDM (60%), and FDDM (70%), with no statistically significant differences. The mean PES was 12.0 in the UDD group, 11.1 in the IDDM group, and 11.0 in the FDDM group. Although the UDD group showed slightly higher PES values, the difference was not statistically significant.

**Conclusion:** All three forms of ATDGs demonstrated comparable and favorable outcomes in terms of postoperative patient satisfaction and peri-implant soft tissue esthetics. Different processing techniques did not significantly affect these outcomes, suggesting that graft selection could be guided by clinical judgement and biological rationale

**Keywords:** Autogenous dentin graft, alveolar ridge preservation, patient satisfaction, implant esthetics.

### 1. Introduction

Tooth extraction often leads to inevitable dimensional alterations, especially in the anterior maxilla due to its thin buccal plate of bone. In addition, the buccal bone is composed mainly of bundle bone, relying on the periodontal ligament for its blood supply<sup>1,2</sup>. Following the loss of vascularization, rapid bone resorption is initiated which results in dimensional changes that may compromise future implant placement and esthetic outcomes<sup>3,4</sup>.

To counteract these changes, alveolar ridge preservation (ARP) techniques have been developed with the goal of preserving ridge architecture and facilitating future

implant placement. Socket grafting using different types of bone grafts, mostly used are allografts and xenografts, has become a common practice to support new bone formation within extraction sockets<sup>5,6</sup>. However, allografts may carry a risk of immune response or disease transmission. While xenografts exhibit slow or incomplete resorption with no osteogenic potential<sup>7-9</sup>.

Recently, autogenous tooth-derived grafts (ATDGs) have gained interest as a biomimetic and cost-effective alternative. Dentin shares a similar composition with bone, which contributes to its osteoconductive and osteoinductive potential<sup>10-12</sup>. According to the

processing techniques, ATDGs can be used in different forms; undemineralized dentin (UDD), incompletely demineralized dentin matrix (IDDM), and fully demineralized dentin matrix (FDDM). Each form presents distinct biological and mechanical characteristics, potentially influencing graft performance and clinical outcomes<sup>13-15</sup>.

While the regenerative potential of ATDGs has been supported by several preclinical and clinical studies, most available data have focused mainly on radiographic and histological outcomes. Additionally, there is limited emphasis on patient-centered outcomes such as comfort, healing experience, and overall satisfaction<sup>16</sup>. Furthermore, esthetic outcomes such as the Pink Esthetic Score (PES), which are critical in the esthetic zone, remain underexplored in the context of ATDGs. These subjective and esthetic outcomes are essential to understand the real-world applicability and acceptance of ATDGs from both clinical and patient perspectives<sup>17</sup>.

Therefore, this study was designed to compare postoperative patient satisfaction and esthetic outcomes using the PES following ARP with three different processing forms of ATDGs: UDD, IDDM, and FDDM in the esthetic zone. By evaluating both patient-reported experiences and soft tissue esthetics, this study aims to provide insights to support evidence-based material selection and promote patient-centered care in ARP.

**2. MATERIALS AND METHODS**

**2.1. Trial Design**

This prospective, randomized, controlled clinical trial was conducted at the Faculty of Dentistry, Cairo University with a triple-arm, parallel-group format. Equal allocation to each group was achieved using simple randomization (1:1:1 ratio). All procedures adhered to the Declaration of Helsinki and were reported in accordance with CONSORT guidelines.

**2.2. Patient Selection**

Participants were enrolled from the outpatient clinic between April 2023 and March 2024. Written informed consent was obtained after explaining all procedures and potential risks. Patients were eligible for inclusion if: 1/over 18 years of age 2/ single non-restorable tooth in the esthetic zone 3/intact buccal plate after extraction 4/class I socket morphology<sup>18</sup>. Patients were excluded if: 1/had any systemic conditions affecting bone healing 2/taking medications with influence on bone metabolism 3/having active periodontal disease.

**2.3. Sample Size Determination**

The present study aimed to evaluate esthetic and patient-centered outcomes following ARP using three different forms of ATDGs (UDD, IDDM, and FDDM)

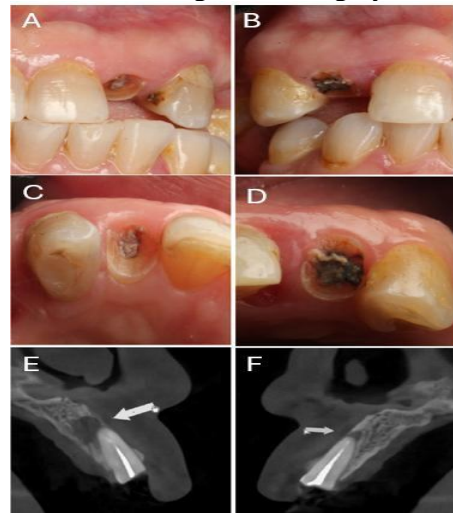
in the esthetic zone. The primary outcome was postoperative patient satisfaction, assessed using a standardized questionnaire. Based on previous studies evaluating satisfaction levels following ARP with ATDGs<sup>19</sup>, a moderate effect size was anticipated. Assuming a Cohen’s *d* of approximately 0.8, the corresponding effect size for ANOVA (Cohen’s *f*) was estimated to be 0.40. A sample size calculation was performed using G\*Power software (version 3.1.9.7; Heinrich Heine University, Düsseldorf, Germany), applying a one-way ANOVA with three groups, a type I error ( $\alpha$ ) of 0.05 and a statistical power (1- $\beta$ ) of 0.80. The required sample size was calculated to be 30 participants, with 10 per group. This group size was deemed adequate for detecting moderate differences in patient satisfaction while maintaining clinical feasibility and minimizing participant burden.

**2.4. Randomization and Blinding**

A computer-generated sequence was used to allocate patients in three groups: Group A= UDD, Group B= IDDM, and Group C= FDDM. An independent researcher handled the allocation using sealed envelopes (M.A.). Blinding the principal investigator was not feasible due to direct involvement in graft preparation.

**2.5. Preoperative Preparation**

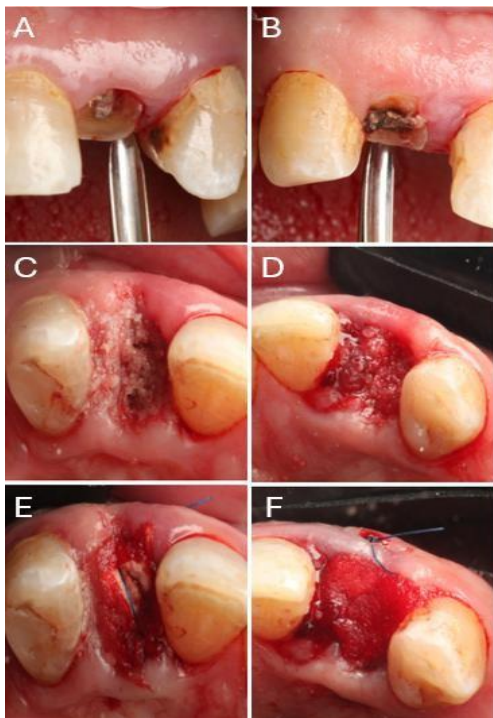
Initial assessment included detailed review of medical and dental histories, clinical examination, and cone beam computed tomography (CBCT) imaging to document socket anatomy and confirm eligibility (Figure 1). All patients received hygiene instructions and professional cleaning before surgery.



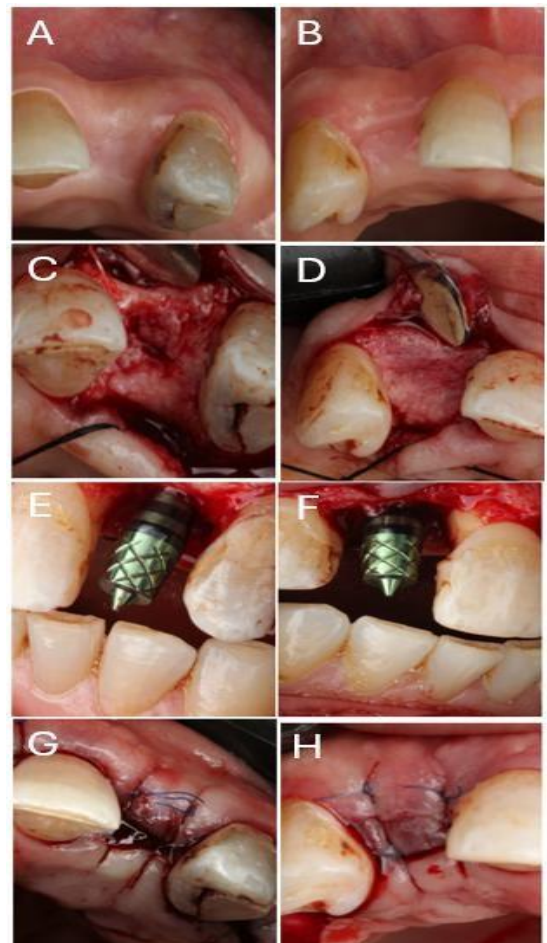
**Figure 1.** (A, B) Frontal intraoral views showing non-restorable remaining roots of the upper left and right lateral incisors. (C, D) Occlusal views confirming the compromised condition of both lateral incisors. (E, F) CBCT sagittal sections revealing periapical infection with thin labial plates at both sites.

**2.6. Surgical Protocol**

All surgical procedures were performed by a single operator under aseptic conditions with supervision. Atraumatic, flapless extraction was carried out under local anesthesia (4% Articaine with Epinephrine), followed by thorough socket debridement. Extracted teeth were processed into particulate grafts after cleaning and pulp removal. The following protocols were applied: UDD: Soaked in a mixture of 0.5M sodium hydroxide (NaOH) and 30% ethanol for 10 minutes, IDDM: Soaked in 2% nitric acid (HNO3), and FDDM: Soaked in 0.6N hydrochloric acid (HCl) for complete demineralization. All particles were rinsed in saline, dried, and used for grafting. Sockets were sealed with a collagen sponge and stabilized with 5-0 polypropylene cross-mattress sutures (Figure 2). After a healing period of four months, dental implants (NeoBiotech Co., Ltd., Seoul, South Korea) were placed following a standardized surgical protocol under local anesthesia (Figure 3). Two months later, definitive screw-retained monolithic zirconia crowns were placed.



**Figure 2.** (A, B) Atraumatic extraction performed using a small straight elevator with a wedging motion. (C, D) Occlusal views of the extraction sockets following placement of dentin grafts (UDD and FDDM, respectively). (E, F) Occlusal views showing placement of a collagen sponge over the grafted sites, stabilized using cross-mattress sutures.



**Figure 3.** (A, B) Occlusal views of healed ridges at 4 months post-extraction. (C, D) Full-thickness flap elevation performed using a Buser elevator. (E, F) Checking implant positions using trial abutments. (G, H) Final closure achieved with simple interrupted sutures.

**2.7. Postoperative Care**

Antibiotics (Amoxicillin-clavulanate or Azithromycin) and Ibuprofen were prescribed, alongside 0.12% chlorhexidine rinse. Sutures were removed after two weeks.

**2.8. Study Outcomes**

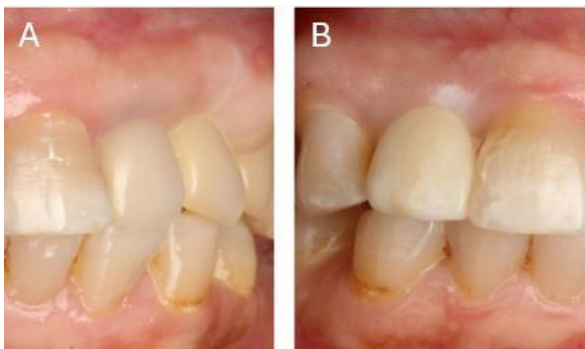
**2.8.1. Postoperative Patient Satisfaction**

Patient satisfaction was assessed immediately after the surgical procedure on the day of extraction. Each participant was asked three standardized questions: (1) whether they were satisfied with the treatment provided, (2) whether they would undergo the procedure again, and (3) whether they would recommend the treatment to others. Responses were recorded as either “yes” or “no” for each item. The cumulative responses were used to categorize overall satisfaction as low (0–1 “yes” responses), moderate (2 “yes” responses), or high

satisfaction (all 3 “yes” responses), as previously described by<sup>20</sup>.

**2.8.2. Esthetic Evaluation Using the Pink Esthetic Score**

Esthetic outcomes were evaluated six months after final crown delivery using the PES, which provides a structured assessment of the peri-implant soft tissue appearance (Figure 4). Standardized clinical photographs were obtained and independently reviewed by two calibrated evaluators who were blinded to group allocation (M.A. and M.T.). The PES system assesses seven soft tissue parameters around implant restorations: mesial papilla, distal papilla, curvature of the facial mucosa, level of the facial mucosa, alveolar process deficiency, soft tissue color, and soft tissue texture. Each parameter is scored from 0 to 2, with a maximum total score of 14. Higher scores indicate superior esthetic integration of the peri-implant soft tissues. Any discrepancies in scoring were resolved through discussion to reach a consensus. The resulting scores were used for intergroup comparisons to determine the esthetic effectiveness of the different graft materials.



**Figure 4.** Final screw-retained zirconia crowns 6 months after crowns delivery. Standardized frontal views were obtained for PES evaluation to assess per-implant soft tissue esthetics. (A) UDD group with PES of 12 (B) FDDM group with PES of 11

**2.9. Statistical Analysis**

Data analysis was performed using IBM SPSS Statistics version 28.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation (SD) and median with interquartile range (IQR). Categorical variables were reported as frequencies and percentages. Normality of continuous data was assessed using the Shapiro-Wilk test. One-way analysis of variance (ANOVA) was used to compare means among the three graft groups for normally distributed variables, while the Chi-square or Fisher’s exact test was applied for categorical comparisons, as

appropriate. Interobserver reliability was evaluated using the intraclass correlation coefficient (ICC), which yielded an ICC value of 0.91, indicating excellent agreement. A two-sided P-value of less than 0.05 was considered statistically significant.

**3. RESULTS**

**3.1. Demographic and Baseline Characteristics**

A total of 30 patients (10 per group) requiring single-tooth extraction in the esthetic zone were recruited and randomly allocated to receive ARP using UDD, IDDM, or FDDM. The mean age of participants was 38.3 ± 7.83 years, with no statistically significant differences among the three groups (P = 0.472). Gender distribution included 3 males and 7 females in the UDD group, 4 males and 6 females in the IDDM group, and 5 males and 5 females in the FDDM group, with no significant intergroup variation (P = 1.000).

Extracted tooth types, including incisors, canines, and premolars, were similarly distributed among the groups (P = 0.623; Table 1).

**Table 1.** Demographic and Baseline Characteristics of Study Participants (n=30)

Characteristic	UDD (n=10)	IDDM (n=10)	FDDM (n=10)	P-value
Age (years), mean ± SD	39.8 ± 8.65	36.2 ± 7.96	38.8 ± 6.65	0.472
Gender, n (%)				1.000
-Male	3 (30.0%)	4 (40.0%)	5 (50.0%)	
-Female	7 (70.0%)	6 (60.0%)	5 (50.0%)	
Tooth type, n (%)				0.623
-Incisor	4 (40.0%)	3 (30.0%)	5 (50.0%)	
-Canine	1 (10.0%)	1 (10.0%)	0 (0.0%)	
-Premolar	5 (50.0%)	6 (60.0%)	5 (50.0%)	

Abbreviations: UDD= undemineralized dentin, IDDM= incompletely demineralized dentin matrix, FDDM= Fully demineralized dentin matrix, and SD= standard deviation

**3.2. Patient Satisfaction**

All participants completed the postoperative satisfaction questionnaire on the day of extraction. Based on cumulative responses to the three standardized questions, satisfaction levels were categorized as low, moderate, or high. In the UDD group, 8 patients (80.0%) reported high satisfaction, 1 patient (10.0%) reported moderate satisfaction, and 1 patient (10.0%) reported

low satisfaction. As for the IDDM group, 6 patients (60.0%) reported high satisfaction, 3 patients (30.0%) reported moderate satisfaction, and 1 patient (10.0%) reported low satisfaction. Whereas in the FDDM group, 7 patients (70.0%) reported high satisfaction, 2 patients (20.0%) reported moderate satisfaction, and 1 patient (10.0%) reported low satisfaction. The distribution of satisfaction levels was not significantly different among the three groups ( $P = 0.842$ ; Table 2).

**Table 2.** Postoperative Patient Satisfaction among Study Participants (n=30)

Satisfaction Level	UDD (n=10)	IDDM (n=10)	FDDM (n=10)	P-value
High	8(80.0%)	6 (60.0%)	7 (80.0%)	0.842
Moderate	1(10.0%)	3 (30.0%)	2 (20.0%)	
Low	1(10.0%)	1 (10.0%)	1 (10.0%)	

### 3.3. Pink Esthetic Score

Esthetic outcomes were assessed six months after final crown placement using the PES. The UDD group showed the highest PES of  $12.0 \pm 0.63$ , followed by the IDDM group with  $11.1 \pm 0.57$ , and the FDDM group demonstrated a mean of  $11.0 \pm 0.63$ . Although the UDD group showed a numerically better esthetic outcome, statistical analysis revealed no significant differences in PES among the three groups ( $P = 0.083$ ; Table 3).

**Table 3.** Comparison of Pink Esthetic Score among study participants (n=30)

Group	Mean $\pm$ SD	Median (IQR)	Minimum	Maximum	P-value
UDD	$12.0 \pm 0.63$	12.0 (11.5-12.5)	11	13	0.083
IDDM	$11.1 \pm 0.57$	11.0 (11.0-12.0)	10	12	
FDDM	$11.0 \pm 0.63$	11.0 (10.5-11.5)	10	12	

Abbreviations: IQR= interquartile range

## 4. DISCUSSION

The primary objective of ARP is to reduce post-extraction alveolar bone loss and create favorable conditions for subsequent implant placement. Although there are different types of grafts that are commonly employed in clinical practice, they always have

limitations such as prolonged remodeling periods and low osteoinductive potential<sup>20</sup>. Accordingly, there has been a shift towards autogenous materials like ATDGs. Dentin in particular, shares biological and structural similarities with bone, including the presence of type I collagen, non-collagenous proteins, and growth factors such as BMPs and TGF- $\beta$ , making it an attractive grafting alternative<sup>11</sup>.

This study aimed to evaluate two critical aspects of ARP in the esthetic zone: patient satisfaction and peri-implant soft tissue esthetics, as assessed by the PES. While prior research has predominantly emphasized radiographic and histologic parameters, subjective outcomes such as patient-reported satisfaction and esthetic perception are increasingly recognized as vital components of treatment success<sup>19</sup>.

Patient satisfaction was high across all three groups, with no statistically significant differences. These findings align with prior studies suggesting that ATDGs are well-accepted by patients and are generally associated with favorable healing and minimal morbidity<sup>14,18</sup> also demonstrated high patient acceptance of ATDGs, noting that the use of the patient's own tooth was perceived as both natural and preferable to synthetic or animal-derived substitutes. Furthermore, in a comparative study by<sup>25</sup>, patients who received ATDGs reported higher satisfaction scores than those treated with xenografts, although the difference was not statistically significant which overall supports the results of the current study. The comparable satisfaction rates among groups imply that the degree of dentin demineralization does not substantially affect patient-perceived outcomes during the early postoperative period. This may be attributed to standardized surgical techniques, strict inclusion criteria (systemically healthy non-smokers with intact socket morphology), and the short-term nature of the subjective assessment. In terms of the esthetic outcomes, the PES was evaluated six months after crown delivery, allowing sufficient time for soft tissue maturation. Although the UDD group demonstrated a slightly higher mean PES, the differences among the groups were not statistically significant. These findings are consistent with the concept that all forms of ATDGs provide a suitable scaffold for soft tissue support and integration. Similar PES values have been reported in studies using xenografts and alloplasts. For instance,<sup>21</sup> reported mean PES values of 11.1 in esthetically successful cases following immediate implant placement with xenografts. In a study by<sup>22</sup>, PES values ranged from 9.5 to 12.5 depending on flap design and tissue phenotype. These comparisons suggest that ATDGs perform similar

to conventional graft materials in terms of soft tissue esthetics.

It should be highlighted that only few clinical studies have specifically evaluated PES in the context of ATDGs.<sup>11</sup> reported favorable soft tissue outcomes following their use in ARP, although PES was not directly assessed. In another study), PES values following ARP with ATDGs were comparable to those reported with xenografts and alloplasts, reinforcing the esthetic viability of tooth-derived materials. Thus, the current study provides novel data by directly comparing PES outcomes between different types of ATDGs. The application of PES in this context adds an objective and quantifiable measure to esthetic evaluation, complementing the subjective satisfaction data. This dual assessment provides a deeper understanding of treatment success which is especially important in the esthetic zone.

Despite these promising outcomes, certain limitations must be acknowledged. The sample size, although adequately powered for moderate effects, was relatively small and may not fully reflect broader population variability. Additionally, esthetic outcomes were assessed at a single time point, six months post-restoration, which may not capture long-term tissue stability. Prior studies, such as those by<sup>4</sup> and<sup>26</sup>, highlight the importance of extended follow-ups to assess soft tissue remodeling and midfacial recession. Similarly, satisfaction was only evaluated immediately after the surgical procedure; longitudinal assessment using validated patient-reported outcome measures (PROMs), such as the Oral Health Impact Profile (OHIP) or a visual analog scale (VAS), could better capture evolving patient perceptions over time<sup>23</sup>.

## 5. CONCLUSION

Within the limitations of this study, all three forms of ATDGs demonstrated similarly high levels of postoperative patient satisfaction and favorable esthetic outcomes as measured by the PES following ARP in the esthetic zone. No statistically significant differences were found among the groups regarding satisfaction levels or PES results. These findings suggest that the degree of dentin demineralization does not adversely impact patient-centered or esthetic outcomes. Therefore, graft selection may be guided by clinical judgment and biological factors rather than anticipated differences in patient satisfaction or soft tissue esthetics.

## DECLARATIONS

### Competing interest

The authors declare that there are no competing interests.

### Funding

The work was not funded.

### Ethical Approval

“Not applicable”

### Consent for publication

“Not applicable”

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