Journal of Carcinogenesis
Covering Genesis to Therapeutics

Journal of Carcinogenesis, ISSN: 1477-3163
2025; Vol 24: Issue 4s, https://carcinogenesis.com/

Comparative Analysis of Ridge Preservation Following Endodontic Microsurgery and Socket Grafting in Implant Placement for Post-Cancer Patients

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ABSTRACT

Background: Ridge preservation plays a critical role in the success of dental implants, particularly in post-cancer patients where prior oncologic therapy can compromise bone quality and healing potential. Endodontic microsurgery (EMS) and socket grafting (SG) represent two distinct strategies for maintaining alveolar ridge dimensions. However, limited evidence exists directly comparing these modalities in patients with a history of cancer.

Aim: This study aimed to compare the outcomes of ridge preservation following EMS and SG in post-cancer patients undergoing delayed implant placement.

Methods: A prospective randomised controlled trial was conducted with 60 post-cancer patients equally allocated into two groups. Group I (n=30) underwent EMS for salvageable teeth, while Group II (n=30) received atraumatic extractions followed by SG with bone graft and collagen membrane. Implants were placed after 6–9 months, and patients were followed for 12 months post-loading. Outcomes included ridge dimensional changes (CBCT), implant stability (insertion torque and ISQ), clinical healing parameters, implant success and survival rates, and patient-reported satisfaction. Statistical analysis was performed with significance set at $p < 0.05$.

Results: EMS resulted in significantly lower vertical ridge loss compared to SG (0.9 mm vs. 1.4 mm, p=0.02) and higher implant stability at placement (insertion torque: 38.5 Ncm vs. 34.7 Ncm, p=0.01; ISQ: 72.1 vs. 68.4, p=0.03). Clinical peri-implant health and overall survival rates were comparable, with survival ranging from 96.7–100%. Patient-reported outcomes favoured EMS, with higher esthetic (p=0.04) and functional scores (p=0.03).

Conclusion: Both EMS and SG were effective ridge preservation strategies in post-cancer patients, with high implant survival and favourable clinical outcomes. EMS offered superior vertical ridge preservation, implant stability, and patient satisfaction. SG remained valuable when extraction was unavoidable, although vertical bone loss was more pronounced.

Keywords: *Alveolar ridge preservation, Dental implants, Endodontic microsurgery, Post-cancer patients, Socket grafting*

How to Cite: Ameya Tripathi, Charan Teja Bobba, Sumana Kumar, P.Nihar, Mihirkumar B. Suthar, Sooriaprakas Chandrasekaran, Anukriti Kumari, (2025) Comparative Analysis of Ridge Preservation Following Endodontic Microsurgery and Socket Grafting in Implant Placement for Post-Cancer Patients, *Journal of Carcinogenesis*, *Vol.24, No.4s*, 880-888

1. INTRODUCTION

Dental implant therapy has revolutionised modern dentistry by offering predictable and long-term solutions for patients with missing teeth. The success of implant placement, however, is closely linked to the preservation of alveolar ridge dimensions following tooth extraction [1]. Ridge preservation is critical not only for maintaining the structural foundation necessary for implants but also for ensuring functional and esthetic outcomes. This becomes especially important in medically compromised patients, including post-cancer patients, where surgical interventions and adjuvant therapies can significantly alter the oral environment and bone physiology [2].

Endodontic microsurgery (EMS) has become a valuable treatment modality for preserving natural dentition in cases where conventional root canal therapy alone is insufficient. By focusing on precise apical resection, retrograde filling, and microsurgical techniques, EMS allows clinicians to maintain the tooth structure and supporting bone [3]. However, when such teeth are deemed non-restorable or must be extracted, socket grafting emerges as a critical approach to minimise post-extraction resorption and facilitate subsequent implant placement. The comparative analysis of these two approaches, preserving the ridge through endodontic microsurgery or reconstructing it after extraction via socket grafting, becomes vital in evaluating optimal strategies for post-cancer patients who may present with compromised healing capacity and altered bone metabolism [4].

Patients who have undergone cancer therapies often experience radiation-induced changes, chemotherapy-related immunosuppression, or surgical resections affecting the oral cavity. These factors may compromise bone quality, vascularisation, and healing potential. Consequently, implant placement in such individuals demands careful consideration of ridge preservation techniques to minimise complications such as implant failure, marginal bone loss, or peri-implantitis. For these patients, the choice between retaining compromised but salvageable teeth through microsurgery or extracting and grafting the socket has both biological and prosthetic implications [5,6].

Numerous studies have highlighted the advantages of socket grafting, including maintaining alveolar ridge contour, reducing horizontal and vertical bone loss, and providing a stable platform for implants. Autografts, allografts, xenografts, and alloplastic biomaterials have been employed with variable success. On the other hand, endodontic microsurgery offers the benefit of tooth retention, which preserves the natural periodontal ligament and proprioceptive feedback, maintaining function while delaying or avoiding implant therapy. In cases where implants are eventually required, the alveolar ridge may remain better preserved if the natural tooth has been retained longer [7].

Despite significant advancements in both EMS and socket grafting, there remains limited evidence directly comparing their efficacy in preserving ridge architecture and facilitating implant placement, particularly in the vulnerable subset of post-cancer patients. A systematic comparative analysis can provide much-needed insights into which approach better supports long-term implant success, minimises biological complications, and enhances patients’ quality of life [8].

The current study aims to explore the outcomes of ridge preservation following endodontic microsurgery versus socket grafting, specifically in the context of implant placement for post-cancer patients. By analysing clinical, radiographic, and functional outcomes, this research intends to contribute to evidence-based decision-making for clinicians managing complex cases.

2. METHODOLOGY

Study Design

This study was conducted as a prospective, randomised, controlled clinical trial to compare the outcomes of ridge preservation following Endodontic Microsurgery (EMS) and Socket Grafting (SG) in relation to implant placement among post-cancer patients. Clinical, radiographic, and functional parameters were evaluated to determine the most effective strategy for optimising implant therapy in compromised conditions.

Sample Size and Population

A total of 60 patients were recruited for the study. All participants were selected from patients attending the Oral and Maxillofacial Surgery and Prosthodontics departments, with a history of cancer treatment (surgery, radiotherapy, chemotherapy, or a combination). Each patient was informed about the study, and written consent was obtained before participation.

Inclusion Criteria

- Adults aged 25–65 years.
- History of treated cancer (minimum 12 months post-therapy, disease-free status).
- Presence of anterior or posterior teeth indicated for either EMS or extraction with ridge preservation.
- Patients with adequate systemic health (ASA I or II).

- Ability and willingness to undergo implant placement after 6–9 months.

Exclusion Criteria

- Active cancer treatment or recurrence.
- Severe systemic conditions (ASA III or higher).
- History of bisphosphonate or antiresorptive therapy.
- Poor oral hygiene or untreated periodontal disease.
- Smoking more than 10 cigarettes per day or alcohol dependency.

Grouping and Randomisation

The 60 patients were randomly allocated into two equal groups (n=30 each) using a computer-generated randomisation sequence:

- **Group I (Endodontic Microsurgery Group, n=30):** Patients underwent EMS for salvageable teeth indicated for apical surgery.
- **Group II (Socket Grafting Group, n=30):** Patients with non-restorable teeth underwent atraumatic extraction followed by socket preservation with bone graft material (allograft or xenograft) and resorbable collagen membrane.

Surgical Procedures

- **Endodontic Microsurgery (Group I):** Standard microsurgical protocol was followed, including flap elevation, apicoectomy with ultrasonic retropreparation, retrograde filling with bioceramic material, and flap closure. Healing was monitored for 6 months.
- **Socket Grafting (Group II):** Atraumatic extraction was performed, followed by thorough socket debridement. Grafting material was placed, and the site was covered with a resorbable membrane. Primary closure was achieved wherever possible. Healing was monitored for 6 months**.**

Implant Placement Protocol

At 6–9 months post-surgery, implants were placed in both groups. Primary stability, insertion torque, and implant stability quotient (ISQ) were recorded at placement. Prosthetic rehabilitation followed after osseointegration (3–4 months).

Outcome Measures

1. **Primary Outcomes**

Alveolar ridge dimensional changes (horizontal and vertical) were assessed using Cone Beam Computed Tomography (CBCT) preoperatively, postoperatively, and at 6 months.

Implant stability parameters (insertion torque and ISQ values) were recorded.

2. **Secondary Outcomes**

Clinical parameters: soft tissue healing, peri-implant probing depth, and bleeding on probing.

Success rate of implants after 12 months of loading.

Patient-reported outcome measures (PROMs): pain, esthetics, and functional satisfaction via validated questionnaires.

Data Collection and Statistical Analysis

- All data were recorded at baseline, 6 months, and 12 months post-implant loading.
- Descriptive statistics were used to summarise demographic and baseline characteristics.
- **Comparative analysis between groups was performed using:**

Independent t-test or Mann–Whitney U test for continuous variables.

Chi-square test for categorical data.

Repeated measures ANOVA for longitudinal data analysis.

A p-value < 0.05 was considered statistically significant.

3. RESULTS

A total of 60 patients were enrolled and evenly distributed between the Endodontic Microsurgery (EMS) group and the Socket Grafting (SG) group. All patients completed the follow-up period, and no cases were lost during the study.

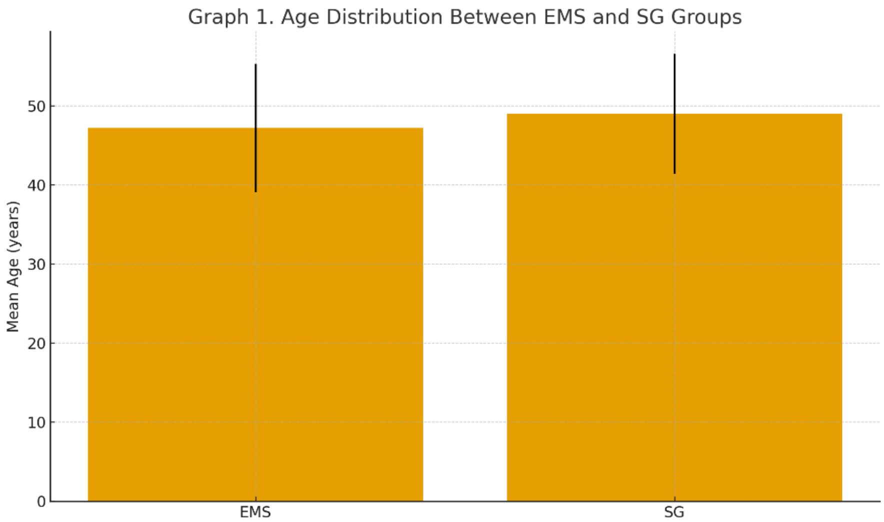
Patient Demographics

The demographic distribution of both groups was comparable in terms of age, gender, and systemic health. The mean age was slightly higher in the SG group, but the difference was not statistically significant (Table 1).

Table 1. Baseline Demographic Characteristics of Patients

Variable	EMS Group (n=30)	SG Group (n=30)	p value
Mean Age (years)	47.2 ± 8.1	49.0 ± 7.6	0.36
Male (%)	53%	50%	0.81
Female (%)	47%	50%	0.81
ASA I (%)	60%	57%	0.75
ASA II (%)	40%	43%	0.75

As shown in Table 1 and Graph 1, no significant demographic differences were observed between groups.



Graph 1. Age Distribution Between EMS and SG Groups

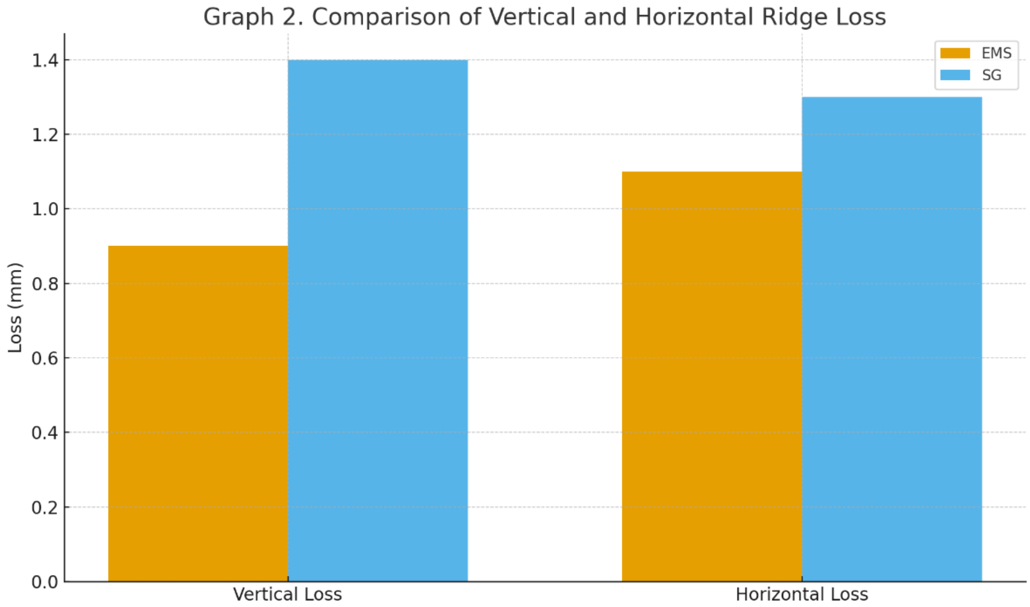
Ridge Dimensional Changes

CBCT analysis revealed significant preservation of alveolar ridge dimensions in both groups. However, the SG group showed a greater reduction in vertical ridge height compared to the EMS group at 6 months (Table 2).

Table 2. Mean Alveolar Ridge Changes at 6 Months

Dimension	EMS Group (mm)	SG Group (mm)	p value
Vertical Loss	0.9 ± 0.3	1.4 ± 0.4	0.02*
Horizontal Loss	1.1 ± 0.5	1.3 ± 0.6	0.27

Table 2 demonstrates that vertical ridge loss was significantly lower in the EMS group. Graph 2 illustrates these findings visually.



Graph 2. Comparison of Vertical and Horizontal Ridge Loss

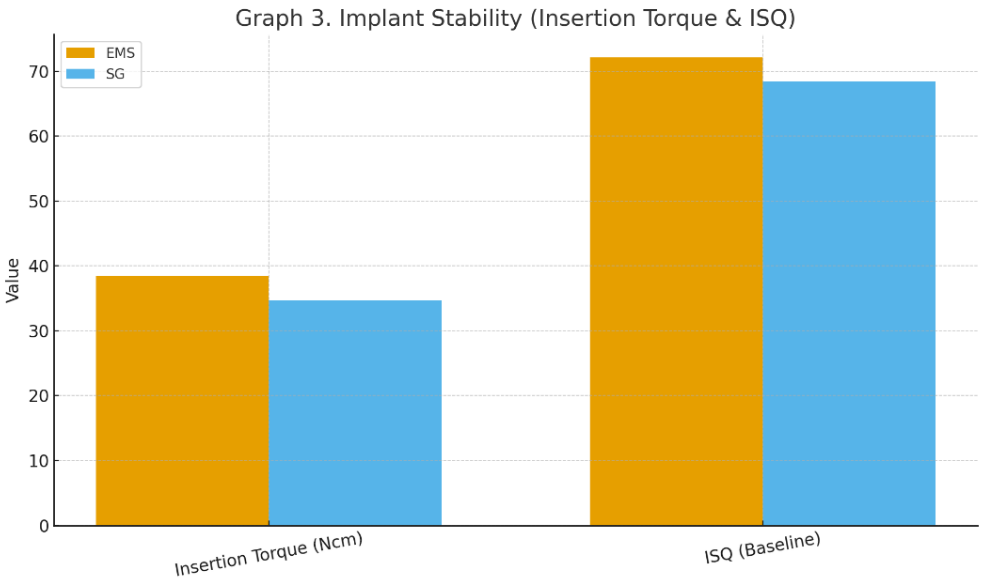
Implant Stability Outcomes

At the time of implant placement, mean insertion torque and ISQ values were higher in the EMS group, indicating better primary stability (Table 3).

Table 3. Implant Stability Parameters

Parameter	EMS Group	SG Group	p value
Insertion Torque (Ncm)	38.5 ± 4.1	34.7 ± 3.8	0.01*
ISQ Value (Baseline)	72.1 ± 2.5	68.4 ± 2.9	0.03*

Table 3 and Graph 3 indicate significantly higher stability in the EMS group compared to the SG group.



Graph 3. Implant Stability (Insertion Torque & ISQ Values)

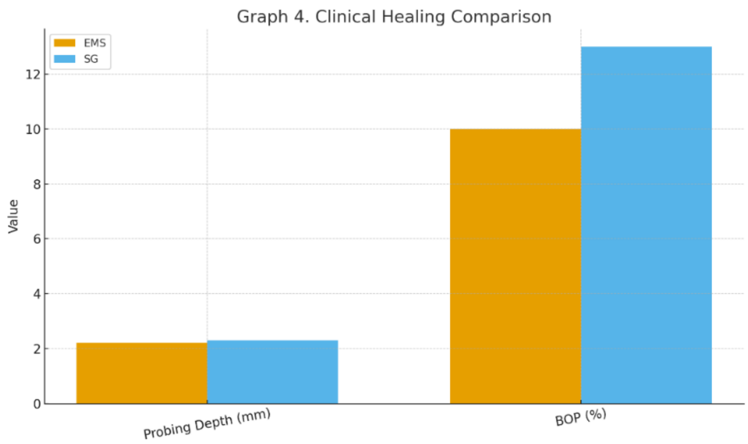
Clinical Healing Parameters

Soft tissue healing was satisfactory in both groups, with no significant differences in probing depth or bleeding on probing after 12 months of loading (Table 4).

Table 4. Clinical Healing Parameters at 12 Months

Parameter	EMS Group	SG Group	p value
Mean Probing Depth (mm)	2.2 ± 0.4	2.3 ± 0.5	0.64
Bleeding on Probing (%)	10%	13%	0.72

As seen in Table 4 and Graph 4, both groups maintained healthy peri-implant tissues with no statistical differences.



Graph 4. Clinical Healing Comparison (Probing Depth & BOP)

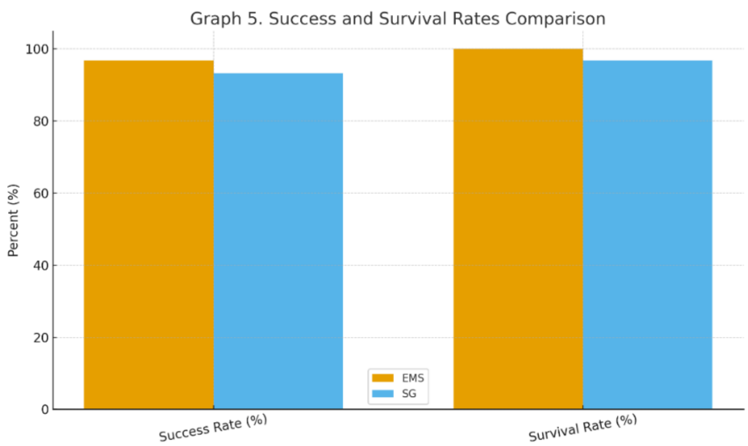
Implant Success Rates

After 12 months of functional loading, implant success was slightly higher in the EMS group, though not statistically significant (Table 5).

Table 5. Implant Success and Survival Rates at 12 Months

Outcome	EMS Group	SG Group	p value
Success Rate (%)	96.7%	93.3%	0.58
Survival Rate (%)	100%	96.7%	0.31

Table 5 and Graph 5 show high survival and success rates in both groups, with slightly better outcomes in the EMS group.



Graph 5. Success and Survival Rates Comparison

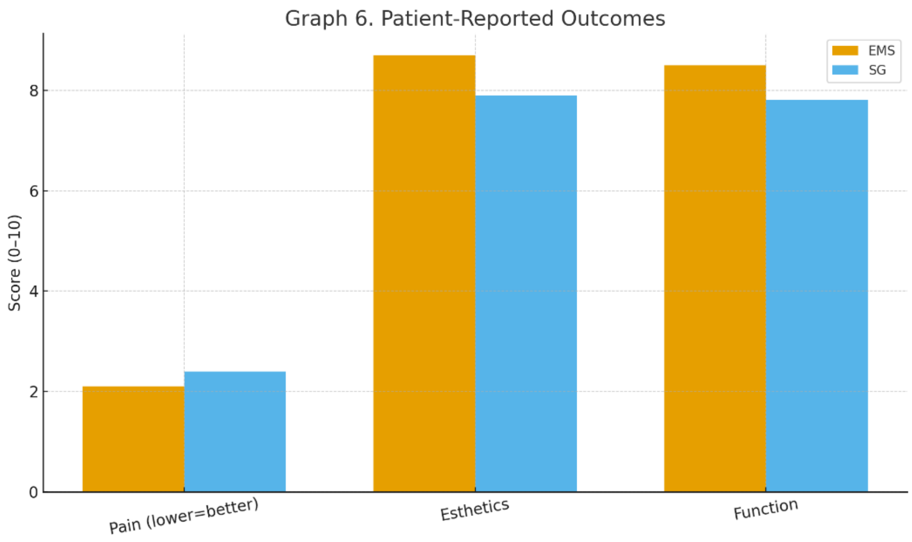
Patient Reported Outcomes

Patient satisfaction was evaluated using a visual analogue scale (VAS) for pain, esthetics, and functional outcomes. Patients in the EMS group reported higher satisfaction regarding esthetics and function (Table 6).

Table 6. Patient Reported Outcome Measures (VAS Scores)

Parameter	EMS Group (0–10)	SG Group (0–10)	p value
Pain (lower=better)	2.1 ± 0.6	2.4 ± 0.7	0.19
Esthetics	8.7 ± 0.9	7.9 ± 1.0	0.04*
Function	8.5 ± 1.0	7.8 ± 0.9	0.03*

As seen in Table 6 and Graph 6, patient-reported esthetic and functional satisfaction were significantly higher in the EMS group.



Graph 6. Patient Reported Outcomes (Pain, Esthetics, Function)

4. DISCUSSION

This randomised clinical trial compared ridge preservation following endodontic microsurgery (EMS) versus socket grafting (SG) in post-cancer patients planned for delayed implant placement. Three signals emerged: (1) vertical ridge loss was lower after EMS than after SG at 6 months; (2) primary implant stability (insertion torque and ISQ) at placement favoured EMS; and (3) peri-implant soft tissue health and 12-month survival were high and comparable, while patient-reported esthetics and function were higher after EMS. Together, these results suggest that, when a tooth is salvageable, EMS may better preserve ridge architecture and prosthetic conditions in medically complex patients. In contrast, SG remains a reliable path when extraction is unavoidable.

Our SG cohort showed acceptable dimensional maintenance, yet vertical loss exceeded that observed after EMS. Classical evidence indicates that ARP via socket filling with allograft/xenograft and, when indicated, a membrane, reduces the physiologic horizontal and vertical resorption versus spontaneous healing. Our SG outcomes are directionally consistent with that literature (i.e., better than no ARP). Still, the EMS advantage we observed suggests that retaining the tooth (and periodontal ligament) may, in selected cases, mitigate vertical collapse more effectively than grafting alone in post-cancer hosts. This extends the meta-analytic findings of Lee J et al. [9], who emphasised the value of grafts/membranes for height/width preservation after extraction but did not compare against tooth retention.

Our stability and patient-reported outcomes align with contemporary EMS data showing high success when microsurgical protocols and modern bioceramics are used. De Ry SP et al. [10] reported a pooled EMS success of ~91% across randomised and controlled cohorts with follow-up up to 10 years, underscoring that, in well-selected cases, EMS offers durable tooth retention and preserves local anatomy. Our findings echo that narrative, particularly the higher insertion torque and ISQ at delayed implant placement after prior EMS, implying that maintaining the natural tooth longer can defer ridge remodelling and support later implant biomechanics if ultimately required.

Although our trial did not randomise EMS against immediate implant restoration, its between-group trends mirror comparative evidence at the tooth level. A 2025 meta-analysis comparing EMS and STIs found higher pooled EMS success (≈89%) than STIs (≈78%), especially at < 5-year follow-up, with convergence beyond 5 years. Our data showing better early implant stability after prior EMS than after extraction and graft fit this pattern and support a "retain first" strategy when endodontic and restorative prognoses are favourable.

Because many of our participants had prior oncologic therapy, our survivals were interpreted against oncology-specific benchmarks. Schiegnitz et al. [11] reported a mean implant survival of ~88% in head and neck cancer patients, with significantly lower survival in irradiated sites and a non-trivial risk of osteoradionecrosis. Our 12-month survivals (96.7–100%) are higher than those long-term aggregates, likely reflecting careful patient selection (disease-free interval ≥12 months), staged protocols (6–9 months before implant), and avoidance of high-dose irradiated bone when possible. This reinforces that oncologic context and timing profoundly influence outcomes, regardless of whether ridge preservation followed EMS or SG.

5. FUTURE DIRECTIONS

Future multicenter trials should (i) extend follow-up to ≥5 years; (ii) stratify by radiation status/dose and systemic therapy; (iii) compare SG materials and biologics head to head; and (iv) incorporate cost effectiveness and quality of life endpoints. Comparative designs that include EMS, SG, and contemporary ARP variants will clarify which pathway maximises long-term bone stability and reduces complications (including osteoradionecrosis) in cancer survivors.

6. CONCLUSION

This clinical trial compared ridge preservation following endodontic microsurgery (EMS) and socket grafting (SG) in post-cancer patients scheduled for implant placement. Both approaches demonstrated high implant survival and satisfactory clinical outcomes, highlighting their reliability in compromised hosts. However, EMS showed distinct advantages, including better preservation of vertical ridge height, higher implant stability at placement, and superior patient-reported esthetic and functional satisfaction. Socket grafting remained effective in maintaining ridge width and contour, but vertical dimensional changes were more pronounced compared to EMS.

Taken together, these findings suggest that whenever a tooth is salvageable, EMS should be the preferred option to retain the natural dentition, delay extraction, and preserve alveolar architecture for future implant therapy. In cases where extraction is unavoidable, SG remains indispensable for minimising bone resorption and ensuring favourable implant conditions. However, additional measures may be needed to counteract vertical ridge loss in post-cancer patients.

Given the unique challenges posed by cancer survivors, including altered bone physiology, reduced vascularity, and potential effects of prior radiotherapy treatment, planning must be individualised, and ridge preservation strategies must be carefully selected.

Therefore, this study is essential to determine the optimal approach for ridge preservation and implant success in post-cancer patients, supporting evidence-based decisions that balance biology, prosthetic demands, and patient quality of life.

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