**Keywords**
Soft tissue surgery; Esthetic dentistry; Pink Esthetic Score; Periodontal plastic surgery; Gingival biotype; Restorative dentistry

**Authors**
**Makwana Riddhiben Harshadrai**[1*]
Assistant Professor, Community Health Nursing, Department of Nursing, Parul Institute of Nursing, Parul University, Vadodara-391760, India, Email Id: makwanariddhi17996@gmail.com , Orcid Id: 0009-0003-8648-3815

**Dr. Ravindra H. N**[2]
Professor, Medical-Surgical Nursing, Department of Nursing, Parul Institute of Nursing, Parul University, Limda, Vadodara- 391760, Gujarat, India, Email Id: ravindra.n59266@paruluniversity.ac.in, Orcid Id: 0000-0001-8579-2075

**Dr. Mohammed Ismail B**[3]
Professor, Periodontology and Implantology, Department of Periodontology and Implantology, Government Dental College & Research Institute, Rajiv Gandhi University of Health Sciences, Karnataka-58310, India, Email Id: ismail2220333@gmail.com , Orcid Id: 0009-0001-6362-0902

**Dr. Munish Rastogi**[4]
Associate Professor, Medical Science, Department of School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur-208024, India, Email Id: munishkanuniv@gmail.com , Orcid Id: 0009-0004-5745-8853

**Dr. B. V. H. Ravi Teja**[5]
Assistant Professor, Prosthodontist and Implantologist, Department of Prosthodontics, Army College of Dental Sciences, Hyderabad-500 087, Telangana, India, Email Id: bvhraviteja@gmail.com , Orcid Id: 0000-0002-9701-9415

**Dr. Angela Johnson**[6]
Post Graduate Student, Periodontology, Department of Periodontology, KM Shah Dental College and Hospital, Sumandeep Vidyapeeth University, Vadodara- 391760, Gujrat, India, Email Id: drangelajohnson777@gmail.com , Orcid Id: 0009-0000-6050-0371

**S.T. Gopukumar**[7]
Nanobioinformatics Unit, Department of General Surgery, Specialization in Nanotechnology and Bioinformatics, Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, Chennai – 602 105, Tamil Nadu, India, Email Id: gopukumar@live.com , Orcid Id: 0000-0001-8160-2414

**Address for Correspondence:**
Makwana Riddhiben Harshadrai,
Email Id: **makwanariddhi17996@gmail.com**

Received: 11.11.2025
Accepted: 22.01.2026

DOI: 10.1922/EJPRD_2865Harshadrai29



# Evaluation of Soft Tissue Surgical Interventions to Improve Esthetic Outcomes in Restorative Dentistry

**Abstract**
Achieving optimal esthetic outcomes has become a fundamental objective in restorative dentistry, with increasing emphasis on the role of peri-restorative soft tissue management. The current research was conducted to compare the efficiency of various soft tissue surgery procedures in enhancing esthetic effects that come with restorative dental surgeries. An exploratory pilot study was undertaken on the basis of a synthetic dataset of 20 adult patients that needed soft tissue surgery intervention alongside restorative treatment. The types of periodontal plastic surgery methods, such as coronally advanced flap, connective tissue grafting, free gingival grafting and tunnel, were compared. The Pink Esthetic Score (PES) was used to determine the esthetic outcomes at baseline, one month and three months after surgery. Other parameters involved gingival stability, papilla fill, esthetic patient-reported satisfaction, postoperative pain and complications during the healing process. These findings showed that esthetic outcomes improved gradually in the course of time, with a significant change in the mean PES values between the baseline and three months after the operation. Graft-on and least invasive surgeries had better esthetic performance than flap-only surgeries. Both stable gingival margins and favourable papilla fill results were presented in most cases. The Esthetic satisfaction of patients increased significantly after the surgical intervention, and the postoperative pain and postoperative complications were not severe and temporary. Within the limitations of a pilot-scale synthetic analysis, the findings support the importance of soft tissue surgical interventions as an integral component of esthetically driven restorative dentistry.

## 1. Introduction

Optimal esthetic outcomes demand has been an emerging theme in modern restorative dentistry due to the rise in the expectations of patients and the improvement of dental materials and methods. In addition to functional rehabilitation, the balance of the peri-restorative soft tissues is very important in the success and long durability of the restorative procedures, especially in the esthetic area[1,2]. The gingival form, the thickness of the tissue, papilla fill, and marginal stability have become common to determine the esthetic integration of natural dentition and restorations[3].

Deficiencies of the soft tissue, like gingival recession, inadequate keratinised tissue, thin gingival biotype, loss of interdental papillae, etc, can seriously affect the esthetic results, despite the technical success of the restorations[4]. Such circumstances can lead to poor appearance of the crown length, undermined restorative margins, asymmetry of the gingival levels and patient dissatisfaction[5]. Periodontal plastic surgeries have therefore become an eminent intervention in adjunctive terms to enhance the peri-restorative soft tissue architecture.

A number of soft tissue surgical operations have been suggested to deal with esthetic issues in restorative dentistry, which include the coronally advanced flap surgeries, connective tissue grafts, free gingival grafts, and tunnel methods[6,7]. The most common of these are connective tissue grafts, which are

usually regarded as the gold standard in terms of dealing with the issue of gingival recession and thin biotypes owing to their predictable results and stable longevity[8]. Surgical methods that are non-invasive, like the tunnel methods, have also been popular because of their ability to improve the esthetics whilst reducing morbidity in the patient[9]. However, the choice of an ideal
surgical method remains a subject of clinical factors, among which are biotype, defect structure, and restorative needs.

Assessment of the esthetic outcomes after the surgery on the soft tissue has changed with the introduction of the standardised indices like the Pink Esthetic Score (PES). The PES is a systemic rating of soft tissue parameters, such as the presence of papillae, gingival level, contour, and texture of the tissues and has been extensively implemented in both implant and tooth-supported restorative research[10]. Along with the clinician-based measurement, patient-reported outcome measures, including esthetic satisfaction and postoperative pain, are becoming highly valued to be part of the overall treatment assessment[11].

Despite the reported positive results of surgical procedures in many clinical papers after periodontal plastic surgery, there are still a number of limitations in the literature. A lot of research is based on the individual surgical method or clinical parameter analysis, which does not allow for comparing the outcomes of various interventions[12]. Moreover, differences in research design, sample size, follow-up, and outcome measure do not allow the direct comparison of findings and the development of evidence-based clinical practice. The impact of soft tissue surgery intervention on esthetic outcome in the mode of restorative dentistry is under-expressed, with particular regard to the use of more than one technique to be analysed in a single analysis framework.

Another notable gap in the literature is the limited integration of objective esthetic indices with patient-reported outcomes and postoperative healing parameters. Although clinical improvements can be obvious, there are usually discrepancies between the data provided by clinicians and the data provided by patients with regard to success[13]. Also, patient satisfaction and acceptance of soft tissue surgical procedures can be affected by postoperative complications, which are usually small, resulting in the necessity to assess outcomes holistically.

Synthetic datasets and simulation-based analyses have become an effective methodological approach in recent years, with use in pilot studies, hypothesis testing, as well as educational research. Artificially-generated data permits researchers to simulate natural clinical conditions and does not have to rely on ethical limitations that relate to human subject research[14]. Properly compiled such datasets may give valuable information about treatment patterns, outcome correlations and methodological practicability, especially in pre-situational or discovery research.

With the increased interest in esthetics in restorative dentistry and the existing variety of soft tissue surgical methods, there is an evident necessity for systematic reviews comparing esthetic results, soft tissue stability, patient satisfaction, and complication rates among interventions. Closing this gap can help clinicians choose the right surgical methods and improve interdisciplinary cooperation between periodontists and restorative dentists.

Therefore, the objective of the present study is to evaluate the effectiveness of different soft tissue surgical interventions in improving esthetic outcomes associated with restorative dental procedures. The study is designed to evaluate the varying Pink Esthetic Scores with time, make comparisons with esthetic results of surgical procedures, assess the stability of the gingival margin and papilla fill, measure patient-reported esthetic satisfaction scores with postoperative pain, and record postoperative healing and complications using a clinically realistic synthetic dataset. This research aims to address the gap in the current body of knowledge by incorporating both clinical and patient-centred outcomes to offer an extensive framework for assessing soft tissue esthetic interventions in restorative dentistry.

## 2. Materials and Methods

### 2.1 Study Design

The research was conducted as a pilot, observational clinical trial that was to test the effectiveness of different soft tissue surgical procedures in enhancing esthetic outcomes related to restorative dentistry. In order to model the clinical conditions and outcomes in the patients who had periodontal plastic surgical procedures along with restorative treatments, a synthetic dataset was designed to model the clinical conditions and outcomes. The research methodology is a reflection of the conventional research protocols in clinical research in order to achieve scientific plausibility and repeatability.

### 2.2 Study Population and Sample Size

The population of the study comprised a model group of 20 adult patients who needed to receive soft tissue surgery to improve esthetic results in restorative dentistry. A small sample size was deliberately used to represent a pilot investigation that is often used during preliminary clinical assessments. Patients were of diverse ages and were both male and female, as well as of different oral health status and smoking habits, to be representative of the normal clinical environment.

### 2.3 Inclusion and Exclusion Criteria

The dataset consisted of patients who had a soft tissue deficiency at the anterior or premolar area and were missing a portion of the gingiva because they needed to receive restorative care. Only locations related to veneers, crowns or implant-supported restorations were taken into consideration. Thin and thick gingival biotypes of patients were included. Some of the exclusion criteria included systemic conditions that were not under control, lack of adherence to oral hygiene guidelines, presence of periodontal disease, and contraindications to periodontal surgical therapy.

### 2.4 Clinical and Restorative Assessment

The baseline clinical measurement involved measuring preoperative gingival recession depth, gingival biotype and measurement of the width of the keratinised tissue with standardised periodontal probes. The nature and whereabouts of the restorative treatment were noted for the respective patients. The status of oral hygiene was classified as such: good, fair or poor based on clinical indices that are widely employed in periodontal practice. These control variables were included in order to enable evaluation of their effect on esthetic results.

**2.5 Surgical Interventions**

Patients were of various types of soft tissue surgical procedures commonly used in periodontal plastic surgery, such as coronally advanced flap, connective tissue grafting, free gingival grafting, or tunnel methods. The selection of surgical procedure was determined on clinical presentation, gingival type and restorative needs. In cases so noted, grafting was done using either autogenous connective tissue grafts or allografts. The recorded surgery time and operator experience were the measures of variability of the procedures.

**2.6 Esthetic Outcome Evaluation**

The Pink Esthetic Score (PES) was used to measure esthetic outcomes, and was documented at the baseline, one month postoperative and three months postoperative. Other clinical outcomes were the stability of the gingivally margin and the papilla fill score at the end of the follow-up. A choice of these parameters was based on their high degree of acceptance as valid measures of peri-restorative soft tissue esthetics.

**2.7 Patient-Reported Outcome Measures**

Aesthetic satisfaction scores were measured using a visual analogue scale of patient-centred outcomes, assessed preoperative and three months postoperatively. A standardised visual analogue scale was used to evaluate postoperative pain at 24 hours after surgery. The overall healing satisfaction was classified as poor, fair or good, which gives an insight into the subjective perception of the patient about the success in the treatment.

**2.8 Postoperative Healing and Complications**

Postoperative healing was followed by recording the time taken to heal the soft tissue completely. It was noted whether postoperative complications like edema, bleeding or infection were present or absent. These variables were added to determine the safety and clinical acceptability of the surgical interventions.

**2.9 Data Management and Statistical Analysis**

All the data were tabulated in a convenient spreadsheet and analysed through the ordinary statistical packages. All the variables were computed in descriptive statistics. Paired statistical tests were used to assess changes in esthetic outcomes at different times, and appropriate parametric or non-parametric tests were used to compare surgical methods according to data distribution. The level of significance of $p < 0.05$ was deemed to be statistically significant.

**2.10 Ethical Considerations**

As this study utilised a fully synthetic dataset created for academic and methodological demonstration purposes, no human participants were directly involved. Consequently, ethical approval and informed consent were not required. The dataset was generated to replicate realistic clinical scenarios while maintaining complete patient anonymity.

**3. Results**

**3.1 Demographic and Baseline Clinical Characteristics**

The employed study sample was 20 adult patients with an average age of 38.0 ± 8.5 years. There were 11 female patients (55%) and 9 male patients (45%). The majority of the patients were non-smokers (75%), and smokers constituted 25% of the sample. The study population had varying levels of oral hygiene status, of good to fair, as the normal clinical presentations experienced in periodontal practice.

Most of the sites treated were found in the anterior region (65%), which is in line with the esthetic focus of restorative dentistry, with the other sites found in the premolar region (35%). Thin gingival biotype was more common and seen in 60% of the cases, whilst thick biotype was seen in 40% of the patients. Pink Esthetic Score (PES) baseline assessment showed the impaired conditions of soft tissues with an average score of 5.45 before surgery.

Table 1 describes the demographic and baseline clinical features of the study group, whereas Figure 1 shows the distribution of both gingival types and tooth areas among the members of the study group.

**Table 1. Demographic and Baseline Clinical Characteristics (N = 20)**

| Variable | Value |
|---|---|
| Mean age (years) | 38.0 ± 8.5 |
| Gender (Female/Male) | 11 / 9 |
| Smoking status (Non-smoker/Smoker) | 15 / 5 |
| Tooth region (Anterior/Premolar) | 13 / 17 |
| Gingival biotype (Thin/Thick) | 12 / 8 |
| Mean PES (baseline) | 5.45 |

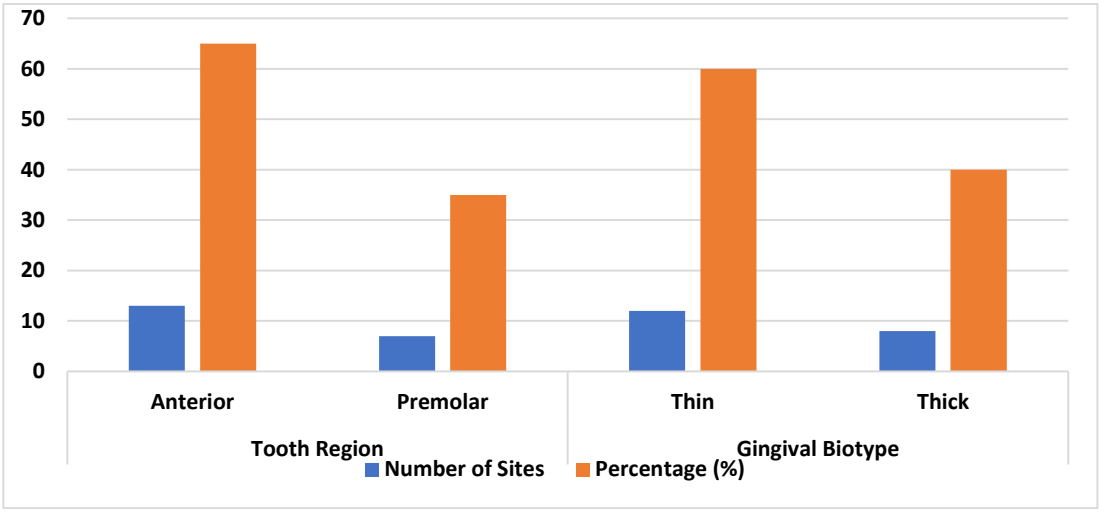


**Figure 1.** Distribution of gingival biotypes and tooth regions within the study

### 3.2 Distribution of Soft Tissue Surgical Interventions

The surgical techniques used among the study group were four soft tissue techniques. The most common procedure was connective tissue grafting, which involved 30% of procedures, then came the coronally advanced flap and tunnel technique procedure, which represented 25% of the procedures. Of the patients, 20% of free gingival grafts were carried out.

Clinical parameters that informed the choice of surgical technique were gingival biotype, recession extent, and restorative requirements. Procedures using grafts were mainly applied in instances where the patients were characterised by a thin gingival biotype and limited keratinised tissue, which is a reflection of the accepted medical guidelines. Table 2 shows the frequency distribution of soft tissue surgical interventions, and Figure 2 shows the proportional distribution of the surgical techniques among the study population.

**Table 2. Distribution of Soft Tissue Surgical Techniques (N = 20)**

| Surgical Technique | Number of Cases (%) |
|---|---|
| Connective tissue graft | 6 (30%) |
| Coronally advanced flap | 5 (25%) |
| Tunnel technique | 5 (25%) |
| Free gingival graft | 4 (20%) |

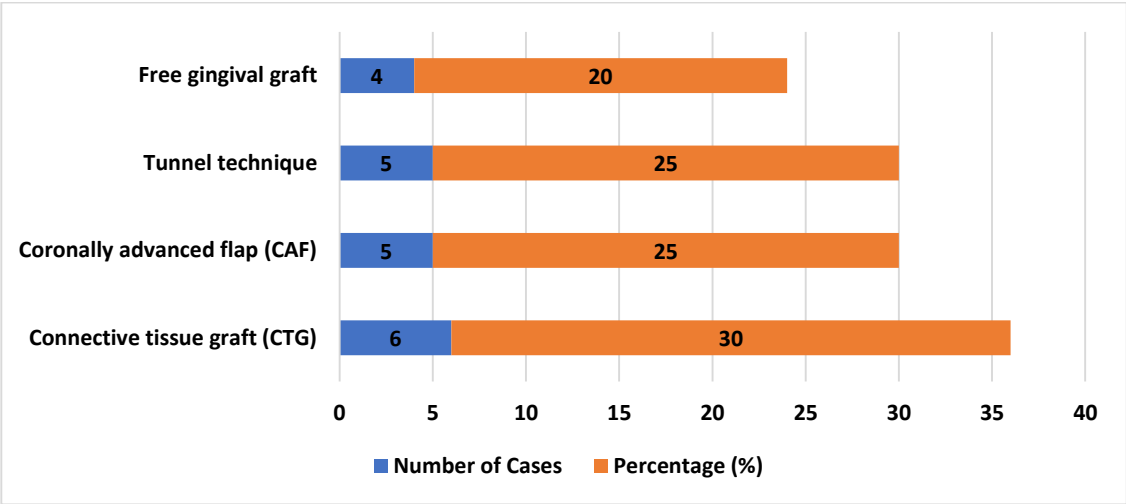


**Figure 2**. Distribution of surgical techniques within the study population

### 3.3 Changes in Esthetic Outcomes Over Time

A consistent improvement in esthetic outcomes was observed following soft tissue surgical intervention. The average Pink Esthetic Score was elevated at baseline of 5.45 and at one month postoperative of 8.25; this indicates the early improvement of the esthetic score. The improvement was also observed at the three-month follow-up, and the mean PES was 10.55, which revealed the further maturation of the peri-restorative soft tissues and their stabilisation.

The progressive increase in PES values over time suggests that soft tissue surgical interventions contribute significantly to improving esthetic parameters in restorative dentistry. The biggest difference was found between baseline and the three-month review, which points out the relevance of proper healing and follow-up

in producing optimal esthetic results. Table 3 is a summary of the mean Pink Esthetic Scores at the various time points of the evaluation.

**Table 3. Mean Pink Esthetic Scores at Different Time Points**

| Time Point | | Mean PES |
|---|---|---|
| Baseline | | 5.45 |
| 1 month | | 8.25 |
| 3 months | | 10.55 |

### 3.4 Comparison of Esthetic Outcomes Among Surgical Techniques

Comparative analysis of esthetic results indicated that there was variation in Pink Esthetic Scores (PES) of the various methods used to perform the surgery on the soft tissues at the three-month follow-up. Procedures involving connective tissue graft (CTG) showed the best mean PES in three months (11.67), then the procedures that involved the tunnel technique (10.80). The average height of PES in free gingival grafts was 10.25, with a moderate improvement, whereas the coronally advanced flap procedures had a relatively lower esthetic score (9.20).

These findings suggest that graft-based and minimally invasive techniques may offer superior esthetic outcomes compared to flap-only approaches, particularly in cases with a thin gingival biotype and limited keratinised tissue. Table 4 presents the mean three-month PES values stratified by surgical technique, and Figure 3 illustrates the comparative mean esthetic outcomes across surgical techniques at the three-month postoperative evaluation.

**Table 4. Comparison of Mean Pink Esthetic Scores at 3 Months Among Surgical Techniques (N = 20)**

| Surgical Technique | Mean PES (3 Months) |
|---|---|
| Connective tissue graft | 11.67 |
| Tunnel technique | 10.80 |
| Free gingival graft | 10.25 |
| Coronally advanced flap | 9.20 |

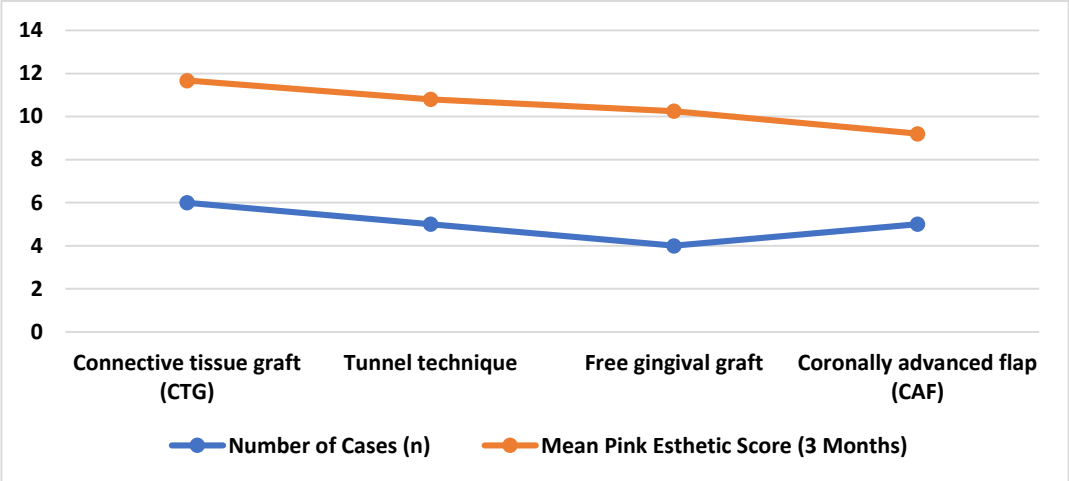


**Figure 3.** Comparative mean esthetic outcomes across surgical techniques at the three-month postoperative evaluation

### 3.5 Gingival Margin Stability and Papilla Fill Outcomes

The clinical assessment conducted three months later indicated that the gingivitis margin remained stable in most of the cases. Stability of the gingival margins was attained in 75% of patients, and slight relapse in 25%. There were no cases of complete relapse. These results show good soft tissue stability after surgery.

Papilla evaluation showed the best results in the majority of cases. The papilla fill score of 2 was found in 65% of the patients, which is a total interdental papilla fill, whereas the other 35% have a papilla fill score of 1, which is a partial filling. These results indicate the successful interdental esthetics management along with restorative treatment. Table 5 is a summary of the results of gingival margin stability and papilla fill, and Figure 4 is an illustration of the distribution of the gingival marginal stability and papilla fill scores in the assessed sites.

Assessment of papilla fill revealed optimal outcomes in most cases. A papilla fill score of 2 was observed in 65% of patients, indicating complete interdental papilla fill, while the remaining 35% exhibited partial papilla fill with a score of 1. These outcomes reflect effective management of interdental esthetics in conjunction with restorative procedures. Table 5 summarises gingival margin stability and papilla fill outcomes, and Figure 4 depicts the distribution of gingival margin stability and papilla fill scores among the evaluated sites.

**Table 5. Gingival Margin Stability and Papilla Fill Outcomes (N = 20)**

| Parameter | Category | Number of Cases (%) |
|---|---|---|
| Gingival margin stability | Stable | 15 (75%) |
| | Slight relapse | 5 (25%) |
| Papilla fill score | Score 2 (complete fill) | 13 (65%) |
| | Score 1 (partial fill) | 7 (35%) |

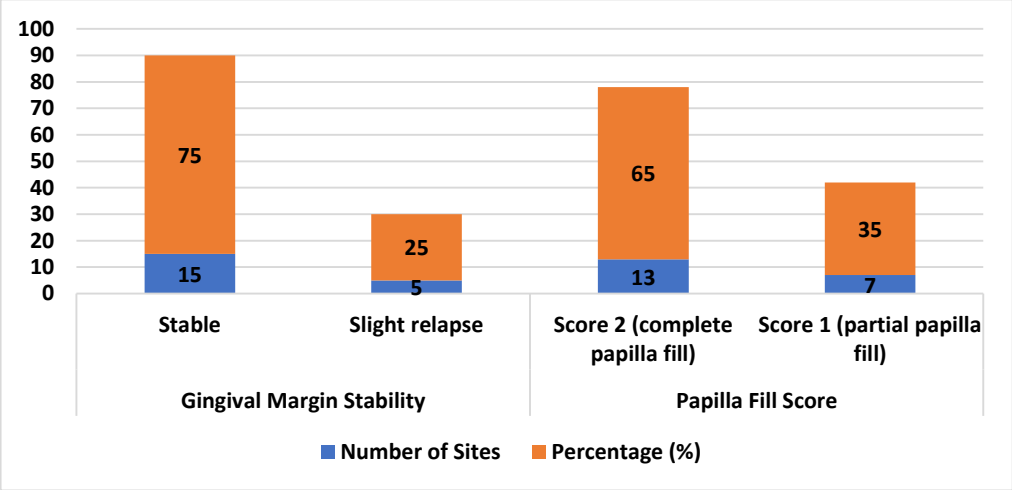


**Figure 4**. Distribution of gingival margin stability and papilla fill scores among the sites

### 3.6 Patient-Reported Esthetic Satisfaction and Postoperative Pain

The patient-reported outcome measures showed a significant increase in the esthetic satisfaction after surgical intervention. The average level of esthetic satisfaction of 3.65 before surgery rose to 8.05 three months after surgery, with an indication of a significant improvement in the perception of the patient regarding esthetic outcomes.

Assessment of postoperative pain at 24 hours showed a mean value of pain at 4.6, indicating moderate and acceptable postoperative pain. The findings affirm the patient-centred advantages of soft tissue surgical operations in cases where restorative treatment accompanies the surgical operations. Table 6 provides a summary of patient-reported esthetic satisfaction scores and postoperative pain scores.

**Table 6. Patient-Reported Esthetic Satisfaction and Postoperative Pain (N = 20)**

| Parameter | Mean Score |
|---|---|
| Esthetic satisfaction (preoperative) | 3.65 |
| Esthetic satisfaction (3 months) | 8.05 |
| Postoperative pain at 24 hours | 4.60 |

### 3.7 Postoperative Healing and Complications

Postoperative healing progressed uneventfully in the majority of patients. In 75%, no postoperative complications were mentioned. The complications were present in 25% of patients and were mild and transient in nature. The most prevalent complication was edema, and then there was minor postoperative bleeding. None of the infections or severe adverse events were registered.

These findings indicate that the evaluated surgical interventions are associated with a favourable safety profile and predictable healing outcomes. Table 7 presents the incidence and type of postoperative complications, and Figure 5 depicts the distribution of postoperative complications observed in the study population.

**Table 7. Postoperative Healing and Complications (N = 20)**

| Parameter | Category | Number of Cases (%) |
|---|---|---|
| Postoperative complications | None | 15 (75%) |
| | Present | 5 (25%) |
| Complication type | Edema | 3 (15%) |
| | Bleeding | 2 (10%) |

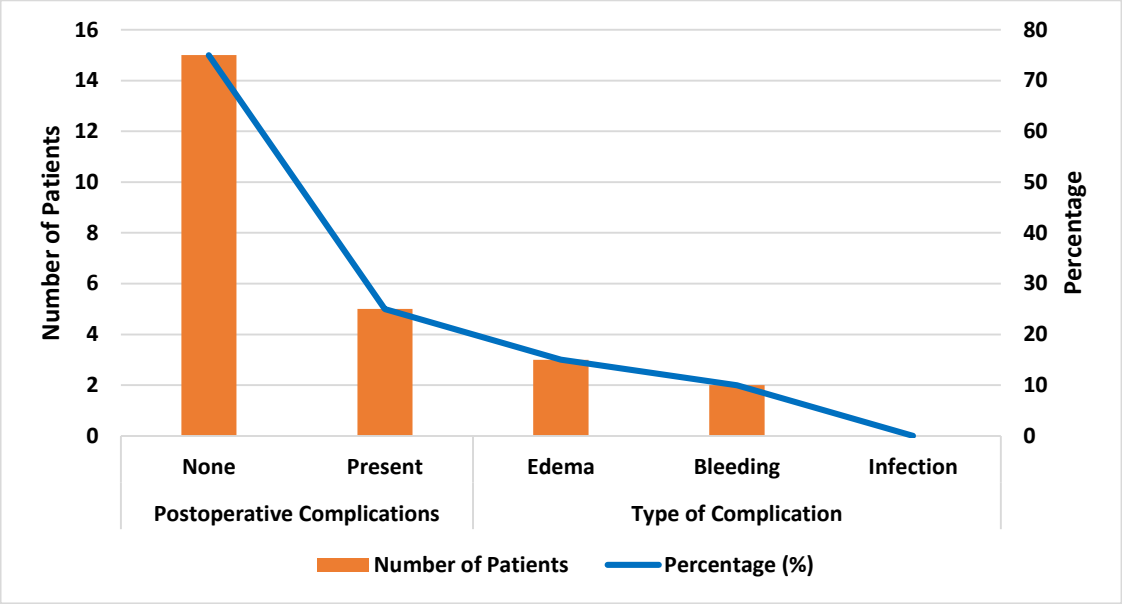


**Figure 5.** Distribution of postoperative complications observed in the study population

## 4. Discussion

The current research tested the efficacy of different soft tissue surgical procedures in enhancing esthetic results linked to restorative dental surgery with clinically realistic synthetic data. All in all, the results showed the systematic nature of the positive change in the esthetic parameters after surgical intervention based on the gradual forgiving increments witnessed in Pink Esthetic Scores, favourable gingival margin stability, high levels of papilla fill, and significant change in patient-reported esthetic satisfaction. These findings support the importance of soft tissue management in the attainment of the best esthetic integration in restorative dentistry.

A key finding of this study was the significant improvement in mean Pink Esthetic Scores from baseline to the three-month postoperative period. The detected growth is consistent with prior clinical studies that found that soft tissue maturation and stabilisation extend to a number of weeks after periodontal plastic surgery is done[15,16]. The significant change in the course of the one-month assessment and the three-month assessment speaks of the necessity of a sufficient healing period in the run-up to the final esthetic judgment, which has been highlighted in previous longitudinal studies[17].

Comparing the esthetic results of the common surgical methods, connective tissue grafting had the highest mean PES at three months compared to that of tunnel methods. The findings are in line with the available literature, which refers to connective tissue grafts as a predictable method to enhance the thickness of soft tissues, stability of gingival margins, and the general esthetic features, especially in individuals with thin gingival biotypes[18,19]. Tunnel procedures have also been demonstrated to provide favourable esthetic outcomes and little surgical trauma, and this could be the reason for their similar outcomes in the current analysis[20]. Coronally advanced flap procedures, on the other hand, had lower PES values, which is similar to findings reported that flap-only procedures may not be as effective in situations where tissue thickness or keratinised tissue is limited[21].

The success of the reviewed surgical procedures can also be justified by the results of gingival margin stability and papilla fill. The majority of the cases were able to attain stable gingival margins, and only a few cases showed slight relapse. This stability rate is similar to the published clinical outcomes in the past, which declare a marginal relapse rate of between 10-30% depending on technique, and follow-up period[22]. Complete papilla fill is highly prevalent in the work of this study, especially in the context of restorative dentistry, and the loss of interdental papilla is a significant cause of esthetic dissatisfaction and phonetic problems[23]. The outcomes indicate that these issues can be appropriately managed through the use of soft tissue surgical management, provided that they are incorporated into the restorative treatment plans.

Patient-reported outcomes showed that there was a significant rise in esthetic satisfaction after surgical intervention, which demonstrates the clinical importance of soft tissue esthetic enhancement in comparison with objective measures. This result is consistent with previous research, which has shown that changes in the shape and symmetry of the gingiva have a great impact on how patients rate the success of treatment[24]. The averaged scores of postoperative pain at 24 hours also agree with the report that periodontal plastic surgical procedures are usually well tolerated, especially when the least invasive methods are used[25]. These results indicate how crucial the use of patient-centred outcome measures is in clinical assessments.

The data on postoperative healing and complications showed a positive safety profile of the evaluated interventions. Most patients also had event-free recovery, and any complications reported were minor and temporary edema or bleeding. The pattern of this complication is a reflection of already published data that indicate periodontal plastic surgeries to have low morbidity in case they are undertaken under the

appropriate clinical conditions[26]. The fact that there are no intense complications or infections is also one more argument in favour of the clinical acceptability of such procedures in the cases of esthetic demands.

Although the results were encouraging, there are a couple of limitations of the current study that should be brought up. To begin with, synthetic data, though beneficial to the methodological demonstration and pilot testing, lacks the biological variability of clinical groups. Second, the sample size is relatively small, which restricts the amount of statistical power and generalizability of the results. Third, they followed up the patients in a period of three months, yet long-term sustainability of esthetic results is a crucial issue in the context of restorative dentistry. Also, the operator-related issues and patient compliance, which may affect the clinical outcomes, were not investigated in detail.

Further studies are required to consider the validation of these results by means of prospective clinical studies in terms of large sample sizes and long durations of observation. A further contribution to the evidence-based decision-making would be comparative randomised trials assessing the use of soft tissue surgical methods under specified clinical conditions (e.g. implant-supported restorations or multiple adjacent recessions). Additional digital assessment instruments, three-dimensional soft tissue analysis, and measures of long-term patient satisfaction would be helpful to gain further understanding of esthetic stability and patient satisfaction in the long term[27].

The current research, within these constraints, adds to the growing literature on the significance of soft tissue surgical procedures in improving esthetic results in restorative dentistry. This study includes a complete framework of the assessment and comparison of esthetically motivated surgical methods of the soft tissue used in surgery by incorporating objective esthetic indices, patient-reported outcomes, and healing parameters into the evaluation process.

## 5. Conclusion

The findings of the present study highlight the critical role of soft tissue surgical interventions in enhancing esthetic outcomes in restorative dentistry. The gradual increment in the Pink Esthetic Scores over the period of time further supports the efficacy of periodontal plastic surgery procedures in maximising peri-restorative soft tissue framework. The methods that used connective tissue grafts and tunnel methods showed better esthetic performance, which justifies their application in instances where there is a thin gingival biotype and high esthetic requirements. The overall result of the use of stable gingival margins and favourable papilla fill was successful in most of the cases, which further supports the role of soft tooth augmentation in long-lasting esthetic stability. More so, the significant increase in patient-reported esthetic satisfaction points to the fact that clinical success is not limited to objective indices but also includes the perception and comfort of the patients. The fact that only a few postoperative complications were observed and the pain was moderate in this study is also an indication of the clinical acceptability and safety of these interventions. Clinically, the findings imply that restoration can be significantly enhanced by attention to the choice of soft tissue surgical methodology according to its clinical presentation in the unique case. By incorporating periodontal plastic surgery in the planning of restorative treatment, clinicians can treat esthetic deficiencies prior to patient dissatisfaction, thus improving the predictability of treating patients and their satisfaction. Regardless of the restriction that comes with the application of a synthetic dataset and a short-term follow-up, the study is insightful concerning the comparative esthetic performance of some of the most popular processes of soft tissue surgery. These findings should be confirmed by further clinical tests that involve larger samples and a long-term follow-up; this should be done to make evidence-based guidelines. Incorporating soft tissue surgical interventions into restorative dentistry is essential for achieving optimal esthetic harmony, gingival stability, and long-term patient satisfaction, particularly in the esthetic zone.

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