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SOCKET-SHIELD TECHNIQUE VERSUS CONVENTIONAL IMMEDIATE IMPLANT PLACEMENT IN THE MAXILLARY ESTHETIC ZONE: A RANDOMIZED CONTROLLED CLINICAL TRIAL

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ABSTRACT
Some changes in facial bone and soft tissue contour, and reduced esthetic outcomes, can be associated with immediate implant placement in the esthetic zone. This randomized clinical trial involved 100 patients who needed to replace a single tooth in the maxillary esthetic zone (METZ), and the socket-shield technique was compared to conventional immediate implant placement. A total of 50 participants were randomly divided into the socket-shield group and conventional immediate implant placement group, and followed for 12 months. The main outcome was the presence of horizontal bone loss, and secondary outcomes were vertical bone loss, midfacial recession, Pink Esthetic Score, implant stability, probing depth, patient satisfaction, postoperative complications, implant survival, and clinical success. The horizontal bone loss was significantly less in the socket-shield group compared to the conventional group at 12 months (0.26 ± 0.11 mm vs 0.69 ± 0.16 mm; $p < 0.001$). Also significantly reduced were vertical bone loss and midfacial recession. The socket-shield group reported higher Pink Esthetic Scores and patients' higher satisfaction level, while no difference was found in implant stability, probing depth or implant survival between groups. The implant survival rates were 98% and 98% for the two groups, with clinical success rates of 96% and 88%, respectively. There were 6% socket-shield cases that were shield exposed. The socket-shield technique resulted in better preservation of peri-implant hard and soft tissues, better esthetic outcomes and did not affect implant survival.

KEYWORDS: socket-shield technique; immediate implant placement; facial bone loss; Pink Esthetic Score; randomized clinical trial

1. INTRODUCTION
Immediate implant placement is a well-described strategy for the replacement of teeth with no opportunity for healing and has been associated with treatment time savings, fewer surgical steps and preservation of the pre-existing architecture of the gingiva. However, it starts the biological remodeling of the alveolar socket, especially the resorption of the thin facial bundle bone. This process can result in the formation of horizontal and vertical ridge contractions, midfacial recession, lack of papillary support, and poor implant aesthetics. The anterior maxilla is especially of concern because such subtle shifts in tissue configuration can be clinically significant. The predictable results of conventional immediate implant placement thus rely on facial bone thickness, gingival phenotype, three-dimensional implant positioning, the primary stability, gap management, and the provisional restoration.
The socket-shield technique was created to minimize post-extraction remodeling, keeping a well-prepared facial part of the tooth root and its periodontal ligament attachment. This preservation will be aimed at providing a vascular supply and limiting the resorption of the facial plate in the root–periodontal ligament–bundle bone complex. The clinical evaluation in the early stages also indicated that the socket-shield technique had a positive role in the preservation of peri-implant tissue in immediate implant placement (Barakat et al., 2017). A preliminary critical review, however, found that there was limited evidence that the technique was biologically promising, but that the operative protocol was inconsistent and there was a lack of prospective evidence (Blaschke & Schwass, 2020). A clinical study was then conducted to compare two methods of immediate placement complete extraction of the root or the use of a socket shield, which led to better preservation of the peri-implant tissues (Tiwari et al., 2020).

The clinical interest has grown as more than just osseointegration is needed for implant esthetics to be successful. In a pilot comparison, Kumar et al. (2021) reported more positive radiographically and Pink Esthetic Score results with socket-shield treatment compared to conventional immediate placement. In addition, a randomized clinical trial also showed that there was little change in crestal bone thickness of the face after socket shield treatment with a promising esthetic result (Santhanakrishnan et al., 2021). There is also evidence of a correlation between this technique and reduced marginal bone loss and higher Pink Esthetic Score, with a comparable implant failure rate between the two techniques, according to a meta-analysis (Velasco Bohórquez et al., 2021). However, the certainty of these outcomes could be highly dependent on the selection of cases, preparation of the shields, position of the implants, and the operator's experience (De Angelis et al., 2021). A subsequent quantitative synthesis revealed that socket-shield treatments could favor a reduction of horizontal and vertical bone remodeling and an enhancement of the implant esthetic features when compared with conventional immediate implants (Lin et al., 2022).

The technique remains unconventional and technique sensitive, due to the risk of complications arising if the amount of shield is too thick, too mobile, causes internal exposure or interferes with the placement of the implant (Sharma et al., 2022). However, prospective observations have recorded good short-term implant survival and maintenance of peri-implant tissues in the maxilla (Shadid, 2022a). Comparative cohort evidence has also indicated that the process of placing the socket shield might offer some degree of protection of ridge width compared to the traditional dual zone immediate implant approach (Shadid, 2022b). The use of it in the esthetic zone is thus still of clinical interest, but should be carefully assessed for risks and executed with precision (Verma, 2022).

Clinical effectiveness issues as shield exposure, infection, migration and peri-implant inflammation are still applicable to the complications. (Oliveira et al., 2021) Oliva et al. (2023) identified a systematic review with favorable implant survival and esthetic results, but with significant variability in the techniques, outcomes, and time periods of follow-up. Digital planning and guided surgery can enhance the control during the preparation of the shield and over the prosthetically driven implant positioning (Mato et al., 2022). There are, however, numerous studies available, and these often do not have large numbers of patients, non-randomized designs or a long follow-up period that can limit definitive comparison to conventional immediate implant placement.

Accordingly, the aim of this randomised clinical trial was to relate the socket-shield technique with conventional immediate implant placement. Changes in straight and vertical bony dimensions of the face, midfacial recession, implant stability, Pink Esthetic Score, probing depth, patient satisfaction, complications, implant survival, and 12-month clinical success were included in the scope. The main aim was to see if the 12-month horizontal facial bone loss could be reduced with the socket-shield treatment. Subordinate aims of the study were to assess the radiographic, soft-tissue, esthetic, patient-reported, and implant-related outcomes of the treatment groups.

2. METHODOLOGY

2.1 Study Design and Setting

A future, parallel group, randomized controlled clinical trial was planned to evaluate the clinical, radiographic, biological and esthetic aftermaths of the socket-shield approach compared with conventional immediate implant placement. Patients who needed extraction and immediate implant-supported rehabilitation in the maxillary esthetic section were included in the study. The participants were recruited from January to August 2025 and followed for 12 months following implant placement. The trial was designed and presented in line with the CONSORT rules of randomized clinical trials.

2.2 Study Population and Eligibility Criteria

In total, 100 participants who needed single-tooth replacement in the maxillary central incisor, lateral incisor, canine or first premolar region were included. The patient's inclusion criteria were that they had a non-restorable tooth, sufficient bone height and width in the alveolar process at the site for primary implant stability, an intact or clinically manageable buccal plate and oral hygiene sufficient for implant treatment. Patients were barred if they had uncontrolled complete disease, active periodontal disease or periapical infection, severe buccal defect, inadequate bone volume for immediate implant placement, untreated periodontal disease, parafunctional habits, pregnancy, or any condition that could compromise osseointegration or wound healing. Current smoking status was collected and taken into account for subgroup and adjusted analyses.

2.3 Sample Size and Group Allocation

The final study sample comprised 100 participants, with 50 participants allocated to each intervention group. Participants were randomly assigned in a 1:1 ratio to:

1. **Socket-shield system group:** Immediate implant placement while retaining a prepared buccal root fragment.
2. **Conventional immediate implant settlement group:** Complete atraumatic descent followed by immediate implant placement without retention of a root fragment.

Randomization sequence was computer-generated and allocation was concealed. The operating clinician was informed about the group assignment immediately prior to the surgery. Surgeon blinding was not possible due to the nature of the interventions, but whenever feasible, radiographic and esthetic evaluations were carried out by assessors who were blinded with regard to the treatment allocation.

2.4 Preoperative Assessment

Pre-surgery demographic and clinical data, such as age, sex, smoking history, implant site, gingival phenotype, and location of the jaw, were collected. All implants inserted in the upper jaw. A clinical and radiographic examination was

conducted to evaluate the condition of the tooth, presented bone volume, the thickness of the buccal plate and the suitability for instant implant placement. The thickness of the basiplate and the expected horizontal gap of jumping was measured in millimetres. The stability of the implant was then assessed using the implant stability quotient and the esthetic status was assessed using the Pink esthetic score.

2.5 Surgical Procedures

All the surgical procedures were done under local anaesthetic, and standard aseptic techniques were adhered to. Prophylactic and postoperative medications were prescribed based on the institutional implant-surgery protocol.

2.5.1 Socket-Shield Technique

The clinical crown was cut off, and the root was divided lengthwise in the mesiodistal direction in the socket-shield group. The palatal root was carefully removed and the facial root portion was left in intimate contact with the buccal socket wall. The remaining shield was thinned to about 1.0-1.5mm and was placed at, coronal to or slightly apical to the level of the crestal bone, depending on the clinical anatomy. The preparation of the implant osteotomy was done palatal to the remaining shield and to avoid immediate contact between the implant and the shield. The implant was inserted with primary stability and torque was recorded during insertion (Ncm). The space between the transplant and the facial structures was evaluated and particulate grafting material was applied when necessary.

2.5.2 Conventional Immediate Implant Placement

The conventional group was treated with tooth extraction atraumatically with special consideration given to preserving the wall of the facial socket. Thoroughly debrided and inspected for defects was the socket. The extraction socket was prepared toward the palatal aspect of the abstraction site and they were all immediately placed. When clinically needed peri-implant jumping gap was grafted and insertion torque was recorded. There was no root fragment remained in this group.

2.6 Prosthetic and Postoperative Management

Satisfactory primary stability implants were treated with a standardized protocol of provisionalization/healing. When a provisional is used, it was adjusted to avoid centric and eccentric occlusal contacts. Definitive prosthetic rehabilitation was achieved within a proper healing period with implant-supported restorations, which emerged at an appropriate profile to support the peri-implant soft tissues. Post operative advice was given, oral hygiene, not causing mechanical trauma at the surgical site and the use of prescribed medications. The participants were called back for clinical and radiographic assessments at 3, 6 and 12 months.

2.7 Outcome Measures

Primary outcome was at 12 months, horizontal facial bone loss. The amount of horizontal bone loss was determined on the standardized radiographical or three dimensional dimensions in millimetres from the postoperative reference line. Secondary radiographic criteria were horizontal bone level at 3 and 6 months and vertical bone level at 3, 6 and 12 months. Measurements of the midfacial soft tissue recession were performed at the same follow-up periods in millimetres. Pink Esthetic Score was logged at baseline and at 3, 6 and 12 months to evaluate esthetic outcomes. The implant stability quotient in baseline and each follow-up visit was used to evaluate implant stability. The other clinical results were pain intensity at 24 hours (measured on a VAS), peri-implant probing depth at 12 months, wound dehiscence, postoperative infection, shield exposure, implant survival, clinical success and overall patient satisfaction at 12 months. A surgeon deemed a successful implant to be a functional one at the 12-month exam. The criteria for clinical success were defined as survival of the implant in the jaw without chronic pain, uncontrolled infection, clinically relevant implant mobility, progressive peri-implant bone loss and complications that lead to the removal of the implant.

2.8 Radiographic and Clinical Standardization

Radiographic evaluations were made using the same imaging geometry and a calibrated digital measurement software. Data was collected using landmarks that were reproducible on the implants, and distances were recorded in millimetres. A calibrated periodontal probe was used to measure clinical measurements. Two experienced examiners independently assessed a sub-sample of the radiographs and clinical photographs for measurement reliability. Intra-examiner and inter-examiner reliability for continuous variables was evaluated by calculating intraclass correlation coefficients and for categorical variables by calculating Cohen's kappa. We sought consensus in resolving disagreements.

2.9 Statistical Scrutiny

An existing statistical software package was used for geometric analyses. Data for continuous variables were reported as mean and standard deviation or median and interquartile range, depending on the distribution. Frequencies and percentages were used for categorical variables. Independent-samples t-test or Mann–Whitney U test was used for continuous variables, and chi-square or Fisher's exact test was used for definite variables to assess baseline comparability between the groups. Linear mixed-effects models with treatment group, time and behaviour-by-time interaction fixed effects and contestant random effect were used to analyse the longitudinal outcomes, such as horizontal bone loss, vertical bone loss, midfacial recession, Pink Esthetic Score and implant stability amount. The primary between-group comparison was the difference in horizontal bone loss at 12 months (adjusted mean difference with 95% confidence interval). Clinically relevant covariates were included in the models as appropriate age, smoking, gingival phenotype, baseline thickness of

buccal plate, implant site, use of graft, and baseline value of outcome. Risk Ratios (or Risk Differences) and 95% Confidence Intervals were used to compare the following binary outcomes wound dehiscence, infection, shield exposure, implant survival, and clinical success. Survival of the implants might also be demonstrated with Kaplan–Meier analysis if implant failure data were available. The analyses were performed on the intention to treat opinion. Missing follow-up observations were addressed with mixed-effects modelling, assuming that they are missing randomly. A sensitivity analysis with full cases was done to assess the robustness of the results. Two-sided test statistics with a p-value of <0.05 were regard as statistically significant.

2.10 Ethical Considerations

Approval from the appropriate organized ethics committee was needed before recruitment of participants. All contributors were given information about the procedures and possible benefits of the study, any potential complications, and also about the alternative treatment options, and then gave written informed consent. To ensure the participants' confidentiality, codes were used to identify them, and the trial had to be registered in a clinical-trial registry before enrolment.

3. RESULTS

3.1 Participant Distribution and Baseline Characteristics

In total, 100 participants were analyzed, with 50 participants receiving treatment with the SST and 50 participants receiving CIIP treatment. The planned 12-month assessment was completed by all participants, except for one observation that was missing from the fully adjusted regression analysis. The mean age was 38.81 ± 10.64 years in the SST group and 39.56 ± 9.68 years in the CIIP group. There were no statistically significant variations between the groups for age, sex, smoking status, gingival phenotype, baseline buccal plate thickness, baseline implant stability quotient, baseline Pink Esthetic Score or 24-hour postoperative pain. These results showed a good baseline comparability between the randomized groups. There were no statistically significant changes between the socket-shield and conventional immediate implant groups with regard to demographic, clinical, radiographic and operative characteristics at baseline (Table 1).

Table 1. Baseline demographic, clinical, and operative characteristics

Characteristic	SST (n = 50)	CIIP (n = 50)	p-value
Age, years	38.81 ± 10.64	39.56 ± 9.68	0.712
Female sex	22 (44.0%)	19 (38.0%)	0.685
Current smoker	7 (14.0%)	7 (14.0%)	1.000
Thin gingival phenotype	24 (48.0%)	23 (46.0%)	1.000
Baseline buccal plate thickness, mm	1.03 ± 0.26	0.97 ± 0.24	0.246
Jumping gap, mm	1.67 ± 0.47	1.66 ± 0.46	0.940
Bone graft used	10 (20.0%)	17 (34.0%)	0.176
Insertion torque, Ncm	37.09 ± 4.90	37.75 ± 4.52	0.490
Baseline ISQ	70.86 ± 4.06	71.03 ± 3.63	0.826
Baseline PES	7.32 ± 0.78	7.08 ± 0.88	0.149
Pain at 24 hours, VAS	2.98 ± 1.32	3.36 ± 1.35	0.162

Data are expressed as mean ±SD or as a number (%). SST: socket-shield technique; CIIP: conventional immediate implant placement; ISQ: implant stability quotient; PES: Pink Esthetic Score; VAS: visual analogue scale.

3.2 Horizontal and Vertical Bone Changes

The amount of horizontal facial bone loss was seen to gradually worsen in both groups; the SST group still showed substantially less loss at each evaluation. The mean difference was −0.22 mm between the SST group (0.12 ± 0.07 mm) and the CIIP group (0.34 ± 0.14 mm) at 3 months. The mean horizontal bone loss was 0.26 ± 0.11 mm and 0.69 ± 0.16 mm at 12 months in the SST and CIIP groups, respectively. The unadjusted between-group mean difference was −0.44 mm (95% CI: −0.49 to −0.38; $p < 0.001$). A consistently lower amount of vertical bone loss was also observed following the socket-shield procedure. At 12 months, vertical bone loss was 0.24 ± 0.10 mm in the SST group and 0.50 ± 0.16 mm in the CIIP group, producing a mean difference of −0.26 mm (95% CI: −0.31 to −0.21; $p < 0.001$). As seen in Table 2, the horizontal bone loss, vertical bone loss and midfacial recession all rose with time in both groups, and were significantly lower in the socket-shield group at all follow-up measurements. As seen in Figure 1, horizontal facial bone loss was progressive in both groups over 12 months, and mean bone loss was significantly lower in the socket-shield group contrasted to the conventional immediate implant group.

Table 2. Radiographic and soft-tissue dimensional changes during follow-up

Outcome	SST	CIIP	Mean difference (95% CI)	p-value
Horizontal bone loss at 3 months, mm	0.12 ± 0.07	0.34 ± 0.14	−0.22 (−0.27 to −0.18)	<0.001
Horizontal bone loss at 6 months, mm	0.19 ± 0.09	0.50 ± 0.14	−0.32 (−0.37 to −0.27)	<0.001
Horizontal bone loss at 12 months, mm	0.26 ± 0.11	0.69 ± 0.16	−0.44 (−0.49 to −0.38)	<0.001
Vertical bone loss at 3 months, mm	0.11 ± 0.08	0.24 ± 0.12	−0.13 (−0.17 to −0.09)	<0.001
Vertical bone loss at 6 months, mm	0.18 ± 0.09	0.37 ± 0.14	−0.20 (−0.24 to −0.15)	<0.001
Vertical bone loss at 12 months, mm	0.24 ± 0.10	0.50 ± 0.16	−0.26 (−0.31 to −0.21)	<0.001
Midfacial recession at 3 months, mm	0.14 ± 0.12	0.39 ± 0.23	−0.25 (−0.33 to −0.18)	<0.001

Midfacial recession at 6 months, mm	0.18 ± 0.13	0.49 ± 0.23	−0.31 (−0.39 to −0.24)	<0.001
Midfacial recession at 12 months, mm	0.22 ± 0.13	0.62 ± 0.25	−0.40 (−0.48 to −0.32)	<0.001

Negative mean differences favour the socket-shield technique.

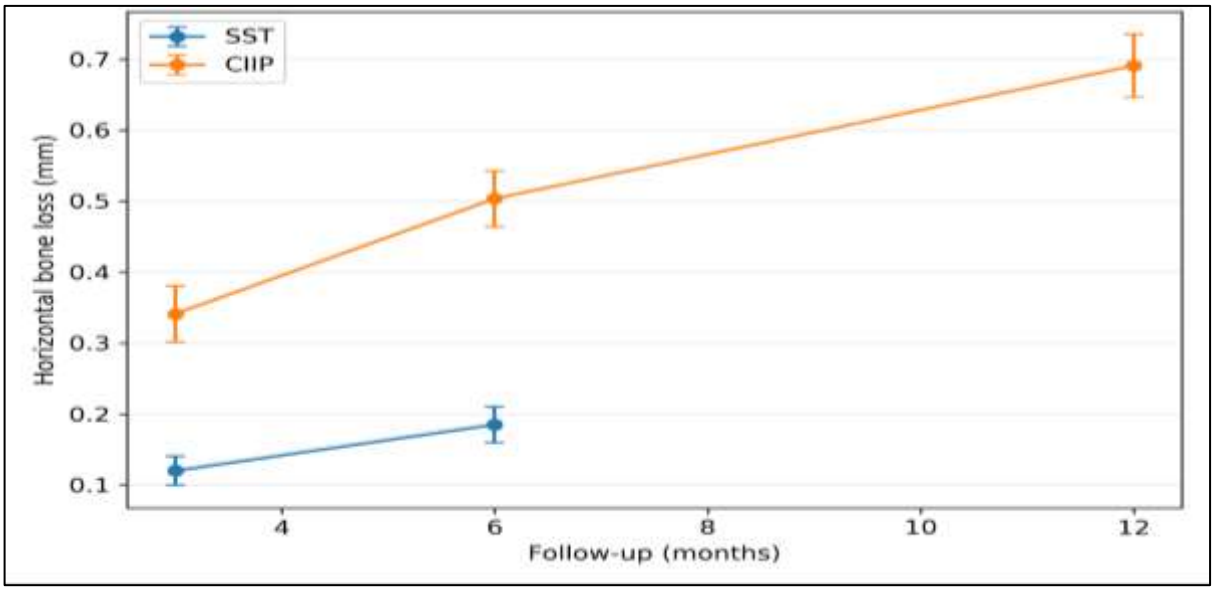

Figure 1. Mean horizontal facial bone loss in the SST and CIIP groups over 12 months. Error bars represent 95% confidence intervals

3.3 Midfacial Soft-Tissue Recession

In the SST group, significantly better preservation of the soft tissue margin of the midface was found. At 3 months, recession was 0.14 ± 0.12 mm in the SST group and 0.39 ± 0.23 mm in the CIIP group. This discrepancy increased in the follow-up. The mean downturn was 0.22 ± 0.13 mm for the socket-shield procedure and 0.62 ± 0.25 mm for conventional immediate implantation at 12 months. The resulting mean difference of −0.40 mm was statistically significant (95% CI: −0.48 to −0.32; $p < 0.001$). As shown in Figure 2, midfacial recession occurred during the follow-up in both groups, but was significantly less after the socket-shield technique.

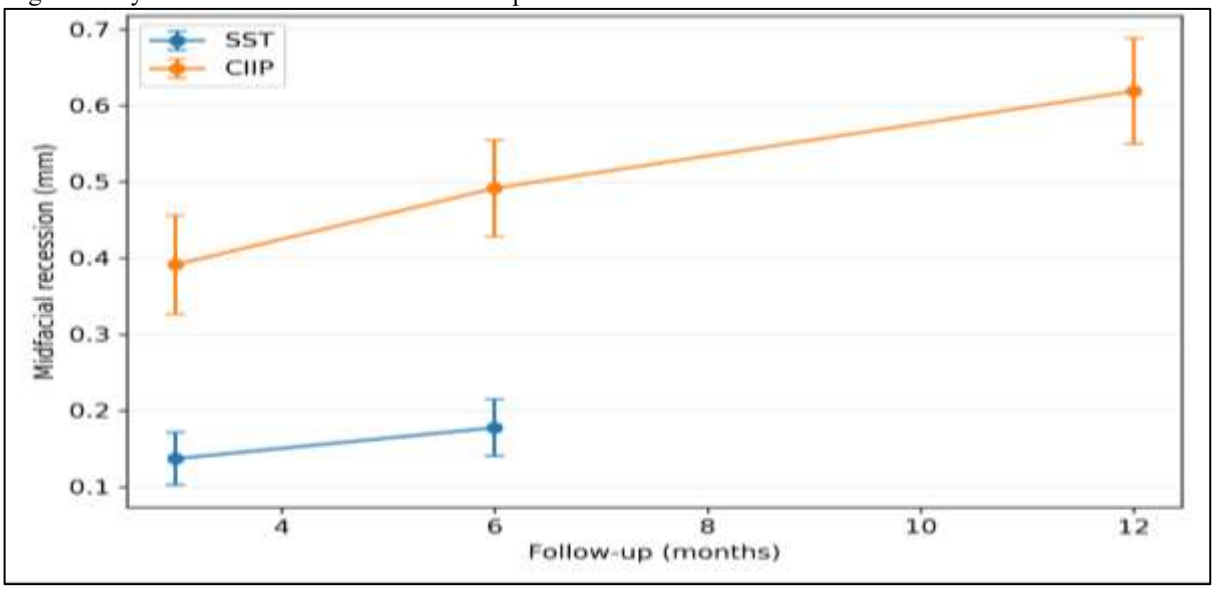

Figure 2. Mean midfacial recession following socket-shield and conventional immediate implant placement. Error bars represent 95% confidence intervals

3.4 Esthetic Outcomes and Implant Stability

The scores of both groups showed a gradual increase in pink, but the increase was drastically higher in the SST group. At 3 months, the mean PES was 8.66 ± 0.84 in the SST group compared with 7.69 ± 1.00 in the CIIP group. At 12 months, the corresponding values were 10.01 ± 0.89 and 8.20 ± 1.03, representing a mean difference of 1.81 points ($p < 0.001$). Both groups showed increased stability of implants during follow-up. But there was no variation between the groups at three, six or 12 months. At 12 months, mean ISQ values were 74.95 ± 5.80 in the SST group and 74.87 ± 4.29 in the CIIP group ($p = 0.939$). Similarly, there were no significant differences in peri-implant probing depth between the groups. However, at 12 months, the mean satisfaction scores for the SST group were significantly greater (9.02 ± 0.71) than those for the CIIP group (7.91 ± 0.74) ($p < 0.001$). Figure 3 depicts an increase in the mean PES from baseline to 12-months,

with higher and more gradual improvement in the socket-shield group. The mean values for PES and patient-satisfaction scores were suggestively higher in the socket-shield group than in the other groups, and there was no significant difference in the implant stability score and PIP values between the groups, as shown in Table 3.

Table 3. Esthetic, implant-stability, and patient-reported outcomes

Outcome	SST	CIIP	Mean difference	p-value
PES at 3 months	8.66 ± 0.84	7.69 ± 1.00	0.97	<0.001
PES at 6 months	9.58 ± 0.88	8.08 ± 1.02	1.50	<0.001
PES at 12 months	10.01 ± 0.89	8.20 ± 1.03	1.81	<0.001
ISQ at 3 months	72.53 ± 4.71	72.78 ± 3.76	−0.25	0.770
ISQ at 6 months	74.27 ± 5.55	74.04 ± 4.31	0.24	0.813
ISQ at 12 months	74.95 ± 5.80	74.87 ± 4.29	0.08	0.939
Probing depth at 12 months, mm	2.61 ± 0.47	2.71 ± 0.41	−0.11	0.225
Patient satisfaction at 12 months	9.02 ± 0.71	7.91 ± 0.74	1.10	<0.001

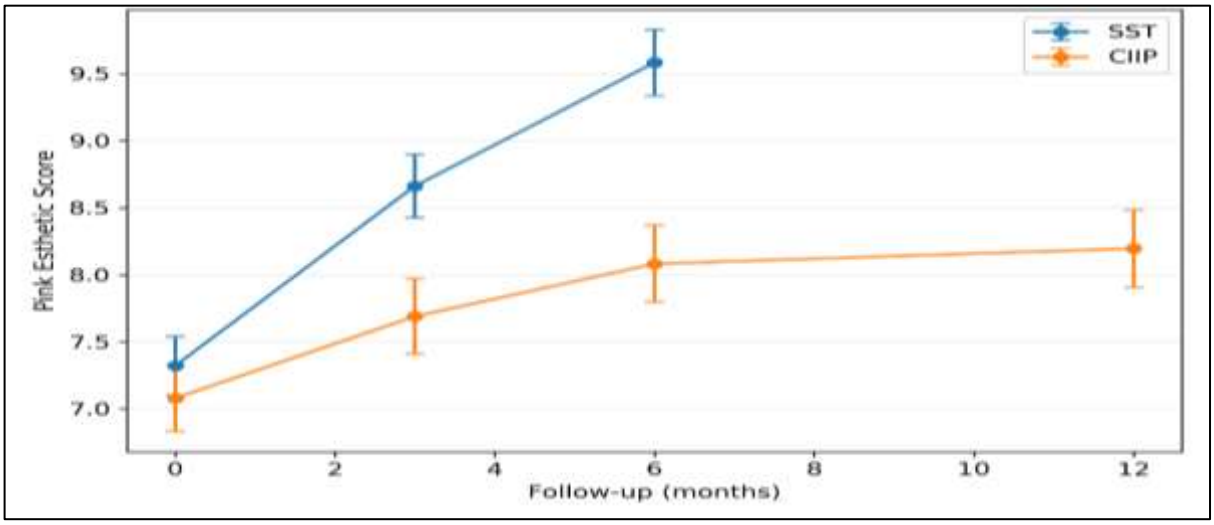

Figure 3. Changes in the Pink Esthetic Score from baseline to the 12-month follow-up. Error bars represent 95% confidence intervals.

3.5 Complications, Implant Survival, and Clinical Success

The 12-month implant survival was the same for both treatment groups, with 49/50 implants surviving in each treatment group (survival rate: 98.0%). In the SST group, clinical success was seen in 48 patients and 44 patients in the CIIP group with 96.0% and 88.0% respectively. A higher success rate (higher numbers) was achieved with the technique employed with the socket shield, however this was not statistically important (p = 0.269). One participant in each group (SST and CIIP) experienced wound dehiscence while three individuals experienced postoperative infection in the CIIP group. In the 3 participants who underwent socket-shield procedure, a total of 3 shields were shielded from exposure, whereas a technique-specific complication of shield was not applicable in the conventional group. None of the complication comparisons were significant. Table 4 indicates that the existence rate of the implants was the same in both groups, while the accomplishment rate was slightly higher in the socket-shield group. Complications after surgery were rare and similar in both groups. The comparable implant-survival rates between the groups and the higher clinical-success rate in the socket-shield group are exhibited in figure 4, whereas both treatment arms had low frequencies of postoperative complications.

Table 4. Twelve-month implant survival, clinical success, and postoperative complications

Outcome	SST, n (%)	CIIP, n (%)	Risk ratio	p-value
Wound dehiscence	1 (2.0%)	3 (6.0%)	0.43	0.617
Postoperative infection	1 (2.0%)	3 (6.0%)	0.43	0.617
Shield exposure	3 (6.0%)	0 (0.0%)	7.00	0.242
Implant survival at 12 months	49 (98.0%)	49 (98.0%)	1.00	1.000
Clinical success at 12 months	48 (96.0%)	44 (88.0%)	1.09	0.269

A continuity correction was used to obtain risk ratios for zero events. The difference in the amount of exposure occurred only in the socket-shield group and should be considered a technique-related complication.

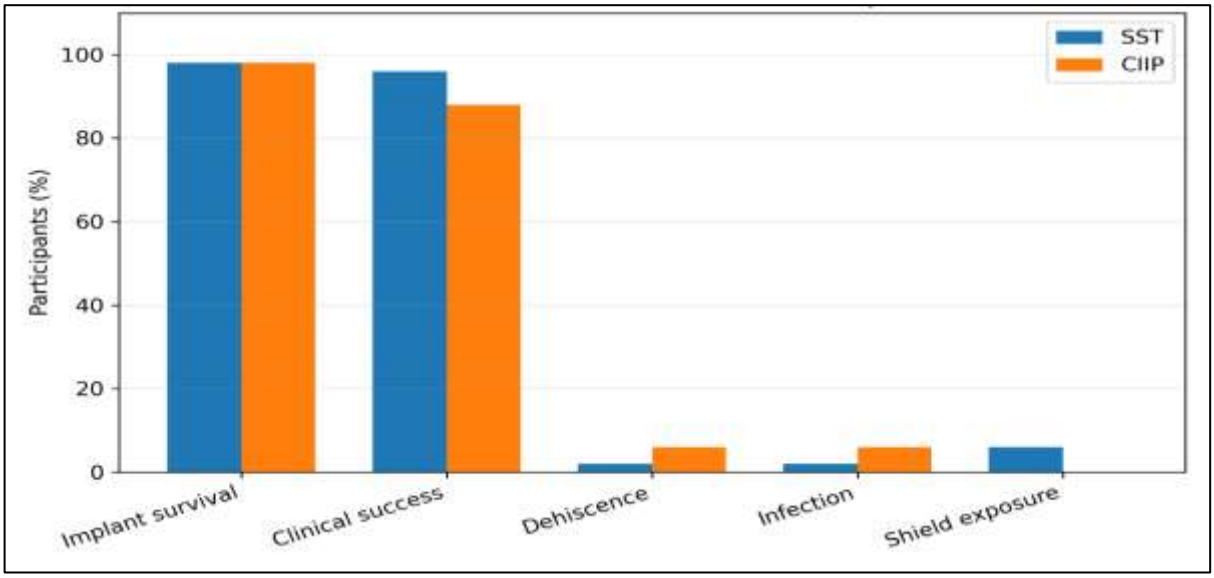

Figure 4. Twelve-month implant survival, clinical success, and complication rates in the two treatment groups.

3.6 Adjusted Analysis of the Primary Outcome

Multivariable linear regression model was used to gauge relationship between treatment allocation and horizontal bone loss 12 months after adjustment for age, smoking, gingival phenotype, baseline buccal plate thickness, jumping gap and bone-graft use. The socket-shield technique continued to be independently correlated with the decreased horizontal bone loss. There was no difference in vertical bone loss between the two groups, but the SST group exhibited 0.43 mm less flat bone loss than the CIIP group (adjusted $\beta = -0.432$; 95% CI: −0.489 to −0.375; $p < 0.001$). The adjusted model accounted for 71.0% of the variance in 12-month horizontal bone loss. There were no independent associations of these factors with the primary outcome: age, smoking status, gingival phenotype, baseline buccal plate thickness, jumping gap, and use of bone grafting. Table 5 indicates that the socket-shield technique had an independent effect of significantly lessening horizontal bone loss at 12 months after modifying for demographic and clinical covariates.

Table 5. Multivariable analysis of horizontal bone loss at 12 months

Predictor	Adjusted β	95% CI	p-value
Socket-shield technique versus CIIP	−0.432	−0.489 to −0.375	<0.001
Current smoker	−0.016	−0.098 to 0.066	0.697
Thin gingival phenotype	−0.043	−0.115 to 0.028	0.231
Bone graft used	−0.009	−0.088 to 0.070	0.825
Age, per year	−0.001	−0.004 to 0.002	0.595
Baseline buccal plate thickness, mm	−0.074	−0.214 to 0.066	0.298
Jumping gap, mm	−0.021	−0.096 to 0.054	0.580

Model n = 99; adjusted $R^2 = 0.710$. Negative coefficients indicate lower flat bone loss.

In general, the socket-shield technique resulted in significantly better facial soft and hard tissue preservation and better esthetic and patient role satisfaction results. There was no sizable difference in implant stability, probing depth, implant survival or incidence of postoperative complications.

4. DISCUSSION

The present randomized clinical trial showed that the socket-shield technique was superior in preserving facial hard and soft tissue when compared to traditional immediate implant placement. Mean horizontal facial bone loss in the socket-shield group was 0.26 mm while 0.69 mm was reported in the conventional group at 12 months (Badawy, 2025). Additionally, vertical bone loss was less in the socket-shield treatment group (0.24 mm) than in the control group (0.50 mm). These results are in line with the hypothesized biological effects of maintaining the facial periodontal attachment and align with three-dimensional clinical findings of a decreased bone alteration around socket-shield implants (Chaudhary et al., 2024). The socket-shield group had an average midfacial collapse of 0.22 mm, whereas the average midfacial recession after conventional immediate placement was 0.62 mm. The maintenance of the overlying peri-implant mucosa by preservation of the facial plate likely contributed to the maintenance of the emergence profile and marginal gingival position (Natale et al., 2025). The significance of facial bone integrity and soft-tissue stability has also been highlighted in studies that investigated the timing of implant placement in type I extraction sockets in the esthetic zone (Santhanakrishnan et al., 2024). The scores of the pink esthetic scores tended to increase over time in both groups, with significantly higher scores following socket-shield treatments. The mean scores at 12 months in the socket-shield group and the common group were 10.01 and 8.20 respectively. This difference indicates that preservation of facial tissues may have a beneficial effect on gingival curvature, papillary fill, mucosal level and overall peri-implant harmony. A randomized comparison for up to 36 months follow-up also showed reduced MBL and greater esthetic scores for the

socket-shield implants (Durrani et al., 2024). Sockets shield treatment has been shown, in more recent meta-analysis, to generally result in better facial bone preservation and esthetic outcomes than conventional immediate implantation (Lu et al., 2025). There was no difference in the stability of the implants between groups, suggesting a lack of detrimental effect of the retention of the facial root fragment on primary or secondary osseointegration when the implant is placed correctly. A high survival rate of implants (98%) and clinical success (96%) were obtained in both groups, whereas the conventional placement had a survival rate of 98% and clinical success of 88%. The equal survival rates suggest the primary advantage of the socket shield may not be that implants are more likely to stay in place, but that the tissue preservation is more important. This is consistent with the systematic evidence that demonstrates better esthetic and marginal bone results without a significant difference in implant failure (Altalhi et al., 2025). The socket-shield group had an overall higher level of patient satisfaction (9.02 vs. 7.91). The difference is possibly due to less recession and better mucosal contours in the facial esthetic zone. Case based evidence has also demonstrated the technique can maintain tissue architecture after traumatic tooth loss when there is sufficient facial root structure (Tang et al., 2025). In addition to properly performed socket-shield surgery, adjunctive biologic materials such as concentrated growth factor may aid peri-implant healing, but any extra benefits over such a correctly executed surgery must be carefully investigated (Mahalakshmi et al., 2025).

Balancing is important for complications. Exposure was only a problem in the socket-shield group, and wound dehiscence and postoperative infection were more common in the conventional placement group. Exposure of the root fragment is technique-dependent—may happen if the coronal shield is not enough reduced, unstable, sharp or close to the mucosal edge. Retention of periodontal attachment to maintain alveolar architecture has been shown outside of implant placement as in orthodontic extraction sites but this is insufficient to prove long-term implant safety (Zhang et al., 2026).

Treatment allocation remained a significant independent contributor to 12-month horizontal bone loss after the age, smoking, gingival phenotype, initial buccal plate thickness, jumping-gap width, and grafting were taken into consideration. This discovery reinforces the hypothesis that the measured difference was largely due to the socket-shield intervention, and not to preexisting factors. However, the single clinical setting, moderate number of patients, and operator dependence restrict generalizability for the 12-month follow-up. The protocol heterogeneity and a lack of long-term comparisons have remained pertinent limitations in recent systematic evidence (Cosola et al., 2026).

In general, socket-shield treatment resulted in better preservation of the facial bones, stabilization of midfacial soft tissues, esthetic outcomes, experimental outcomes, and patient pleasure in comparison to conventional immediate implant settlement, without compromising implant survival. Therefore, this technique should be considered a promising, but technically challenging approach to a well-selected esthetic-zone case and not a replacement for the traditional immediate implant.

5. CONCLUSION

Thus, the present randomized clinical trial confirmed that the socket-shield technique leads to more favorable hard-tissue, soft-tissue and esthetic outcomes in comparison to the conventional immediate implant placement over a period of 12 months. In the present study, socket-shield treatment demonstrated statistically momentous reductions in horizontal and vertical facial bone loss, midfacial recession, and higher Pink Esthetic Scores, greater patient satisfaction, and higher numbers of successful implants, when compared with no treatment. The implant stability and survival were found to be similar for both groups, suggesting that the procedure is not detrimental to osseointegration if performed correctly. The results indicate that the main benefit of the socket-shield procedure is the defence of the peri-implant tissue architecture, especially in the esthetic zone where the maintenance of the buccal plate and gingival contour are of paramount importance. But in the socket-shield group, exposure of the shield was found, indicating that the technique is still challenging and relies heavily on proper case selection, preparation of the shield, implant placement, and operator experience. The overall results suggest that the socket-shield technique could be regarded as an replacement to the conventional immediate implant placement for selected anterior cases requiring optimal esthetic preservation. However, larger, multicentre, randomized studies with longer follow-up and standardized operating techniques should validate long-term safety, biological stability and reproducibility, to enable broader clinical application.

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