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Effectiveness of Socket Shield Technique Compared to Conventional Immediate Implant Placement for Clinical, Radiological, and Esthetic Rehabilitation: A Systematic Review

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Abstract

Introduction: Immediate implant placement is often indicated when extraction is due to trauma, endodontic lesions, root fractures, root resorption, root perforations, or unfavorable crown-to-root ratios with intact alveolar bone walls. The socket shield technique (SST) has been proposed to minimize post-extraction tissue loss and optimize esthetic outcomes.

Methods: This systematic review followed the PRISMA 2020 guidelines and was registered in PROSPERO (CRD42024497579). Electronic searches were conducted in PubMed (including MEDLINE), Cochrane, and Google Scholar from January 2014 to May 2024, supplemented by manual searches. Studies involving adult patients receiving immediate implant placement using SST were compared with conventional immediate implant placement. Primary outcomes included marginal bone loss, buccal bone width change, and radiographic bone thickness. Secondary outcomes included pink esthetic score (PES), implant stability quotient (ISQ), implant failure rate, and complications.

Results: Seven randomized controlled or prospective clinical studies met the inclusion criteria. Across studies, SST consistently demonstrated reduced marginal bone loss and buccal bone resorption, with better PES values compared to the conventional technique. ISQ values improved in both groups, with a slightly greater increase in SST cases. Implant survival rates were high for both approaches, but SST was associated with improved soft tissue stability and patient satisfaction.

Conclusion: Within the limitations of the available evidence, SST appears to preserve peri-implant hard and soft tissues more effectively than conventional immediate implant placement, particularly in the esthetic zone. While survival rates are similar, SST may offer superior esthetic outcomes and reduced labial bone loss. Further long-term, high-quality studies are needed to confirm these findings.

Keywords: Socket Shield Technique, Immediate Implant Placement, Pink Esthetic Score, Marginal Bone Loss

Introduction

In 1965, Brånemark placed the first implants into healed edentulous ridges, with implant placement signifying insertion into a healed extraction socket after a minimum of 5–6 months.1 In 1989, Lazzara placed implants at the time of tooth extraction and confirmed its reliability.1 Hansson *et al*. in 1983 and Ericsson in 2000 found that immediate placement reduces surgical trauma, decreases the risk of bone necrosis, and permits the bone remodeling process to occur, enabling a rapid healing period where woven bone is transformed into lamellar bone [1, 2].

Immediate implant placement is most commonly indicated when tooth extraction is due to trauma, endodontic lesions, root fractures, root resorption, root perforations, or unfavorable crown-to-root ratios, provided the bony walls of the alveolus are intact [2]. Contraindications include active infection, insufficient bone (<3 mm) beyond the socket apex for initial implant stability, and wide and/or long gingival recession [2]. Although active infection has traditionally been viewed as a main contraindication to post-extraction immediate implant placement, recent findings suggest that immediate implant insertion into infected sockets, when combined with thorough debridement and decontamination, does not increase failure risk compared to non-infected sites, and is gaining acceptance [3].

The concept of immediate loading has developed with excellent results, as appropriate loading promotes osteogenesis and beneficial soft tissue changes [4, 5]. Post-extraction dimensional alterations in the residual alveolar ridge are more pronounced in the buccal bone plate than the palatal plate [5]. Such hard and soft tissue changes cause apical migration of soft tissue, resulting in papilla collapse and the formation of black triangles between teeth [5]. To prevent or minimize these effects while achieving optimal esthetic outcomes, techniques such as immediate provisionalization, connective tissue grafts, bone graft incorporation into the buccal gap, and buccal plate overbuilding have been proposed [5].

An alternative to augmentation procedures is partial extraction therapy, specifically, the socket shield technique (SST), which offers several advantages [5]. SST has shown promising outcomes in terms of implant survival rate, peri-implant soft and hard tissue stability, and esthetic results when used with immediate implants in the esthetic zone [6, 7]. At the time of second-stage implant surgery, complete hard tissue fill has been observed in the gap between the implant and buccal root fragment, with a superficial soft tissue layer consistently covering the root–implant gap, confirmed radiographically at 6 months using CBCT [7].

In a prospective case study by Hinze *et al*., all patients in the SST group were highly satisfied with both function and esthetics, reporting a mean visual analogue scale (VAS) score of 9.37/10 [8]. Gluckman *et al*. reported 128 SST cases with 4 years of follow-up, showing a 96.1% survival rate and concluding that SST performs competitively compared to conventional immediate and delayed implant protocols [9]. Thus, SST serves as a predictable technique for preserving soft and hard tissues, making it particularly suitable for high-esthetic-risk cases such as those with a high lip line in the maxillary anterior region [10]. However, its clinical, radiological, and esthetic outcomes should be interpreted cautiously due to the limited follow-up periods reported in current literature. In this context, the aim of this systematic review was to evaluate the effectiveness of the SST compared to conventional immediate implant placement in terms of clinical, radiological, and esthetic outcomes. The objective was to synthesize and analyze available evidence on primary outcomes, including marginal bone loss, buccal bone width changes, and radiographic bone thickness, as well as secondary outcomes such as pink esthetic score, implant stability, implant survival, and complication rates, to determine the relative clinical efficacy of the two techniques.

Materials and Methods

Study Design and Registration

This study was conducted as a systematic review in strict accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) guidelines [1]. The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) under the registration number CRD42024497579. The methodological framework was based on the Cochrane Handbook for Systematic Reviews of Interventions (Version 5.1.0) and the 4th Edition of the JBI Reviewer's Manual.

Review Question

The primary research question was to determine whether there is a difference in the effectiveness of the SST compared to conventional immediate implant placement in achieving superior clinical, radiological, and esthetic outcomes. The review question was structured using the PICO framework, which defined the population as adult patients undergoing immediate implant placement in any tooth region, the intervention as immediate implant placement utilizing SST, the comparison as conventional immediate implant placement without socket shield retention, and the outcomes as primary measures of marginal bone loss, buccal bone width change, and radiographic bone thickness, as well as secondary measures including pink esthetic score, implant stability quotient, implant failure rate, and complications.

Eligibility Criteria

Studies were included if they were randomized controlled trials, quasi-experimental studies, or prospective clinical trials published in English up to 31 May 2024, with full-text availability. Only studies directly comparing SST with conventional immediate implant placement and reporting at least one of the defined primary or secondary outcomes were eligible. Studies were excluded if they were observational, review articles, case series with fewer than five patients, *in vitro* or animal research, lacked a valid comparison group, or were available only as abstracts.

Search Strategy

A comprehensive electronic search was carried out in PubMed (including MEDLINE), the Cochrane Library, and Google Scholar, supplemented by a manual search of relevant journals and reference lists of included studies. The search covered literature from January 1, 2014, to May 31, 2024. Both controlled vocabulary terms (MeSH) and free-text keywords were applied, using Boolean operators "AND" and "OR" to refine results. Keywords included terms related to the intervention, comparator, and outcomes such as "socket shield technique," "partial extraction therapy," "root retention technique," "immediate implant placement," "marginal bone loss," "bone thickness," "pink esthetic score," and "implant success." In PubMed, search strings combined population, intervention, and outcome terms, while in Google Scholar, filters were applied to clinical trials in human subjects. The Cochrane search targeted clinical trials and systematic reviews relevant to SST. Manual searches included recent issues of journals in implantology and proceedings from relevant conferences.

Study Selection

All retrieved records were imported into Mendeley Desktop software for reference management and duplicate removal. Following deduplication, two calibrated reviewers independently screened the titles for relevance, excluding articles such as literature reviews, case reports, and studies outside the scope of the review. Abstracts of potentially eligible studies were then reviewed in detail, and those that met the inclusion criteria progressed to full-text assessment. Discrepancies between reviewers were resolved through discussion, and if necessary, a third reviewer was consulted

to reach consensus. The PRISMA flow diagram was used to illustrate the process of study identification, screening, exclusion, and inclusion.

Data Extraction

Data extraction was conducted independently by two reviewers using a standardized collection sheet. Extracted details included author names, year of publication, country, study design, participant characteristics, intervention and comparator protocols, outcome measures, and key numerical results. Additional information such as funding sources, conflicts of interest, and reported study limitations was also recorded. Any disagreements in extracted data were resolved through discussion until consensus was achieved.

Risk of Bias Assessment

The methodological quality of included randomized controlled trials was appraised using the Cochrane Collaboration's Risk of Bias Tool. This tool evaluates domains such as random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, completeness of outcome data, selective reporting, and other potential biases. Each domain was graded as having a low, high, or unclear risk of bias. Assessments were performed independently by two reviewers, with consensus reached after discussion of any differences in interpretation.

Data Synthesis

Due to heterogeneity in study designs, follow-up durations, outcome measures, and reporting formats, a meta-analysis was not conducted. Instead, a narrative synthesis approach was employed. The results of the included studies were summarized descriptively and grouped according to each primary and secondary outcome. Patterns of agreement and divergence among the studies were identified, and where possible, direct comparisons between SST and conventional techniques were highlighted.

Results

Study Selection

The initial database and manual searches identified a total of 475 records. After removing duplicates using Mendeley reference management software, titles and abstracts were screened independently by two reviewers. Of these, 445 studies were excluded based on irrelevance to the review's scope, leaving 30 articles for abstract screening. Seventeen studies were excluded after abstract review for reasons including ineligible study design, inadequate sample size, or absence of a valid comparator. Full-text evaluation was performed for 13 studies, resulting in the inclusion of seven studies that fulfilled all eligibility criteria [12, 13, 16, 17, 20-22]. The PRISMA flow diagram (Fig 1) summarizes the study selection process. The data extracted from these studies is collectively listed in Table 1.

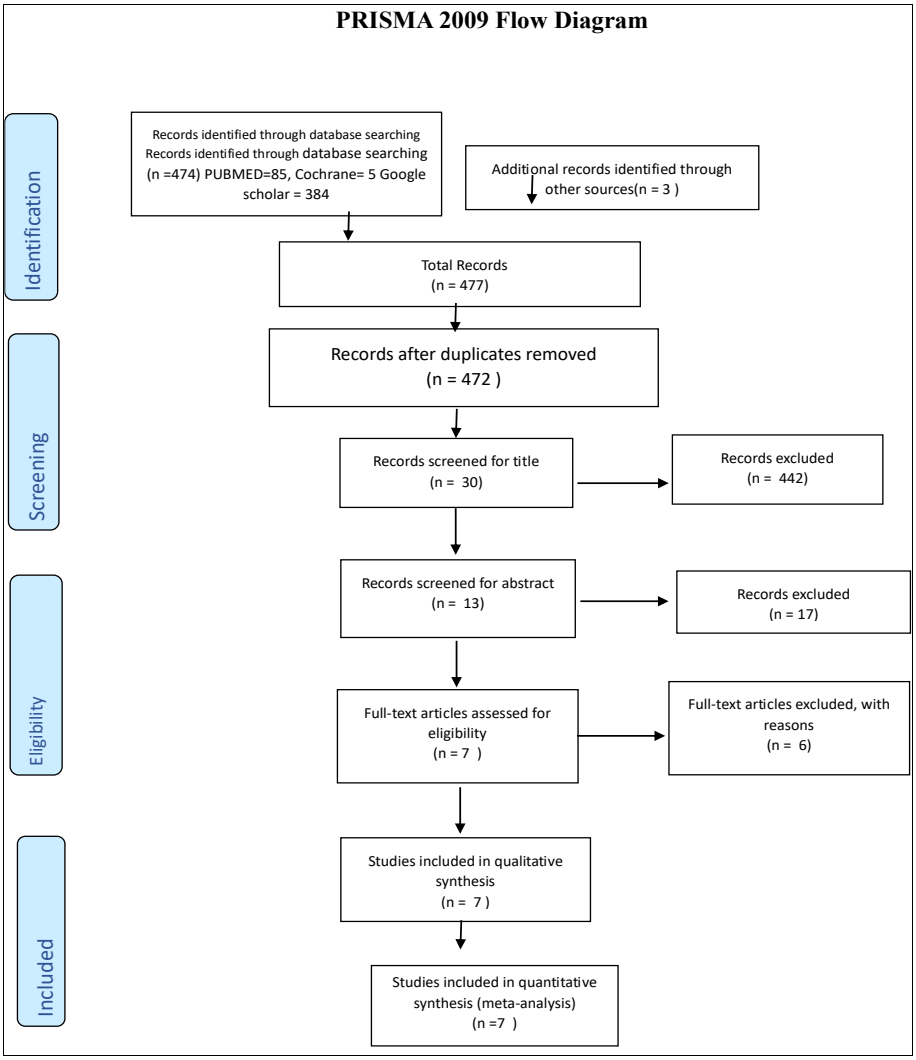

Fig 1: PRISMA Flow Diagram

Table 1: Characteristic data of the included studies

Author (Year)	Intervention	Comparison	Methodology	Outcome parameter assessed	Results	Conclusion
Ahmed Abd-Elrahman (2020) [12]	Immediate temporisation	Conventional immediate implant placement with socket shield	Randomised control trial	Radiological outcome, pink esthetic score, clinical outcome	Horizontal bone loss: 0–0.26 (0.15) mm vs 0.03–0.44 (0.32) mm; Vertical bone loss: 0.11–0.55 (0.31) mm vs 0.25–1.51 (0.7) mm; ISQ: 68.6 ± 3.81 to 76.7 ± 3.49 vs 66.4 ± 5.64 to 75 ± 4.4; PES: 11 to 12 vs 13 to 9	SST with immediate temporization is reliable for reducing labial bone loss following teeth extraction
Mohamed Atef 2021	Xenograft, single immediate implant	Conventional immediate implant placement and socket shield	Randomised control clinical trial	Clinical, radiological, esthetic outcome	Vertical resorption: 0.35 (±0.62) mm vs 1.71 (±1.02) mm; Horizontal resorption: 0.29 (±0.34) mm vs 1.45 (±0.72) mm; Midfacial mucosal recession: 0.466 (±0.58) mm vs coronal migration 0.45 (±0.75) mm; No significant difference in PES	SST preserves hard and soft peri-implant tissues following immediate implant placement
Shamita Tiwar 2019	Immediate implant	Immediate implant vs socket shield	Randomised control trial	Labial bone thickness	Labial thickness reduced after follow-up in immediate implant placement patients	Reduction in labial bone thickness observed without SST
Ennio Bramanti 2018	Immediate implant	Conventional immediate implant and socket shield	Randomised control trial	Clinical, radiological, esthetic assessment	Implant survival: 100% in both groups at 3 years; SST showed better marginal bone level and PES (P<0.05)	SST is safe and provides better aesthetic results compared with the conventional postextractive technique
Hesham Fattouh (2018) [17]	Immediate implant	Conventional vs socket shield	Randomised control trial	Clinical, radiological, esthetic parameter	Implant survival: 100% in both groups; SST demonstrated significantly better marginal bone levels	SST is a promising option with better esthetic outcomes than guided bone regeneration
Payal Rajender Kumar 2021	Immediate implant	Conventional immediate implant and socket shield	Pilot study	Clinical, radiological, esthetic outcome	PES: 9.07 vs 6.87 (p < 0.05); Buccal bone maintained in SST group vs loss in control group	Better soft tissue parameters with SST compared to conventional graftless technique
Muthukumar Santhanakrishnan 2021	Immediate implant placement	Conventional vs immediate	Randomised control trial	Clinical, radiological, esthetic outcome	CBT reduction: 0.05 ± 0.02 mm in SST; No significant difference in mean PES within/among groups; Individual PES scores showed significant difference (P<0.001)	SST demonstrated minimal reduction in CBT and superior PES at 6 months compared with IIP and DIP

Characteristics of Included Studies

The seven included studies were published between 2018 and 2021 and consisted of six randomized controlled trials and one pilot study. Sample sizes ranged from small-scale pilot investigations to trials with multi-year follow-up. All studies compared SST with conventional immediate implant placement, with variations in adjunctive measures such as immediate temporization or the use of xenografts. The studies collectively assessed a range of clinical, radiological, and esthetic outcomes, including marginal bone loss, buccal bone width changes, radiographic bone thickness, pink esthetic score (PES), implant stability quotient (ISQ), survival rates, and complication rates.

Marginal Bone Loss

Across the included trials, SST consistently demonstrated reduced marginal bone loss compared to the conventional immediate implant approach. Ahmed Abd-Elrahman (2020) [12] reported horizontal bone loss ranging from 0 to 0.26 mm in the SST group compared to 0.03 to 0.44 mm in the control group, with vertical bone loss also lower in SST (0.11–0.55 mm) versus control (0.25–1.51 mm). Ennio Bramanti (2018) and Hesham Fattouh (2018) [17] both recorded statistically significant improvements in marginal bone level preservation with SST, despite high implant survival rates in both techniques.

Buccal Bone Width and Radiographic Bone Thickness

Maintenance of buccal bone width was a consistent finding in SST groups. Mohamed Atef (2021) reported significantly less vertical and horizontal buccal bone resorption in SST patients (0.35 mm and 0.29 mm, respectively) compared to controls (1.71 mm and 1.45 mm). Muthukumar Santhanakrishnan (2021) observed minimal reduction in crestal bone thickness (CBT) with SST (0.05 ± 0.02 mm), which was significantly lower than in immediate implant placement (IIP) and delayed implant placement (DIP) groups. In contrast, Shamita Tiwar (2019) noted measurable reduction in labial bone thickness in conventional immediate implants without SST, underscoring the protective effect of the technique.

Pink Esthetic Score (PES)

Five studies evaluated esthetic outcomes using PES. Ahmed Abd-Elrahman (2020) [12] recorded an increase in PES from 11 to 12 in the SST group, while the control group experienced a decline from 13 to 9. Payal Rajender Kumar (2021) reported significantly higher PES in SST cases (mean 9.07) compared to control (mean 6.87) at 15 days post-restoration. Although Mohamed Atef (2021) found no statistically significant difference in total PES between SST and xenograft groups, the SST group exhibited favorable soft tissue migration patterns. Muthukumar Santhanakrishnan (2021) noted no significant difference in mean PES within and among groups, but individual score comparisons favored SST.

Implant Stability Quotient (ISQ)

Two trials reported ISQ changes. In the study by Ahmed Abd-Elrahman (2020) [12], ISQ values in the SST group improved from 68.6 ± 3.81 to 76.7 ± 3.49, while in the control group, they rose from 66.4 ± 5.64 to 75 ± 4.4. Although both groups demonstrated improved stability over time, the SST group showed a slightly greater increase, possibly due to preserved buccal bone support and minimized resorption.

Implant Survival and Complications

All included studies reported high implant survival rates, with several noting 100% survival in both SST and control groups over follow-up periods of up to three years. No major biological complications related to SST were reported. Ennio Bramanti (2018) and Hesham Fattouh (2018) [17] found SST to be a safe and predictable option, while maintaining marginal bone and soft tissue architecture.

Patient Satisfaction and Soft Tissue Stability

Studies that included patient-reported outcome measures indicated high levels of satisfaction with SST. Mohamed Atef (2021) reported a mean VAS score of 9.37/10 in SST patients, correlating with favorable midfacial mucosal positions and reduced soft tissue recession compared to controls. Payal Rajender Kumar (2021) also demonstrated superior soft tissue maintenance in SST cases, with no buccal bone loss observed.

Overall Synthesis

The narrative synthesis of the evidence suggests that SST offers consistent advantages in maintaining peri-implant hard and soft tissue dimensions, particularly in the esthetic zone. While implant survival rates are comparable between SST and conventional immediate placement, SST appears to confer benefits in esthetic outcomes, PES scores, buccal bone preservation, and patient satisfaction. The findings are generally aligned across studies, although variations in methodology, sample sizes, and follow-up durations limit the strength of definitive conclusions.

Risk of Bias Assessment

The overall risk of bias assessment indicates that while most studies demonstrated a low risk in terms of random sequence generation, several methodological shortcomings were evident that could influence the reliability of the findings (Fig 2). The limited reporting of allocation concealment and the absence of blinding, both of participants and outcome assessors, introduce potential performance and detection biases. Incomplete details on selective reporting and the frequent omission of sample size estimation further suggest a moderate to high potential for bias in certain domains. Although the general trend of results across studies was consistent in favor of the socket shield technique, these methodological limitations underscore the need for cautious interpretation of the evidence and highlight the importance of conducting future trials with more rigorous design and transparent reporting standards.

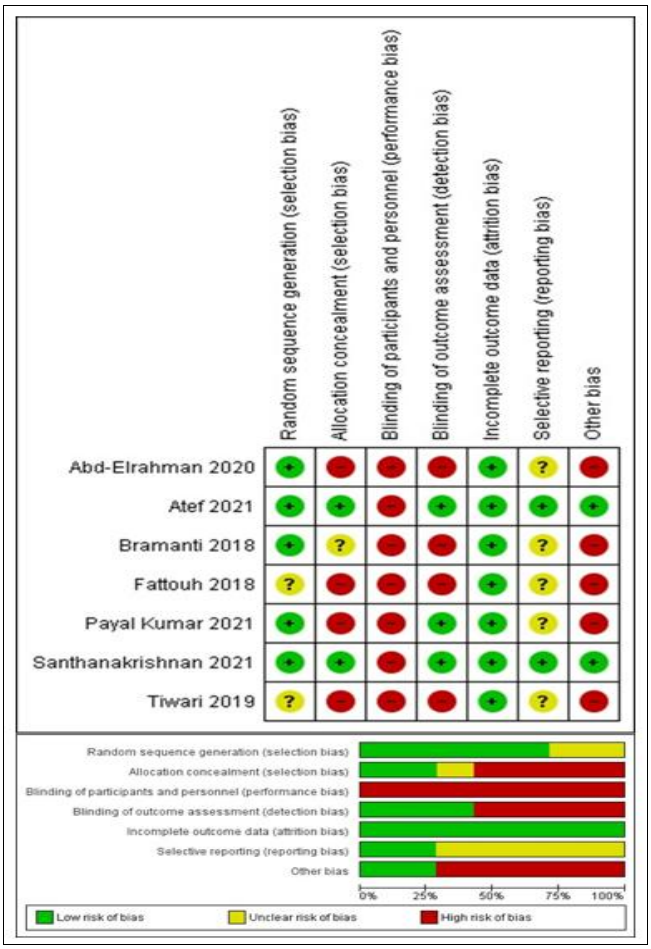

Fig 2: Risk of bias in the included studies

Discussion

The success of osseointegrated dental implants is closely dependent on the presence of adequate volume and quality of healthy bone at the recipient site during placement. Placement of implants in sites with a thin buccal crestal ridge, such as post-extraction ridges, is commonly associated with significant buccal bone resorption. The SST has been shown to mitigate this effect by preserving the buccal plate and supporting soft tissue stability, as reflected in reduced peri-implant probing depth and improved implant stability values. For example, Ahmed S. Abdel-Raheim (2019) [11] reported an increase in implant stability quotient (ISQ) from 60.30 ± 6.43 to 69.80 ± 3.77 after six months of SST application, while maintaining the integrity of the root fragment without apical resorption throughout the follow-up period, thus preserving ridge contour and shape [11]. Bäumer *et al*. (2015, 2017) also demonstrated favorable dimensional stability, reporting a mean horizontal loss of 1 mm after final restoration and marginal bone loss of only 0.33 mm

mesially and 0.17 mm distally, highlighting the minimal remodeling achievable with SST [15].

The concept underlying SST is rooted in the earlier "root submergence technique" introduced by Casey and Lauciello in the 1970s, which was adapted to implant dentistry to preserve alveolar ridge dimensions in the esthetic zone.[15] Modifications in SST preparation have been proposed to optimize clinical outcomes. Hürzeler *et al*., Gluckman *et al*., and Bäumer *et al*. recommended reducing the shield to 1 mm above the labial bone crest to maintain supracrestal marginal gingival fibers, while Gluckman *et al*. later described preparation flush with the labial crest to address shield exposure risks [15, 18]. Histological observations show cementum formation predominantly at apical contact areas between the implant and root surfaces rather than mid-root regions [15]. Clinically, Abdel-Raheim *et al*. reported bone-to-implant contact of 76.2% in the coronal threads adjacent to the shield, with PES improving from 11 to 12 at six months in the SST group, in contrast to a decline from 13 to 9 in the conventional group; these findings were derived from a randomized comparison of conventional immediate placement versus SST with immediate temporization [12]. These PES improvements align with findings by Bäumer *et al*. (2017) [15], who documented a mean PES of 12 in SST cases alongside lower horizontal and vertical bone loss compared with conventional immediate placement [15].

Mohamed Atef *et al*. confirmed these radiological and soft tissue preservation benefits in their randomized controlled trial, where complete hard tissue fill in the implant–shield gap was radiographically evident at six months [13]. While PES differences between SST (12.12 ± 0.64) and xenograft (11.86 ± 0.35) groups at 12 months were not statistically significant, SST produced favorable midfacial mucosal coronal migration (0.45 ± 0.75 mm) compared to recession in the xenograft group (0.466 ± 0.58 mm, $P = 0.017$). Radiographically, SST demonstrated vertical and horizontal buccal resorption of only 0.36 mm and 0.29 mm, respectively, with high patient satisfaction reflected by a mean VAS of 9.37/10 [13]. Comparable preservation of ridge contour was observed by Dalia A. Baraka *et al*., who emphasized that the biological processes immediately following extraction can be favorably influenced by root retention, in agreement with prior evidence that decoronation can maintain alveolar ridge form [14]. Bäumer *et al*., in a five-year retrospective evaluation, reported no biologic implant-related complications, stable keratinized tissue width, and oro-facial tissue resorption averaging only 0.37 mm, reinforcing the long-term dimensional stability of SST [15]. Ennio Bramanti *et al*., in their randomized controlled study with standardized radiographic protocols, demonstrated consistently higher pink aesthetic scores in the SST group at all follow-up intervals up to 36 months ($P < 0.05$), corroborating the technique's capacity to maintain hard and soft tissue stability and achieve predictable esthetic outcomes in the maxillary anterior region [16].

However, certain limitations must be acknowledged when interpreting these findings. The number of high-quality randomized controlled trials directly comparing SST with conventional immediate implant placement remains limited, and several included studies had relatively small sample sizes, short follow-up durations, and heterogeneity in surgical protocols, operator experience, and implant systems used. The lack of standardized criteria for shield preparation and positioning across studies makes it challenging to establish universally applicable clinical guidelines. In addition, most available evidence focuses on the maxillary anterior region, leaving gaps in understanding the applicability of SST in posterior or functionally demanding sites. Radiographic assessments in many studies relied on two-dimensional imaging rather than three-dimensional volumetric analysis, which may underestimate subtle dimensional changes. Future research should aim to address these gaps through well-designed, multicenter randomized controlled trials with larger cohorts, standardized SST protocols, longer follow-up periods, and objective quantitative assessments, including CBCT-based volumetric analysis. Investigations into the biological healing processes at the implant–shield interface and the influence of SST on long-term peri-implant health and prosthetic success will further strengthen the evidence base and refine its clinical indications.

Conclusion

Within the limitations of the available evidence, this systematic review indicates that the SST offers distinct advantages over conventional immediate implant placement in preserving peri-implant hard and soft tissue dimensions, particularly in the esthetic zone. SST demonstrates reduced marginal and buccal bone loss, favorable pink esthetic scores, improved soft tissue stability, and high patient satisfaction, while maintaining comparable implant survival rates. These findings suggest that SST is a predictable and clinically viable approach for enhancing esthetic outcomes in immediate implant placement; however, further long-term, high-quality studies with standardized protocols are necessary to validate these benefits and broaden its application across different clinical scenarios.

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