Clinical Oral Investigations
https://doi.org/10.1007/s00784-021-04266-z

REVIEW

Could the socket shield technique be better than conventional immediate implantation? A meta-analysis

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Received: 22 September 2021 / Accepted: 7 November 2021

Abstract

Objectives The purpose of this study was to evaluate whether the clinical outcome of socket shield technique (SST) is superior to that of conventional immediate implantation (CII).

Materials and method Five electronic databases (PubMed, Cochrane, Web of Science, CNKI, and Google Scholar) were searched to identify randomized controlled trials up to June 31, 2021. Five evaluation indexes were extracted, namely, buccal bone resorption at the horizontal and vertical levels (BBH and BBV), the soft tissue recession assessed by pink evaluation scores (PES), patient satisfaction (PS), ISQ, and the success rate of implantation (SRI), to compare the superiority between SST and CII operations. All data analyses were performed using Review Manager (version 5.4).

Results Ten studies were included in this review. The sample included 388 implants, with 194 in the SST group and 194 in the CII group. Compared with the CII group, the SST group had a lower BBH and BBV (standardized mean difference (SMD), − 1.77; 95% CI, − 2.26 to − 1.28; $P < 0.00001$ and SMD, − 1.85; 95% CI, − 2.16 to 1.54; $P < 0.00001$), higher PES improvement (SMD, 2.27; 95% CI, 1.59 to 2.95; $P < 0.00001$), higher rate of PS (OR, 3.12; 95% CI, 1.08 to 9.04; $P = 0.04$), and slightly higher ISQ (SMD, 0.71; 95% CI, 0.28 to 1.15; $P = 0.001$).

Conclusions Compared with CII, SST could be a better option for esthetic area implantation, but evaluation of its long-term success is still needed.

Clinical relevance By comparing and analyzing the operations of immediate implant in esthetic zone, we could choose SST to effectively alleviate the absorption of bone tissue and improve the contouring of soft tissue after anterior teeth extraction, so as to achieve a more stable and superior clinical outcomes of implant in esthetic zone.

Keywords Socket shield · Immediate implantation · Pink esthetic · Labial bone resorption

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Published online: 16 November 2021

Introduction

Many causes could lead to the tooth loss, including dental caries, periodontitis, dental injuries, developmental defects, and genetic disorders [1]. Over the past 30 years, the dental implantation has become an increasingly popular treatment option for failing teeth [2, 3]. It does not damage normal teeth, has relatively few complications, and is a stable procedure, and the implants are as comfortable as natural teeth [4]. However, traditional protocols for implant prosthetic treatment normally require the bone to heal following tooth extraction prior to placement of a dental implant, which usually takes 3 months [5]. A few studies [6, 7] have shown that patients who lost anterior teeth preferred short treatment protocols to a delayed approach, which led to the concept of immediate implantation. However, immediate implantation still does not completely solve the issue of alveolar bone resorption and soft tissue recession in anterior tooth sites after tooth extraction [8]. Preclinical and clinical studies have demonstrated that alveolar bone loss after extraction is an irreversible process regarding both horizontal and vertical reduction [9]. Furthermore, the resorption of the alveolar ridge is more pronounced on the buccal aspect than on the lingual aspect of the extraction socket [10, 11]. Therefore, in anterior tooth sites, the dentist is confronted with difficulty regarding how to avert the volumetric changes in the esthetic area.

A few studies found that the maintenance of alveolar bone and soft tissues was mainly determined by the existence of the vascular support from the periodontal ligament [12], so the idea of leaving the residual root part on the labial plate was proposed. This method is called "socket shield technology" [33], as the root fragment functions like a shield that preserves the buccal bone from resorption, whose concept originates from root submergence application to retard alveolar bone resorption for overdentures [13]. Some researchers [14] observed the histological sections of socket shields from animals and humans and showed different outcomes regarding whether the socket shield technique could reach the osseointegration. Many cases have demonstrated the failures and complications of this technique [15–17], although some other publications have shown good long-term results [18, 19]. None of the previous systematic reviews have included sufficient randomized controlled trials to finish a relatively complete meta-analysis, so updated studies are necessary to find more reliable, consensus results.

The purpose of this study was to compare the clinical outcomes of socket shield technology (SST) and conventional immediate implantation (CII) based on primary outcomes including buccal bone resorption and pink evaluation scores (PES), for soft tissue recession. The secondary considered outcomes included patient satisfaction (PS), ISQ, and the success rate of implantation (SRI). We hypothesized that SST could significantly alleviate buccal bone resorption and soft tissue recession and possesses superior PS compared with CII, while ISQ and SRI may not yield distinct differences.

Materials and methods

Literature search

Two reviewers independently searched the PubMed, Cochrane Library, Web of Science, CNKI, and Google Scholar databases to identify randomized controlled trials (RCTs) up to June 31, 2021. The key search items were as follows: socket shield and immediate implant. There was no language restriction. Furthermore, citations of potentially relevant studies from retrieved articles were reviewed. The details of the PubMed and Web of Science search strategies are listed in the Appendix as an example.

Inclusion and exclusion criteria

We included articles that met any of the following criteria:

1. The study was a prospective RCT that explored the effect of the socket shield technique compared with conventional immediate implantation in the anterior tooth area.
2. The participants' anterior teeth had at least one nonrestorable tooth in the maxillary region requiring immediate implantation. The age range of patients was 20 to 60 years old without restrictions on sex, race, or socioeconomic status.
3. The outcomes included at least one of the following: horizontal and vertical buccal bone resorption (BBH and BBV, detected by radiological evaluation), pink evaluation scores (PES) for soft tissue recession, and the success rate of tooth implantation (SRI).
4. The experimental group underwent immediate implantation via the socket shield technique, and the control group underwent conventional immediate implantation.

Studies meeting the following criteria were excluded:

1. Case reports, review articles, and cohort studies.
2. Not RCT studies.
3. Trials involving participants who were pregnant; took any medication that may affect implantation assessment; had systemic diseases that would interfere with normal healing, such as uncontrolled diabetes mellitus; had a

history of radiation therapy to the head and neck; and were heavy smokers.
4. Trials involving participants who were unable to follow the instructions or cooperate during the study.
5. Repetitive publications (with the better-described publication being included).
6. Trials conducted before 2005.

Quality assessment

Quality assessment of the included studies was determined according to the Cochrane Collaboration tool [20], which includes 7 criteria: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias.

Data extraction

Using a previously created data extraction form, 2 reviewers (Aobo Zhang and Yuping Liu) independently extracted the data from the eligible studies. The following data were extracted: first author; year of publication; patient characteristics; implants sample size; study design; intervention; and outcomes of BBR, soft tissue recession, PS, ISQ, and SRI. The soft tissue recession was evaluated using the PES scoring system introduced by Furhauser et al. in 2005 [21].

Data analysis

Data analysis was conducted using Review Manager (version 5.4; the Cochrane Collaboration, London, UK). The weighted mean differences or standardized mean differences (SMDs) with 95% confidence intervals (CIs) were used to assess continuous variables. If pooled outcomes were evaluated by inconsistent methods, the SMD was used. Odds ratios were used to evaluate dichotomous variables. Statistical heterogeneity was assessed by the I^2 test at $a = 0.1$. A fixed-effects model was used for meta-analysis if I^2 was less than 50%; otherwise, a random-effects model was adopted. We would perform a subgroup analysis if there were different study designs or any other conditions and performed a sensitivity analysis by omitting the study data sequentially to explore causes of heterogeneity. The statistical significance of the hypothesis test was set at $P < 0.05$. We used forest plots to show pooled outcomes.

Results

Characteristics of the included studies

The search process was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement [22]; the flowchart is shown in Fig. 1. We identified 515 related studies from 5 electronic

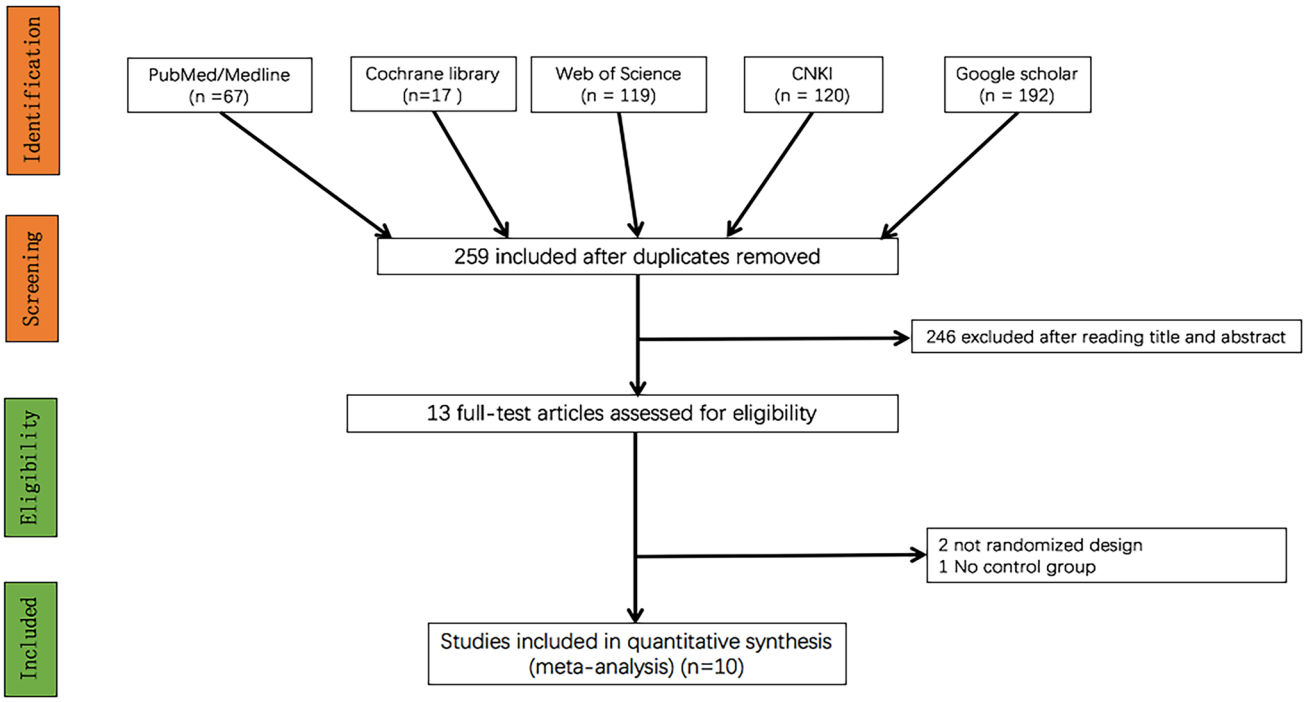

Fig. 1 Flow diagram of searching process

Table 1 Characteristics of studies

Study	Year	Study design	*N* (implants)	Age (year): mean + SD	Intervention	Follow-up time (after surgery)	Evaluation index
Abd-Elrahman[23]	2019	RCT (split-mouth)	40	30.9 ± 5.5	SST CCI	< 1 month, 6 months	BBR, PES, SRI, ISQ
Bramanti[24]	2018	RCT (parallel)	40	NR	SST CCI	3, 6, 36 months	BBR, PES, SRI
Li[25]	2021	RCT (parallel)	80	38.09 ± 10.51	SST CCI	Pre-operation to 12 months	BBR, PES, SRI, ISQ, PS
Atef[26]	2020	RCT (parallel)	42	36 ± 5.55	SST CCI	< 1 month 12 months	BBR, PES, PS
Sun[27]	2019	RCT (parallel)	30	> 25	SST Flap-less CCI	24 months	BBR, PES, ISQ
Fattouh[28]	2018	RCT (parallel)	20	> 18	SST CCI	12 months	BBV, PES, SRI
Tiwari[29]	2019	RCT (parallel)	16	18–50	SST CCI	12 months	BBR
Zhang[30]	2020	RCT (parallel)	60	37.0 ± 3.7	SST CCI	Pre-operation to 12 months	BBR, PES, PS, SRI
Hana[31]	2020	RCT	40	51.0 ± 9.25	SST CCI	12 months	PES, SRI
Barakat[32]	2017	RCT (parallel)	20	35.0 ± 7.5	SST CCI	7 months	BBH, BBV, ISQ, SRI

Abbreviation: *RCT*, randomized controlled trail; *SD*: standard deviation; *NR*, not recorded; SST, socket shield technique; *CII*, conventional immediate implantation; *BBH and BBV*, buccal bone resorption in horizontal and vertical dimension; *PES*, pink evaluation scores; *PS*, patient satisfaction; *ISQ*, implant stability quotient; *SRI*, the success rate of implantation

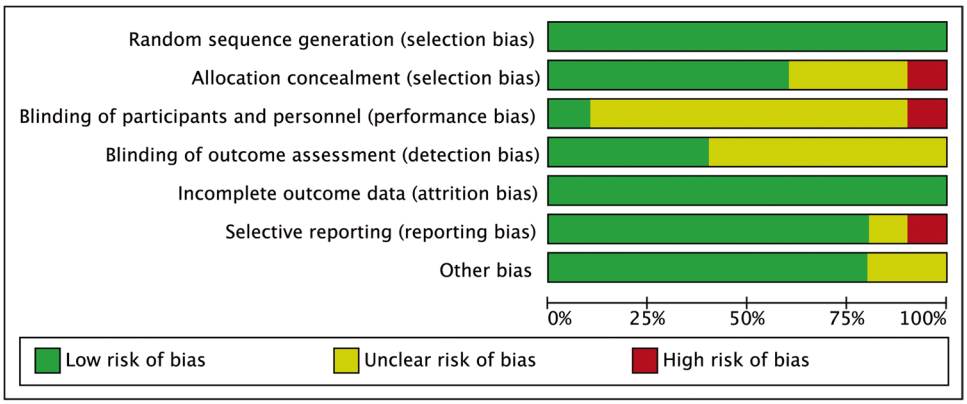

Fig. 2 Quality assessment of included studies

databases (PubMed, 67; Cochrane, 17; Web of Science, 119; CNKI, 120; and Google Scholar, 192), of which 256 were duplicates. After screening titles and abstracts, we excluded 246 unrelated studies. Of the 13 remaining studies, 3 were excluded after reading the full text because they were not randomized, leaving 10 studies for inclusion [23–32]. In total, 388 implants were included in this review, with 194 in the socket shield technique group and 194 in the conventional technique group. All included articles were published from 2010 to 2021. Eight studies were in English [23–30], and two were in Chinese [31, 32]. Each study's characteristics are presented in Table 1, and the quality assessment of the included studies is shown in Fig. 2.

Primary outcomes

Buccal bone resorption: horizontal and vertical levels (BBH and BBV)

The buccal bone resorption calculation was analyzed by using two dimensions: one is the thickness of the labial bone plate, which is horizontal bone resorption (BBH), the other is the height of the alveolar ridge, which is vertical bone resorption (BBV). Seven included studies recorded the BBH [23–27, 29, 30], whereas the BBV data were provided by six studies [23, 24, 26–28, 32]. We calculated the change in BBH and BBV at the baseline (before surgery) and the end point of follow-up time from each article according to Cochrane handbook (www.cochrane-handbook.org). The SST and CII groups both included 154 implants. Because the measurement sites of the labial bone plate were slightly different in each study, the SMD statistical method was used. The pooled outcomes showed that the resorption of the BBH in the SST group was significantly lower than that in the CCI group (SMD, − 1.77; 95% CI, − 2.26 to − 1.28; $P < 0.00001$), with moderate heterogeneity ($I^2 = 67\%$, $P = 0.006$; Fig. 3). After conducting a sensitivity analysis, we found that the study by Zhang et al. produced high heterogeneity. After the exclusion of this study and subsequent reanalysis, a new forest plot of BBH was created (SMD, − 1.93; 95% CI, − 2.36 to − 1.50; $P < 0.00001$), which showed lower heterogeneity ($I^2 = 44\%$, $P = 0.11$). Resorption of the BBV in the SST group was also significantly lower than that in the CCI group (SMD, − 1.85; 95% CI, − 2.16 to − 1.54; $P < 0.00001$; Fig. 4), with low heterogeneity observed ($I^2 = 0\%$, $P = 0.63$).

PES changes based on soft tissue assessment

We included 7 studies [23–27, 27, 30, 31] that recorded PES results, but Atef et al. [26] did not report the baseline PES value, so this study was excluded. Therefore, 6 studies were

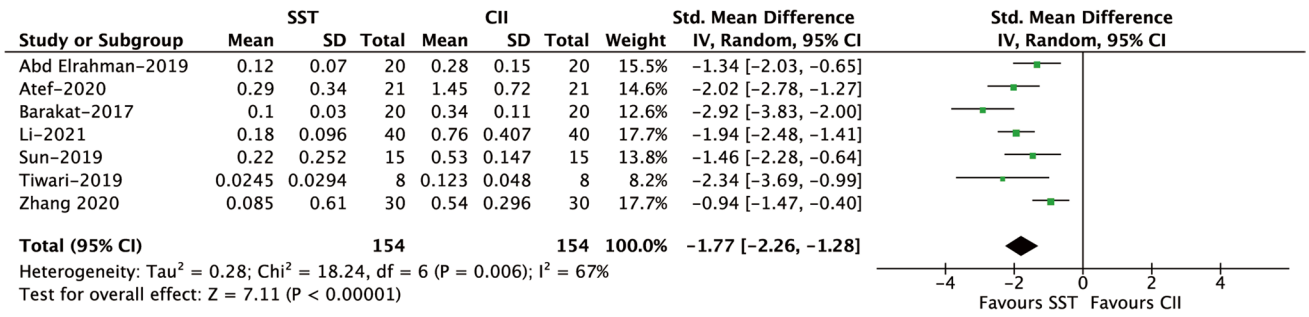

Fig. 3 Forest plot of meta-analysis for comparing buccal bone resorption in horizontal dimension between SST and CII in esthetic zone. Abbreviations: SST, socket shield technique; CII, conventional immediate implantation; CI, confidence interval; IV, inverse variance; SD, standard deviation; Std, standard

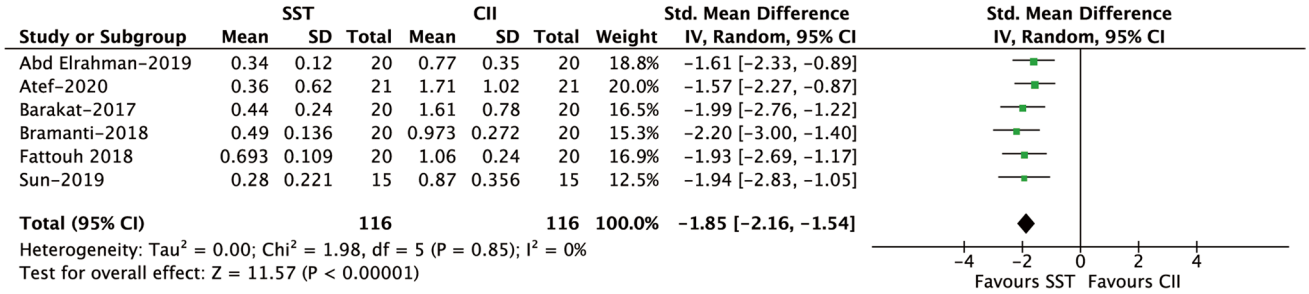

Fig. 4 Forest plot of meta-analysis for comparing buccal bone resorption in vertical dimension between SST and CII in esthetic zone

ultimately included in the PES assessment. The sample sizes of the socket shield and the conventional immediate implantation groups were 145 and 145 implants, respectively. We calculated the change in PES at the baseline (before surgery) and at the end point of follow-up from each article according to the Cochrane handbook (www.cochrane-handbook.org). A positive value indicated improvement in peri-implant soft tissue esthetics and a negative value indicated a reduction in peri-implant esthetics. From Fig. 5, the pooled results showed that the PES improvement in the socket shield group was higher than that in the conventional immediate implantation group (SMD, 2.27; 95% CI, 1.59 to 2.95; $P<0.00001$), with high heterogeneity observed ($I^2=85\%$, $P<0.00001$; Fig. 5). After conducting a sensitivity analysis, we found that the study by Ahmed et al. had high heterogeneity. With the exclusion of this study and reanalysis, a new forest plot of PES was generated (SMD, 1.96; 95% CI, 1.52 to 2.39; $P<0.00001$), showing moderate heterogeneity ($I^2=57\%$, $P=0.10$), which was not significantly different from the previous plot.

Secondary outcomes

Patient satisfaction

Three articles [25, 26, 30] recorded patients' assessments of satisfaction with the two different operations. A total of 182 implants were included, with 91 in the socket shield group and 91 in the conventional immediate implantation group. All the studies used the visual analog scale (VAS) to evaluate the patient satisfaction (PS) and categorized the VAS scores into two groups, satisfied and dissatisfied degree, so we calculated the number of patients accordingly. The results are expressed as the odds ratios (ORs). The pooled outcomes showed that the socket shield resulted in a PS rate that was 3.12 times higher than that of the conventional immediate implantation group (OR, 3.12; 95% CI, 1.08 to 9.04; $P=0.04$; Fig. 6), with low heterogeneity ($I^2=0\%$, $P=0.53$).

Implant stability quotient and the success rate of implantation

Four studies [23, 25, 27, 32] reported the implant stability quotient (ISQ) calculated by the resonance frequency analysis device [sennerby2008]. The socket shield group included 95 implants, and the conventional immediate implantation group included 95 implant. The pooled outcomes showed that the ISQ of the socket shield was slightly higher than that of the CII group (SMD, 0.71; 95% CI, 0.28 to 1.15; $P=0.001$; Fig. 7), with moderate heterogeneity ($I^2=51\%$, $P=0.10$). After conducting a sensitivity analysis, we found that the study by Li et al. had high heterogeneity. With the exclusion of this study and subsequent reanalysis, a new forest plot of ISQ was created (SMD, 0.51; 95% CI, 0.13 to 0.89; $P=0.009$), with a low heterogeneity ($I^2=0\%$, $P=0.43$).

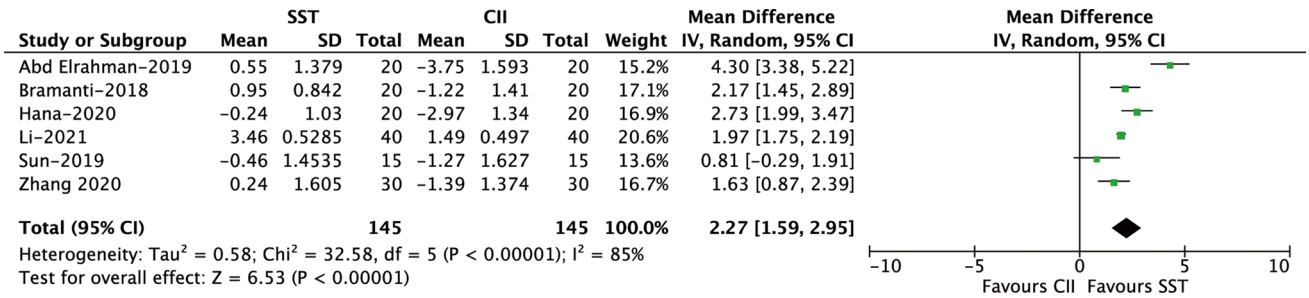

Fig. 5 Forest plot comparing the changes of pink estimate scores for peri-implant soft tissue between SST and CII in esthetic zone

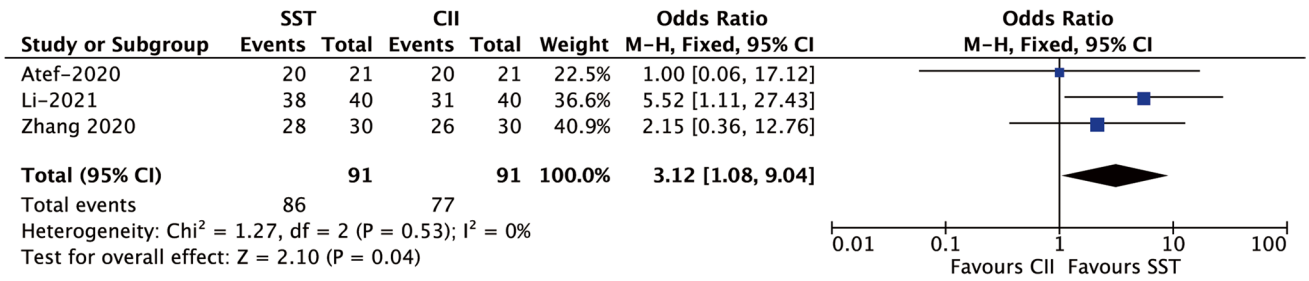

Fig. 6 Forest plot comparing the scores of patients' satisfaction evaluated by visual analog scale between SST and CII

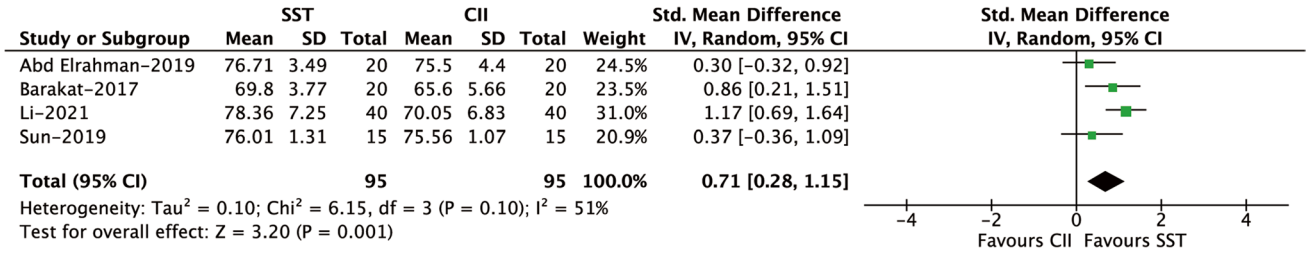

Fig. 7 Forest plot comparing implant stability quotient between SST and CII

Five studies reported success rate of implantation (SRI) results. Most of the included studies showed a 100% success rate and achieved a suitable prosthetic outcome, except Hana et al., who reported a 5% failure rate in both groups due to shield exposure in SST and soft tissue recession in the CCI group, respectively, which means that the SRI of both groups was suitable and the desired outcome of osseointegration was achieved.

Discussion

Socket shield originated due to the submerged roots from overdentures, and non-infected vital roots that are completely submerged within the alveolus may be an expedient and inexpensive way of preserving alveolar bone for the support of complete or removable partial dentures [13]. Recently, Hurzeler et al. [33] and Schwimer et al. [34] conducted animal and human studies of socket shields, respectively. Schwimer et al. described the histology of socket shields in humans and the use of the socket shield technique in immediate implantation. Based on the histology results, the tissue that was intimately connected between the implant screw thread and socket shield was identified as mature living bone tissue, with concentric lamellae and osteocytes [34]; afterwards, the fibers of periodontal ligaments shuttled between bone occupying the implant and ambient bone [35]. This is the desired outcome of osseointegration. From this study, we found that the SRI in both the SST group and CCI group reached 100%, except for one article, in which the SRI reached 95%; similarly, the ISQ from both groups was mostly over 70, while the ISQ of the socket shield group was higher than that of the control group, which means that these implants of both groups were successful and osseointegration was achieved. These results are consistent with some case reports [36].

In fact, the main characteristics of the socket shield technique are bone resorption preservation and esthetic assessment for peri-implant soft tissues. Theoretically, the socket shield could alleviate the loss of alveolar bone as a function of residual root fragments, and thus enhance the contour of the hard tissues and increase the esthetic outcomes of soft tissues [37], ultimately leading to patient satisfaction. Regarding the mechanism to prevent the buccal bone resorption and peri-implant soft tissue recession, Bäumer et al. [19] have demonstrated that the remaining root fragments could help to preserve alveolar bone by maintaining the periodontal attachment, including the periodontal ligament, bundle bone, and cementum, which all play an important role in the resorption process of peri-implant tissues. Therefore, we can deduce that the width and height of buccal bone resorption and the PES of peri-implant soft tissues could be improved after immediate implantation with the socket shield technique. Through this meta-analysis, we proved the following: the loss in height and width of the alveolar ridge and bone plate was significantly lower in the SST group than in the CII group; the PES of peri-implant soft tissue in the SST group was significantly higher than that in the CII group, indicating that patients could achieve a more esthetic result; and the PS scores in the SST group were 3.12 times

higher than those in the control group, which correspond to the BBR and PES outcomes. These outcomes are also consistent with some of case reports [38–40].

The heterogeneity in primary outcomes may be mainly due to the different measurement sites or positions of implants in the included studies. For instance, Sun et al. gauged the width of the buccal bone plate at the fifth thread level on the implant, whereas Ahmed measured it at the implant shoulder. Tiwari et al. evaluated the buccal bone plate thickness at different sites according to the distances from the crest. In addition, the tooth sites receiving implants in the included studies were different, including incisors and canines, whose buccal bone plate situations are not exactly the same.

Limitations and future prospects

Several unresolved issues related to SST remain. First, there is still no common standard criterion for the success of SST, and most dentists use conventional implantation criteria for the assessment of SST, such as osseointegration, implant loosening, and no shadow of implant area on X-ray. However, we believe that the peri-plant tissue structure of SST is obviously different from that of CCI. More specifically, the structures surrounding implants of CCI all cling tightly to alveolar bone, thereby stabilizing the implant in the extraction socket by osseointegration. However, as a result of the existence of residual roots, the SST implant failed to have direct contact with the labial bone plate after the socket shield operation, although the histology of the socket shield showed the existence of bone on the implant surface, and the current studies still do not to make an objective comparison with the histological results of SST versus CCI in animals or humans. Therefore, based on the above differences, a rigorous new standard or guideline is needed to measure the success of socket shield implantation. Additionally, the follow-up time should be extended to 5 or even 10 years later. Finally, this study did not evaluate the data for the 5-year success rate or 10-year success rate after root shield surgery.

Conclusion

Based on this study, we found that the socket shield technique in esthetic area can improve the ISQ value and patient satisfaction and significantly reduce the loss of the labial bone plate and recession of peri-implant soft tissue. Regarding the success rate of implantation, both techniques achieved the desired outcome of osseointegration.

The socket shield technique could be a better option for esthetic area implantation, although further evaluation of its long-term success is needed.

Appendix

Search Strategies.

PubMed (MEDLINE):

(((((Socket Shield Technique[Title/Abstract]) OR (Socket Shield Techniques[Title/Abstract])) OR (Technique, Socket Shield[Title/Abstract])) OR (Socket-Shield Technique[Title/Abstract])) OR (Socket-Shield Techniques[Title/Abstract])) OR (Technique, Socket-Shield[Title/Abstract]).

Result: 67 studies.

WEB OF SCIENCE:

Socket Shield Technique (Topic) or Socket Shield Techniques (Topic) or Technique, Socket Shield (Topic) or Socket-Shield Technique (Topic) or Socket-Shield Techniques (Topic) or Technique, Socket-Shield (Topic) and Clinical Trial (Document Types).

Result: 119 studies.

Funding This work was supported by research grants from the National Nature Science Foundation of China (81671006, 30901680) and CAMS Innovation Fund for Medical Sciences (2019-I2M-5–038).

Declarations

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

Conflict of interest The authors declare no competing interests.

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