

# Socket-shield Technique: A Systematic (Scoping) Review of Case Series and Case Reports

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## ABSTRACT

**Aim:** The present study is aimed to evaluate the effectiveness of the socket-shield technique (SST) and immediate implant placement (IIP) as the treatment of choice for the stabilization of soft and hard tissues at the extraction site and correlate with patient-related and implant-related factors.

**Methodology:** An electronic search was performed on Cochrane, EBSCO host, Medline/PubMed, Scopus, Wiley Library, Google website search, and Web of Science databases from January 2010 to September 2021. The search terms used were "socket-shield technique," "modified SST," "root membrane technique," "pontic shield technique," and "immediate implant." Case report and case series, both retrospective and prospective in nature, where SST procedures were done with IIP after tooth extraction were considered for the study. However, clinical trials on animals and studies with less than 3-month follow-up after implant placement were not considered for the study. The studies were collected, analyzed, and tabulated for further analysis to evaluate the aim and objectives of the study.

**Results:** Preliminary search identified through databases resulted in 350 articles, which on further screening led to exclusion of 299 articles based on the selection criteria. Therefore, 51 articles were considered for the final analysis which comprised 11 case studies and 40 case reports. With a wide age-group, the maxillary anterior region was the site of choice for the SST with IIP when compared to the posterior region. Better adaptability, maintenance of ridge contour, and good success rate followed by limited complications were observed among case series and reports.

**Conclusion:** SST was successful in providing stability, esthetics, with lesser marginal bone loss and higher pink esthetic scores. However, well-designed prospective case series are few in number; thereby insufficient data on its reliability and longtime stability limit its application.

**Clinical significance:** SST provides a promising result and better esthetic outcome with minimal requirement of soft tissue grafts, thereby increasing its popularity and its application. However, further studies with a larger sample size and effective clinical research designs with a follow-up period are a requirement to establish the procedure and its reliability.

**Keywords:** Esthetic, Bone preservation, Bone regeneration, Dental implants, Immediate implant, Socket-shield technique.

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## INTRODUCTION

Tooth loss due to extraction or trauma results in the absence of a periodontal ligament which is associated with variable but inevitable time-dependent bone resorption. The literature documents dramatic resorption of the buccal cortical plate when compared to the lingual plate.<sup>1,2</sup> Alternation of ridge contour leads to compromised ideal positioning of the implant; hence, the support and stability of the surrounding soft and hard tissues may be altered, thereby affecting the esthetic outcome.<sup>3,4</sup>

Preservation of a thin buccal cortical plate in a freshly extracted socket has been a topic of debate. Different methods were introduced to intercept the challenge. Immediate implant placement (IIP) postextraction<sup>5,6</sup> has been an appealing method with added advantages of preservation of tissue contour and dimension, limiting the number of surgical procedures, thereby reducing the treatment time.<sup>7</sup> Other methods include bone substitute materials and/or barrier membranes. The amount of ridge maintained by this procedure is still questionable.<sup>8-10</sup> Complete preservation and/or entire regeneration of the extraction socket have not yet been documented.<sup>11,12</sup> Anatomical differences between the thin buccal and lingual bones and the physiologic presence of osteoclasts within the extraction socket all favor pronounced buccal wall resorption.<sup>3,13</sup>

Socket-shield technique (SST), a clinical technique, introduced by Hurzeler et al.,<sup>11</sup> demonstrated the establishment of cementum on the implant surface when positioned in contact with intentionally

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retained roots.<sup>4,11,14-16</sup> It was observed that on the preservation of the coronal one-third of the buccal root followed by IIP palatal to the root fragment, the former functioned like a shield, prevented the buccal bone resorption, enhanced tissue contour, and increased the esthetic outcomes.<sup>3,17,18</sup> This technique underwent modifications,

such as modified SST<sup>10,19–21</sup> for root membrane technique,<sup>22</sup> and for proximal and interproximal SST,<sup>23</sup> to achieve better success and overcome a few limitations of SST.

Though implant positioning, insertion, and cementation of the final restoration is a challenge in the maxillary anterior esthetic zone,<sup>24–31</sup> however, with the advancement in implant materials, designs, equipment, and placement protocol, the outcomes have improved gradually.<sup>30,32–34</sup> Also, the periimplant soft tissue conservation, providing an appropriate emergence profile to the implant suprastructure restoration, and the tissue grafting process all are equally important to overcome the ridge contour changes after extraction.<sup>35–38</sup>

These implant technique advancements and modifications of SST made it popular for its widespread use among clinicians for restoration irrespective of the arch.<sup>39–46</sup> However, owing to the scarcity of the literature documentation on SST, little is known about the survival or/and success rates, complications, and failures associated with it.<sup>35,36,38,43,46,47</sup> Therefore, the present systematic review was carried out to summarize the effectiveness of the SST as a treatment of choice for the stabilization of the soft and hard tissues in the extraction site. Further, the study is also aimed to assess whether there is any association between patient gender, age, arch, region, and position of the IIP with SST. Lastly, other parameters that are aimed to assess are the influence of cause of extraction, length and diameter of the implant, complications, and suprastructure prostheses type, with the technique.

## MATERIALS AND METHODS

### Search Strategy and Selection Criteria

The present review was designed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines,<sup>48</sup> with some modifications specified by recently published systematic reviews.<sup>49,50</sup> An electronic search was performed on Cochrane, EBSCO host, Medline/PubMed, Scopus, Wiley Library, Google website search, and Web of Science databases from January 2010 to September 2021. The search terms were “socket-shield technique,” “modified SST,” “root membrane technique,” “pontic shield technique,” and “immediate implant.”

### Inclusion and Exclusion Criteria

Case report and case series, both retrospective and prospective in nature, where SST procedures with IIP were done after tooth extraction were included in the study. Clinical studies on animals and studies with less than 3-month follow-up after implant placement were excluded.

### Search Method, Screening, and Data Extraction

Two reviewers (MMA and FAA) evaluated the title, abstract, and available text of articles and assessed for relevance, eligibility, and data extraction. On application of the selection criteria, the title and abstracts of shortlisted articles were screened individually. Full texts of the related articles were reviewed for additional evaluation. The extracted data from the selected studies were as follows: author(s) name, publication year and country; age, gender, position, and site of implant placement w.r.t. cases; loading protocol and the main outcome of the studies; complications, survival rate, follow-up period, and type of final prostheses (Table 1) of the case series and (Table 2) the case reports. Implant osseointegration, shield exposure, shield infection, shield migration, soft tissue contour, and the radiologic outcome for buccal and/or crestal bone loss were also assessed.

## Quality Assessment of Selected Studies

The quality of each involved study was evaluated by two independent evaluators (AK and NAIH), and any possible discrepancies were resolved by consensus. The included articles were evaluated using the “Checklist for Case Reports and/or Series.” All data were arranged and presented in designated tables. The mentioned variables in the case reports and case series were summarized and analyzed.

## RESULTS

The preliminary search identified through databases resulted in 345 articles that were analyzed. Further, a manual search of the related journals resulted in the addition of five more research papers. Each reviewer further screened the publications and excluded similar studies and those that are not related to the research question. Therefore, 250 articles were excluded from further evaluation. On thorough screening of the remaining 100 articles, 49 studies were excluded as they did not address the present study objectives. Eventually, a total of 51 articles were considered; of which 11 were case studies and 40 were case reports (Flowchart 1).

### Qualitative Analysis

Variables concerning SST in both case series (Table 1) and case reports (Table 2) were author(s) name year and country of the study; medical and smoking habit history of the participant; age, gender, implant site, type of arch, tooth number, number of implants, causes of extraction, loading type, use of soft tissue graft, and implant width and length; osseointegration rate and complications if any; survival rate and follow-up periods were recorded. Also, classification of SST, marginal bone loss (MBL), and the type of final prostheses were assessed.

### Study Characteristics and Quality of the Reports

#### Case Series

A total of 11 case series published between 2014 and 2020 were analyzed and the relevant findings were tabulated (Table 1). The highest number (three) of studies were published in 2020 by Nguyen et al.,<sup>4</sup> Germi et al.,<sup>14</sup> and Mathew et al.,<sup>15</sup> from Canada, Iran, and India, respectively followed by two studies in 2017 by Mitsias et al.<sup>10</sup> and Baumer et al.<sup>3</sup> and two studies in 2014 by Glocker et al.<sup>2</sup> and Troiano et al.,<sup>31</sup> the remaining four studies each were authored by Habashneh et al.,<sup>17</sup> Zhu et al.,<sup>24</sup> Gluckman et al.,<sup>33</sup> and Lagas et al.<sup>30</sup> (Table 1 and Fig. 1).

#### Case Reports

Of the 40 case reports that were analyzed, 3 were published in 2021 by Oliveira et al.,<sup>25</sup> Alone and Niswade,<sup>26</sup> and Srivastava et al.<sup>27</sup> Other reports were published between 2010 and 2020, with the maximum number of articles (11) in 2018,<sup>20,39–42,51–56</sup> followed by 9 reports in 2017 by Buser et al.,<sup>57</sup> Huang et al.,<sup>21</sup> Durrani et al.,<sup>58</sup> Al-Dary and Alsayed,<sup>59</sup> Mitsias et al.,<sup>10</sup> Roe et al.,<sup>60</sup> Petsch et al.,<sup>61</sup> Pour et al.,<sup>62</sup> and Saeidi Pour et al.<sup>35</sup> (Table 2 and Fig. 2).

### Data Synthesis for Systemic Review

#### Case Series

Studies carried by Lagas et al.,<sup>30</sup> Zhu et al.,<sup>24</sup> Gulikman et al.,<sup>33</sup> and Mathew et al.<sup>15</sup> were the only ones that mentioned the number of implants: 5 central and 5 lateral teeth, 14 implants in the anterior maxilla, 10 implants in the anterior region, and finally 16 implants in the anterior region, respectively. Those studies did not mention

**Table 1:** Qualitative analysis of case series studies included in this review

Researcher(s)/ year/country	Age/gender/arch/region	Medical history/ smoker	Classification/type of loading	Cause of extraction/ diameter and length of implant/insertion torque/	Treatment outcome/soft tissue results and PES/MBL	Survival rate/restoration type/follow-up
Nguyen et al./2020	72-year/female/max/ anterior #21 and 22	Fit/	Buccal only class I/ immediate—graft placed	Failure RCT (horizontal) 3.5 × 13 mm	SST preserves not only marginal BB but also interimplant papilla No changes in soft tissue dimensions. MBL 0.1 ± 0.2 mm	100%/SRCC/72 months
	87-year/male/max/anterior #22			Previous trauma (vertical) 3 × 15 mm	Hard and soft tissues appear very stable	100%/SRCC/60 months
	62-year/female/max/ anterior #21			Failure of RCT (horizontal) 3.5 × 13 mm/35 N/cm <sup>2</sup>	Well-preserved hard and soft tissue profiles observed	100%/SRCC/24 months
Germi et al./2020	8-males/10-females/max/ anterior #13(2); 12(2); 11(4); 21(4); 22(2); 23(1) posterior #24 (3)	Fit/ nonsmokers	IIR—graft placed	NM/35 N cm <sup>2</sup>	I/RT patient selection → optimum esthetic results PES/6 months (8–10)/9.44 ± 0.783 <sup>SD*</sup> PES at 12 months (6– 10)/8.56 ± 0.1.003 <sup>SD*</sup> ↓↓↓ Central incisors gained complete scores for PES.	100% 6, 12 months
Mathew et al./2020	25–60 years/max centrals (5) max/laterals (5) five cases; SST and five cases; CIIP	Fit/ nonsmokers	(Buccal bone only) Immediate—graft placed (socket wall intact)	NM	SST prevents soft, natural, hard tissue changes, resorption, and more esthetically pleasing, good results obtained. PES score 12.2 <sup>sig</sup> MBL or resorption 0.68 mm CIIP	100% PFM crowns 3, 6, 12 months
Habashneh et al./2019	20–54 years/anterior #11 Posterior #15 Anterior #21 Posterior #14 Anterior #22	Fit/ nonsmoker	Buccal only/class I Buccal only/class I Buccal only/class I Buccal and palatal Buccal only/class I	Failure → RCT horizontal type Horizontal fractured Horizontal fractured Complex fractured Horizontal fractured 3.5–4.2 mm × 13–16 mm	SST and IIP improved buccal contour stability/better esthetic outcomes can be achieved SST with IIP is a minimally invasive approach that can preserve hard and soft tissues and the contour of the ridge can be implemented in areas of high esthet- ic demands for better esthetic outcomes.	100% SR-PFMCs/12 months
Zhu et al./2018	26–66 years/max nine patients/10 implants/ anterior	Fit/ nonsmokers	Immediate—No graft	NM	SST provides good esthetic outcomes in max anterior PES 13.5 Mesio buccal BL 0.17 and Distobuccal 0.22 mm	100% 32 months



Author	Age/sex	Fit	Delayed	Bone-implant contact (76.2%)	Root membrane technique (RMT) and I/P effective in preventing BBP resorption of anterior maxilla	Success rate
Mitsias et al./#12	68 year/male/max anterior	Fit	Delayed		Human histologic evidence RMT preserves BBP → clinical use to maintain hard and soft tissues over time and optimize esthetic results. 4 mm PDAI	100% 60 months
Baumer et al./2017	Over 25 years/five males and five females/anterior #11 (2) Anterior #12 (2) Anterior #21 (2) Posterior #14 (1) Posterior #24 (2) Posterior #25 (1)	Fit/nonsmoker	NM	Failure of RCT and failure of RCT (horizontal) Cariou teeth and failure of RCT (horizontal) Cariou teeth and failure of RCT (horizontal) Failure of RCT (horizontal)	SST good implants in esthetic zone ↔ second premolar SST ↓ invasiveness at surgery time, high esthetic with effective preservation of facial tissue contour. PES positive results in all cases (mean 12) BBL—37.0 mm (16.0–66.0), facial-mid average—33.0 mm, loss recession mesial 33.0 mm, bone marginal 17.0 mm distal. Volumetric and contour analysis, low changes in extraction and I/P follow-ups. Mucosal recession at implant was comparable to neighboring teeth.	100% CCs/(51–63) 58 months
Gluckman et al./2016b	Patients 10 Implants 14 Anterior maxilla	NM	Immediate—xenograft	NM	Tissue volume preserved One patient had complications/all three socket-shields exposed due to the failure of soft tissue closure. One socket-shield exposure	90% 12–18 months
Lagas et al./2015	16 patients—CIIP (10 patients), Delayed IP (6 patients)	Fit/nonsmokers	Immediate—no graft Delayed—no graft	NM	Good treatments results One shield failed due to infection One case showed deficiency of alveolar ridge	88.0% 6–30 months
Glocker et al./2014/ Switzerland Modified SST	60 years/female/anterior #13 28 years/female/anterior #11 28-years/female/anterior #22	Fit/nonsmoker Fit/smoker	Buccal only/class I Delayed 6 months with bone graft	Failure of RCT and PFM bridge (horizontal) Failure of RCT (horizontal) and chromatic aberration	MSST → prevents alveolar ridge resorption and is cost-effective and minimally invasive. MSST avoids bundle bone resorption	100% CCs 6 months
Troiano et al./2014/ Root-T-Belt Technique Case S/series	Max incisors (4) Max canines (3) Mand canines (3)	Fit/nonsmokers	Immediate—graft placed	Orthodontic trauma → necrosis → RCT → failure (horizontal), and chromatic aberration Failure of RCT (horizontal) 13 × 3.75 mm × 32 N cm Failure of RCT (horizontal) 16 × 3.75 mm × 32 N cm <sup>2</sup> Failure of RCT (horizontal) 13 × 3.75 mm × 32 N cm	No implant immobility, peri-implant radiolucency/infection, pain, no paresthesia in the treated area Root-T-Belt T conserving dental, predictable bone structure, preservation of peri-implant gingiva, more Mean CBL (1.3 ± 0.2 mm) Not more than 1.5 mm	100% SCRCs/ 1–72 months

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**Table 2:** Qualitative analysis of case report articles included in the present review

Researcher(s)/year/ country	Age/gender/arch/region/ tooth#	Medical history/smoker	Classification/type of loading	Extraction cause/implant diameter and length/insertion torque	Treatment outcome/complications	Survival rate/restora- tion type/follow-up
Oliveira et al./2021/Brazil	45 years/female/max/ posterior left #15	Fit/ nonsmoker	Buccal class I/imme- diate—graft placed	Carious tooth (horizontal)/3.75 × 10.0	SST maintains alveolar bone preservation and contour tissue that facilitates 3D implant positioning Low cost with good esthetic outcomes	100% SR-PFM/3 months
Alone and Niswade/2021/ India	35 years/male/max/ anterior #11	Fit/ nonsmoker	Buccal class I/imme- diate—no graft	Carious tooth (complex)/4 × 13 mm	SST shows promising results with respect to soft and hard tissue preservation in the cases of postextraction immediate implant	100% PFM crown/3 months
Srivastava et al./2021/India	21 years/female/max/ anterior #21 and 22	Fit/ nonsmoker	Buccal class I/de- layed—xenograft	Grossly decayed teeth (vertical)	SST with IIP in the esthetic zone provides promising treatment in preserving both soft and hard tissues	100% PFM crown/3 months
Zuhr et al./2020/ Germany	60 years/male/max/ anterior #11	Fit/ nonsmoker	Buccal class I/imme- diate—graft placed	Failure of RCT (vertical)	Shield around the buccal aspect of the implant was mobile where an 8-mm probing depth could be detected. Implant incisal edge was lower compared to the adjacent tooth, suggesting continuing growth of the neighboring tooth	0.00% CC 60 months
Alshammari et al./2020/Saudi Arabia	38 years/female/max/ anterior #12	Fit/ nonsmoker	Buccal class I/ immediate—no graft	Failure of RCT (horizontal) 3.5 × 13 mm	SST prevents soft and hard tissue changes happening during alveolar socket healing after extraction. Pink esthetic score was 12.	100% SR restorations 36 months
Ganz et al./ 2020/USA	28 year/male/max/ anterior #21 and 22 posterior right #25	Fit/ nonsmoker	C-shape class III Immediate—graft placed	Failure of RCT (horizontal) 4.5 × 13.0 mm/45 N cm 80 ISQ	PET, RM concept, and SST are proven to preserve bundle bone and tissue volume with and without IIP; yet, this minimally invasive treatment modality is highly technique-sensitive	100% 6 months
Pollis-Yanes et al./2020/Spain	50 year/male/max/ anterior #11 and 21	Fit/ nonsmoker	Buccal class I/ immediate—no graft	Horizontal fractured after RCT and crowning/3.5 mm–3.8 × 12 mm/30 N/cm	<i>Pontic shield techniques and SST</i> procedures that should be considered in oral rehabilitation in selected cases	100% CC/cantilever bridge
Dash et al./2020/ India	40 years/male/max/ anterior #21	Fit/ nonsmoker	Buccal class I/ delayed—bone graft	Gross carious/failure of RCT (combined)/ 3.8mm × 13mm/20 N cm	SST shows promising results in esthetic dentistry and maintaining diastema	100% PFM crown/6 months
Goel et al./2020/ India	23 year/male/max/ anterior #21	Fit/ nonsmoker	Buccal class I/ immediate— no-graft	Traumatic accident (vertical)/4.5 mm × 12 mm	SST and root submergence allows restoration of normal form and attachment complex by preventing bone resorption in the esthetic zone	100% —
Patel et al./2019/ India	Male/max/anteriors #11, 12, 13	Fit/—	Buccal class I/ immediate—no graft	RCT → grossly carious (horizontal)	SST along with the provision of smoothsurfaced DIs, stabilized with cortical engagement, replacement of missing maxillary anterior teeth. Patient reported satisfied esthetic outcomes	100% PFM crown/12 months
Arabbi et al./2019/ India	28 year/male/max/ anterior #11 and 21	Fit/—	Buccal class I/ immediate—graft placed	Fractures of crowns (horizontal)	SST with IIP is the technique of choice in esthetic area → resulted in excellent esthetic appearance	100% CC/6 months

Schwimer et al./2019/South Africa	Male/max/posterior right #27	Fit/—	Buccal class I/ delayed—xenograft	Fractures of crowns (horizontal)	SST preserves tooth structure, maintaining ridge implant sites and alveolar ridge anterior and posterior (MOLAR) at the IIP site horizontally and vertically	100% SR restoration 4 months
Kumar and Kher/2018/India	Adult/female/max/ anterior # 11	Fit/—	Buccofacial 1/2 root class II/immediate—no graft	Buccal and palatal parts (horizontal) 3.8 mm x 15 mm	Preservation of hard and soft tissues, both horizontally and vertically	100% E-Max CC/3, 6, 12 months
Verma et al./2018/India	27 years/male/max/ anterior #11	Fit/—	Buccal class I/ immediate—no graft	NM	SST valuable, minimize buccal contour after extraction. Also, healthy peri-implant soft tissue and ridge preserved	100% CC 12 months
Guo et al./2018/China	28 years/female/max/ anteriors # 21	Fit/ nonsmoker	Buccal class I/ delayed—PRF	In proper post and core → (complex) 3.3 x 12 mm	SST with PRF, IIP may be effective for preservation and maintenance of stable peri-implant tissue	100% CC/18 months
Mattar/2018/Egypt	25-years/male/max/ anteriors #12	Fit/ nonsmoker	Buccal class I/ delayed—no graft	Grossly decayed 21 (horizontal) and PFM crown of 11	SST and IIP provide solution to prevent the collapse of thin buccal bone → excellent esthetic outcomes.	100% CC/18 months
Esteve-Pardo and Esteve-Colomina/2018/Spain	76 years/male/max/ anteriors #12 and 22	Fit/smoker	Buccal class I/ immediate—no graft	Roots subgingivally and peripherally decayed (horizontal)	Inflammations in socket, change of insertion and maintains tissue volume in esthetic area Two implants supported six max anterior teeth with cantilever on both canines*	100%/SR ceramic cantilever bridge/5–6 months
Fonseca/2018/Portugal	65 year/female/max/ anterior #11	Fit/ nonsmoker	Buccal class I/ immediate—graft-placed	Heavily restored and failing (horizontal) 4.5 mm x 12 mm/45 N cm	Proper case selection, planning → esthetically challenging scenarios Positive esthetic results—↑PES and WESs (≥12)	100% CSRC/24 months
Schwimer et al./2018/USA	45 years/female/max/ posterior right #24	Fit/ nonsmoker	Buccal class I/ immediate—no graft	Failure of implant (peri-implantitis)	SST and IIP with provisionalization → Bone occupy space ↔ implant surface and SS as osseointegration outcome. ↑ probing depth and crestal bone loss First human histological evidence that bone occupies space ↔ implant surface and socket	0.00% CC/24 months
Aslan/2018/Turkey	32 years/male/max/ anterior #11	Fit/ nonsmoker	Buccal class I/ immediate—deminerallized bovine bone	Incomplete RCT (horizontal)/3.9, 11.5 NN/15/ DN/35 N cm/	MSST and IIP maintain natural emergence profile, improved volume, contour stability obtained by retaining the shield in IIP Thin buccal bone (0.39 mm) after 1 year	100% E-Max CC/12 months
Gluckman et al./2018/South Africa	43 years/male/max/ anterior #21	Fit/ nonsmoker	Buccal and palatal class IV/ immediate—graft placed	Heavily restored post and core for RCT, resorption (complex) 4 x 13 mm	SST in conjunction with IIP and provisionalization positively supported the facial ridge of the implant	100% CC/12 months
Dayakar et al./2018/India	40 years/male/max/ anterior #22	Fit/ nonsmoker	Buccal class I/ delayed—graft placed	Cariou tooth (horizontal)	SST with IIP is a good alternative to preserve BCP in esthetic area and healthy peri-implant tissue	100% CC/3 months

(Contd...)

Table 2: (Contd...)

Researcher(s)/year/ country	Age/gender/arch/region/ tooth#	Medical history/smoker	Classification/type of loading	Extraction cause/implant diameter and length/insertion torque	Treatment outcome/complications	Survival rate/restora- tion type/follow-up
Nevins et al./2018/ Canada	First molars Case 1: bio-oss	Fit/ non-smoker	NM	Case 1: Advanced peri- implantitis, RF attached to mesial aspect evident  Case 2: loss of integration	Case 1: Human histology revealed implant in bone contact consistent with osteointegration, graft biomaterial in close proximity to fixture, direct implant contact to cementum of retained root surface, no sign of periodontal ligament  Bone ↔ implant surface and root fragment late implant failure might → to unintentionally remaining RFs	NM
Buser et al./ 2017/Australia	44 years/female/max/ anterior #11	Fit/—	Buccal class I/ immediate—graft placed	Trauma → subluxation → RCT → external resorption and failure of RCT/4 × 14 mm/more than 25/20N cm	Marginal tissues and level of mid-facial mucosa were healthy, shallow probing pockets and absence of bleeding after gentle probing	100% ZSRC/12 months
Huang et al./2017/ China	52 years/female/max/ anterior #11	Fit/—	Buccal class I/ modified SST/ immediate—no graft	Posttrauma pain and (horizontal) fracture line in the cervical area	PES score of 12/or more was defined as perfect. In this case, PES score was 13. RMT, human histologic good after 5 years of function	100% CC/6 months
Durrani et al./ 2017/India	22 years/male/max/ anterior #21	Fit/ nonsmoker	Buccal class I/ immediate—bovine bone graft	Carious tooth (horizontal)/3.4 × 13 mm	SST and PDL-mediated RMT may be the future of esthetics with hard and soft tissue volume maintenance	100% E-Max CC/24 months
Al-Dary and Alsayed/2017/ Kuwait	40 years/female/max/ anterior #11 and 21	Fit/ nonsmoker	Buccal class I Immediate/No-graft	Esthetic for max four incisors Horizontal fractured under crowns 3.2 × 12 mm	Replace two splinted PFM prosthesis covering max central incisors	100% ZCs/5 months
Mitsias et al./2017/ Greece	63 years/male/max/ anterior # 12	Fit/—	Buccal class I/ immediate no-graft	Trauma (horizontal) 3.5 × 11.5 mm	Historical. RMT prevents BBP resorption of anterior maxilla → maintains both tissues and optimizes esthetic results	100% CC/60 months
Roe et al./2017/ USA	56 years/male/max/ anterior #11	Fit/ nonsmoker	C-shape class III/ immediate—no graft	Failure of RCT 3.5 × 13 mm	Clinical. Stable peri-implant architecture, no inflammation Radiographic. Stable proximal bone levels, along with no pathology ↔ FRF and implant surface SST and IIP excellently maintain osseous- gingival architecture Facial window approach improves access to the residual root Clinician manages longer roots by ↓ implant-root-contact	100% SR- PFM crown/24 months
Petsch et al./2017/ Germany	47 years/male/max/ anterior #11	Fit/—	Buccal class I/ delayed—xenograft	Failure RCT (horizontal)	Thin biotype, peri-implant tissues were preserved successfully No change (soft tissue, pocket depth, plaque accumulation)	100% CC/24 months



Pour et al./2017/ Germany	38 years/male/max/ anterior #23	Fit/—	Buccal class I/ immediate—bovine bone graft	Trauma → external resorption and failure of RCT 4 × 14 mm/more than 25/20 N cm	SST favorable system practice → highly esthetic, ↓time ↓expense, less patient restorative team psychological stress No added cost for patient, one surgical procedure, ↓morbidity	100% SRCC/3 months
Saeidi Pour et al./2017/Iran	38 years/male/max/ anterior #13	Fit/smoker	Buccal class I/ delayed—no graft	Failure RCT (horizontal)	SST ↓invasive approach, less patient—clinician stress SST → soft and hard tissue stability around implant, offers high esthetic outcome to patients	100% CC/3 months
AlDary and Al Hadidi/2015/ Jordan	55 years/female/max/ posterior right #24	Fit/ nonsmoker	Buccal class I/ immediate—graft placed	Replace unstable 3-unit splinted PFM prosthesis (#23–25) (complex)/4.3 × 12 mm/25 Newton #24	SST → ultimate esthetic outcome imitating natural emergence profile, preserving soft and hard tissue	100% ZCs/3 months
Wadhvani et al./2015/Iran	Male/max/anterior #11	Fit/ nonsmoker	Buccal only class I/ immediate—graft placed	Failure of RCT (vertical)	SST suggested alveolar bone preservation	NM
Baumer et al./2015/ Germany	Max/canine-SST central incisor No socket-shield	Fit/ nonsmoker	Buccal class I/ immediate—graft placed	Non	SST sensitive, needs more scientific data, not recommended for clinicians in daily practice Yet, observed results are promising	100% — 12 months
Cherel and Etienne/2014/ France	40 years/male/max/ anterior #11 and 21	Fit/smoker	Mesial part only/ Class II/immediate— graft	Recurrence PA infections and root fracture (horizontal)	Interproximal ST by MSST Preserved BCB in esthetic zone	100% ZCs/6, 12 months
Chen and Pan/2013/Taiwan	58 years/male/max/ posterior right #25	Fit/ nonsmoker	Buccal class I/ delayed—no graft	Fracture 3 mm apical to palatal gingiva (vertical)/ 14.1 × 12 mm/35 N-cm	Preapical X-ray shows no bone change SST for high esthetic concern.	100% PFM crown/12 months
Al-Dary/2013/ Jordan	40 years/female/max/ anterior #11	Fit/—	Buccal class I/ delayed—no graft	Replacement prosthesis (horizontal) 12 × 3.2 mm	Peri-implant soft tissue is observed lingually* SST with IP viable technique to achieve osseointegration without inflammatory or resorptive response	100% ZC/6 month
Kan and Rungcharassng/ 2013/USA	45 years/male/max/ anterior #11	NM	Mesial and distal class IV/ osseous bone and allograft	Failure of RCT (horizontal)	PSS with IP maintaining bone level, dentogingival fibers attached to proximal supracrestal cementum, preservation of interimplant papilla Satisfactory results, but long evidence needed	100% Procera CC/12 months
Hurzeler et al./2010/ Germany	45 years/male/max/ anterior #21	Fit/ non-smoker	Buccal class I/ immediate—graft placed	Fracture due to trauma (vertical) 4 × 13 mm	SST does not interfere with osseointegration, be beneficial in preserving bundle buccal bone plate, reduced resorption postextraction	100% SRCC/3 months

MBL, marginal bone loss; CBL, crestal bone level; CBR, crestal bone level; BBP, buccal bone plate; BBL, buccal bone loss; CLIP, conventional immediate implant placement; MSST, modified socket-shield technique; IP, immediate implant placement; PRF, platelet-rich fibrin; BCP, buccal cortical plate; RF, root fragment; ABL, alveolar bone loss; PPD, pocket probing depth; P, premolars; IS, implant surfaces; RCT, randomized clinical trial; PES, pink esthetic score; ↑, increase; ↓, decrease; ↔, between; →, resulted in; %, percentage; NM, not mentioned; ACC, ceramic crown; SRCC, screw-retained ceramic crowns; PFM, porcelain-fused-metal; SR-PFM, screw-retained porcelain-fused-metal; ZC, zirconia crown; ZA, zirconia abutment

Flowchart 1: Flowchart of the study selection process

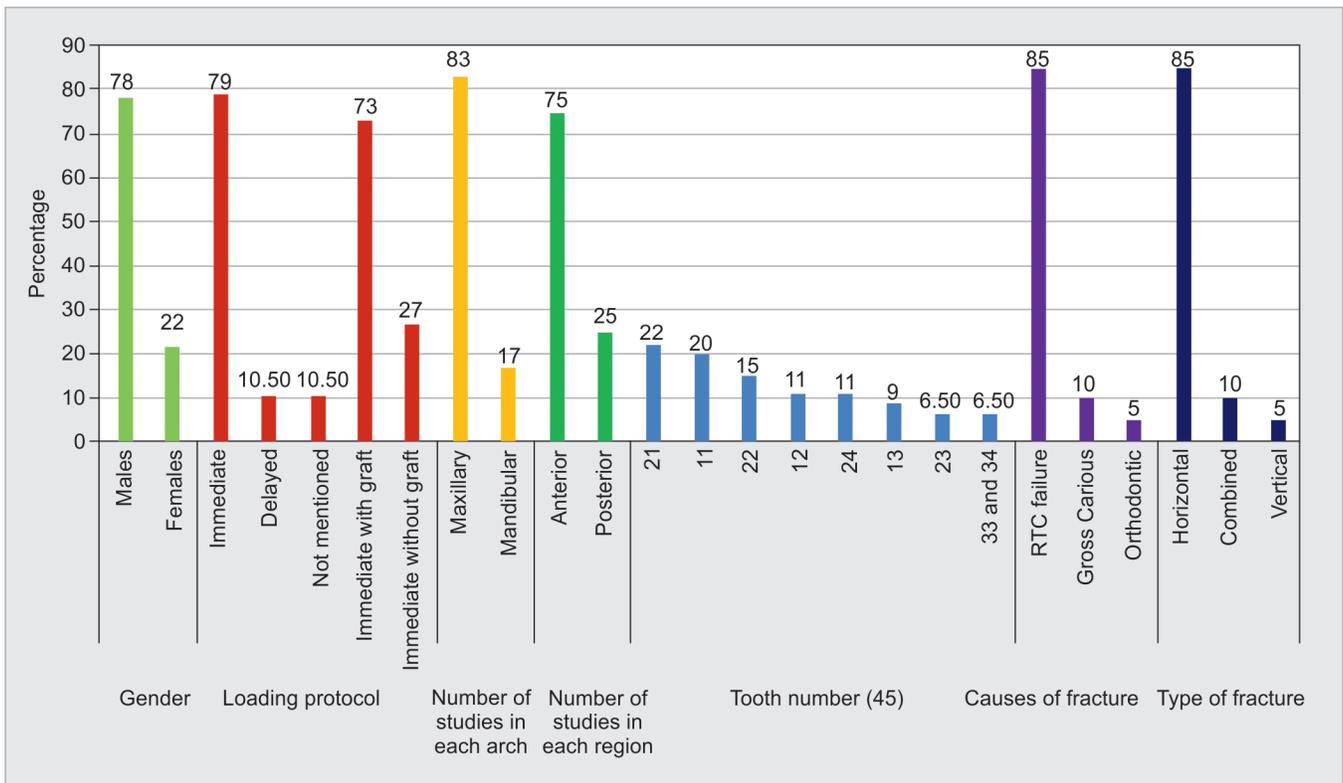
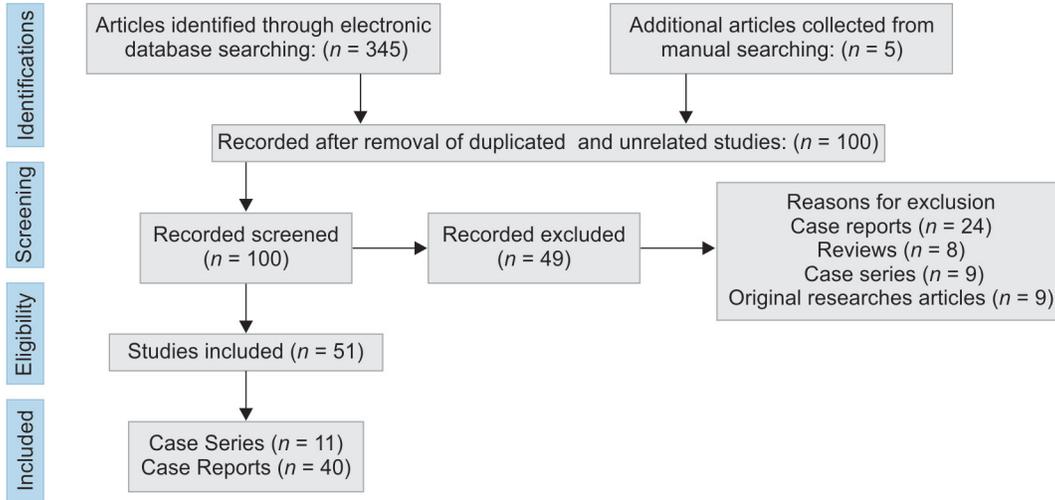


Fig. 1: Results of different parameters investigated in case series (n = 11 studies)

the tooth type (50 implants). The age of the patients was between 20<sup>17</sup> and 87 years;<sup>4</sup> two participants were smokers in this review. The survival rate was high in all case series and reached 100%, while a single study by Lagas et al.<sup>30</sup> recorded 88%; more than half of the articles (64%) mentioned the type of the final restoration.

SST with IIP showed preservation of the hard and soft tissues with better stability without any changes in dimension, optimum esthetic results, improved and preserved buccal ridge contour regions (maxillary anterior up to the premolars), and better outcomes.<sup>2,4,10,14,15,17</sup> Tissue volume remained unchanged<sup>3,12</sup> with

good osteointegration.<sup>31</sup> Pink esthetic score (PES) was between 8–10 and 6–10 after 6 and 12 months in a study;<sup>14</sup> while Mathew et al.<sup>15</sup> recorded a PES of 12.2 with a complete score for central incisors, Zhu et al.<sup>24</sup> scored 13.5 mm and Baumer et al.<sup>3</sup> recorded a mean PES of 12. Only a single article mentioned the PES and MBL for IIP which were 10.8 and 0.88 mm, respectively.<sup>15</sup> MBL for SST of 0.1 ± 0.2 mm for Nguyen et al.<sup>4</sup> was 0.68 mm, but for Mathew et al.<sup>15</sup> and Zhu et al.<sup>24</sup> was 0.17–0.22 mm. Pocket depth around implant (PDAI) was 4 mm as mentioned by Mitsias et al.<sup>10</sup> and Mathew et al.;<sup>15</sup> compared between SST and IIP, they found significant differences



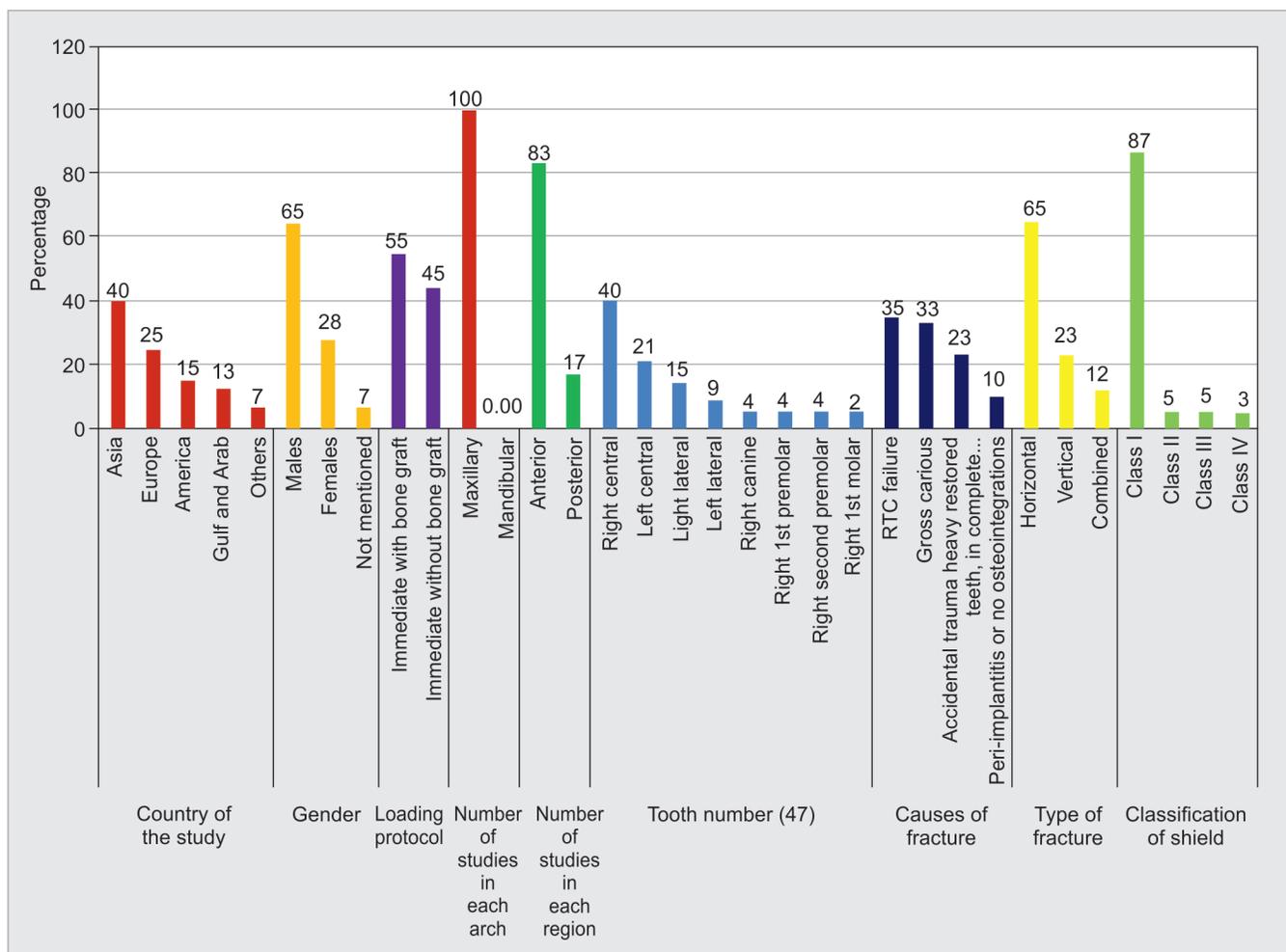


Fig. 2: Results of variables assessed in case reports (n = 40 articles)

between the two techniques for PES and MBL. Complications raised during the follow-up of case series were one shield failed due to infection, one case showed a deficiency of alveolar ridge,<sup>30</sup> and one patient had complications with the other three socket-shields exposed due to the failure of soft tissue closure<sup>12</sup> (Table 1 and Fig. 1).

### Case Reports

The age reported among the case records ranged from a minimum of 21 years to a maximum of 76 years. All case reports narrated the site of the immediate implant with SST in the maxillary arch while only one study did not state the site of the implant.<sup>56</sup> Anterior SST with or without IIP<sup>29</sup> showed preservation of hard and soft tissues, both horizontally and vertically,<sup>39</sup> maintaining ridge implant sites and alveolar ridge in posterior sites,<sup>25,29,36,56</sup> and the tissue volume was unchanged and minimal crestal bone loss was observed.<sup>20,53</sup> Further, an increase in PES and white esthetic scores (WES) ( $\geq 12$ ) was recorded by Fonseca.<sup>42</sup> Modified SST and IIP maintained natural emergence profile, improved volume, and contour stability obtained by retaining the shield in IIP, with minimum buccal bone loss of 0.39 mm after 12 months.<sup>20</sup> Pour et al.<sup>63</sup> concluded that SST in addition to the high esthetic outcome is a favorable practice with a surgical step, decreasing the time, minimal expenses, and reducing the psychological stress. SST in conjunction with

IIP and provisionalization positively supported the facial ridge of the implant.<sup>54</sup> The survival rate was high in all case series and reached 100%. Screw type restorations in the form of all ceramic or porcelain-fused-to-metal (PFM) were slightly higher than cemented types. The follow-up period ranged between 3 and 60 months (Table 2 and Fig. 2).

### DISCUSSION

In the last decade, the literature reports that SST with IIP assisted in the maintenance and preservation of alveolar bone, as well as hard and soft tissue contour, thereby facilitating good implant positioning. Moreover, it presented with a good esthetic outcome in the maxillary anterior area, recorded a minimum score of 12 for the PES, and described nominal changes during socket healing. Additionally, being relatively affordable, it also registered minimal buccal bone resorption over a period of time.<sup>25-28,38</sup> SST is considered the technique of choice in the maxillary anterior zone since it documented the least marginal bone resorption,<sup>15</sup> preserving not only the marginal buccal bone but also the interimplant papilla<sup>4</sup> with no changes in soft tissue dimensions.<sup>64</sup> Recent studies have observed that SST provides similar results for the posterior area with IIP<sup>14,17,63</sup> and in the mandibular arch too.<sup>31</sup>

This systematic review was carried out to characterize the effectiveness of the SST with IIP in the esthetic zone within the last decade and to evaluate whether this technique is the treatment of choice for the stabilization of the soft and hard tissues in the extraction site and further to assess the association of this technique in relation to factors, such as patient gender, age, arch, region, position of the IIP, length and diameter of the implant, complications, suprastructure prosthesis type, and the follow-up period.

Shaheen<sup>65</sup> allocated the partial extraction therapy into five different classes. In the present review, class I was the most common type—observed SST (78%), wherein the shield was located in the buccal area alone (Flowchart 1; Table 1). Next was the pontic shield technique considered in oral rehabilitation cases with pontic area deficiency.<sup>44</sup> While the root membrane concept with the soft tissue is proven to preserve the bundle bone and tissue volume with and without IIP, yet this minimally invasive treatment modality is highly technique-sensitive.<sup>29,33,66</sup> Siormpas et al.<sup>67</sup> reported that root membrane procedures are much accurate than conventional IIP. Also, Aslan<sup>20</sup> recommended the modified socket-shield system and IIP to maintain natural emergence profile, improved tissue volume, and contour stability.

Siormpas et al.<sup>67</sup> in their retrospective clinical study with a 10-year follow-up stated that the reasons for tooth extraction were a fracture that accounts for 61.2% while caries to 36.4%. However, from the summarized data of the present study, the cause of root extractions was RCT failure (85%), and horizontal root fracture (85%) was the highest.

The majority of the articles in the review reported the highest number of SST and IIP in the maxillary and anterior regions 83 and 75% for case series and 100 and 83% for case reports, respectively, when compared to the posterior area. This is in agreement with studies conducted by Han et al.,<sup>68</sup> where they suggested that this technique was more appropriate to the anterior esthetic region than the posterior molar region which was commonly characterized with either an unrestorable tooth with extensive caries, root fractures at different levels, lack of ferrule, or failed endo, restorative or post and core treatment(s) and even may be subjected to root resorption, thereby limiting the use of this technique.

On review of present study results, the maxillary teeth were recorded as the highest to be treated with SST and IIP. It was supported by Mangano et al.<sup>69</sup> and Siormpas et al.,<sup>67</sup> wherein the order followed were right central incisors (21 + 19), left central incisors (11 + 10), right lateral incisors (5 + 5), and left lateral incisors (13 + 7). These observations are in accordance with Mangano et al.<sup>69</sup> who reported that the maxillary incisors followed by lateral incisors were commonly indicated for the procedure. Further, it was also noted that canine was the least recorded incisor for the procedure. However, premolars scored different values among the studies ranging from 12 to 32.5%, where both maxillary right and left premolars were 8% in both case series and reports. Studies have recorded that the maxillary central, lateral incisors, canine, and premolars were the highest number treated by SST and IIP, respectively. On compilation of the results in the present review, a similar order as the former was identified.

On evaluating the cause of extraction, root fracture was the common complaint reported in both case reports and case series with 35 and 85%, respectively. While dental caries accounted for 10% in case series and 33% for case reports, fractures dominated the reason for extraction in both case series and reports; of which the horizontal fracture (85%) was predominant. Other notable

causes reported were accidental trauma, heavily restored teeth, and incomplete RCT. Of particular interest was root resorption and the lack of osteointegration formation that recorded almost 10% in both case reports and case series (Flowchart 1 and Fig. 1).

It is also observed that cases with IIP and SST were higher with a bone graft (56%) when compared to those without a bone graft (44%). Relatively lesser frequency of cases used soft tissue graft as recorded by Han et al.<sup>68</sup> when compared to 72% as recorded by Mangano et al.<sup>69</sup> In relation to the survival rates during the follow-up period, Han et al.<sup>68</sup> and Mangano et al.<sup>69</sup> recorded 95% but Han et al.<sup>68</sup> recorded higher numbers of their cases treated by SST and IIP. On the contrary, smaller percentages were documented in a study by Siormpas et al.<sup>67</sup>

## Limitations of the Study

Though the present study was able to achieve its aim and objectives, consideration of case reports and case series alone may act as a limitation as case-control studies or randomized control studies may support the findings further and aid in better evaluation for implementation as a technique or procedure.

## CONCLUSION

SST is gaining popularity owing to its promising result, better esthetic outcomes, and minimal requirement of soft tissue grafts, irrespective of the site of interest. Additionally, lesser MBL and higher PESs are recorded by the technique. However, well-designed prospective case series are few in number; thereby, insufficient data on its reliability and longtime stability limit its application. Hence, further clinical studies, such as prospective randomized controlled clinical trials, are a requirement, which will allow power analysis to control an acceptable cohort size to notify statistical explanation which would permit conclusions to be drawn.

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