Biomedical Communication

On the Ten-Year Success in the Application of Partial Extraction Therapy: A Systematic Review

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ABSTRACT

Hürzeler presented the socket-shield technique (SST) more than 10 years ago. The partial extraction therapy (PET), a collective concept of utilizing the patient's own tooth root to preserve the periodontium and peri-implant tissue, has been remarkably developed. PET comprises a group of novel techniques for post-extraction implant placement. Several modifications of PET and simultaneous implant placement have been presented since its inception. Since its origin, several alterations have been employed in the methodology of partial extraction of the root and the simultaneous implant placement. A repeatable, predictable protocol is needed to provide tooth replacement in esthetic dentistry. Moreover, a standardized procedure provides a good framework for clinicians to report data relating to the technique with procedural consistency. This review aims to illustrate a reproducible and systematic protocol for the PET techniques with immediate implant placement at the aesthetic zone. The most used technique is the socket-shield technique, which is potentially offers promising results, minimizing the necessity for invasive bone grafts round implants in the aesthetic area, clinical data to support this is very inadequate. The limited research data existing is cooperated by a deficiency of well-designed prospective randomized controlled investigations. The present case studies and techniques are of actual incomplete technical value. Retrospective studies published in limited records but are of inconsistent plan. At this point, it is indistinct whether the socket-shield technique will offer a stable long-time outcome or not.

KEY WORDS: PARTIAL EXTRACTION THERAPY, PONTIC SHIELD, PROXIMAL-SOCKET SHIELD, ROOT SUBMERGENCE, SOCKET SHIELD TECHNIQUE.

INTRODUCTION

Qualitative and quantitative variations, which arise in the alveolar ridge next tooth removal, can complicate the implant-prosthetic restoration. Several socket and alveolar ridge preservation systems have been developed to minimize the alveolar ridge atrophy. The tooth root can be conserved to limit bone resorption under a fixed or removable denture (Pagni et al. 2012). PET, as a socket shield technique, was first introduced by Hürzeler in (2010) and this process was first carried out on dogs, followed by a single implant placement in a human as a proof of concept (Hürzeler et al. 2010). Finally, a fabricated screw retained abutment was placed with an out of occlusion provisional crown. Many cases followed the concept and became published (Han et al. 2018; Gluckman et al. 2018; Schwimer et al. 2019).

The concept of PET is composed of four different techniques that aim to preserve slice of the tooth in the bone, thereby minimizing the loss of the bone vasculature and periodontal ligament attachment, thus eliminating the remodeling and resorption of both hard and soft tissues associated with tooth removal. Gluckman et al. (2016a), and Shaheen (2021) found that partial extraction therapy (PET) includes root submergence (RST), socket shield (SST), proximal socket shield (PSST), and pontic-shield (PST) (BUSER et al. 2000; Abadzhiev et al. 2014; Troiano et al. 2014; Al-Dary and Al Hadidi 2015; Durrani et al. 2017; Mitsias et al. 2017; Al-Dary and Alsayed 2017; (Durrani et al. 2017; Esteve-Pardo and Polis-Yanes et al. 2020; Abd-Elrahman et al. 2020).

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These systems have provided excellent mechanical, biological, and esthetic outcomes in the hands of experienced operators with meticulous treatment planning and case selection. In addition, a modified SST was presented by (Glocker et al. 2014). Han et al. 2018 used a 1.5-mm thick shield with the most coronal portion, while Guo et al. 2018 modified the SST by placing platelet-rich fibrin (PRF) in the gap between the root fragment and the implant and found that that peri-implant tissue was well preserved by the SST without significant peri-implant tissue resorption (Aslan 2018). The most commonly used indices for the evaluation of the aesthetic dimension of anterior single-tooth implants are the pink and white aesthetic score (PES/WES) indices, and they have been used in several studies (Belser et al. 2009; Buser et al. 2013; Mangano et al. 2014a; Zhao et al. 2016). Pink esthetic score evaluates the anterior esthetic of the implant-supported single crown on seven points, including mesial and distal papilla, soft-tissue color, contour, level, texture, and deficiency of alveolar (Fonseca 2018 and Mourya et al. 2019).

It comprises 10 variables such as mesial papilla, distal papilla, curvature of the facial mucosa, level of the facial mucosa, the root convexity, soft tissue color, and texture at the facial aspect of the implant site, tooth form, volume, color, surface texture, and translucency. A score of 2, 1 or 0 is assigned to all parameters. All parameters are assessed by direct comparison with the natural, contralateral reference tooth, estimating the degree of match or mismatch (Belser et al. 2009). Based on the Kaplan–Meier survival estimator, the cumulative implant survival rate (implant-based) was high. The complications were the infection of the root portion, with suppuration and fistula formation, which occurred in four cases at 83, 51, 59, and 12 months after implant insertion) and the infection of the root associated with peri implant mucositis in 1 case (at 113 months from the insertion of the fixture (Mangano et al. 2019).

Infection of the root membrane with fistula was determined in 50% of cases the occurrence of periimplantitis that caused the loss of two implants (at 12 and 59 months after insertion). In the remaining 50% of cases, however, the implant was not affected by the infection (Gluckman et al. 2016; Siormpas. et al. 2018). The prosthetic complications were divided into minor complications, such as no treatment needed or 60 min chair time and additional laboratory costs, repositioning of a loosened abutment, and removal of a fractured abutment or fabrication of new restorations. Static and dynamic occlusions were evaluated using standard occluding papers. All prosthetic complications were carefully registered and managed if possible, during the follow-up visits. Mangano et al. (2016) and Han et al. (2018) have shown a prosthetic complication such as abutment screw loosening, abutment fracture, and/or chipping/fracture of the ceramic restorations. Al-Dary and Alsayed (2017) replaced missing maxillary 2 central incisors with zircon cantilever bridge (Abd-Elrahman et al. 2020). This review aims to illustrate a reproducible and systematic protocol for the PET techniques with IIP at the aesthetic zone and summarize the clinical outcome of this technique during the last 10 years.

MATERIAL AND METHODS

An electronic exploration was achieved to identify related research. The search was restricted to May (2010) to October (2021), at the time of gathering of the information with the resulting databases from Medline/PubMed, Cochrane, Scopus, EBSCO host, Google website, Web of Science, and Wiley Library. The search terms included "Partial extraction therapy", "socket shield technique," "modified SST", "root membrane technique", "Pontic-shield technique", "type of the final restoration", and "immediate implant placement", and case report, series, and clinical studies. The study was finalized manually by evaluating the particular reference tilts of similar articles. Studies published from (2010 to 2021) were included if they met the following measures: case report, case series, prospective and retrospective studies, clinical trial study, and involves the use of PET and procedures with IIP after tooth extraction.

The exclusion criteria were clinical studies on human and follow-up not less than 3 months after implant assignment. Two review authors (Al MM and A.M.A) evaluated the title, abstract, and available text of articles documented in the electronic search and the inclusion and exclusion criteria. All published papers related to PET reports were evaluated for relevance, eligibility, and data extraction. For all type of studies, the implant osseointegration, shield exposure, shield infection, shield migration, soft tissue contour, and type of prostheses were recorded. Radiologic result for buccal and/or crestal bone loss were assessed. The selected studies were analyzed for complications and adverse effects stated by corresponding author(s).

All data were extracted, and the contents were screened by the author. Full texts of the associated studies were reviewed for further assessment. This systematic review was designed in accordance with the Preferred Reporting Items for Systematic reviews (Moher et al. 2009) with some modifications specified by recent systematic reviews published in the previous studies (Siormpas et al. 2018; Blaschke and Schwass 2020; Ogawaa et al. 2021; Magadmi 2021). The extracted data from the nominated studies were as follows: author(s) name, publication year, type of technique used, arch, region, tooth type, causes of extractions, implant placement, loading protocol, final restoration type, complications, survival rate, and follow-up period (Table 1). The quality of each involved study was evaluated by the authors (Al MM and A.M). The included articles were evaluated using the Checklist for Systematic Review, Case Reports and/or Series. Data were organized and summarized in designed tables. The mentioned variables in all collected studies in any form were summarized and analyzed (Blaschke and Schwass 2020; Ogawaa et al. 2021; Magadmi 2021).

RESULTS AND DISCUSSION

The flowchart for the selection of articles based on their eligibility for the current systematic review is presented in Figure 1. The database search across literature resulted in 561 articles related to questions raised, and these articles were gathered and analyzed. The author further separated

the publications and removed similar studies and other papers articles not correlated to the question elevated. A total of 496 studies were removed, because they are duplicates or not related to the study. By screening 65 articles, 21 studies were omitted, because they were not related to the review, leaving 44 studies (Figure 1: Flowchart). Eight studies were included for each of clinical studies and case series, while the remaining articles were case reports (28).

Variables related to PER among clinical studies or both case series and reports were presented in Table 1. The extracted items were included the author(s) name, publication year, type of technique used, arch, region, tooth type, causes of extractions, implant placement, loading protocol, final prostheses type, complications, survival rate, and follow-up period. A total of 44 articles were included in the present review, as shown in Table 1. Eight clinical studies and eight case series were conducted between 2014 and 2021. Majority of the case reports were about SST and immediate implant placement. All cases were followed up with minimum of 3 months and extended up to 10 years. All the parameters' data are represented and arranged. Graph 1 represents the outcome of screened studies in relation to PET with immediate implant.

The highest percentage of the type of technique used. The proportion of implant loading technique (immediate vs. delayed), arch involved maxillary or mandibular arch, the place of studies applied, and the ratio of each tooth type are shown. Parameters such as causes of extraction, follow-up period, and survival rate for each study are presented in Graph 2. The details of the materials used for final prosthesis and the number of screws retained or cemented prosthesis are shown in Graph 3.

Table 1. Qualitative analysis of studies included in this review and arranged ascending

Investigator(s) /Year	Arch/ Region/ Tooth	Extraction Cause /Loading Type	Technique Type/ Pink esthetic score/ Complications	*Restoration Type*	Survival Rate/ Follow-up
Hurzeler et al./ *2010/SST*	*Case report*/ *Maxilla*/ Right Central Incisor	Fracture (Trauma)	**SST** does not interfere with osseointegration, is beneficial in preserving bundle buccal bone plate, ↓resorption post extraction.	*SRCC*	**100% 3 Months**
Abadzhiev et al./ 2014/ *SST*	Prospective clinical and radiological trail study	**NM** **SST cases (10)** **IIP/ CIIP & Graft (10)**	**CIIP** [12% bone loss = 5 mm]/ **SST** [2% bone loss = 0.8 mm] Mean **CBL**=0.8 mm] Soft tissue volume or quantity of attached gingiva [**CIIP** = 18% SST implant = 2%] Aesthetic results [**SST**/ 98% Perfectly and 2% Very good] [**CIIP**/ 50%-Perfectly, 2% VG, 10/ Compromise, 20% Bad] SST for peri-implant tissue preservation in esthetics zone	CC & PFM Cs	**80% 24 Months**
Glocker et al./ *2014 Modified SST*	*Case Series* / Maxilla/Right Central Incisor; Left Lateral Incisor; Canine	Failure RCT (3) PFM bridge	**MSST**→ prevents alveolar ridge resorption, cost-effective and minimally invasive. **MSST** avoids bundle bone resorption	*All Ceramic Crowns*	**100% 6 Months**
Troiano et al./ 2014/ *Root-T-Belt Technique*	*Case Series*/ Maxilla **Incisors (4), Canines (3), Canines (3)**	Failure of RCT (10)	No implant immobility, peri-implant radiolucency or infection, pain, and paresthesia in the treated area. **Root M T** conserves all dental structure, preserves peri-implant gingival, and results in more predictable bone structure. CBL, not more 1.5 mm; *Mean crestal bone loss = 1.3, 6,0.2 mm*	SCRCs/	**100% 1–72 Months**
AlDary and Al Hadidi/2015/ *SST*	*Case report* Maxilla/ Left 1st Premolar	**NM** Replace PFM 23-25	**SST** →ultimate aesthetic outcome, natural emergence profile, preserving soft and hard tissue.	*ZCs* /	**100% 3 Months**
BUSER et al./ 2017/ *SST*	*Case report* Maxilla/ Right Central Incisor	Failure RCT	Marginal tissues of mid-facial mucosa healthy, shallow probing pockets and no bleeding after gentle probing.	*ZSRC*/	**100% 12 Months**
Huang et al./ 2017/ *RMT*	*Case report* Maxilla/ Right Central Incisor	Post-Trauma Pain	**PES** score of 12 /more defined as perfect. case PES 13 **RMT**, human histologic good after 5 years of function	*Ceramic Crown*	**100% 6 Months**
Durrani et al./ 2017/ *RMT*	*Case report* Maxilla/ Left Central Incisor	Carious Tooth	**SST&PDL-mediated RMT** may be future of aesthetics with hard and soft tissue with volume maintenance.	*E-Max CC*/	**100% 24 months**
Mitsias et al./ 2017/ *RMT*	*Case report* Maxilla/ Left Central Incisor	Trauma	**Histological RMT** prevents bone resorption of BBP of anterior maxilla,→ maintains hard soft tissues; optimizes aesthetic result	**CC** /	**100 % 60 Months**
Roe et al./ 2017/ *SST*	*Case report* Maxilla/ Right Central Incisor	Failure RCT	**Clinical.** Stable preimplant architecture, no inflammation. **Radiographic.** Stable proximal bone levels, along with no pathology ↔ FRF and implant surface. **SST** with IIPP maintains osseous and gingival architecture. **Facial window approach** improves access to residual root.	*SR- PFM Crown*/	**100% 24 Months**
Petsch et al./ 2017/ *SST*	*Case report* Maxilla/ Right Central Incisor	Failure RCT	In the presence of thin biotype, peri-implant tissues were well preserved, indicating successful operation. No-change in soft tissue, pocket depth plaque accumulation	*All Ceramic Crown*	**100% 24 Months**
Pour et al./ 2017/ *SST*	*Case report* Maxilla/ Left Canine	External resorption	**SST** favorable system dental practice →highly aesthetic, ↓time, expense, less psychological stress patient restorative team No added cost for patient, single surgical procedure, ↓morbidity.	*SRCC*	**100% 3 Months**

Continue Table 1

Investigator(s) /Year	Arch/ Region/ Tooth	Extraction Cause /Loading Type	Technique Type/ Pink esthetic score/ Complications	*Restoration Type*	Survival Rate/ Follow-up
Baumer et al./ *2017/ SST*	*Randomize clinical trail* **10 Patients** Maxilla/ Right Central Incisor **(2);** Right Lateral Incisor **(2);** Maxilla/Right 1st Premolar (1) Maxilla/ Left central Incisor **(2);** Left 1st Premolar **(2);** Left 2nd Premolar **(1)**	Failure RCT (4)& Carious teeth (3)	**SST** Good implants in aesthetic zone ↔2nd premolars **SST** ↓invasiveness at surgery time, high aesthetic with effective preservation of facial tissue contour. **PES** positive results in all cases (Mean 12) BBL -37.0mm (16.0-- 66.0), Facial-mid average-33.0 mm, Loss Recession mesial 33.0, Bone marginal mm 17.0 distal. Volumetric analysis, low degree contour changes in extraction and **IIP** follow-ups. Mucosal recession at implant restoration was comparable to neighboring teeth.	*All Ceramic Crowns*	**100% (51–63) 58 Months**
Arora & Ivanovski /2017/ *SST*	*Prospective clinical study* / Maxilla / Centrals (46), Laterals (6), Canines (6)	**NM** 100 Pt (Type I-N33), (Type 2-N14); after 4-8 weeks; (Type 3-N19); after 8-16 weeks (Type 4--N44) ≥16 week	**PES;** Male; 10.52 ± 2.01/ Females; 9.40 ± 2.21SD* **WES;** Specialist; 8.47±1.54/ G. Practitioner;7.90± 1.27 **Gender SD*, Specialist Vs General Practitioners SD*** Biological Complications (6) / Prosthetic 2 cases only **No significant effects of time**	SPFM & CPFM	**88% 26.3 Months**
Saeidi Pour et al./ 2017/ *SST*	*Case Series/* Maxilla/ Right Canine	Failure RCT	**SST** is a minimally invasive implant approach offers less stress to patients and clinicians. **SST** → Results in soft-hard-tissue stability around implant and provides high esthetic outcome to patients	*All Ceramic Crown*	**100% 3 Months**
Hinze et al./ 2018 / *SST*	*Prospective clinical study* **15 patients 17 SST** Maxilla / **Anterior & Posterior ↔ 2nd Premolar**	**NM**	**SST** & **CIIP** with protyproization →Preservation buccal root ↓buccal contour changes after tooth extraction **SST:** 8/15 Patients suffer recession **SST:** 0.31±0.64mm mesial&0.38±0.57mm distal-papilla↑ change **GM Change** buccal contours 0.37 – 0.32mm (0.17 ± 0.67)	*PFM and CCs*	**100% 3 Months**
Kumar & Kher/ 2018/ *SST*	*Case report/* Maxilla/ Right Central Incisor	**NM**	Preservation of hard soft tissues both horizontally and vertically	*E-Max CC*	**100%/ 3, 6, 12 Months**
Han et al./ 2018/ *Modified SST*	*Prospective clinical study* **/30 Patients** Maxilla **(34) Mandibula (6)** Central (12), Lateral (10), Canines (5), Premolars (13), Parafunction/ Bruxism/Clenching (7)	Failure RCT (16) Carious/ (14) L[Plot Area]7.0 (8), 10.0 (3), 11.5 (34), 13.5 (2) Diameter/mm 3.5(8), 4.0 (16),4.5(11)5.0(4),5.5(1)	**MSST** with IIP, because root fragment does not affect osseointegration &benefits aesthetics; protects BBE resorption. Gender, Age Groups Sig, Smoking Sig/ PFHs Sig Location Maxilla/Mandibula Sig/ Position Non-S/ Length and Widths Sig/ Insertion torque Non-S/ Implant stability at placement No biologic, 2.5%- Prosthetic or Mechanical complications	*All Ceramic Crowns*	**100% 24 Months**
Verma et al./ 2018/ *SST*	*Case report* Maxilla/ Right Central Incisor	**NM**	**SST** valuable, minimizes buccal contour after extraction. Results in healthy peri-implant soft tissue and preserves ridge.	*Ceramic Crown*	**100% 12 Months**
Guo et al./ 2018/ *SST*	*Case report* Maxilla/ Left Central Incisor	In-proper Post &Core	**SST** with PRF, IIP may be effective for the preservation and maintenance of stable peri-implant tissue.	*All Ceramic Crown*	**100% 18 Months**
Mattar AA/ 2018/ *SST*	*Case report* Maxilla/ Left Central Incisor	Grossly and PFM crown	**SST** & IIP prevent the collapse of thin buccal bone → excellent aesthetic. *Inflammations in socket, changed of insertion*	*All Ceramic Crown*	**100% 18 Months**

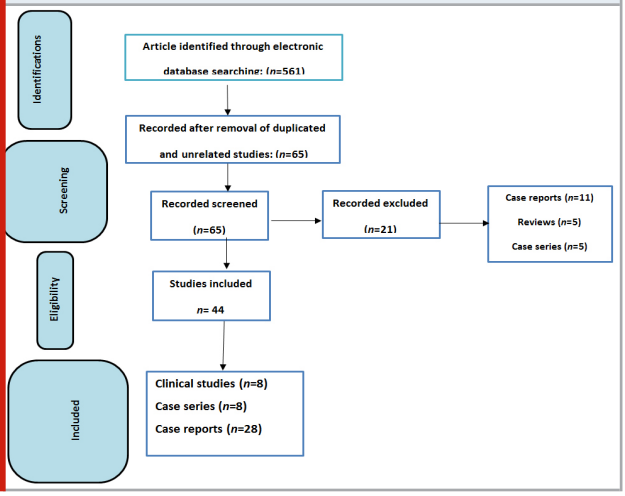
Investigator(s) /Year	Arch/ Region/ Tooth	Extraction Cause /Loading Type	Technique Type/ Pink esthetic score/ Complications	*Restoration Type*	Survival Rate/ Follow-up
Esteve-Pardo, Esteve-Colomina / 2018 / *SS*	*Case report* Maxilla/ Left Central and Lateral Incisors	Roots subginigivally	**SST** & IIP → successful aesthetic restoration maintains tissue volume in aesthetic area. ***Two implants supported 6 Max anterior teeth with cantilever****	*CS-Retained Cantilever bridge*	**100%/ 5-6 Months**
Fonseca DL/ 2018/ *SST*	*Case report* Maxilla/ Right Central Incisor	Heavily restored failing	Case-selection, planning→ Aesthetically challenging scenarios Positive aesthetic results-↑PES & WESs (≥12)	*CSRC /*	**100% 24 Months**
Schwimer et al./ 2018/ *SST*	*Case report* Maxilla/ Left 1st Premolar	Failure of Implant (Peri-implantitis)	**SST** & **IIP** with provisionalization→ Bone occupy space ↔ implant surface and SS as osseointegration outcome. ↑probing depth and crestal bone loss	*Ceramic Crown*	**0.00% 24 Months**
Aslan S/ 2018/ *Modified SST*	*Case series* Maxilla/ Right Central Incisor	Incomplete RCT	**MSST** maintains natural emergence profile and improved volume and contour stability can be obtained by retaining thin shield in IIP. Thin buccal bone (0.39mm) after I year.	*E-Max CC*	**100% 12 Months**
Gluckman et al./ 2018/ *SST*	*Case report* Maxilla/ Left Central Incisor	Post & Core/ Resorption	**SST** in conjunction with IIP and provisionalization positively supported facial ridge of implant.	*Ceramic Crown*	**100% 12 Months**
Dayakar et al./ 2018/ *SST*	*Case report* Maxilla/ Left Lateral Incisor	Carious tooth	**SST** with IIP is a good alternative to preserve BCP in aesthetic area and healthy per-implant tissue	*All Ceramic Crown*	**100% 3 Months**
Patel et al/ 2019/ *SST*	*Case Series* Maxilla/ Left Central, Lateral Incisors, and Canine	RCT & Grossly carious	**SST** along with provision of smooth-surfaced DIs, stabilized cortical engagement, replacement missing maxillary anterior teeth. Patient reported no discomfort satisfied aesthetic	*PFM Crown /*	**100% 12 Months**
Habashneh et al./ *2019/ SST*	*Case Series* Maxilla/ Right and Left Central Incisor; Right Lateral Incisor; Left 1st and 2nd Premolars	Failure RCT	**SSt and IIP** Improved buccal contour stability/better esthetic **SST with IIP** is a minimally invasive approach that can preserve hard and soft tissue, contour of ridge can be implemented in areas of high aesthetic demands for better esthetic outcomes.	*SR-PFMCs*	**100% 12 Months**
Arabbi et al./ 2019/ *SST*	*Case report* Maxilla/ Left & Right Centr Incisors	Fractures of Crowns	**SST** with **IIP** technique of choice in aesthetic area →resulted in excellent aesthetic appearance	*All Ceramic Crowns*	**100% 6 Months**
Schwimer et al./ 2019 / *SST*	*Case report* Maxilla/ left 2nd Molar	Fractures of Crowns	**SST** preserves tooth structure, maintain ridge implant sites. **SST** maintains alveolar ridge in posterior (MOLAR) at IIP site.	*SR Restoration*	**100% 4 Months**
Zuhr et al./ 2020/ *SST*	*Case report* Maxilla/ Right Central Incisor	Failure RCT	Shield around buccal aspect of implant was mobile 8-mm depth. Incisal edge of implant was lower to adjacent tooth, suggesting ongoing vertical growth of neighboring tooth.	*All Ceramic Crown*	0.00%
Sun et al./ 2020/ *SST*	*Randomize clinical trail* 30 Implants/ 30 Patients	**NM**	**CIII**[Plot Area]re: 11.33 ± 1.76 **SST:** PES score: 12.07 ± 1.62	**SR-PFM**	**24 Months**
Alshammari et al./ 2020/ *SST*	*Case report* Maxilla/ Left Central Incisor	Failure RCT	**SST** prevents soft and hard tissue changes during alveolar socket healing after extraction. **PES** score was 12.	*SR Restoration*	**100% 36 Months**
Hana et al./ 2020/ *SST*	*Prospective clinical study* **40 Patients** Maxilla **SST;**(20/Patients) Central (8), Lateral (6), Canines (6) **CIIP** (20/Patients); Central (9), Lateral (6), Canine (5)		**SST**; 12 Months (1) case internal (1) external shield exposure **PES;** Mean 12.3 **CIIP;** 12 Months (5) cases, need tissue graft manage recession & inadequate keratinized tissue affect aesthetic **PES;** Mean 9.6.	*PFM-CR*	**95% 3, 6,12 Months**
Polis-Yanes et al./ 2020/ */PSTs*	*Case report* Maxilla/ Left and Right Cent Incisor	Failure RCT	**Pontic Shield Techniques & SST** procedures that should be considered in oral rehabilitation in selected cases	*CC/ Bridge Cantilever*	**100%**

Continue Table 1

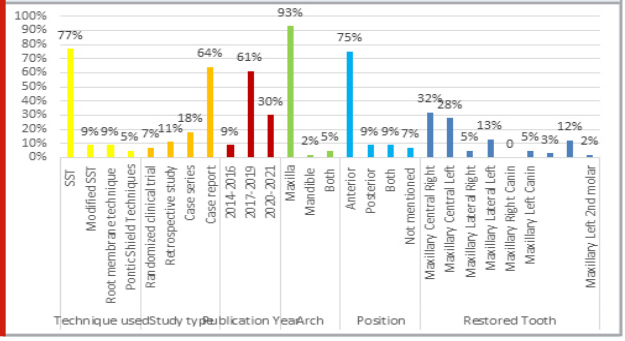
Investigator(s) /Year	Arch/ Region/ Tooth	Extraction Cause /Loading Type	Technique Type/ Pink esthetic score/ Complications	*Restoration Type*	Survival Rate/ Follow-up
Abd-Elrahman et al/ 2020/ *Pontic Shield Techniques*	*Randomize clinical trail*	NM SST with IT (20- Exp G) IIP with IT (20 - Cot G)	***PES*** 0-0.26 (0.15)/ 0.11-0.55 (0.31)/↑ 11-12**mm** ↓BBL & ↑ PES 0.03-0.44 (0.32)/0.25-0.51(0.7)/↓ 13-9**mm** IIP ↓ PES	***PFM***	**100%** **6 Months**
Dash et al./ 2020/ *SST*	Case report / Maxilla/ Left Central Incisor	Gross Caries/ Failure RCT	**SST** shows promising result in aesthetic dentistry, maintain diastema	*PFM crown/*	**100%** **6 Months**
Mathew et al./ 2020/ *SST*	*Case Series/* Maxilla / **Centrals (5)** Maxilla / **Laterals** (5) **5 cases; SST & 5 cases; CIIP**	**NM**	**SST** prevents soft, natural, hard tissue changes, resorption, more aesthetically pleasing, and acceptable results **PES** Score 12.2*Sig MBR 0.68mm **PES** Score 10.8 Marginal bone resorption = 0.88mm*$ H Sgn	PFM Crowns	**100%** **3,6,12 Months**
Nguyen et al./ 2020/ *SST*	*Case Series* Maxilla **/anteriores/** Left Central & Lateral incisors Maxilla **/anterior/** Left Centra l& Lateral incisors	2. Failure RCT 1. Previous trauma	**SST** preserve not only BB marginal but also inter-implant papilla. **No changes in soft tissue dimensions.** Marginal bone loss = 0.1 ± 0.2 mm Hard and soft tissues became very stable Well-preserved hard and soft tissue profiles are observed.	SRCC	**100%/ 72, 60, 24 Months**
Gluckman et al./ 2019/ *MSST*	*Case report* Maxilla /anterior/ Left Cental incisor	Failure RCT (4)	**PET** is a collective concept of utilizing the patient's own tooth root to preserve the periodontium and peri-implant tissue.	SRCC	**100%** **12 Months**
Alone& Niswade / 2021/ *SST*	*Case report* Maxilla/ Right Central Incisor	Carious tooth	**SST** provides promising results with respect to soft and hard tissue preservation in cases of post extraction II	*PFM Crown*	**100%** **3 Months**
Srivastava et al./ 2021/ *SST*	*Case report* Maxilla/ Left Centl&Lateral incisors	Grouse decayed teeth	**SST** with IIP in esthetic zone provides promising treatment in preserving both soft and hard tissue	*PFM Crown*	**100%** **3 Months**
Oliveira et al./ *2021/ SST*	*Case report* Maxilla /Posterior left #15	Carious tooth	**SST** maintains alveolar bone preservation and contour tissue that facilitate 3D implant positioning. involves low cost good esthetic	*SR- PFM*	**100%** **3 Months**

Abbreviations:
Partial Extraction Therapy -PET; Root Submergence – RST; Socket Shield- SST; Proximal Socket Shield-PSST; Pontic-Shield -PST; Marginal Bone Loss- MBL; Crestal bone level -CBL; Crestal bone resorption- CBR; Buccal bone plate- BBP; BBL- buccal bone loss; Conventional immediate implant placement- CIIP; Modified socket shield technique - MSST; Immediate implant placement- IIP; Delayed – PRF ; Buccal cortical plate – BCP; Root fragment – RF; Alveolar bone loss - ABL; Pocket Probing Depth— PPD; implant surfaces- IS; Randomized clinical trial- RCT; Pink esthetic score- PES; ↑-Increase-; ↓-Decrease; ↔-Between; → Resulted in % - Percentage-; ↔-Between; NM-Not mentioned; Zirconia Abutment-ZA; Ceramic Crown-CC; Zirconia Crown- ZC; Screw-retained Ceramic Crowns- SRCC; All Ceramic Crown-ACC; Screw Retained All Ceramic-SRAL; Screw Retained Porcelain-Fused-Metal-SR-PFM; Porcelain-Fused-Metal-PFM

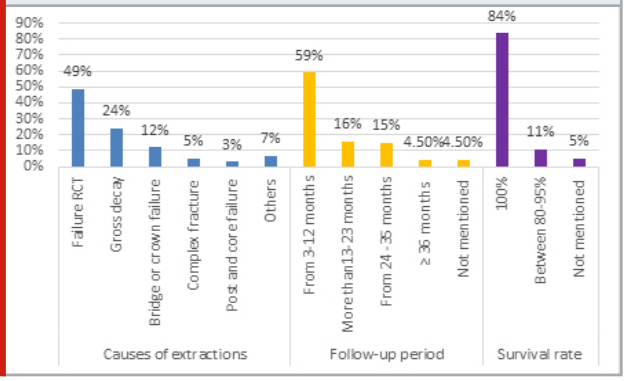
Figure 1: Flowchart of the study selection process (Moher et al. 2009; Siormpas et al. 2018; Blaschke and Schwass 2020; Ogawaa et al. 2021; Magadmi. 2021).



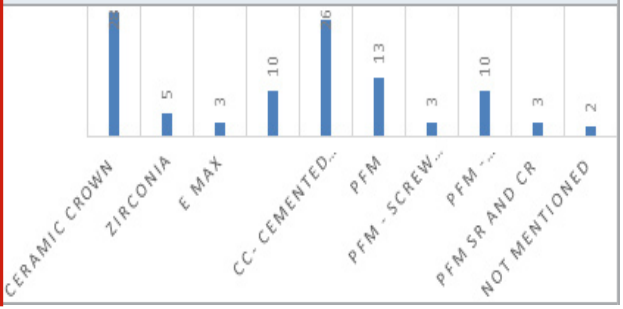
Graph 1: Extracted data in relation to type of PET. Study type, arch type, position, and restored tooth type.



Graph 2: Causes of tooth extraction, follow-up period, and survival rate of studies included in this review.



Graph 3: Numbers of different types of prostheses (final restoration) used in studies and cementation technique.



In addition to that the studies by Arora and Ivanovski (2018), Han et al. (2018); Hana et al. (2020); Mathew et al. (2020) recorded 102,33,25,13,7, and 3 maxillaries central, lateral, canine, 1st and 2nd premolar, and mandibular canines were recorded, respectively. Abadzhiev et al. (2014) (80%), Arora and Ivanovski (2017) (88%), Schwimer et al. (2018) (100

%); Zuhr et al. (2020) (100.00%), Hana et al. (2020) (95%) found high percentage of success with different period of follow-up as recorded after each one. Canti-lever of 6 unites from maxillary canine in the left side into canine on other side with two abutments. Lateral's incisors were used by Polis-Yan et ai. (2020).

Cemented retained cantilever all ceramic with abutment was lateral incisor and the pontic was the adjacent central incisors, while Abadzhiev et al. (2014) used mixed ceramic and PFM crowns for their final restoration after SST with or without IIP. Other authors used mixed PFM and CC as Arora and Ivanovski (2017) used Screw R PFM, cemented PFM. Pour et al. 2017 used SR CC, while Hinze et al. (2018) used PFM and ceramic crowns (Esteve-pardo and Colombia 2018). Various PET techniques have provided outstanding biological, mechanical, and aesthetic consequences in hands of knowledgeable clinicians with careful treatment arrangement and case collection. A uniform assessment of PET outcomes needs to be established to provide objective findings, in addition to a consistent protocol for root portions preparation and to place dental implants in the ideal place and achieve long term success of treatment. This review aims to determine the advantages of different PET techniques aesthetic outcome IIP in the aesthetic zone and the different types of final prostheses used (Esteve-pardo and Colombia 2018; Oliveira et al. 2021).

Among the PET techniques, SST is the most used technique because of its many advantages in cases of post extraction immediate implant with IIP, such as high stability and well-preserved hard and soft tissue; it preserves the buccal bone marginal and inter-implant papilla with minimum marginal bone loss, maintains alveolar bone level, and does not change soft tissue dimensions (Nguyen et al. 2020; Alone and Niswade 2021; Srivastava et al. 2021; Oliveira et al. 2021). This method is good alternative to preserve BCP in aesthetic area and healthy per-implant tissue, improved buccal contour stability and or better esthetic outcomes can achieved (Dayakar et al. 2018; Patel et al. 2019; Arabbi et al. 2019; Schwimer et al. 2019; Dash et al. 2020).

In a case series by Habashneh et al. (2019) and Alshammari et al. (2020) they show minimally invasive approach that can preserve hard and soft tissue and contour of ridge, and this method was implemented in areas of high aesthetic demands to achieve good esthetic outcomes. SST with IIRP preserved hard and soft tissue and kept it stable without any changes in dimension, resulting in optimum aesthetic results and improving and preserving the buccal contour of ridge areas of high aesthetic demands (maxillary anterior up to premolars) to achieve good esthetic outcomes (Glocker et al. 2014; Mitsias et al. 2017; Habashneh et al. 2019; Mathew et al. 2020; Nguyen et al. 2020; Germi et al. 2020). Tissue volumes remain unchanged, and good osteointegration was achieved (Troiano et al. 2014; Gluckman et al. 2016b; Baumer et al. 2017). In addition to the above characteristics, a group of clinical studies showed excellent scores for PES and was in clinical studies (Sun et al. 2020; Hana et al. 2020; Abd-Elrahman et al. 2020).

Ideally, a method for the prevention of alveolar ridge resorption should be cost-effective and minimally invasive. Various methods of guided bone regeneration (GBR) have been described to retain the original dimension of the bone after extraction. All these procedures are cost-intensive and technique-sensitive. The presented method is cost-effective but is a technique-sensitive SST that avoids the resorption of the bundle bone by leaving a buccal root segment (socket shield) in place (Mourya et al. 2019; Ogawa et al. 2021). The SST seems to be beneficial for ridge preservation despite its insufficient documentation. In this case report series, implants were placed immediately after extracting a hopeless tooth by using this technique, and the patient was followed up for 1 year to document functional and esthetic outcomes (Mourya et al. 2019; Ogawa et al. 2021).

PES was between 8–10 and 6–10 after 6 and 12 months, while previous studies recorded 12.2 PES with complete score for central incisors, recorded 13.5 mm, and recorded a mean PES of 12. Only a single article recorded PES and MBL for CIIP of 10.8 and 0. 88 mm by, respectively. The MBL for SST was 0.1 ± 0.2 mm as determined in the previous studies and 0.17-0.22 mm as determined in the previous studies (Baumer et al. 2017; Zhu et al. 2018; Germi et al. 2020; Mathew et al. 2020; Sun et al. 2020; Mathew et al. 2020; Mathew et al. 2020). Other information in relation to case series are available in Table 1 and Graph 1.

The advantage of RST is inexpensive preservation of alveolar bone dimensions to provide a good retentive surface area for RDP or to preserve alveolar bone for a future dental implant, or to preserve the tissues' dimensions in the pontic's area under a tooth supported FDP, with a chance of developing bone and new cementum and connective tissue coronal to submerged segment. It also preserves the tissues next to a dental implant and improves the predictability of interdental papillae height in DIT (Roe et al. 2017; Petsch et al. 2017; Baumer et al. 2017; Pour et al. 2017; Kumar and Kher 2018; Verma et al. 2018; Guo et al. 2018; Mattar 2018; Patel et al. 2018; Schwimer et al. 2019).

In the aesthetic area, the preservation of the interdental papilla among two implants is one of the major challenges of implant rehabilitation, and the PSST was first proposed and described by involving the similar values of the SST, but the distal root piece was used instead of the buccal one. Consequently, studies about this technique are lacking (Chen et al. 2018). The complications observed during follow-up of case series include a shield failure caused by infection, a case of deficiency of alveolar ridge, a patient who had complications with the three other socket shields exposed caused by failure of soft tissue closure (Lagas et al. 2015; Gluckman et al. 2016b; Schwimer et al. 2019).

The pontic ST was recognized as the modified SST, and it was introduced to preserve both hard and soft tissues in the pontic extents following the same technique as the SST. However, instead of inserting an IIP in the socket, a bone grafting material was used to seal the socket, and the socket was closed by a repositioned flap, gingival graft, or membrane. Moreover, under the presence of an apical

pathology, the buccal pieces can be conserved, while all the other tooth structures and apical lesions are detached, which overcomes a matter that was identified with the use of RST (Nisar et al. 2020).

CONCLUSION

The findings of the present study suggests that although PET can be used for dental implant treatment, it remains difficult to predict long-term success of this technique until high-quality evidence becomes available. Studies published from 2010 to 202 were included. A total of 40 studies were included, as randomized controlled trial, cohort studies, clinical case reports, and case series. 123 patients were treated with PET, most of them underwent SST with IIP. The follow-up was conducted between 3–120 months after placement. Several complications were recorded, but it was manipulated. Most studies reported implant survival without complications (91%). Most of cases that were followed up for more than 12 months after implant placement achieved a good aesthetic appearance. The failure rate was low without the complications, although some failures occurred because of failed implant osseointegration, socket shield mobility and infection, socket shield exposure or migration, and apical root resorption.

Data Availability Statement: The database generated and /or analysed during the current study are not publicly available due to privacy, but are available from the corresponding author on reasonable request.

Conflict of Interest: Authors declare no conflicts of interests to disclose.

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