Immediate Implant Placement in Intact Fresh Extraction Sockets Using Vestibular Socket Therapy Versus Partial Extraction Therapy in the Esthetic Zone: A Randomized Clinical Trial

Abdelsalam Elaskary, BDS[1]/Hams Abdelrahman, MS[2]/Basem Elfahl, MS[3]/
Hossam Elsabagh, MS[4]/Gillan El-Kimary, PhD[5]/Noha Ayman Ghallab, PhD[6]

Purpose: This randomized clinical trial aimed to assess esthetic and soft and hard tissue outcomes 6 months after immediate implant placement using vestibular socket therapy (VST) (test) versus partial extraction therapy (comparator) in intact thin-walled fresh extraction sockets in the esthetic zone. ***Materials and Methods:*** Twenty-four patients with hopeless maxillary anterior teeth requiring immediate implant placement were randomly assigned to two equal groups to receive either VST or partial extraction therapy. Definitive restorations were delivered after 3 months. Pink esthetic scores (PESs) and vertical soft tissue alterations in millimeters were measured 6 months after restoration using intraoral digital scans of the distal papilla, midfacial gingival margin, and mesial papilla. Facial bone thickness was measured using CBCT scans at baseline and after 6 months. Implant survival and peri-implant pocket depth were assessed. ***Results:*** Both groups showed 100% implant survival after 6 months. The overall PESs after 6 months were 12.67 (± 1.3) in the VST group, while the partial extraction therapy group score was 13.17 (± 1.19), with no significant difference between them ($P = .02$). The mean (± SD) vertical soft tissue measurements for the VST group were 0.08 (± 0.55), 0.01 (± 0.73), and −0.03 (± 0.52) mm, and for the partial extraction therapy group, they were −0.24 (± 0.25) mm, −0.20 (± 0.10) mm, and −0.34 (± 0.13) mm for the mesial papilla, midfacial gingival margin, and distal papilla, respectively. No significant differences were observed between the groups at any of the reference points ($P \geq .05$). Both techniques demonstrated a significant gain in millimeters of labial bone thickness after 6 months compared to baseline ($P \leq .05$). Regarding VST, the apical, middle, and crestal mean bone gain was 1.68 (± 2.73), 1.62 (± 1.35), and 1.33 (± 1.22) mm, respectively, while partial extraction therapy showed 0.58 (± 0.62), 1.27 (± 1.22), and 1.53 (± 1.24) mm, respectively, with no significant difference detected between them ($P \geq .05$). Additionally, the mean (± SD) peri-implant pocket depth after 6 months for VST was 2.16 (± 0.44) and 2.08 (± 1.02) mm for partial extraction therapy with no significant difference between them ($P = .79$). ***Conclusion:*** This investigation suggests that both VST and partial extraction therapy preserved alveolar bone structure and peri-implant tissues following immediate implants. The novel VST might be considered a predictable alternative treatment approach for immediate implant placement in intact thin-walled fresh extraction sockets in the esthetic zone.
Int J Oral Maxillofac Implants 2023;38:468–478. doi: 10.11607/jomi.9973

Keywords: immediate implant, partial extraction therapy, socket shield, vestibular socket therapy

[1]Private Practice, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.
[2]Dental Public Health Department, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.
[3]Oral Medicine and Periodontology, Faculty of Dentistry, Tanta University, Tanta, Egypt.
[4]Oral Medicine and Periodontology Department, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.
[5]Oral Medicine, Periodontology, Oral Diagnosis and Radiology Department, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.
[6]Department of Oral Medicine & Periodontology, Faculty of Dentistry, Cairo University, Cairo, Egypt.

Correspondence to: Prof Noha A. Ghallab, Faculty of Dentistry, Cairo University, 43 Zahraa Street, Dokki, Guiza, 12311, Egypt. Email: noha.ghallab@dentistry.cu.edu.eg

Submitted March 20, 2022; accepted June 28, 2022.
©2023 by Quintessence Publishing Co Inc.

Currently, implant dentistry offers long-term maintenance of optimal esthetic outcomes.[1] However, post-extraction tooth alveolar ridge remodeling represents a challenge for both vertical and horizontal components during the first year.[2–4] This is referred to as the loss of the buccal plate vascular support from the periodontal fibers, which often leads to possible midfacial recession and poor esthetic outcomes, especially in the anterior region,[5,6] that is unavoidable in most cases.[5,7,8] However, immediate implant placement failed to halt the remodeling of this thin buccal bony plate, particularly in patients with a thin gingival phenotype.[9–11] Consequently, several treatment approaches have been proposed to enhance the esthetic outcomes following immediate implant placement in thin-phenotype sockets, including soft tissue grafting of the socket rim,

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

using platform-switched implants, grafting the dual zone around the implant surface along with the use of immediate screw-retained temporalization, and retaining the labial root surface using partial extraction therapy.[8,12,13] Also, long-term studies and systematic reviews have verified stable esthetic results with immediate placement.[11,13–16]

Hürzeler et al[17] was the first to introduce the socket shield technique in an animal model, in which the submerged tooth root was sectioned, the buccal root fragment was attached to the periodontium, and an immediate implant was placed. This was based on the fact that if the buccal periodontal attachment was preserved, it might prevent the previously mentioned cascades.[18] To date, few randomized clinical trials have investigated partial extraction therapy techniques and their modifications compared with conventional immediate implants,[19–23] besides retrospective case reports.[1,17,24–26] Recently published narrative and systematic reviews have reported the benefits of partial extraction therapy.[6,18,27,28] Conversely, two case reports showed the potential occurrence of peri-implantitis and exposures of the root through the overlying soft tissues, resulting in undesirable esthetic outcomes.[1,29]

Recently, Elaskary et al[30] introduced vestibular socket therapy (VST) as a novel minimally invasive surgical protocol to treat fresh extraction sites: thin, defective, compromised, and/or presenting with infective signs with immediate implant placement. This technique aims to overcome the remodeling sequelae of tooth extraction and minimize the likelihood of midfacial periimplant gingival recession. The results showed highly predictable esthetic outcomes. Another cohort study concluded that VST reduced both midfacial recession and dimensional changes of the buccal plate in compromised fresh extraction sockets with or without signs of infection.[31] Moreover, 2-year[32] and 3-year[33] follow-up clinical studies provided evidence for predictable long-term stability of both bone and soft tissue architectures using radiographic, esthetic, and periodontal assessments. The authors advocate the benefits of VST for immediate implant placement in compromised fresh extraction sockets.

Recent systematic reviews have recommended well-conducted randomized clinical trials to prove the plausibility of partial extraction therapy esthetic and functional outcomes. Although VST as a novel concept has been documented in previous case series at different time intervals and with potential esthetic and radiographic outcomes,[30–33] case series still only generate a hypothesis. Being placed at the highest level of evidence, randomized controlled trials offer the most robust evidence for effectiveness.[34] Currently, there are no available randomized clinical trials testing the esthetic and functional advantages of VST. Hence, to validate the efficacy and test the hypothesis of the VST approach, a randomized controlled clinical trial was needed. Given the existing gap of knowledge, this randomized controlled clinical trial aimed to assess the esthetic and soft and hard tissue outcomes 6 months after immediate implant placement using VST compared to partial extraction therapy in an intact thin-walled fresh extraction socket in the esthetic zone.

MATERIALS AND METHODS

Study Population

This randomized clinical trial was registered at clinicaltrials.gov (ID: NCT05112796), approved by the Central Research Ethics Committee of the Supreme Council of University Hospitals, Egypt (NO-0313), conducted in accordance with the Helsinki Declaration of 1975, as revised in 2013, and reported according to CONSORT guidelines 2012[35] (Fig 1). This study included 24 patients (4 men and 20 women, aged 18 to 57 years) recruited from a private practice clinic in Alexandria, Egypt, between November 2019 and September 2020, meeting the following inclusion criteria: adult (> 18 years) patients with a single nonadjacent hopeless maxillary tooth in the esthetic zone, type I socket (intact but thin labial plate of bone and intact overlying soft tissues), adequate palatal bone, and ≥ 3 mm of apical bone to engage the immediately placed implants (a minimum of 30 Ncm insertion torque). Exclusion criteria were: smokers, pregnant women, patients with systemic diseases, periodontal disease, gingival recession, infected sockets, periapical pathosis, and history of chemotherapy or radiotherapy within the past 2 years. Eligible patients agreed to sign written informed consent to participate in this trial and were informed about the details of the investigation.

Randomization and Blinding

Sequence generation was executed using simple randomization by generating numbers from 1 to 24 using random allocation software[36] by an investigator (A.H.) not involved in recruitment or treatment procedures. Allocation concealment was implemented by the same investigator using sequentially numbered, opaque, sealed envelopes handled by the surgeon (E.A.) who did not open them until the beginning of interventions. After recruitment, extraction sites of the eligible participants who agreed to be included in the study were randomly assigned into two equal parallel groups with a 1:1 allocation ratio to receive either an immediate implant using VST (test group) or immediate implant using partial extraction therapy (comparator) based on the generated sequence. Due to differences in techniques, the operating surgeon (E.A.) and participants

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

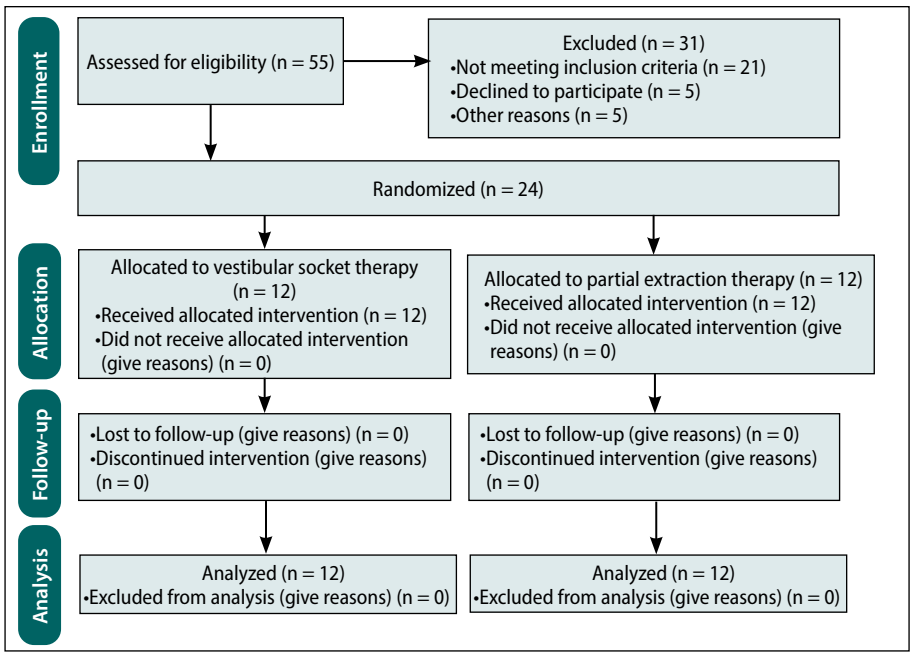

Fig 1 CONSORT flow diagram.

could not be blinded to the procedure. The outcome assessor (E.B.) and statistician (G.N.) were blinded.

Preoperative Assessment

All recruited patients underwent full-mouth supragingival and subgingival debridement and were prescribed 0.12% chlorhexidine HCl mouthwash twice daily for 2 weeks (Arab Drug Company for Pharmaceutical & Chemical Industries), including patient motivation and oral hygiene instructions. Prior to tooth extraction, CBCT images (Carestream Health, CS 8100 3D System) with a high-contrast resolution detector (high bit depth) and a field of vision of 6 × 8 were taken to inspect the bone topography. The imaging protocol was standardized by radiographing the patients with a wax interocclusal record to separate the maxillary and mandibular teeth at a KVp between 5 and 10. These specifications reduce the beam-hardening effect. All patients were scanned preoperatively using an intraoral scanner (IOS) (TRIOS, 3Shape A/S).

Surgical Procedures

Vestibular socket therapy group (test group). The surgical technique in the VST group (Fig 2) was performed using the Elaskary VST kit (Stoma, Storz am Mark; Fig 3). Tooth extraction was carried out using periotomes and luxators (Stoma, Storz am Mark) to minimize the trauma induced to the socket-related soft tissues. This was followed by a through-socket curettage and lavage simultaneously with 100 mL of antianaerobic infusion solution of 500 mg metronidazole (Minapharm Pharmaceuticals) using the Elaskary VST irrigation curette (Stoma, Storz am Mark), which combines both curettage and flushing, thus enabling a more thorough debridement. A 1-cm-long vestibular access incision was made using a 15c blade at the apical part of the socket sulcus to expose the socket bone. This was followed by periosteal dissection in the incisal direction toward the socket orifice using the Elaskary VST vestibular elevator (Stoma, Storz am Mark). The remaining attached tissues closer to the socket orifice were then dissected from the incisal direction and apically to release any attached soft tissues at the socket orifice, thus creating a tunnel between the socket orifice and the vestibular access incision. This was performed using the Elaskary VST hammerhead periotome (Stoma, Storz am Mark). A prefabricated CAD/CAM surgical guide (Surgical Guide Resin, Form 2, Formlabs) was used to place the implant in its planned location (Tapered Pro, BioHorizons) to provide optimal primary stability and to benefit from its switched platform to enhance the peri-implant tissue thickness,[37] engaging 3 to 4 mm of the sound intact apical bone to stability, reaching 30-Ncm torque. The vestibular tissues were then retracted using the Elaskary VST forklift retractor (Stoma, Storz am Mark) to allow complete access and visibility of the labial plate of bone. A 0.6-mm-thick flexible equine cortical membrane (OsteoBiol Lamina, Tecnoss), termed a bone shield, was tailored and inserted into the labial tunnel using the Elaskary VST bone shield holder (Stoma, Storz am Mark). The cortical equine membrane shield was tacked onto the apical bone using two membrane tacks (AutoTac System Kit, BioHorizons). The vestibular incision was sutured using 7/0 nylon sutures (Stoma, Storz am Mark).

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

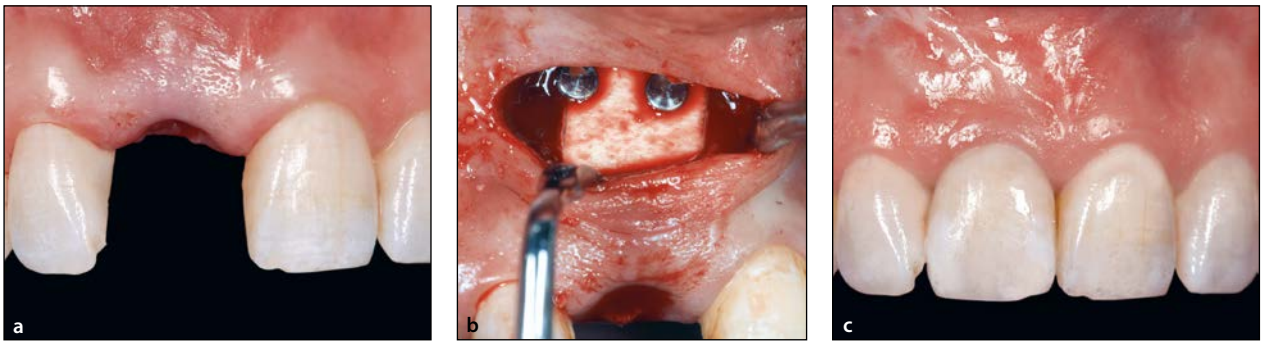

Fig 2 The VST technique. *(a)* Fresh extraction site with thin-walled socket. *(b)* Bone shield stabilization using two membrane tacks. *(c)* Customized healing abutment connected. *(d)* Frontal view of definitive restoration after 2 months.

Partial Extraction Therapy Group (Comparison)

In the comparator group, the partial extraction technique (Fig 4) was performed using a partial extraction therapy kit (Megagen PET kit). First, the hopeless tooth was decoronated 1 mm coronal to the gingival margin using a diamond bur. Then, the labial root segment was gently separated from the root with a Lindemann bur in sweeping strokes mesiodistally from the gingival margin to the root apex, separating the palatal and labial root segments. A fine periotome was then wedged between the palatal root section and the palatal alveolar plate. The separated palatal portion was carefully detached without disturbing the labial segment. Coronal reduction of the labial segment was performed near the alveolar crest, then contoured to a concave shape by careful thinning mesiodistally and apicocoronally with a long-shanked round diamond bur and beveled using a no. 6 guided chamfer drill to allow for adequate periimplant soft tissue seal. Then, the socket was carefully debrided to remove any remaining debris, followed by gentle probing to exclude shield mobility. A prefabricated CAD/CAM surgical guide was prepared to deliver the implant (Tapered Pro, BioHorizons). An immediate implant (BioHorizons) was placed using a 3D printed surgical guide (Surgical Guide Resin, Form 2, Formlabs). The implant was delivered to its planned location 3 to 4 mm apically, thus achieving adequate primary stability not less than 30-Ncm torque.

For both groups, a delayed loading protocol was implemented. After the completion of the surgical intervention for the VST and partial extraction therapy, an anatomical customized transmucosal PEEK healing abutment (PEEK Temporary Cylinder, BioHorizons) was used to seal the socket orifice and maintain the original socket architecture during the healing phase. The socket orifice gaps were filled with flowable composite resin around the PEEK temporary abutment (Filtek Supreme Ultra Flowable Restorative, 3M), then finished and polished extraorally. All subjects in both groups were scanned with an intraoral digital scanner for the definitive crown fabrication; the abutments used for both groups were customized cement-retained abutments, with the anatomical finish line located 0.5 mm below the gingival margin. The fabricated zirconia crowns were designed with an S-shaped design[38] at the tranmucosal part to support soft tissue profile and minimize the tendency for postrestorative recession. All crowns were cemented using glass-ionomer luting cement (Medicem, Promedica). To control the cement flow into the transmucosal areas, the Wadhwani and Pineyro technique[39] was implemented for cementation.

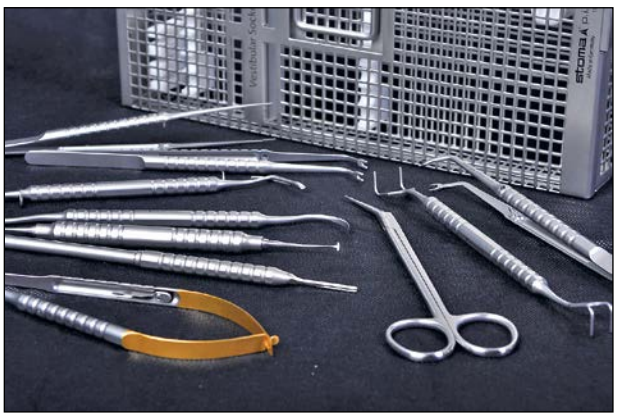

Fig 3 The VST kit.

Postoperative Phase

Sutures were removed 10 days after surgery, and the definitive crowns (full anatomical zirconia, bruxzir, Glidewell) were cemented 2 months after implant placement. Antibiotics, including 500 mg metronidazole and 500 mg ciprofloxacin (Minapharm Pharmaceuticals), were prescribed to all patients every 12 hours for 24 hours preoperatively and 5 days after extraction. On the first postoperative day, extraoral cold packs were applied at the surgical site. A nonsteroidal anti-inflammatory drug (Catafast sachets 50 mg, Novartis) was prescribed whenever needed to relieve

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

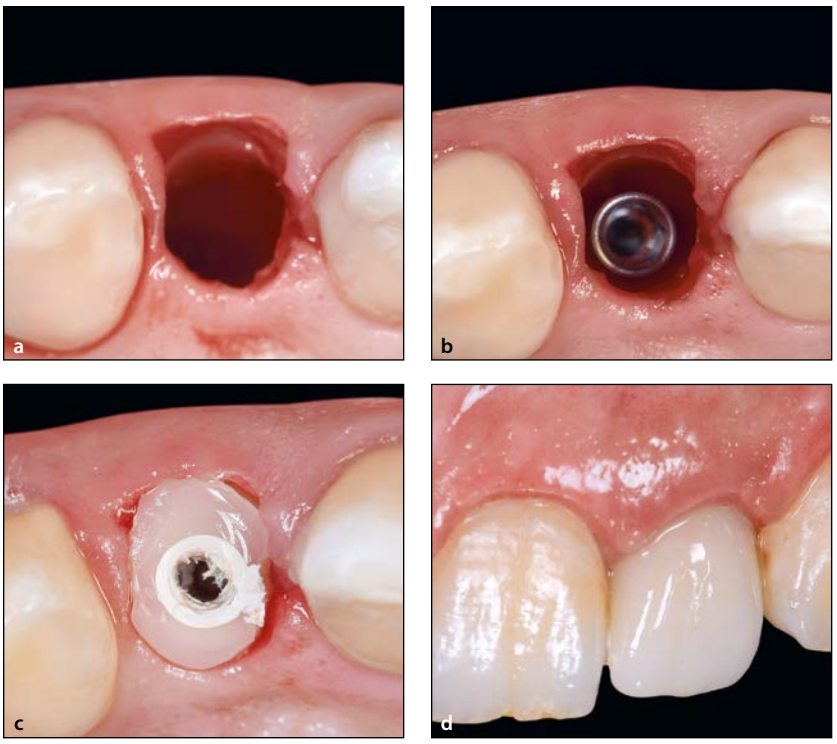

Fig 4 The partial extraction technique. *(a)* The buccal root fragment left in the site after tooth extraction with the remaining root part carefully removed. *(b)* Implant stabilized and placed palatally leaving a jumping gap of approximately 2 mm. *(c)* Customized healing abutment connected. *(d)* Frontal view of definitive restoration after 3 months.

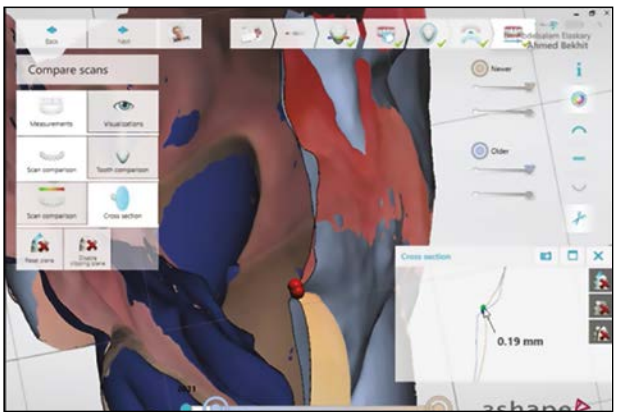

Fig 5 Soft tissue measurements superimposing the preoperative and postoperative intraoral scans to determine the exact difference that occurred.

postoperative pain, and chlorhexidine mouthwash 0.12% was also prescribed for 2 weeks postoperatively.

Outcome Assessment

The pink esthetic score (PES)[40] was the primary outcome assessed in this study. After 6 months, it was assessed from clinical photographs by two independent well-trained examiners (Y.G. and M.M.) with good intraexaminer agreement (0.82 k value). The PES matches the peri-implant mucosa around an implant-supported restoration of the contralateral natural tooth. This score comprises seven domains: mesial papilla, distal papilla, soft tissue level, soft tissue contour, deficient alveolar process, soft tissue color, and texture. Each domain was recorded from 0 to 2, with 2 as the best score. The total PES is the sum of the scores of the seven domains, ranging from 0 to 14 (14 is the best score, indicating an almost similar appearance to the contralateral natural tooth).

The soft tissue changes were assessed by three measurements, taken at the tip of the mesial papillae, tip of the distal papillae, and midfacial gingival margin on the day of the definitive restoration delivery and were compared to measurements after 6 months. The changes in soft tissue height in millimeters were identified in the three reference points by superimposing the baseline file with the postoperative file using the Standard Triangle Language (STL) files of the models obtained via IOS. The 3D software (NemoSmile Design 3D, Nemotec) roughly aligned three identical points identified on the surface of the baseline and postoperative models. The best-fit algorithm of the software perfected the superimposition process (Fig 5). Measurements were performed on the superimposed models that were imported into an STL viewer (OrthoViewer, 3Shape). This was shown to be an accurate method for hard and soft tissue volumetric measurements.[41]

To measure labial bone thickness, CBCT scans (Carestream 8000D, Carestream Dental) were performed before extraction and were considered at baseline and 6 months postoperatively. Images were imported to a special workstation (Scanora 4.2, Sorredex) from which DICOM files were exported to other image reconstruction software (OnDemand3D version 1.0.9, Cybermed). The two images were superimposed in three dimensions

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

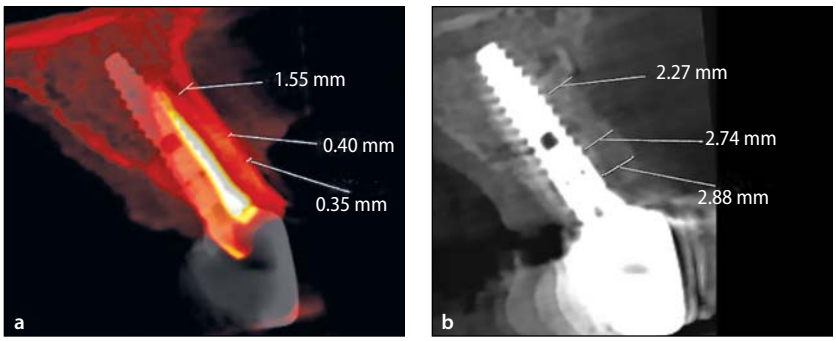

Fig 6 CBCT measuring labial bone thickness in VST group at three points: implant platform (crestal thickness), half of the implant length (middle thickness), and implant apex (apical thickness). *(a)* Baseline. *(b)* 6 months postoperatively.

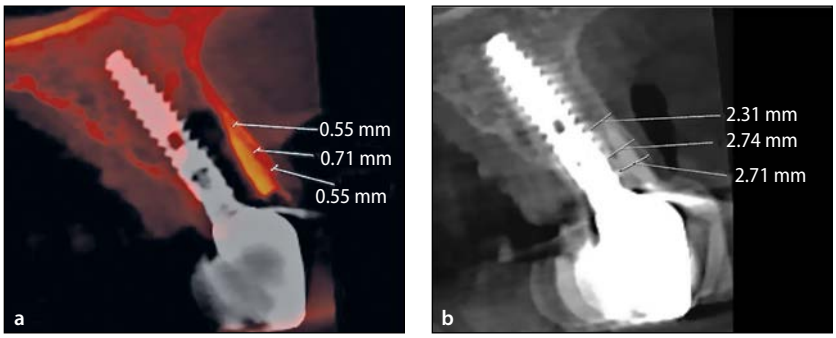

Fig 7 CBCT measuring labial bone thickness in partial extraction therapy group at three points: implant platform (crestal thickness), half of implant length (middle thickness), and implant apex (apical thickness). *(a)* Baseline. *(b)* 6 months postoperatively.

(sagittal, coronal, and axial) using a fixed reference point (eg, the incisal edge) by image fusion.[42] To facilitate the identification of both images during the fusion process, the color of one of them was changed to make it more transparent than the other. The software automatically completed the superimposition process to ensure optimal accuracy. Labial bone thickness was described as the distance between the implant surface and the outer bony surface on the CBCT scan after 6 months and as the distance from the root surface to the outer bony surface on the CBCT scan at baseline. Labial bone thickness was measured at three points: the implant platform (crestal thickness), half of the implant length (middle thickness), and the implant apex (apical thickness). The same points were projected on the CBCT scans at baseline, and the bone thickness was also measured (Figs 6 and 7).

Peri-implant probing depth was measured after 6 months at four points around the implant-supported crown. The criteria proposed by Smith and Zarb[43] was used to evaluate implant success.

Statistical and Power Analysis

A total sample size of 20 patients was calculated to detect a mean difference of 2 in PES with SD of 1.51 based on previous data,[30] with .05 level of significance and 80% power, which was increased to 24 patients to account for those lost to follow-up (power and sample size program: https://ps-power-and-sample-size-calculation.software.informer.com/download/). Normality of the data was explored using Kolmogorov-Smirnov and Shapiro-Wilk tests, and data were described as mean, standard deviation (SD), mean difference, 95% confidence interval, and frequencies and percentages. The unpaired Student *t* test was used for quantitative data, and the chi-square test was used for qualitative data. The significance level was set at $P \leq .05$. Statistical analyses were performed using IBM SPSS Statistics (IBM SPSS Statistics for Windows version 23.0, IBM).

RESULTS

The patient demographic and clinical data are shown in Table 1. The VST was performed in 12 patients (9 women and 3 men), with a mean age of 37.42 (± 15.6) years, while the partial extraction therapy was performed in 12 patients (11 women and 1 man), with a mean age of 32.5 (± 12.57) years; no significant difference was observed regarding age between the two groups. Both groups showed 100% implant survival after 6 months.

Table 2 shows the PES after 6 months in both groups. The present statistical analysis showed no statistically significant difference in PES between the two groups ($P = .33$). The mean (± SD) total PES was 12.67 (± 1.3) in the VST technique, while the scores in patients treated with the partial extraction therapy demonstrated were 13.17 (± 1.19). Additionally, the mean (± SD) peri-implant probing depth after 6 months for the VST technique was 2.16 (± 0.44) and 2.08 (± 1.02) for partial extraction therapy, with no significant difference between them ($P = .79$).

The vertical changes in the soft tissue in millimeters after 6 months in both studied groups are shown

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

Table 1 Patient Demographics and Clinical Data

	VST (n = 12)	PET (n = 12)	*P* value
Age (y) (mean ± SD)	37.42 ± 15.6	32.5 ± 12.57	.40
Male n (%) Female n (%)	3 (0.25) 9 (0.75)	1 (0.08) 11 (0.92)	.27
Central incisor (n) Lateral incisor (n) Canine (n)	12 – –	6 3 3	–
Implant survival n (%)	12 (100)	12 (100)	1

Table 2 Pink Esthetic Score (PES) after 6 Months in Both Studied Groups (Mean ± SD)

	VST (n = 12)	PET (n = 12)	Mean difference [95% CI]	*P* value
Mesial papilla	2 ± 0.00	1.83 ± 0.39	–0.33 [–0.72, 0.06]	.09
Distal papilla	1.92 ± 0.29	1.83 ± 0.39	–0.25 [–0.66, 0.16]	.22
Soft tissue level	2.0 ± 0.00	2.0 ± 0.00	0.00 [0.00, 0.00]	1.00
Soft tissue shape	1.67 ± 0.49	1.83 ± 0.39	–0.17 [–0.54, 0.21]	.36
Deficient alveolar process	2.0 ± 0.00	2.0 ± 0.00	0.00 [0.00, 0.00]	1.00
Soft tissue color	1.67 ± 0.49	1.92 ± 0.29	–0.25 [–0.59, 0.09]	.14
Soft tissue texture	1.42 ± 0.51	1.75 ± 0.45	–0.33 [–0.74, 0.08]	.10
Total PES	12.67 ± 1.3	13.17 ± 1.19	–0.5 [–1.56, 0.56]	.33

Table 3 Vertical Changes (in mm) of Soft Tissue After 6 Months in Both Studied Groups

	VST (Mean ± SD)	PET (Mean ± SD)	Mean difference [95% CI]	*P* value
Mesial papilla	0.08 ± 0.55	–0.24 ± 0.25	0.33 [–0.03, 0.69]	.07
Midfacial gingival margin	0.01 ± 0.73	–0.20 ± 0.10	0.21 [–0.23, 0.66]	.33
Distal papilla	–0.03 ± 0.52	–0.34 ± 0.13	0.09 [–0.22, 0.41]	.54

*Significant at $P \leq .05$.

Table 4 Thickness in Labial Bone in Both Groups Throughout the Experimental Period

	VST (n = 12)	PET (n = 12)	Mean difference [95% CI]	*P* value
Apical bone thickness (mm)				
Baseline	1.64 ± 1.27	1.82 ± 0.87	–0.17 [–1.10, 0.74]	.69
6 months	3.32 ± 1.72	2.40 ± 0.50	0.92 [-0.15, 1.99]	.08
P value	.05*	.007*	–	–
Bone gain	1.68 ± 2.73	0.58 ± 0.62	1.09 [–0.58, 2.77]	.18
Middle bone thickness (mm)				
Baseline	0.62 ± 0.54	0.48 ± 0.54	0.13 [–0.32, 0.60]	.54
6 months	2.24 ± 0.91	1.75 ±1.00	0.48 [-0.32, 1.29]	.22
P value	.001*	.004*	–	–
Bone gain	1.62 ± 1.35	1.27 ± 1.22	0.35 [–0.74, 1.44]	.51
Crestal bone thickness (mm)				
Baseline	0.53 ± 0.60	0.42 ± 0.36	0.11 [–0.31, 0.53]	.59
6 months	1.87 ± 0.99	1.95 ± 0.95	–0.07 [–0.90, 0.75]	.84
P value	.003*	.001*	–	–
Bone gain	1.33 ± 1.22	1.53 ± 1.24	–0.18 [–1.23, 0.85]	.71

*Significant at $P \leq .05$.

in Table 3. Regarding VST, the clinical measurements after 6 months revealed soft tissue stability at the mesial papilla and midfacial gingival margin of 0.08 (± 0.55) and 0.01 (± 0.73) mm, respectively. The distal papilla showed minimal (–0.03 [± 0.52] mm) gingival recession. However, the partial extraction therapy resulted in gingival recession in all three measurements. The mean (± SD) vertical changes of soft tissue at the mesial papilla, midfacial gingival margin, and distal papilla were –0.24 (± 0.25) mm, –0.20 (± 0.10) mm, and –0.34 (± 0.13) mm, respectively. However, the present statistical analysis showed no significant differences between the two protocols at the three reference points ($P > .05$).

Measurements of labial bone thickness in the two interventions at baseline and after 6 months are

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

presented in Table 4. Both VST and partial extraction therapy demonstrated a statistically significant gain in the labial bone thickness after 6 months compared to baseline values ($P \leq .05$). Regarding the VST technique, the apical, middle, and crestal mean (± SD) bone gain was 1.68 (± 2.73), 1.62 (± 1.35), and 1.33 (± 1.22) mm, respectively. Partial extraction therapy showed 0.58 (± 0.62), 1.27 (± 1.22), and 1.53 (± 1.24) mm bone gain at the apical, middle, and crestal bone thickness. Nevertheless, there was no significant difference in the labial bone thickness between the groups at any of the measured points throughout the experimental period ($P > .05$).

DISCUSSION

Long-term maintenance of optimal peri-implant soft tissue architecture in harmony with adjacent dentition in the esthetic zone remains one of the biggest challenges in implant dentistry over the past decade.[22,25] Novel concepts have been introduced to overcome these challenges. Several narrative and systematic reviews conveyed positive outcomes for partial extraction therapy; however, well-designed randomized controlled studies are recommended.[6,18,27,28] The VST was introduced as a novel protocol for immediate implant placement in thin and compromised fresh extraction sockets that offer superior esthetic and functional advantages; thus, randomized clinical trials are recommended to test its efficacy.[30–32] The rationale of this trial was to compare two totally different techniques for immediate implant placement that are indicated as a replacement for hopeless anterior teeth with intact thin-walled fresh extraction sockets, and to compare their esthetic and radiographic outcomes. Given that partial extraction therapy is a technique-sensitive approach with reported clinical complications and limited indications,[1,18,29] it would be interesting to compare its outcomes to the VST, which is a novel approach recently introduced in the literature.

To the best of the authors' knowledge, this is the first randomized controlled clinical trial to assess the esthetic and soft and hard tissue outcomes 6 months after immediate implant placement using VST versus partial extraction therapy in patients pursuing replacement for hopeless anterior teeth with intact thin-walled fresh extraction sockets. The present results suggest that both techniques maintain alveolar bone volume and surrounding peri-implant soft tissue, thus improving both functional and esthetic outcomes. The jumping gaps in both groups were not filled to minimize the variables that might affect dimensional bony changes.[21] This was based on previous studies that suggested it is not essential to graft this gap in socket shield procedures.[44,45] In agreement with Gluckman et al,[26] the labial root segment in this trial was coronally reduced to the level of the alveolar crest, and the shield was shaped with a concave contour to avoid exposure of the shield.[21]

In this study, the degree of postrestorative marginal changes in soft tissue and esthetic outcomes was evaluated using PES.[40] The present findings demonstrated that the overall PES value after 6 months was 12.67 in the VST group, while the partial extraction therapy group showed a score of 13.17. Although there were no significant differences in the total PES scores, the results of both groups suggest that optimum implant esthetics were achieved. Similarly, Elaskary et al[30,31,33] observed satisfying esthetic outcomes with good PES scores (11.33, 12.63, and 12.1, respectively) after using the VST to treat intact and compromised fresh extraction sockets with immediate implant placement. A noteworthy outcome in the present clinical trial was the 100% soft tissue level score observed in both groups, revealing < 1 mm midfacial recession after 6 months, which was consistent with the previous studies.[30,31,33] In agreement with Elaskary et al,[30] the enhanced soft tissue results with the VST may be attributed to the maintenance of the original socket walls by using the labial cortical shield, which was thought to lead to the creeping of the socket soft tissue on the cortical shield, thus providing a more incisal location of the biologic width. In addition, the scores observed in partial extraction therapy were in line with previous trials reporting PES ranging from 11 to 12.[20–22,25] In a recent systematic review with meta-analysis, Velasco Bohórquez et al[18] reported a mean PES of 12.27, which is consistent with the present observations. One possible explanation for this superior esthetic result might be the maintenance of the vascular circulation of the buccal bone provided by the periodontal ligament due to the retained root portion.[20]

The use of PES needs to be complemented by other objective outcomes.[31] This clinical trial measured the changes in vertical soft tissue dimensions at the midfacial mucosal margin and the height of both proximal papillae using digital images obtained from an intraoral scanner and implementing the NemoSmile Design 3D software. The vertical soft tissue changes in the VST group after 6 months revealed soft tissue stability at the mesial papilla (0.08 mm) and midfacial gingival margin (0.01 mm), while the distal papillae showed clinically insignificant gingival recession (–0.03 mm). Consistent findings have been reported assessing the esthetic outcomes after the VST approach.[30]

Furthermore, no previous studies have investigated vertical soft tissue changes along with VST when implemented with immediate implant placement; hence, the findings presented herein could not to be compared. However, partial extraction therapy showed slight

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

gingival recession at the mesial, midfacial gingival margin, and distal papilla (–0.24, –0.20, and –0.34 mm, respectively). Bäumer et al[25] reported few changes in the gingival contour and recessions in the partial extraction therapy, which is in line with the present observations. Additionally, Hinze et al[46] observed minor volumetric changes (0.5 mm) in all cases after 3 months. Similar findings were demonstrated by Sun et al,[22] who observed 0.3 mm recession of the midfacial tissues, the mesial and distal papilla, 6 months after partial extraction therapy. The authors concluded that these findings highlighted the benefits of using a socket shield to preserve the buccal bone and facial tissue contours despite the narrow window of its clinical applications, which confirms the present observations. Meanwhile, no significant differences in soft tissue dimensions were observed between the two groups.

Conversely, both VST and partial extraction therapy demonstrated a statistically significant gain in millimeters of labial bone thickness after 6 months compared to baseline. The apical, middle, and crestal mean bone gain was 1.68, 1.62, and 1.33 mm, respectively, for VST, while the partial extraction therapy showed 0.58, 1.27, and 1.53 mm, respectively, with no statistically significant difference detected between them. These measurements were standardized using OnDemand 3D software that was employed to superimpose the images captured at the different study periods and were proven to be reliable.[42] The present observations were confirmed by Elaskary et al,[30] showing an overall 1.8 mm facial plate thickness after 6 months in sockets with intact facial bone after VST. Enhanced bone outcomes were defined as the use of a slowly biodegradable cortical membrane shield above the buccal bone that preserved the original socket architecture during the treatment stages, as it allowed remodeling of the underlying buccal plate of bone until the gap was completely filled, resulting in thicker de novo facial bone.

In addition, the present findings are consistent with those of previous randomized clinical trials evaluating labial bone thickness after using socket shield. Barakat et al[19] reported a 0.02 mm loss in the buccal wall thickness after 4 months. Sun et al[22] also demonstrated reduced bone loss, suggesting that socket shield preserves the buccal fragments. Recently, de Oliveira et al[23] reported that the socket shield technique showed less labial wall thickness than the minimally traumatic extraction approach, yet the difference was clinically insignificant (0.5 mm). The authors attributed this to inflammation or surgical trauma related to the partial tooth extraction. The present findings are also in line with those of other studies that measured bone loss after socket shield technique. In a histologic study, Bäumer et al[24] noticed new bone formed between the implant surface and the root shield with no osteoclastic remodeling of the coronal part of the buccal plate. However, they noticed 0.88 mm mean bone loss following immediate implant placement. In a 5-year clinical trial, Bäumer et al[25] reported that changes in the marginal bone loss at the mesial and distal aspects were 0.33 and 0.17 mm, respectively. In addition, Bramanti et al[20] reported 0.54 mm mean marginal bone loss after 6 months. Recently, Abd-Elrahman et al[21] showed 0.12 mm mean horizontal bone loss and 0.34 mm mean vertical bone loss with socket shield after 6 months. These discrepancies might be due to the different techniques used to assess labial bone alterations.

Changes in the soft tissue contour are directly related to the changes in buccal plate width and height that were reflected in the soft tissue readings.[22] The present soft tissue alterations and PES values were consistent with the gain in labial bone thickness observed in both groups. Therefore, the high PES observed may be due to the minimal soft tissue changes and the preserved marginal bony crest surrounding the immediate dental implants.[18] The integration of these findings might suggest that VST and partial extraction therapy protocols improve esthetic outcomes by preserving the alveolar buccal bone. This might be reflected in the minimal overlying soft tissue recession values observed in both groups. Additionally, the nature of the flapless approach in both groups might prevent further crestal bone and soft tissue loss.[32]

The healing period was uneventful in this investigation, evident by the absence of complications in both groups, which agrees with Bäumer et al.[25] Furthermore, this randomized clinical trial observed 100% survival for all implants. Similar results were demonstrated in previous studies investigating VST for immediate implant placement.[30,31] Gluckman et al[1] reported 96.1% survival rate in 128 socket shield cases in a 5-year retrospective study. Siormpas et al[29] treated 250 immediate implants with the socket shield technique and reported a 98% survival rate after 10 years, which may have been caused by root infections and internal and external shield exposures. A recent systematic review and meta-analysis revealed 1.37% implant failure following the socket shield technique,[18] whereas another systematic review reported 90.5% implant survival.[47] The highlighted strengths of this trial include its design, measuring the vertical soft tissue alterations, and the fact that it was the first trial to compare the VST and partial extraction therapy without using other biomaterials. The main limitation of this study was its short follow-up period; thus, it is considered as a preliminary study. Another limitation might be the discrepancy in the gender of the study population, strongly favoring female subjects. In Egypt, women are more concerned than men with their esthetics and smile. Consequently, women seek dental treatment for missing teeth in the

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

esthetic zone with implant placement, unlike men, who would prefer fixed or partial prostheses for cost-effectiveness. A recent study on the influence of patient gender on dental implants in Baghdad, Iraq, concluded that women were better candidates for dental implant treatment, showing better female attitude toward dental implants. This was reflected by the percentage of female patients (17.81%) requesting immediate dental implants compared to male patients.[48]

CONCLUSIONS

Within the limitations of this randomized clinical trial, it might be concluded that vestibular socket therapy and partial extraction therapy could be considered superior treatment approaches for immediate implant placement in intact thin-walled fresh extraction sockets, particularly in the esthetic zone. Both protocols preserved the alveolar bone structure and peri-implant tissues immediately after implantation. Thus, further multicenter randomized clinical trials with long follow-up intervals are warranted to assess the long-term stability of outcomes. Furthermore, this investigation lacks histologic evidence that can be used in future experimental animal studies.

ACKNOWLEDGMENTS

The authors declare no conflict of interest concerning the authorship and/or publication of this article. The authors would like to thank BioHorizons and Tecnoss for providing the materials used in this study. Also, the authors gratefully recognize Dr Amr Ekram, PhD, Oral and Maxillofacial Consultant, for his participation in the radiographic work included in the study, as well as Dr Abdelrahman Thabet for soft tissue measurements. The study was self-funded by the authors.

REFERENCES

1. Gluckman H, Salama M, Du Toit J. A retrospective evaluation of 128 socket-shield cases in the esthetic zone and posterior sites: Partial extraction therapy with up to 4 years follow-up. Clin Implant Dent Relat Res 2018;20:122–129.
2. Araujo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. J Clin Periodontol 2005;32:212–218.
3. Van der Weijden F, Dell'Acqua F, Slot DE. Alveolar bone dimensional changes of post-extraction sockets in humans: A systematic review. J Clin Periodontol 2009;36:1048–1058.
4. Tan WL, Wong TL, Wong MC, Lang NP. A systematic review of post-extractional alveolar hard and soft tissue dimensional changes in humans. Clin Oral Implants Res 2012;23(suppl 5):1–21.
5. Botticelli D, Berglundh T, Lindhe J. Hard-tissue alterations following immediate implant placement in extraction sites. J Clin Periodontol 2004;31:820–828.
6. De Angelis N, Signore A, Alsayed A, et al. Immediate implants in the aesthetic zone: Is socket shield technique a predictable treatment option? A narrative review. J Clin Med 2021;10:4963.
7. Esposito M, Grusovin MG, Polyzos IP, Felice P, Worthington HV. Timing of implant placement after tooth extraction: Immediate, immediate-delayed or delayed implants? A Cochrane systematic review. Eur J Oral Implantol 2010;3:189–205.
8. Lin GH, Chan HL, Wang HL. Effects of currently available surgical and restorative interventions on reducing midfacial mucosal recession of immediately placed single-tooth implants: A systematic review. J Periodontol 2014;85:92–102.
9. Evans CD, Chen ST. Esthetic outcomes of immediate implant placements. Clin Oral Implants Res 2008;19:73–80.
10. Cosyn J, Hooghe N, De Bruyn H. A systematic review on the frequency of advanced recession following single immediate implant treatment. J Clin Periodontol 2012;39:582–589.
11. Chen ST, Buser D. Esthetic outcomes following immediate and early implant placement in the anterior maxilla—A systematic review. Int J Oral Maxillofac Implants 2014;29(suppl):186–215.
12. Gupta S, Sabharwal R, Nazeer J, Taneja L, Choudhury BK, Sahu S. Platform switching technique and crestal bone loss around the dental implants: A systematic review. Ann Afr Med 2019;18:1–6.
13. Slagter KW, Raghoebar GM, Hentenaar DFM, Vissink A, Meijer HJA. Immediate placement of single implants with or without immediate provisionalization in the maxillary aesthetic region: A 5-year comparative study. J Clin Periodontol 2021;48:272–283.
14. Mangano FG, Mastrangelo P, Luongo F, Blay A, Tunchel S, Mangano C. Aesthetic outcome of immediately restored single implants placed in extraction sockets and healed sites of the anterior maxilla: A retrospective study on 103 patients with 3 years of follow-up. Clin Oral Implants Res 2017;28:272–282.
15. Groenendijk E, Staas TA, Bronkhorst E, Raghoebar GM, Meijer GJ. Immediate implant placement and provisionalization: Aesthetic outcome 1 year after implant placement. A prospective clinical multicenter study. Clin Implant Dent Relat Res 2020;22:193–200.
16. Mareque S, Castelo-Baz P, López-Malla J, Blanco J, Nart J, Vallés C. Clinical and esthetic outcomes of immediate implant placement compared to alveolar ridge preservation: A systematic review and meta-analysis. Clin Oral Investig 2021;25:4735–4748.
17. Hürzeler MB, Zuhr O, Schupbach P, Rebele SF, Emmanouilidis N, Fickl S. The socket-shield technique: A proof-of-principle report. J Clin Periodontol 2010;37:855–862.
18. Velasco Bohórquez P, Rucco R, Zubizarreta-Macho Á, et al. Failure rate, marginal bone loss, and pink esthetic with socket-shield technique for immediate dental implant placement in the esthetic zone. A systematic review and meta-analysis. Biology (Basel) 2021;10:549.
19. Barakat DA, Hassan RS, Eldibany RM. Evaluation of the socket shield technique for immediate implantation. Alex Dent J 2017;42:155–161.
20. Bramanti E, Norcia A, Cicciù M, et al. Postextraction dental implant in the aesthetic zone, socket shield technique versus conventional protocol. J Craniofac Surg 2018;29:1037–1041.
21. Abd-Elrahman A, Shaheen M, Askar N, Atef M. Socket shield technique vs conventional immediate implant placement with immediate temporization. Randomized clinical trial. Clin Implant Dent Relat Res 2020;22:602–611.
22. Sun C, Zhao J, Liu Z, et al. Comparing conventional flap-less immediate implantation and socket-shield technique for esthetic and clinical outcomes: A randomized clinical study. Clin Oral Implants Res 2020;31:181–191.
23. de Oliveira GB, Rebello IMC, Montanha Andrade K, Araujo NS, Dos Santos JN, Cury PR. Evaluation of alveolar process resorption after tooth extraction using the socket shield technique without immediate installation of implants: A randomised controlled clinical trial. Br J Oral Maxillofac Surg 2021;59:1227–1232.
24. Bäumer D, Zuhr O, Rebele S, Schneider D, Schupbach P, Hürzeler M. The socket-shield technique: First histological, clinical, and volumetrical observations after separation of the buccal tooth segment—A pilot study. Clin Implant Dent Relat Res 2015;17:71–82.
25. Bäumer D, Zuhr O, Rebele S, Hürzeler M. Socket shield technique for immediate implant placement—Clinical, radiographic and volumetric data after 5 years. Clin Oral Implants Res 2017;28:1450–1458.
26. Gluckman H, Nagy K, Du Toit J. Prosthetic management of implants placed with the socket-shield technique. J Prosthet Dent 2019;121:581–585.

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

27. Mourya A, Mishra SK, Gaddale R, Chowdhary R. Socket-shield technique for implant placement to stabilize the facial gingival and osseous architecture: A systematic review. J Investig Clin Dent 2019;10:e12449.
28. Blaschke C, Schwass DR. The socket-shield technique: A critical literature review. Int J Implant Dent 2020;6:52.
29. Siormpas KD, Mitsias ME, Kotsakis GA, Tawil I, Pikos MA, Mangano FG. The root membrane technique: A retrospective clinical study with up to 10 years of follow-up. Implant Dent 2018;27:564–574.
30. Th Elaskary A, Y Gaweesh Y, Maebed MA, Cho SC, El Tantawi M. A novel method for immediate implant placement in defective fresh extraction sites. Int J Oral Maxillofac Implants 2020;35:799–807.
31. Th Elaskary A, Gaweesh YY, El Tantawi M, Maebed MA. Vestibular socket therapy: A novel approach for implant placement in defective fresh extraction sockets with or without active socket infection (one-arm cohort study). Int J Oral Maxillofac Implants 2021;36:146–153.
32. Elaskary A, Meabed M, Abd-ElWahab Radi I. Vestibular socket therapy with immediate implant placement for managing compromised fresh extraction sockets: A prospective single-arm clinical study. Int J Oral Implantol (Berl). 2021;14(3):307-320.
33. Supplement: Abstracts of EuroPerio10, Copenhagen, Denmark, 15–18 June 2022. J Clin Periodontol 2022;49(suppl 23):4–385.
34. Burns PB, Rohrich RJ, Chung KC. The levels of evidence and their role in evidence-based medicine. Plast Reconstr Surg 2011;128:305–310.
35. Moher D, Hopewell S, Schulz KF, et al. CONSORT 2010 explanation and elaboration: Updated guidelines for reporting parallel group randomised trials. Int J Surg 2012;10:28–55.
36. Saghaei M. Random allocation software for parallel group randomized trials. BMC Med Res Methodol 2004;4:26.
37. Vandeweghe S, De Bruyn H. A within-implant comparison to evaluate the concept of platform switching: A randomised controlled trial. Eur J Oral Implantol 2012;5:253–262.
38. Gobbato L, Paniz G, Mazzocco F, et al. Significance of crown shape in the replacement of a central incisor with a single implant-supported crown. Quintessence Int 2013;44:407–413.
39. Wadhwani C, Hess T, Piñeyro A, Opler R, Chung KH. Cement application techniques in luting implant-supported crowns: A quantitative and qualitative survey. Int J Oral Maxillofac Implants 2012;27:859–864.
40. Fürhauser R, Florescu D, Benesch T, Haas R, Mailath G, Watzek G. Evaluation of soft tissue around single-tooth implant crowns: The pink esthetic score. Clin Oral Implants Res 2005;16:639–644.
41. Buser D, Weber HP, Lang NP. Tissue integration of non-submerged implants. 1-year results of a prospective study with 100 ITI hollow-cylinder and hollow-screw implants. Clin Oral Implants Res 1990;1:33–40.
42. Meijer HJA, Slagter KW, Vissink A, Raghoebar GM. Buccal bone thickness at dental implants in the maxillary anterior region with large bony defects at time of immediate implant placement: A 1-year cohort study. Clin Implant Dent Relat Res 2019;21:73–79.
43. Smith DE, Zarb GA. Criteria for success of osseointegrated endosseous implants. J Prosthet Dent 1989;62:567–572.
44. Siormpas KD, Mitsias ME, Kontsiotou-Siormpa E, Garber D, Kotsakis GA. Immediate implant placement in the esthetic zone utilizing the "root-membrane" technique: Clinical results up to 5 years postloading. Int J Oral Maxillofac Implants 2014;29:1397–1405.
45. Mitsias ME, Siormpas KD, Kotsakis GA, Ganz SD, Mangano C, Iezzi G. The root membrane technique: Human histologic evidence after five years of function. Biomed Res Int 2017;2017:7269467.
46. Hinze M, Janousch R, Goldhahn S, Schlee M. Volumetric alterations around single-tooth implants using the socket-shield technique: Preliminary results of a prospective case series. Int J Esthet Dent 2018;13:146–170.
47. Ogawa T, Sitalaksmi RM, Miyashita M, et al. Effectiveness of the socket shield technique in dental implant: A systematic review. J Prosthodont Res 2022;66:12–18.
48. Alhamdani F, Abdulla E. Influence of patient's age and gender on dental implant treatment: Five year retrospective study. Res Rev 2021;4:1461–1467.

© 2023 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.