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Received: 31 July 2017 | Revised: 27 September 2017 | Accepted: 11 October 2017

DOI: 10.1111/cid.12554

ORIGINAL ARTICLE

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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

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Abstract

Objectives: Tooth loss results in an inevitable alveolar ridge reduction. This has established a cautionary approach to extract, wait, augment, and insert the implant, in lieu of immediate placement. However, saving the tooth or part of it whenever possible is more conservative and supports the vital periodontal tissue buccofacial to an implant. The purpose of this cases series was to report on implant survival using this technique in a large cohort of patients at long-term follow-up.

Materials and Methods: A private practice patient database was searched for all patients having received socket-shield treatment in conjunction with immediate implant placement. Of the results returned, 128 met the inclusion criteria of ≥12 months from date of definitive restoration, or failing prior to definitive restoration. These patients were recalled for evaluation of the restored implants 1-4 years post-treatment.

Results: Seventy immediate implants with socket-shield were placed in female patients and 58 in males, age range 24-71 (mean 39 years). The distribution of sites treated were: maxillary incisors (64%), premolars (22%), canines (14%); maxilla (89.9%), mandible (10.1%). About 123/128 implants osseointegrated and survived 1-4 years following restoration (survival rate 96.1%). A combined complication rate of 25/128 implants occurred (19.5%). Five implants failed to osseointegrate and were removed. The remaining 20 complications were all managed or observed without management, with implants surviving at long-term follow-up.

Conclusions: Notwithstanding technique sensitivity and the need for randomized control studies, this case series demonstrates that the socket-shield performs competitively when compared to implant survival rates in both conventional immediate and delayed implant placement.

KEYWORDS

dental implant, implant dentistry, partial extraction therapy, socket-shield technique

1 | INTRODUCTION

It has previously been discussed in detail that tissue loss following extraction is a certainty.[1–3] Single tooth loss, multiple tooth loss, and especially complete removal of the dentition can be devastating for a patient. When multiple teeth or the entire dentition is lost, the alveolar ridge changes discussed here are multiplied.[4] The osseointegration of a dental implant and its subsequent restoration are milestones in a patient's treatment, and yet are not endpoint of treatment. The volume, health, and esthetics of the supporting tissues need to maintain stability over the long-term.[5] To manage these, the clinician typically may employ some form of augmentation procedure. Yet, implant dentistry has evolved in both acknowledging and managing this inevitable dilemma. The focus on treatment goals has shifted from merely implant survival to treatment success.[6,7] These include optimal esthetic results, healthy peri-implant tissues, restoration of function, and the long-term maintenance of these. There has also been a considerable shift toward less invasive, more conservative treatment in patients. None better

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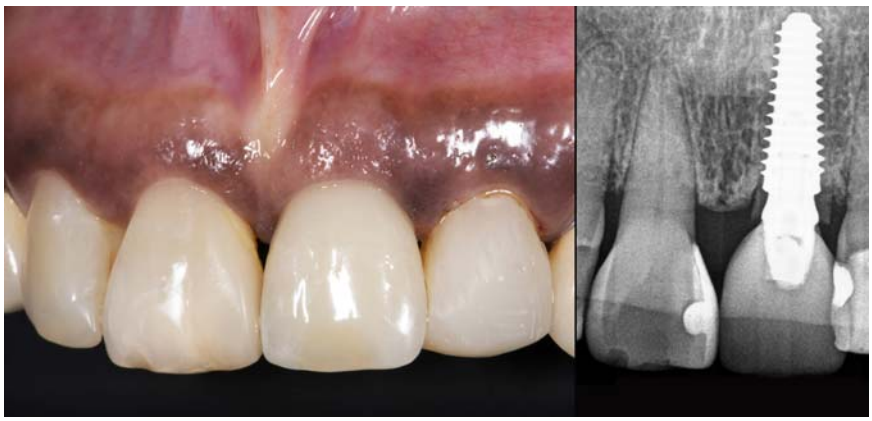

FIGURE 1 Four-year follow-up of a restored immediate implant and socket-shield at tooth site 21

stated than "the dental profession recognizes that an artifact is of less biological value than the original healthy tissue."[8] The theme of a recent implant dentistry symposium was "Key Factors for Long-term Success." The necessity for augmentation was addressed and emphasized two further dilemmas—longevity of treatment in patients, and the importance of maintenance during their lifetime.[9,10] It is questionable whether current treatments can be guaranteed to survive several decades in a patient, especially without maintenance, and these treatments may well need revisions to manage outcomes such as tissue resorption.

A better alternative is required that retains part of the patient's tooth/teeth wherever possible, that provides the clinician with treatment options even later in the patient's life, is more conservative, and requires less or no commercial materials. Such alternatives must be explored and developed to advance dental implant treatment for patients. To reinforce this, data is needed to explore these alternatives, to support their efficacy as well as their safety, and their clinical performance long-term, while ever improving and refining their methodologies. Partial extraction therapies, specifically the socket-shield, encompass all these aforementioned concepts. Hereafter these authors report a 128 socket-shield case series, following up the restored implants in conjunction with this tissue preservation technique, evaluating clinical performance at 1–4 years, including all complications and how they were managed.

2 | MATERIALS AND METHODS

This study was observed in full accordance with the World Medical Association Declaration of Helsinki. This study was undertaken with the understanding and written consent of each participant and according to the above-mentioned principles. The patient cohort was derived from a database search at a private practice of all patients who had socket-shield with immediate implant placement. The selection criteria stipulated:

2.1 | Inclusion

- All patients who previously had socket-shield treatment

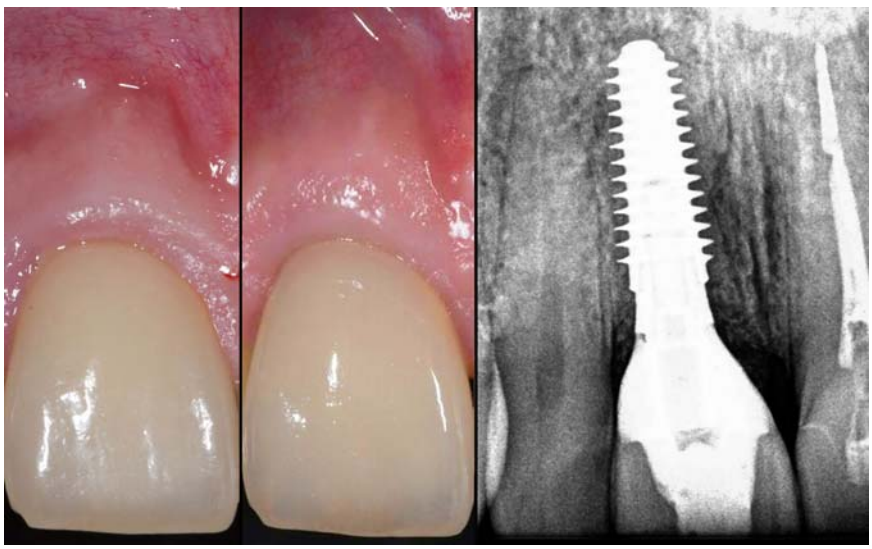

FIGURE 2 Preoperative view of site 11 (left panel), original crown, coronal fracture. Postoperative view (middle panel), screw-retained metal-ceramic crown with periapical radiograph (right panel) at 2-year follow-up

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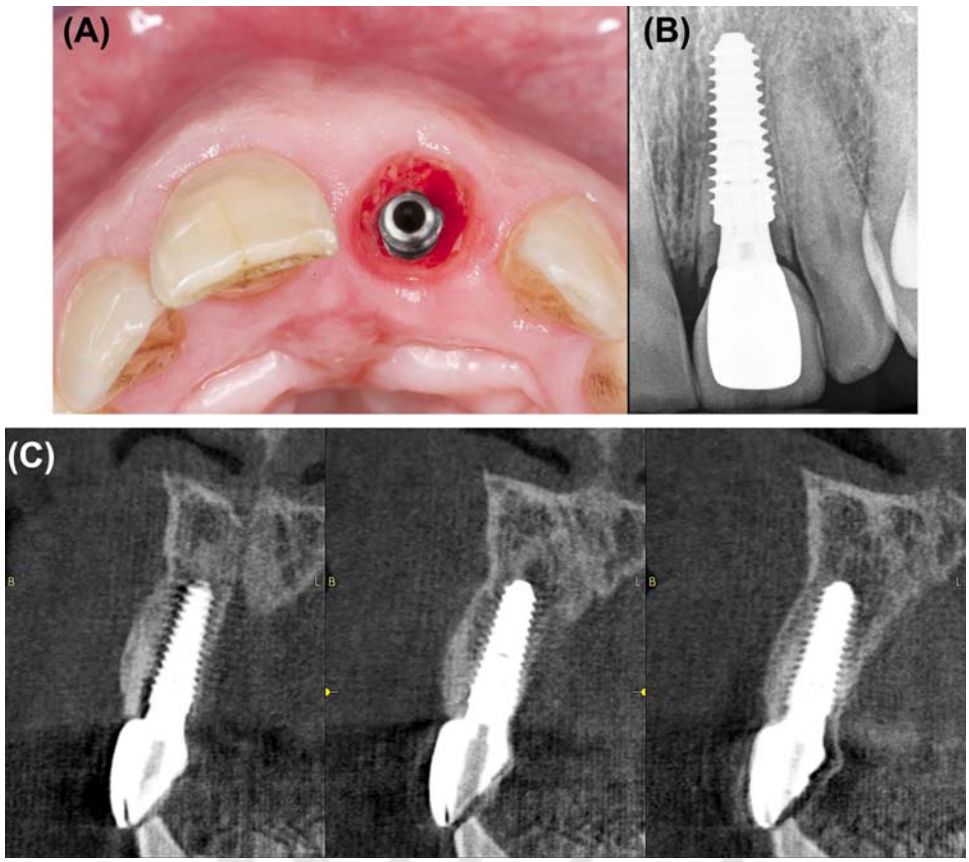

FIGURE 3 A 3-year follow-up immediate implant at socket-shield site 21. Note the bulk of tissue facial to the implant. (c): CBCT scan demonstrates the hard tissue facial to the implant

AQ8

- All patients with minimum mid-term follow-up (≥12 months)
- All mid-term follow-up demonstrable by a clinical examination and minimum of a periapical view radiograph and a clinical photograph
- Follow-up start date defined as day of restoration (provisional or definitive)
- All treatment failures (at placement, during osseointegration, during provisionalization, or post definitive restoration)

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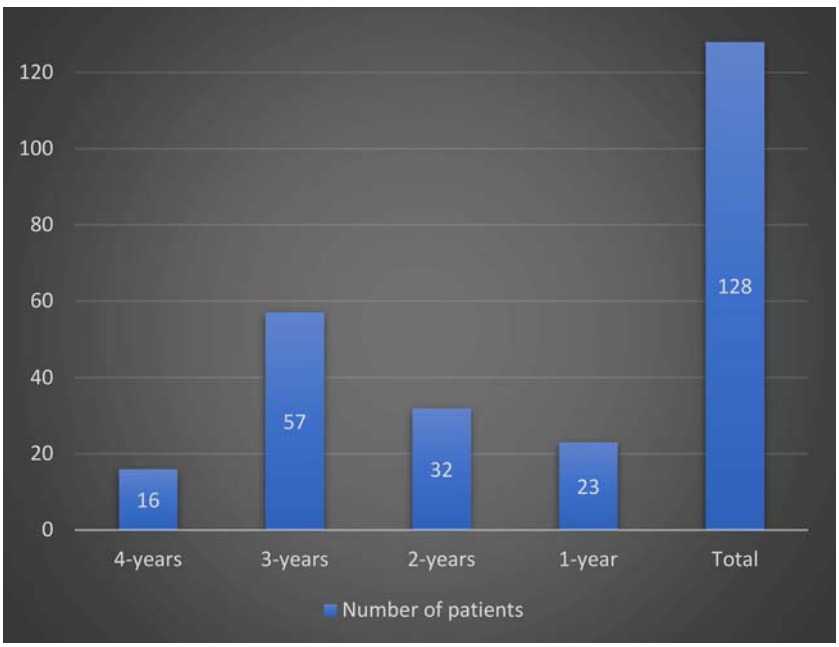

FIGURE 4 The number of patients followed up per years of follow-up (*y*-axis: number of patients, *x*-axis: time in year intervals)

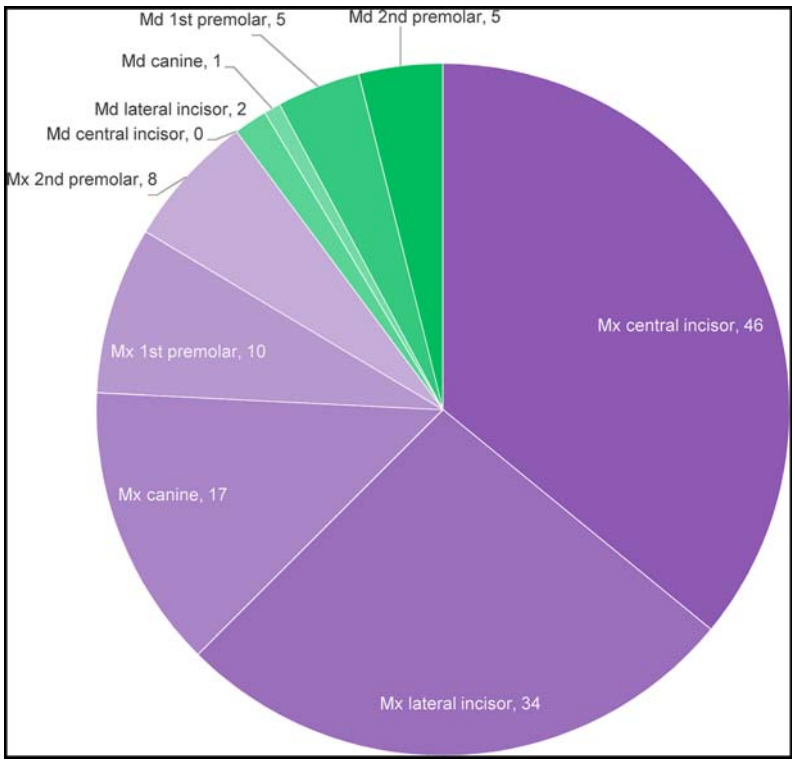

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FIGURE 5 Distribution of socket-shields per tooth sites, per jaw

- All complications (at placement, during osseointegration, during provisionalization, or post definitive restoration)

2.2 | Exclusion

- Implant not loaded by a restoration (provisional or definitive) >12 months
- Patients unable to return for follow-up evaluation despite >12 months elapsed post-restoration

Patients with restored implants at a socket-shield without previous follow-up, or able to present for an additional longer-term follow-up visit, were invited to return for a recall evaluation. All implants evaluated in this study were internal, morse-taper, conical connection implants only (AnyRidge, MegaGen; Ankylos, Dentsply; NobelReplace, Nobel Biocare) as per these authors' standard protocol for socket-shield treatment. At follow-up, a minimum of a periapical radiograph and clinical photograph of the restored implant were taken (Figures 1–3). These together with a clinical examination of the implant and restoration evaluated the treatment by:

2.3 | Primary outcome measure

- Implant survival

2.4 | Secondary outcome measures

- Implant failure
- Signs of peri-implant mucositis
- Signs of peri-implantitis
- Other complications (socket-shield exposure, infection)

Data were compiled into a Microsoft Excel spreadsheet for analyses.

3 | RESULTS

The patient database was searched for all records of socket-shield with immediate implant placement. Of the totaled results returned, 128 cases met the selection criteria. Seventy immediate implants with socket-shield were placed in female patients and 58 in males. The data comprised examination records from previous follow-up visits ≥12 months, or subsequent patient recall for additional follow-up, thus with an inclusion of all 128 patients and zero loss to follow-up. Period of follow-up and the number of patients respectively are demonstrated in Figure 4. Patient age ranged 24–71 (mean 39 years). Maxillary incisors were treated most often (64%), premolars second most often (22%), and canines least often (14%) (Figure 5). Maxillary sites were treated far more often the mandible (89.9% vs 10.1%). A total of 25 complications occurred (19.5% complication rate). Five of these implants failed during the initial osseointegration/healing period. Sixteen socket-shields encountered exposure. Three sites developed an infection. One socket-shield migrated/overerupted (Table 1).

3.1 | Complications and management

3.1.1 | Implant failure

It is not possible to determine with certainty whether the five implants that failed to osseointegrate as a result of the additional socket-shield

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TABLE 1 The totaled complications and management of each

	Tooth	Exposure (internal)	Exposure (external)	Infection	Implant failure	Migration	Timing of complication	Management
1	21				1		At integration check, 3 months	SS intact, implant replaced, osseointegrated, restored
2	11	1					At integration check, 3 months	SS reduced, soft tissue healed, restored
3	21	1					At integration check, 3 months	No treatment, no additional complications
4	33		1				1-year postop	Reduced, CTG, soft tissue healed, restored
5	21			1			2 months postop, prior to integration check	SS removed, implant decontaminated, GBR, restored
6	13				1		At integration check, 3 months	implant replaced, restored, shield intact
7	12, 11		2				1-month postop, prior to 3 months integration check	SS reduced, soft tissue healed, midfacial recession
8	12	1					At integration check, 3 months	SS reduced, restored
9	21		1				2 months, at exposure of adjacent implant	SS reduced, CTG, soft tissue healed, restored
10	12			1	1		1-month postop	SS and implant removed, healed, new implant and GBR, restored
11	11			1	1		1-month postop	SS and implant removed, ridge preservation graft, FPD
12	21	1					9 months, at delivery of definitive crown	No treatment, no additional complications
13	11	1					At integration check, 3 months	SS reduced, restored
14	11	1					At integration check, 3 months	No treatment, no additional complications
15	21	1					9 months later at final check before final crown placed	No treatment, no additional complications
16	21	1					At integration check, 3 months	No treatment, no additional complications
17	23	1					At integration check, 3 months	No treatment, no additional complications
18	22				1		4 months, at time of exposure of adjacent implant	Implant removed, RPD
19	11, 21	2				1	Exposure at 9 months, before delivery of definitive crowns. Migration noted at 3-years.	No treatment, no additional complications
20	34	1					At integration check, 3 months	SS reduced twice, soft tissue healed, restored
Total		12	4	3	5	1	Mean 4 months	25 sites in total, 17 managed and 8 monitored

AQ9 [a]SS, socket-shield.

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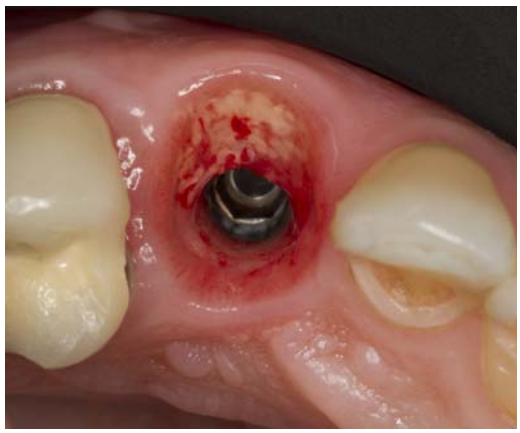

FIGURE 6 Infection and failed implant at socket-shield site

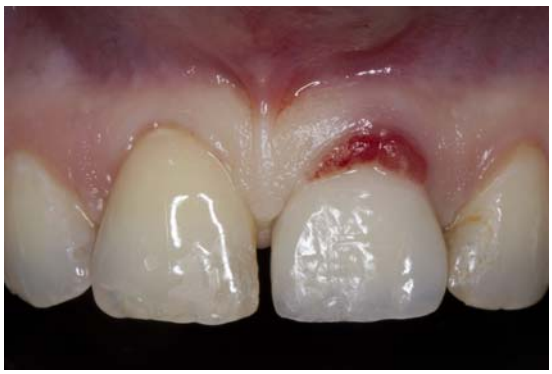

FIGURE 8 Infection at site 21. Restoration removed, socket-shield was mobile and thus removed. GBR procedure was done, implant restored and in function 4-years

F10 F11

procedure. All five implants were removed and the site managed. Three of these socket-shields were still intact and uninfected. The sites were cleaned and the failed implant replaced in two of the cases (Figures 6 and 7). Both implants osseointegrated and were restored. In one case, the implant was removed, the site converted to a pontic shield. In the two other failures, both socket-shield and implant were removed, and the patients opted for a fixed partial denture (FPD) and removable partial denture respectively.

3.1.2 | Infection

Three Socket shields were mobile and developed an infection (Figure 8). In one case, the socket shield was mobile and removed, the site exposed and cleared, the exposed surface of the implant decontaminated, grafted with a GBR procedure, and later restored. In another two cases the socket-shield and implant were both removed. In one scenario the site healed, another implant placed, osseointegrated, and restored. In the other scenario, the site was grafted as a ridge preservation and later restored with a FPD.

3.1.3 | Socket-shield exposure

Exposure (coronal portion of the socket-shield perforating the soft tissue) was the most common complication encountered, and may be denoted as internal exposure (toward the restoration) (Figures 9 and 10) or external (toward the oral cavity) (Figure 11). The incidence of internal exposures (12/128) exceeded external (4/128), 9.4% of all cases vs 3.1%) respectively. All internal exposures were managed by either no treatment and observation, or by reduction of the exposed root portion with a diamond bur coupled to a high-speed handpiece. Four external exposures occurred, all of which were managed by reducing the coronal aspect for soft tissue closure. About 2/4 external exposures had an additional connective tissue graft (CTG) augmentation to assist soft tissue healing. All healed satisfactorily and were. In a case of external exposure in the same patient of both sites 8 and 9, the SS were reduced allowing for tissue to healed over. Both healed and the midfacial tissues receded 2 mm.

3.1.4 | Migration

1/128 socket-shields migrated. In this patient, both sites 8 and 9 also had socket-shields and both demonstrated internal exposure when the provisional restorations were removed for impression taking. One socket-shield had migrated (confirmed on CBCT scan). The prosthodontist restored both implants without reduction of the socket-shields and both have been monitored without additional complication.

123/128 implants osseointegrated and survived 1–4 years following restoration (survival rate 96.1%). Five implants failed to

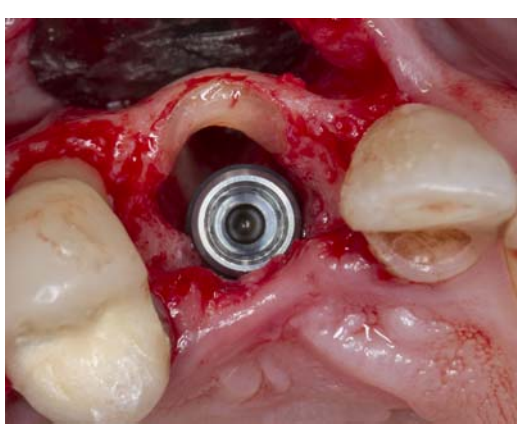

FIGURE 7 Implant removed. Socket-shield checked, immobile, intact, site cleaned, rinsed with saline, and new implant placed

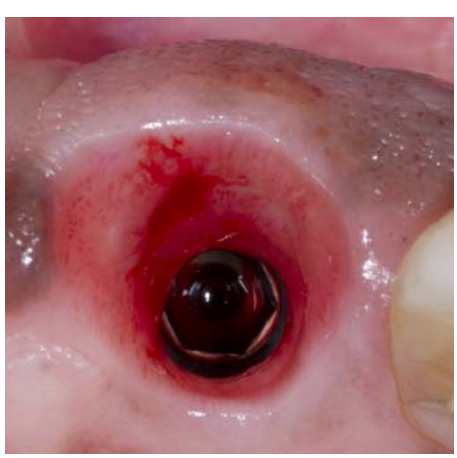

FIGURE 9 Internal exposure with inflammation

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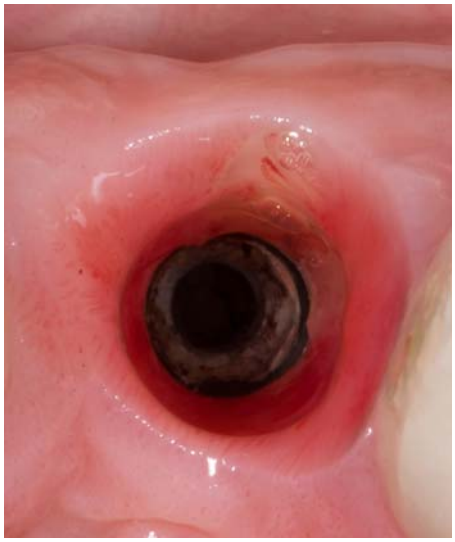

FIGURE 10 Internal exposure without inflammation

osseointegrate and were removed. The remaining 17 complications were all managed or monitored without management and definitively restored, all surviving at long-term follow-up. Subjective evaluation of the definitive restorations at follow-up identified 2 mm tissue recession at adjacent socket-shields after reduction in the same patient. No other situations of recession sufficient to expose the implant-abutment interface or implant to the oral cavity were noted. Blue-gray hue as a sign of implant translucency through the gingival tissue was not noted in any cases. Signs of peri-implantitis, clinically or radiographically, was not noted in any of the cases followed-up. All 128 cases evaluated may be viewed online.[11]

This study is STROBE compliant.

4 | DISCUSSION

The submergence of tooth root portions is not a new concept. Malmgren and coworkers in the 1980s as well as Casey and Lauciello were the pioneers of this ridge preservation concept.[12,13] The outcomes of root fracture during extraction have undoubtedly been experienced by clinicians the world over. There may be one of several outcomes—migration, promulgation of pre-existing infected root canal system,

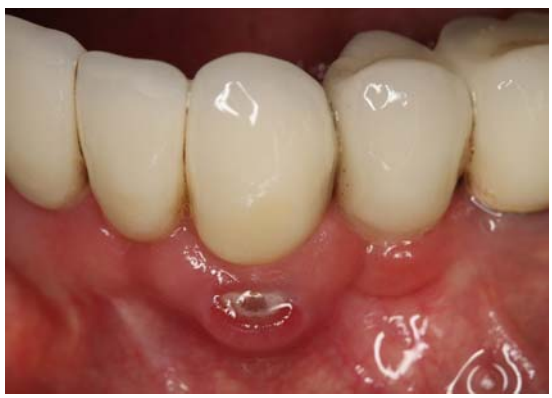

FIGURE 11 External exposure, site 33

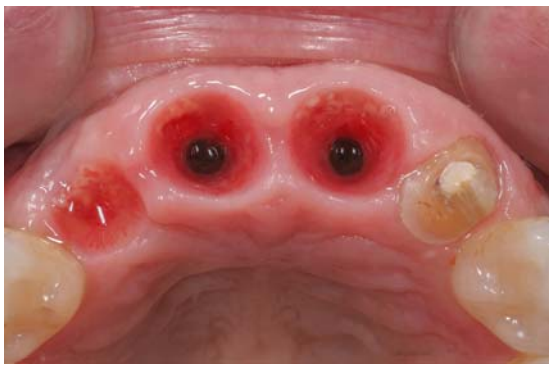

FIGURE 12 Ideal soft tissue presentation at adjacent sites 11, 21, at time of provisional removal and osseointegration check

with or without symptoms, root resorption, ankylosis, or no response.[14] All the partial extraction therapies require complete removal of infection.[1–3] The socket-shield case series reported here required preparation of the buccofacial root portion such that the canal contents (root canal filling material or neurovascular tissue) with the apex be removed. The purpose of retaining this carefully designed and prepared facial root section is maintain the root's periodontal attachment to the facial bundle bone that is prone to collapse post-extraction.[2,3,14–16] The technique is not without failure, yet the survival rate of using the socket-shield technique is consistent with implants placed into extraction sockets as well as healed ridges (97%). Conventional implant treatment also incurs a degree of complication and failure. Augmentation itself has drawbacks. It is an invaluable addition to implant dentistry with sound long-term data. Though, cost, morbidity, technique sensitivity, failure, infection, and so on. similarly beset this technique.[17,18] One technique does not supersede another. Patients are not to be treated epidemiologically. The main duty of the clinician is to practice evidence-based treatment, and when appropriate, properly inform the patient that a said treatment may still be under evaluation. It is also the

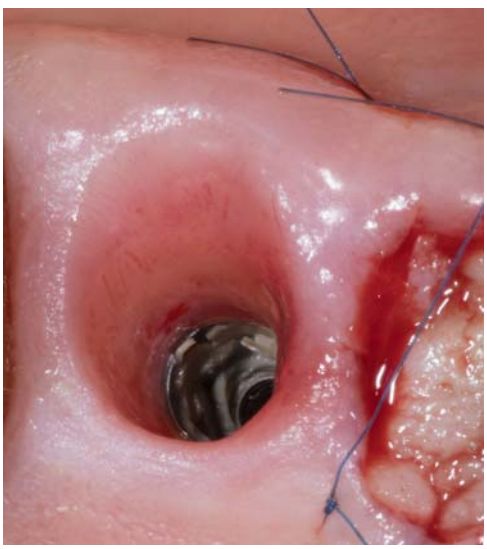

FIGURE 13 Ideal soft tissue emergence profile and health at time of placing adjacent implant

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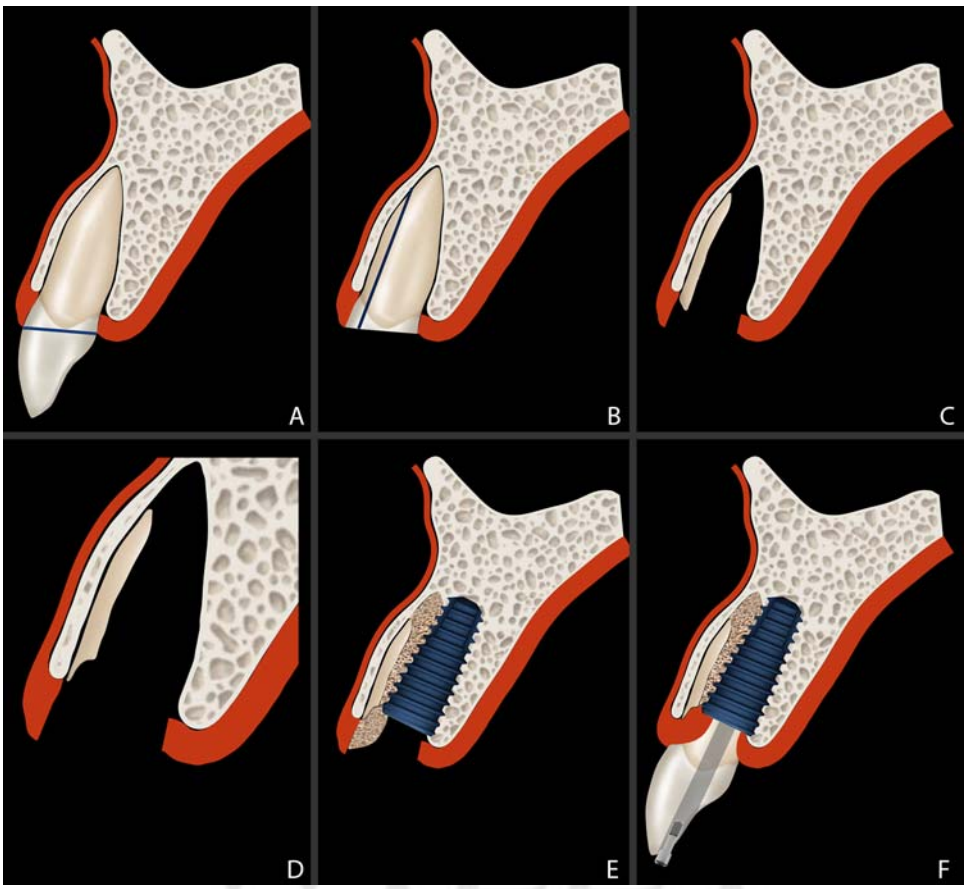

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FIGURE 14 Preparation steps of the socket-shield. Note panel D, the final steps of creating a chamfer bevel

duty of the responsible clinician and scientist to pioneer ever improving treatment modalities for patients and the profession. Partial extraction therapies endeavor such an aim. The "extract-and-augment" emphasis on surgical acumen may well be replaced by improved conservative dentistry and endodontic therapy skill as the socket-shield technique and partial extraction therapies evolve. This underpins a conservative approach to implant dentistry, the profession recognizing that an artifact is of less biological value than the original healthy tissue.[8] It may also facilitate patients from the dentate to partially and fully edentulous state, preserving in part their dental tissues. When supported by a healthy tooth/tooth either side, an implant-supported restoration may perform excellently. However, multiple tooth loss or loss of the complete dentition, even if the treatment milestones are accomplished (osseointegration, healthy and healed tissues, then fully restored) these may at day of restoration appear as a total success. But what about 10, 15, 20 years later? This is a concept emphasized at implant dentistry symposia.[9] It is a contemporary reality that patients are retaining their dentition for longer and living longer, and as a result, the projected treatment outcomes may currently not apply.[19] Implant therapy provided to a patient in their fourth decade of life may have to endure 3, 4, or more decades.

This study would be remiss without mention of its limitations and potential bias, namely a single practitioner highly experienced in the technique who carried out treatment in all cases. A multicenter prospective or retrospective study could address this. Data are now ever increasing reports on the potential for partial extraction therapies with long-term clinical performance at 5 years in two studies,[15,20] histological evidence of the tissue healed at the socket-shield-implant-interface,[14,16] indications/technique/risks/guidelines,[1–3] numerous case reports, and this study of 128 cases with long-term follow-up.

Like all techniques there is the possibility of complications. The most common complication seen in this study was internal exposure of the socket-shield (Figures 9–11). The likely cause is a lack of adequate space between the coronal edge of the shield and the subgingival contour of the crown. The potential for tissue inflammation is not ideal and as yet the long-term effects are not known. This complication was left untreated in some cases but as our technique has developed we have strived for the complete and healthy coverage of the shield with soft tissue (Figures 12 and 13). These authors consider this the only acceptable way to perform a socket shield. Internal exposures are usually noted at the time of removing the provisional restoration and it is advisable to correct this before restoring definitively. At that stage, a micro-flap is raised and the shield is reduced to the bone level and all sharp edges smoothed. It is advised to add a small connective tissue graft into the sulcus to assist soft tissue closure. Although this is not always necessary, these authors have found this to be the most predictable way of achieving complete coverage and soft tissue health. The second most common complication is the external exposure (Figure 11). This also is likely due to an over extension of the shield's coronal aspect, or the sharp coronal aspect that perforates the

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overlying soft tissue, and more likely at sites inherently deficient in facial bone (lower anterior, cuspids, previous orthodontic treatment). From these authors' experience, this complication is also easily managed with a micro flap, reduction of the perforating shield, and in most cases a soft tissue graft to close the exposure.

The occurrence of these complications has lead to a change in the way these authors perform the technique. We originally described preparing the shield to 1 mm above bone crest.[3] The rationale behind this was the maintenance of the periodontal fibers.[16] The possibility of this occurring as well as the need is overstated. As a result of the experience gained since the technique's inception these authors now reduce the socket-shield to bone crest level, and observed best results when a chamfer is created in the crestal 2 mm of the shield, thinning it slightly and providing additional and critical prosthetic space of 2–3 mm between the subgingival crown contour and the shield for soft tissue infill (Figure 14). These modifications of the technique has lead to an almost total elimination of either of these complications.

In conclusion, methods to manage the ridge collapse must be explored. Emphasis on commercial products to augment ridge deficit may better be replaced by improved techniques to preserve the patient's own tissues. This is the first >100 patient case series reporting on implant survival with the socket-shield technique at long-term follow-up. The results support this paradigm change toward tooth root tissue preservation. The technique performs comparably to conventional delayed and immediate implant placement in terms of implant survival and complication rate. These results warrant further extensive inquiry and research.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: 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*. 2017;00:1–9. https://doi.org/10.1111/cid.12554