The socket-shield technique: a step-by-step protocol after 12 years of experience

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Abstract

The socket-shield technique, first published in 2010, has gained worldwide scientific and clinical acceptance. To address possible complications with this innovative approach in esthetic implant dentistry, we provide a comprehensive step-by-step protocol incorporating what we have learnt in the past decade. After initial decoronation of the tooth, the implant bed is prepared through the root of the tooth to be extracted. Following extraction of the palatal root fragments, the shield is prepared according to either a mechanical or biologic ‘locking’ principle. The mechanical ‘locking’ comprises a direct contact between the implant and the shield, whereas the biologic approach facilitates ankylosis of the shield, preventing its coronal displacement. The coronal part of the shield is brought into a concave shape, ending up 0.5 mm coronal to the buccal bone. The implant is consequently inserted, and an individualized healing cap fabricated. When performed according to the underlying biologic and mechanical principles, the socket-shield technique can provide highly esthetic and predictable outcomes.

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Introduction

Complete preservation or reconstruction of the peri-implant soft tissue remains one of the biggest challenges in implant dentistry. To counteract defect formation that negatively influences the esthetic appearance of dental implants, numerous techniques have been described, i.e., hard and soft tissue augmentation procedures, immediate provisionalization, flapless implant placement, a more palatal orientation of the implant in the socket, and the possible use of platform switching. Despite the positive aspects of all these techniques, the reality is that optimal esthetics is only achieved in select cases, as it is not possible to completely prevent or compensate for tissue changes.1,3,4

Nowadays, it is well established that loss of the periodontal ligament and the bundle bone play a significant role in influencing the resorption process that leads to peri-implant soft tissue recession and esthetic deterioration. As those structures will be lost, the buccal bone plate and soft tissue covering will be reduced in height because the bundle bone extends into the tip of the buccal bone wall. In the maxillary anterior, the coronal part of the buccal lamella often consists of bundle bone only, and therefore its loss will lead to the complete resorption of the buccal bone in this area.5

In 1965, Björn et al published the first report of root submersion in humans to gain periodontal reattachment. In 1978, Welker et al were the first group to aim at preventing residual alveolar ridge reduction by the mucosal coverage of the roots.7 Today, the root-submergence technique has been made popular again by Salama et al.8 The principle behind it is simple: the preservation of the periodontal attachment, including the cementum, periodontal ligament, and bundle bone, prevents the resorption of these structures.

A technique called ‘socket shield’ is based on this principle. It was developed to preserve healthy periodontium in the marginal area on the buccal side of the implant by partial root retention.9 The technique combines the advantages of incision-free immediate implants such as a reduced number of interventions, shortened treatment time, reduced morbidity, and superior soft tissue surface texture, with primary prevention of tissue loss. Case reports and cohort studies on the technique have been published in the literature and summarized in a literature review,10 where a failure rate of 6.96% of all implants placed was reported.

Since the first publication on the socket-shield technique,9 our working group has undergone a learning curve. This article intends to standardize the protocol of performing the socket-shield technique. It also addresses ways to minimize possible complications with this technique, and presents a comprehensive review of the surgical approach, incorporating what has been learnt in the past decade.

Step-by-step protocol

The socket-shield technique is only utilized in the zone of high esthetic relevance, namely the maxillary anterior area from canine to canine. In the esthetically less-demanding zones in the posterior and mandibular anterior area, there are well-established implant placement concepts available that omit the need to leave in place parts of the tooth to be extracted.

Before the treatment, it is mandatory to assess the patient’s medical history and oral health status. The absence of periodontal disease and infrabony periodontal defects needs to be confirmed as well as radiographically significant dehiscence in the buccal bone plate of the tooth requiring extraction. Clinically, there should be no vertical and no subcrestal horizontal or oblique
fractures detectable on the facial aspect of the tooth. Following the preoperative analysis of the specific issues concerning the clinical socket shield, the implant position is digitally planned using an optical scan and cone beam computed tomography. The implant position itself is not influenced by the application of the socket-shield technique.

The key to the success of the socket-shield technique is the radiographic analysis of the implant position in relation to the shield. Precise measurements of the horizontal dimension (thickness of the shield), the dimension of the shield interproximally, and the vertical dimension (length of the shield in the apicocoronal direction) are conducted.

In our approach, the shield design reflects the biologic idea of preserving the bundle bone, but nowadays also incorporates our understanding of facial growth and the possibility of resulting complications. As demonstrated in a recent article by Zuhr et al., lifelong growth of the maxilla and the involved teeth can result in complications with the socket-shield technique. Therefore, the need to prevent the antero-caudal movement of the dentin shield compared with the ankylosed implant is addressed by ‘locking’ the shield to the implant.

There are two possible ways to achieve this. The first is the preferred mechanical principle comprising the mere ‘locking’ of the shield with the implant threads in the apical area. The implant shoulder should not have contact with the shield. In the three-dimensional analysis, the possible mechanical ‘locking’ options can be determined. By leaving the apical part of the shield thicker, the implant threads can ‘lock’ the shield apically (Fig 1). A variable thickness of the shield can therefore be expected in this case. Another possibility of ‘locking’ the shield can be found in the interproximal region, by leaving the shield extended in this area (as was suggested by Kan and Rungcharassaeng) (Fig 2). The contact of the implant in this area should always be below the bone level.

The second possible way, the biologic approach, is to create a non-inflammatory ankylosis between the shield and the implant surface, preventing future displacement of the shield, as reported by Zuhr et al. Therefore, the goal when preparing the shield with this approach is to leave as much as possible of the dentin shield in place to facilitate ankylosis. Also, the interproximal sides of the shield should be thinned out to enable vascularization and the subsequent osteogenesis with ankylosis (Fig 3).
1. Decoronation and endodontic post removal

The removal of the crown or other restorations takes place before the surgical procedure (Fig 5). The tooth is ground down to the level of the gingiva. Metal posts are removed by cutting down the dentin mainly on the palatal side to avoid damaging the root on the facial aspect (Fig 6). Fiber posts and composite fillings are removed with a small Linde main bur (Fig 7), following the root canal as far to the apex as possible – the rationale being that these materials are hard enough to blunt the implant burs and therefore need to be removed in advance.

One hour before surgery, a single-shot oral antibiotic is administered comprising 2 g amoxicillin, or 600 mg clindamycin in case of penicillin allergy.

The required instruments for the socket-shield technique should be minimal. Therefore, only the following instruments are recommended in addition to those required for conventional implant placement:
- Straight handpiece.
- Straight desmotome (Deppeler).
- Small Lindemann bur for angled handpiece (Komet Dental) (Fig 4).
- Diamond bur for angled handpiece (Fig 4).
- Round carbide bur for straight handpiece (Fig 4).
- Round diamond bur for straight handpiece (Fig 4).

2. Preparation of the implant bed

The implant bed is prepared through the root using a 2-mm pilot drill and a surgical guide (Fig 8). The preparation should be located toward the palatal side of the root (Fig 9). The intact root guarantees a stable guidance of the bur during implant bed preparation (Fig 10). The implant bed is completely prepared following the specific protocol of the implant manufacturer. As shown in the examples of digitally planned implant positions, the implant bed does not follow the course of the root canal but instead is palatally oriented.
Fig 5  Removal of the crown prior to surgery.

Fig 6  Removal of the posts by the palatal reduction of the dentin, saving the buccal dentin.

Fig 7  Removal of fiber posts and composite fillings with the small Lindemann bur.

Fig 8  Preparation of the implant bed through the root using a surgical template and the 2-mm pilot drill.

Fig 9  The small notch represents the middle of the palatally oriented implant bed preparation.

Fig 10  The intact root guarantees a stable guidance of the bur during implant bed preparation.
Fig 11  The root is separated in a mesiodistal direction using a small Lindemann bur.

Fig 12  A sulcular incision is performed on the palatal side before the extraction of the palatal root.

Fig 13  The palatal root is removed with a desmotome.

3. Removing the palatal part of the root and the apex

After the preparation of the implant bed, the remaining palatal part of the tooth is mostly very thin due to the palatally oriented implant position. With a small Lindemann bur (Fig 11), the root is separated in a mesiodistal direction, creating a buccal and a palatal root piece. A sulcular incision should be made on the palatal side (Fig 12) with a microblade before the palatal piece can be removed carefully with a straight desmotome (Deppeler) (Fig 13). Care must be taken to only apply force to the palatal bone, which functions as the hypomochlion. Levering against the buccal bone and dentin shield will quickly lead to fracture and mobilization of the buccal shield.

4. Preparation of the shield in the horizontal and vertical dimensions

Preparing the buccal shield to be the correct length, thickness, and extension to the interproximal area is the most critical part when performing the socket-shield technique. Visual magnification, with sufficient illumination of the surgical field, as well as a direct line of sight are mandatory to performing this step. The preparation of the shield is initially carried out with a 2.8-mm diameter round
reinforced bur, following the root canal precisely until the former apex (Fig 14). As a tactile support, the index finger of the non-dominant hand should be pressed against the alveolar bone so that possible perforations to the vestibule can be felt in advance. The apex needs to be cut roughly 2 to 3 mm coronal to the tip of the root with a small, long-shafted Lindemann bur. The access and removal of the apical delta is carried out through the implant bed. The removal of the apical delta will counteract possible inflammatory complications originating from bacterially colonized root canal branching. The radiographic image provides additional orientation. Any remaining root canal filling material is removed from the buccal shield under direct vision. The exact dimensional outline of the shield in an apicocoronal direction and interproximally follows the principles described above. Depending on whether a biologic or mechanical ‘locking’ approach is adopted, the horizontal thickness can vary from coronal to apical. In our opinion, a thickness of 1 to 2 mm in general provides enough stability for the shield itself. If the shield can be locked mechanically, the apical thickness is greater than with the biologic approach. The interproximal dimension (how far the shield should extend in the interproximal area) and the design of the shield at the interface to the bone (ie, a feather edge or an edge) also play a role. Preparing the margins of the shield in a feather-edge design facilitates the ingrowth of bone between the shield and the implant surface. However, overly reducing the thickness can render the shield prone to fracture (ie, from 1 to 2 mm moving to 0.5 mm) (Fig 3).

How far the shield is left interproximally also depends on two factors. The first is the presence of natural teeth adjacent to the implant, which allows for a strictly buccally prepared shield. In this case, the preparation from line angle to line angle is sufficient to maintain the natural soft tissue contour. In a case where two implants need to be placed side by side in the esthetic zone, one of the shields should extend further into the interproximal area, giving support to the interimplant papilla. The second factor is the potential need for a mechanical ‘locking’ of the shield. The shield needs to be extended to the interproximal area when a mechanical ‘locking’ approach cannot successfully be achieved, by ‘locking’ the screws to the apicobuccal side. In this case, a direct contact between shield and implant can still be accomplished on either side of the implant interproximally (Fig 2). This interproximal contact should always be below bone level, never in the coronal part.

5. Coronal shield preparation

There are various aspects to consider when preparing the coronal part of the shield. In the presented protocol, we recommend reducing the shield to 0.5 mm above the buccal bone height. The amount of reduction is determined following bone sounding on the buccal side. The first step comprises the preparation of the shield in a concave shape, leaving as much space as possible between the emergence profile of the future crown and the dentin shield. A carbide bur is utilized for this part of the preparation (Fig 14). The reduction in height is realized with a round diamond bur with the same diameter as the carbide bur (Fig 15). By thinning out the concave shape from the inside out until direct contact with the periodontal soft tissue is achieved, the dentin shield is brought down to the desired amount of 0.5 mm above the buccal bone crest. The tissue-friendly diamond bur will create a slightly bleeding surface, without thinning out the tissue as the carbide bur would do (Fig 16). A minor bleeding surface is supportive to create a stable blood coagulum between the shield and the healing abutment or the provisional crown. This increases the chances of a maximal soft tissue infill, thus avoiding shield exposure.
forces draw the staining agent into the crack and enable visual confirmation (Fig 17). When a crack becomes visible, it needs to be opened with the same small Lindemann bur as described above. The opening allows blood vessels to grow into the space, eliminates microorganisms, and enables the ingrowth of bone. As a next step, the absence of mobility of the shield needs to be checked gently with forceps. If instability of the shield is present, the removal of the shield is recommended.
7. Implant placement

In the next step, the implant is inserted (Fig 18), anchored in the bone apical to the former apex. If a mechanical ‘locking’ approach is chosen, the implant design can negatively impact the integrity of the shield. An implant with an aggressive thread design or a tapered body design may create excessive pressure on the shield in the apical area. In this case, the clinician should consider using a parallel-walled implant, which does not administer buccal force to the shield.

The position of the implant shoulder also depends on the implant design. The implant shoulder is positioned at the level of the buccal bone crest, ie, 0.5 mm below the shield, if a butt-joint connection implant is used (Fig 19).

8. Management of the gap

Grafting materials are not used to fill the gap (Fig 19). Various studies have demonstrated the healing potential of the body, showing the ingrowth of the bone and the ankylisis of the shield and implant.\textsuperscript{9,16} Placing any type of grafting material seems unnecessary and might impede the healing process.

9. Soft tissue management

As demonstrated in the first socket-shield technique publication,\textsuperscript{9} there is no need for adding a soft tissue graft. However, it is mandatory that an individualized healing cap or a provisional anatomical crown with the original soft tissue profile be constructed and installed on the implant. The individualized healing cap is fabricated using a sandblasted provisional abutment and flowable, light-curing, bulk-fill composite. The exposed bone and tissue apical to the sandblasted individual abutment is protected by a small piece of rubber dam (Fig 20). Afterwards, the concave emergence profile of the individualized abutment is finalized, polished, and screwed on the implant (Fig 21). When the initial stabilization of the implant allows for an immediate provisionalization, a provisional crown using the same emergence profile as the individualized abutment may be installed. Another option could be a provisional that is screwed on a palatally placed implant (Fig 22), ending up as a pontic over the individualized healing abutment (Fig 23).
Discussion

The socket-shield technique, first described by Hürzeler et al., is a relatively novel approach in esthetic implant dentistry (Figs 24 to 27). After worldwide clinical application of this technique and numerous published studies, it can no longer be called experimental. Over the past decade, we have developed a detailed knowledge of this procedure and its corresponding difficulties.

10. Postoperative maintenance

After rinsing for 1 week postsurgery with chlorhexidine mouth rinse, the patient is instructed to start a regular oral hygiene routine again, using a toothbrush and interdental brushes. Depending on the final insertion torque and the specific implant system, the impression for the final crown is taken 6 to 12 weeks later. The final crown can then be placed.
With this step-by-step protocol incorporating the underlying understanding of post-extractional tissue alterations and skeletal growth, an attempt is made to address the avoidable complications and possible pitfalls when applying the technique.

Currently, two systematic literature reviews have been published on the socket-shield technique. The first, by Gharpure and Bhatavadekar, reported complications occurring in 24% of all included implants in human trails. Various approaches were included, ranging from the T-Belt technique to transdental fixations in animal studies, primarily not intended as a socket-shield procedure. The heterogeneity of the different approaches complicates the comparison of the treatment results and might be a reason for the high number of failures. A more recent literature review by Mourya et al compared clinical studies from 2017 onwards and reported a failure rate of 7%.
A 5-year clinical, radiographic, and volumetric analysis confirmed the value of the socket-shield technique in preventing loss of volume on the buccal side when placing immediate implants. Gluckman et al. demonstrated over 4 years that the survival rate of implants placed with the socket-shield technique is comparable to that of conventional immediate and early/delayed implant placement. The first randomized clinical trial over 2 years reported improved functional and esthetic outcomes with the socket-shield technique by maintaining alveolar bone volume and peri-implant tissue when compared with conventional flapless immediate implantation.

There are minor differences between the most frequently described protocols for the socket-shield technique and our protocol.

The ‘partial extraction therapy’ by Gluckman et al. comprises decoronation of the tooth and sectioning of the root mesiodistally in a longitudinal axis, with the root canal as a reference. The resected palatal half is removed with the help of a micro-perirotome. The labial root shield is reduced to the level of the alveolar labial bone crest, and the most coronal 2 mm of the shield is reduced with a large round bur, creating a beveled chamfer. This allows for additional prosthetic space because, later on, the implant shoulder is placed 1.5 mm below the shield. The oro-vestibular thickness of the labial shield is somewhat reduced. The exact implant position in relation to the shield in the horizontal dimension is not reported on, although the contact of implant and shield does not seem to be encouraged. If a gap between implant and shield is present, we recommended that it be filled with particulate bone-grafting material. An individualized healing abutment or an immediate provisional then needs to be fabricated to support the soft tissue situation.

The ‘root membrane technique’ by Siormpas et al. and Mitsias et al. is another adaptation of the socket-shield approach. After grinding down the tooth to 0.5 to 1.0 mm above the bone crest, the implant bed is prepared through the long axis of the tooth in a more palatal position to preserve the labial socket shield. Two longitudinal cuts are created through the dentin along the long axis of the tooth to lever out the approximal and palatal remnants of the tooth. According to these authors, the oro-vestibular thickness of the shield should be 1.0 to 1.5 mm. The tapered implant seems to be placed at the level of the labial bone. No further information is given as to the shape of preparation of the coronal shield. The provisional is cemented on top of a provisional abutment.

What the above two methods have in common with each other and with our protocol is the initial step of grinding down the tooth to the level of the gingiva. In a similar way to Gluckman et al., we use a navigated surgical template for implant bed preparation. Like Mitsias et al., we leave the root of the tooth in place during implant bed preparation, which provides more mechanical stability for the implant bur during preparation compared with the postextraction empty alveolar socket. Contrary to Mitsias et al., we do not prepare the implant bed along the axis of the tooth, but follow the navigated surgical template. This leads to a more palatally positioned implant compared with the tooth.

The coronal part of the shield is prepared differently to how it is described in the initial publication by Hürzeler et al., where it was suggested to prepare the root 1 mm coronal to the buccal bone plate. Gluckman et al. concluded that the supracrestal preparation frequently results in exposure of the shield. Therefore, they proposed to reduce the shield until it is level with the buccal bone. In 1983, Carnevale et al.
tooth structure up to the alveolar crest and demonstrated a 1 mm loss of buccal bone height after preparing the tooth to the level of the bone. These findings were attributed to the need for a reestablishment of the supracrestal connective tissue barrier. With regard to this study, we hypothesize that preparing the shield on the level of the bone will lead to a resorption of 1 mm of the buccal bone. However, the clinical results analyzed by the pink esthetic score (PES)\textsuperscript{29} will still demonstrate a high level of success and will be as good as the conventional approach of implant placement in the esthetic zone.\textsuperscript{30}

The thickness of the shield is afterwards prepared to about 1.0 to 2.0 mm and can vary in the corono-apical direction. There are many recommendations in the literature about this issue. In their study, Guirado et al\textsuperscript{31} recommend a thickness of 2 mm. Tan et al\textsuperscript{32} suggested an ideal thickness of 0.5 to 1.5 mm. In 2019, Calvo-Guirade et al\textsuperscript{33} advised a short piece of root in the coronal part of the alveolus. In our protocol, the coronal part of the shield is positioned about 0.5 mm above the buccal bone. This is a compromise between limiting the risk of shield exposure and preserving as much facial tissue as possible. The coronal part of the shield is prepared in a concave shape, as was demonstrated in 2013.\textsuperscript{34} In contrast to Mitsias et al\textsuperscript{35} a parallel implant is preferred so as to avoid uncontrollable pressure on the labial shield, if contact is expected. Also, a screw-retained superstructure is used where there is no need for cementation.

In our opinion, the necessity for a biologic or mechanical ‘locking’ of the shield needs to be understood. Björk\textsuperscript{36} and Björk and Skiller\textsuperscript{37} demonstrated the lifelong growth of the maxilla in an antero-caudal direction. This phenomenon could cause a long-term complication of the socket-shield technique.\textsuperscript{11} Zuhre et al\textsuperscript{11} demonstrated how this antero-caudal growth vector provoked a complication with the socket-shield technique. The dentin shield, designed to be very short and not be in direct contact with the implant, moved like a natural tooth in the antero-caudal direction within 6 years of function. After coming into contact with the implant crown placed on the ankylosed implant, oral microorganisms gained access through the disrupted soft tissue barrier around the shield. This caused an infection that necessitated the surgical removal of the shield. Hence, the movement of the shield in the antero-caudal direction needs to be prevented by ‘locking’ the shield to the implant. Due to the short preparation of the shield, which became infected later on, an ankylosis between the shield and the bone had not occurred. This ankylosis would have prevented further movement of the shield and would have kept its relation to the implant. Already in 2010, Hürzeler et al\textsuperscript{9} found newly formed bone on the implant surface toward the shield, and showed new cementum on the shield. It was hypothesized that the application of Emdogain (Straumann) may have caused the newly formed cementum. In 2013, Bäumer et al\textsuperscript{14} did not administer Emdogain in the same animal model in the maxilla. These authors could demonstrate new bone formation between the implant and the shield. Also, in 2018, Schwimer et al\textsuperscript{16} reported on a human histology with evidence of bone fill between the root dentin and an osseointegrated implant surface. Therefore, in our understanding, a noninflammatory ankylosis of the shield to the bone will most likely ensue if a sufficient amount of shield is exposed to the bone. This biologic ‘locking’ approach is facilitated if the shield is left as long as possible in an apicocoronal direction, and if the interproximal areas of the shield are thinned out to allow the best possible vascularization for osteogenesis between implant and shield. Contrary to Gluckman et al,\textsuperscript{13} we recommend (if allowed by the implant position)
the creation of a direct contact between the implant and shield in the apical area or interproximally achieving a mechanical ‘locking’ of the shield. A small area of contact seems to be sufficient, and no intimate contact between the implant and shield over the length of the entire root is necessary. In our opinion, whenever a parallel wall implant is used, the advocated danger of fracturing the root with the pressure of implant insertion seems to be low. This mechanical ‘locking’ provides the clinician with the direct certainty that the shield will remain in position, compared with the biologic approach where ankylosis has to occur. Nevertheless, if the mechanical ‘locking’ cannot be realized, the ingrowth of bone between the implant and shield needs to be motivated.\textsuperscript{9,16} Biologic ‘locking’ or functionally ankylosing the shield is achieved by the ingrowth of bone between the implant and shield, without there being direct contact between them.

The implant position in the present protocol differs from the position described by Gluckmann et al.\textsuperscript{21} who placed the implant shoulder below the buccal bone using a platform-switched implant. These authors reduced the shield to the level of the bone. This means that with a parallel-wall implant connected with a butt joint, the implant shoulder would be placed on the level of the buccal bone; meanwhile, with a platform-switched implant, the implant shoulder would be placed below the buccal bone. In total, a platform-switched implant would be placed 1 to 1.5 mm deeper. This situation can create additional problems with the contour of the clinical crown on the buccal side.

Although there are many improvements and better understandings available, much remains unknown such as the ideal thickness of the shield, the ideal length, and the ideal extension in the interproximal area. Also, grafting the gap between the shield and the implant, and the height of the shield in relation to the buccal bone, are still issues. The present tendency to reduce the shield to the level of the buccal bone may end up with some loss of the buccal bone, but could be safer in terms of shield exposure. In addition, it is still not clear whether the ingrowth of bone between the shield and implant surface can be influenced by any parameters. Nonetheless, it is evident that the socket-shield technique is technically demanding and sensitive, and requires a high level of skill, experience, and biologic understanding on the part of the clinician.

With the knowledge we have gained in the 12 years of using this technique as well as our understanding of relevant mechanical and biologic factors, we believe that very positive and predictable outcomes can be achieved if the procedure is executed correctly, even in very challenging clinical situations like the replacement of adjacent teeth in the esthetic zone (Figs 28 to 30).

**Conclusion**

A considerable amount of data about the socket-shield technique have been published in recent years. The latest systematic literature review,\textsuperscript{10} as well as our findings over the past decade, suggest that the technique works predictably and delivers satisfying short- and long-term success. To mitigate the known possible risks of applying the technique in a wider field, standardization of this procedure is necessary. For this reason, this article offers a comprehensive review of the protocol, and introduces the concept of ‘locking’ the shield to prevent its coronal displacement. Given the right indication in high esthetic cases in the maxillary anterior area, this technique can provide a new treatment option for the patient.
Fig 28  Preoperative view of a socket-shield case with two adjacent implants in the maxillary central incisors.

Fig 29  Clinical situation before placement of the crowns. Notice the col of the interimplant papilla.

Fig 30  7-year follow-up of the case. Complete preservation of the soft tissue can be observed.
References


