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REVIEW ARTICLE

THE SOCKET SHIELD TECHNIQUE

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ABSTRACT

Immediate Implant placement is becoming a popular treatment modality of modern day implant dentistry. The main challenge for the clinician has been the preservation of the residual alveolar bone and prevention of its resorption following the removal of tooth. The socket-shield technique (SST) represents an alternative approach in which a thin section of the remnant root is retained facially at the time of immediate implant placement to preserve buccal periodontal ligament and bundle bone. This review discusses all the literatures available on the socket-shield technique and judge its clinical prognosis and biological acceptability.

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INTRODUCTION

The residual alveolar bone undergoes a continuous resorption process following removal of tooth (Amler *et al.,* 1960; Araujo and Lindhe, 2005; Fickl *et al.,* 2008; Pietrokovski and Massler, 1967; Schropp *et al.,* 2003).Preservation of roots of teeth have proved to be positive factor in retarding the resorption process (Hurzeler *et al.,* 2010). Several research made before have shown that retaining healthy roots, vital or endodontically treated (Salama *et al.,* 2007) preserves the residual alveolar bone from resorption (Filippi *et al.,* 2001; Andersson *et al.,* 2003; Sapir and Shapira, 2008; Malmgren, 2000).The impact of implants placed in contact or close to retained pieces of roots were also investigated (Buser *et al.,* 1990; Warrer *et al.,* 1993; Gray and Vernino, 2004; Jahangiri *et al.,* 2005). Results showed growth or regeneration of periodontal ligament and/or cementum on implant surfaces. In modern times where esthetics becoming the prime factor, attention and emphasis is being given in preserving the buccal bone while an implant is placed following the removal of a tooth. Therefore an innovative technique of placing implants in close contact with planned retained roots was developed thus protecting the buccal bone from resorption (Hurzeler *et al.,* 2010; Baumer *et al.,* 2015; Kan and Rungcharassaeng, 2013; Siormpas *et al.,* 2014; Cherel and Etienne, 2014; Glocker *et al.,* 2014). Hurzeler et al.coined this as the socket-shield technique (Hurzeler *et al.,* 2010). In this the root is sectioned and the buccal piece is retained while the remaining root is removed. This retained buccal piece of root acts as a shield against the resorption. An immediate implant placement is carried out palatal to this root fragment. Histological studies on animals has confirmed the formation of cementum on implant surfaces placed in contact with intentionally retained roots (Hurzeler *et al.,* 2010).Similar animal histologic study have demonstrated the formation of a fibrous capsule around implants (Parlar *et al.,* 2005). At present, all clinical human studies currently available on implants placed in close proximity to intentionally retained root fragments using this technique are lower in the hierarchy of evidence. Hence the purpose of this article is to review the available literature with regard to socket shield technique.

History

Esthetics has always been a determining factor in the success of any prosthodontic treatment plan.

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It is an established fact that deficiency of soft and hard tissues in the esthetic zone can interfere with optimal implant positioning and hamper the overall aesthetic outcome of implant-supported prostheses (Hurzeler *et al.,* 2010). In order to overcome the negative consequences of tooth extraction, various treatment approaches such as immediate implants placement (Botticelli *et al.,* 2004; Arau´jo *et al.,* 2005) graft materials (Carmagnola *et al.,* 2003; Nevins *et al.,* 2006; Arau´jo *et al.,* 2008; Fickl *et al.,* 2008; Arau´jo etv al., 2009) and/or barrier membranes (Lekovic *et al.,* 1997; Lekovic *et al.,* 1998) have been advocated and described in the literature. As a conclusion, the majority of the studies show that socket preservation is a suitable technique for socket augmentation with the ability to maintain the ridge dimension to a certain amount (Arau´jo *et al.,* 2008; Fickl *et al.,* 2008; Arau´jo etv al., 2009). However, a complete preservation and/or entire regeneration of the extraction socket have not been documented yet. The marked alterations after tooth extraction appear to be attributable to the loss of periodontal ligament and the consecutive trauma in particular at the buccal bone plate (Arau´jo and Lindhe, 2005). Thus, it can be assumed that root retention may have an influence on the occurring resorption process. Clinical studies have tested the hypothesis that root retention, either of vital or pulpless teeth, may be able to avoid tissue alterations after tooth extraction. Filippi et al. in his case report described that decoronation of an ankylosed tooth preserved the alveolar bone before implant placement (Filippi *et al.,* 2001). Few studies have demonstrated that the preservation of decoronated roots in the alveolar process not only helps maintaining existing bone volume but also enables vertical bone growth, which can be observed coronally to the decoronated root (Malmgren *et al.,* 1984 Andersson *et al.,* 2003). Bjo¨rn (1963) confirmed regeneration of alveolar bone around endodontic ally treated teeth that were submerged and covered by a surgical flap (Bjo¨rn, 1963).

Reames et al. (1975) demonstrated in an animal study that even though epithelium commonly occurred over the amputation sites of submerged teeth, bone formation coronal to the submerged roots was evident (Reames *et al.,* 1975).O'Neal et al. (1978) showed histological and radiographic evidence that new cementum and connective tissue will form over the coronal surface of submerged roots separating the dentin from the new bone (Neal *et al.,* 1978). Conclusively, histological and radiographic evidences suggest few inflammatory changes and bone apposition around roots that had been submerged for alveolar bone preservation. Bowers et al. (1989) submerged vital teeth with infrabony defects in nine patients and created notches at regions on the root that had been covered with dental calculus. After 6 months, no root resorption, ankyloses, or pulp death was observed (Bowers *et al.,* 1989). Salama et al. (2007) reported that the Root Submergence Technique (RST) maintains the natural attachment apparatus of the tooth in the pontic site, which in turn allows for complete preservation of the alveolar bone frame and assists in the creation of an aesthetic result in adjacent multiple-tooth-replacement cases (Salama *et al.,* 2007). Davarpanah and Szmukler-Moncler (2009) reported implant placement in contact with ankylosed root fragments in a five-case-report study without any specific pathological sign after a period of 12–42 months of loading (Davarpanah and Szmukler-Moncler, 2009). The "socket-shield technique" described by Hürzeler et al. (2010) (Hurzeler *et al.,* 2010), used the retained buccal root in an attempt to preserve the buccal bone and tissues, which is the mainly desired effect, after immediate implant placement (Figure 1). This approach allowed the buccal cortical bone to be successfully preserved after placement of the implant (Figure 2). Another modification of the socket-shield technique has been described by Baumer et al. which may offer a feasible treatment option to procedures using the socket-shield technique in vertically fractured teeth. The case report indicates that it may also be used without severe adverse events and that the desired effect of buccal maintenance might also be achieved in human tissues (Baumer *et al.,* 2015).In 2014 Troiano et al. introduced the Root-T-Belt technique consists of placing the implant in the preserved tooth root, which will surround the implant entire circumference thereof tooth structure, formed by periodontium, dentin and cement will create a protective structure as a belt, which prevents any movement and maintains the peri-implant system structure (Troiano *et al.,* 2014).

Figure 1: Preserved buccal root fragment after sectioning

Figure 2. Implant placement palatal to the buccal root fragment which inturns protect the buccal cortical bone

HISTOLOGICAL EVIDENCES

In the past various histological experiments were carried out on both animals and human beings, to test the outcome of implants placed in proximity to alveolar bone. Parlar et al. were the first to place nine implants in the center of prepared hollow chambers of decoronated roots having slits at the periphery in nine mongrel dogs (Parlar *et al.,* 2005). Four months later, histological examination of the specimens showed newly formed periodontal ligament, alveolar bone, and root cementum in the space between the implant and the wall of the dentin chamber.

A fibrous capsule covered their surfaces and there was absence of any osseointegration. Cellular cementum was deposited on the surfaces of two out of nine implants as well as on the dentinal walls of the chamber. One implant had an exposed edge whereas two implants showed clinical signs of inflammation (Parlar *et al.,* 2005). Hurzeler et al. intentionally left a buccal portion of the remnant root coated with enamel matrix derivative (Emdogain, Straumann), to preserve the buccal cortical plate from resorption during an immediate implant placement (Hurzeler *et al.,* 2010).

They were the first to name this noble and innovative technique as 'socket-shield'. Histological examination of 4 implants placed in a beagle dog demonstrated cementum formation on implant surface where a direct root-implant contact was noted. When the dental implant and the root piece were in close proximity with no physical contact, a 0.5 mm connective tissue band was found between the implant and the buccal root piece. They also presented a clinical case report using this technique wherein the implant was immediately loaded and followed up for 6 months. They justified the socket-shield technique as a viable option to preserve the buccal bone and achieve satisfactory esthetics with osseointegration and without any inflammatory or resorptive response. Baumer et al. further investigated this technique by employing a similar study design but with a larger sample size (Baumer *et al.,* 2015). Their histologic evaluation showed osseointegration and bone formation between the fragments and the implants after 4 months of healing. They proposed that the socket-shield prevented the resorption of the buccal cortical plate after tooth extraction. Additionally, they also presented a clinical case report, which was followed up for a period of 6 months with no apparent adverse effects. A case-control study on the socket-shield was carried out by Abadzhiev et al. where 26 implants were immediately placed in 25 patients. Though the socket-shield group had better results in terms of bone loss, esthetics and soft tissue volume, a mean bone loss of 0.8mm (2%) was noted at 24 months (Abadzhiev and Velcheva, 2016).

Kan and Rungcharassaeng in 2013 carried out an immediate implant placement in a patient where the implant was in contact with the tooth fragment. The implant was immediately loaded and no adverse reaction was seen after 12 months (Kan and Rungcharassaeng, 2013).Chen and Pan in 2013 published their clinical case report in which they carried out an immediate implant placement in proximity to remaining tooth fragment and delayed loading was done after 4 months. They observed 0.72mm horizontal loss on buccal alveolar bone after 12 months (Chen and Pan, 2013). In 2014 Cherel and Etienne placed two immediate implants in the patient's mouth followed by immediate loading. After 11 months when the temporary crowns were removed they noticed small coronal part of root fragment was visible through mucosal bed (Cherel *et al.,* 2014). Siormpas et al. in 2014 placed 46 immediate implants in 46 different patients without any contact with the retained root fragment. The implants were immediately loaded. They were observed over a period of 24-60 months. It was found that the mean crestal bone loss on the mesial side was 0.18±0.09 and on the palatal side it was 0.21±0.09. 1 case of apical root resorption was also reported (Siormpas *et al.,* 2014). Glocker et al. in 2014 placed one implant each in three different patients after 6 months following delayed implant protocol in proximity to roots. No adverse reaction was recorded after 6 months of loading (Glocker *et al.,* 2014).

Troiano et al. in 2014 placed 10 implants in 7 patients immediately and in contact with the retained root fragment. Loading was delayed by 3 months. An average bone loss of 1.3±0.2 mm was observed after 6 months of follow up (Troiano *et al.,* 2014). In 2015 Al Dary and Al Hadadi (Al Dary and Al Hadidi, 2015) and Gluckman et al. (Gluckman *et al.,* 2015) separately carried out an immediate implant placement in close proximity to the root fragment with immediate loading. No adverse reaction was recorded after 12 months of observation in both the studies. In 2015 Wadhwani et al. mentioned in his case report the immediate placement of an implant following socket shield procedure. Loading was delayed by 4 months no negative result after 4 months of follow up (Wadhwani *et al.,* 2015).

DISCUSSION

In the past it has been observed that retaining root fragments in situ and keeping them covered by mucosa serves as an alternative technique for alveolar ridge preservation. Studies supported the fact that root fragments assisted in both the preservation of root volume as well as in vertical bone growth coronally. Thus, a planned preservation of root fragments appears to be an approach towards successful alveolar ridge preservation. Various recent studies have confirmed that the socket shield technique has the potential to reduce bone resorption after removal of tooth followed by immediate implantation, mainly through the retention of the buccal segment of the root (Hurzeler *et al.,* 2010,16,44,47-49). The common factor in all these studies was immediate implant placement at the time of preparation of the socket-shields. But everyone had a different loading protocol and follow-up duration. Other modifications to the original technique were in terms of time of implant placement (Glocker *et al.,* 2014), and location of the shield (Kan and Rungcharassaeng, 2013; Troiano *et al.,* 2014). The studies which were conducted on humans were carried out with single implant placement in the anterior esthetic area with no periodontal pathology(Hurzeler *et al.,* 2010, Baumer *et al.,* 2015, Siormpas *et al.,* 2014; Glocker *et al.,* 2014; Abadzhiev and Velcheva , 2014; Kan and Rungcharassaeng, 2013; Chen and Pan Cherel and Etienne, 2014; Troiano *et al.,* 2014; Al Dary and Al Hadidi , 2015; Gluckman *et al.,* 2015) the human studies were carried out over a period of 12 months to five years which not sufficient to establish the success of this technique.

The requirement was a simple economical technique which can be carried out with minimum surgical intervention.Socket shield technique allowed us to preserve the bone at the proposed implant site, while the thin and prone to resorption buccal bundle bone was retained (Schropp *et al.,* 2003; Arau´jo *et al.,* 2009). The lingual portions of the bundle bone are thicker and less prone to atrophy. In addition, vital anatomical structures, such as blood vessels and nerves, are found especially in the lateral tooth area of the mandible. Thus, a lingual socket shield technique seems to be complicated as well as risky. But it was necessary to point out the technique sensitivity of this novel technique. It was associated with the risk of displacement of either the buccal root fragment, or the buccal lamellar bone. The retained root fragment should be reduced to the level of the height of the alveolar ridge to prevent perforation of the healing buccal mucosa. The buccal shield should be attempted to achieve an implant position where all boundaries are formed by bone, accomplishing a successful osseointegration.

But it is not the same every time. Warrer et al. showed that new cement is deposited on the aspect of the dentin shield facing the former socket. This cement layer should be regarded as a protection against resorption by osteoclasts (Warrer *et al.,* 1993). Periodontal membrane formation around the implant will occur when the implant-root interface has a loose structure and a larger gap is left (Hurzeler *et al.,* 2010), and when the periodontal ligament of the root fragment is in contact (Warrer *et al.,* 1993) with the cement-coated implant surface. There have been multiple studies in the past which have documented the fate of root pieces left after undetected root fractures at the time of extraction. Recently, complications of infection and bone loss were also recorded when implants were placed in contact with left over root debris at the time of extraction. Therefore it will not be too early to think that the socket-shield is full proof and does pose a risk of infection to implants placed in proximity. Boss loss was also found in few cases, especially on the buccal aspect (Troiano *et al.,* 2014; Chen and Pan, 2013). Failure of the socket-shield due to infection and deficiency of alveolar ridge was also reported leading to loss of the buccal bone that was to be preserved, exposing the implant surface. The dental implants used in the studies documented in this review belonged to different manufacturers and possessed dissimilar designs and surface treatments. In spite of diverse implants, similar success results were observed establishing the fact that the implant surface or design may not be so critical in the success or failure of this technique. Within the limitations of this review article every effort was made to review all available literature on the subject, it possible to have missed certain articles describing similar technique but with a different name. Also, certain studies which could not be translated into English were kept out of this review.

Conclusion

In spite of lack of randomized control trials, cohort studies, and better histological study designs, the long-term prognosis and success of the socket-shield technique stands premature. The available literature, the overall evidence in support of the socket-shield technique is too limited.Only three studies at present has histologic evidence which point out towards the formation of either cementum, periodontal ligamament or a periodontal ligamant like fibrous tissue, on implant surfaces in proximity to the shield, all of which are unfavourable for osseointegration and questions the biologic pausibilty of this technique.Additionally, short term follow-ups and limited case selectiveness provided by most case reports are insufficient to certify this technique a successful and safer one. Though this technique has shown a new direction towards preserving residual bone and improving esthetics, but when the clinical success is still questionable and biologic principles are yet to fully established, more studies of higher hierarchy of evidence are required to be done. Until such evidence is available, the clinician should exercise caution when using this technique.

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