Iason Mantalenakis

Socket Shield with Immediate Implant Placement, a Ridge Preservation Technique

Universidade Fernando Pessoa

Faculdade de Ciências da Saúde

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RESUMO

Objetivo-O objetivo deste estudo foi acessar a eficácia da combinação de socket shield com a colocação imediata do implante como um método para produzir um resultado mais estético para uma restauração na zona estética anterior, onde normalmente a reabsorção natural do osso no sitio de extracção não permitiria isso. O socket shield, que é a retenção de um fragmento radicular in situ com o osso alveolar, é usado como uma técnica de preservação do rebordo alveolar e o implante restaura a funcionalidade da oferta de dente.

Materiais e Métodos -Com o objectivo de descrever esta técnica foram efectuadas pesquisas em bases de dados como: Medline e Pubmed e livros entre os meses de de Abril e Julho de 2018. Um número de artigos publicados entre 1967 e 2018. As palavras-chave usadas foram : “socket shield”, “membrana radicular”, “preservação de rebordo alveolar”, “implante imediato”, “remodelação de soquete”, “alterações de crista dimensional”, “histologia periodontal”, “técnica de submersão de raízes”, “estabilidade primária”, reabsorção óssea alveolar ”,“ preservação do rebordo alveolar ”.

Conclusão- Podemos concluir a partir deste estudo que a retenção de uma parte bucal da raiz no interior da cavidade é uma técnica de preservação do rebordo alveolar muito viável e bem sucedida, combinada com a colocação de implantes imediatos. Mostrando excelentes resultados, volumétricos e estéticos.

Palavras-Chave: “socket shield”, “membrana radicular”, “preservação de rebordo alveolar”, “implante imediato”, “remodelação de soquete”, “alterações de crista dimensional”, “histologia periodontal”, “técnica de submersão de raízes”, “estabilidade primária”, reabsorção óssea alveolar”, “preservação do rebordo alveolar”.

ABSTRACT

Aim- The aim of this study was to analyse the effectiveness of combination of socket shield technique with immediate implant placement as a method to produce a more aesthetic result for a restoration in the anterior aesthetic zone where normally the natural resorption of the bone of the post extraction site wouldn't permit that due to alterations of the socket dimensions. Socket shield, which is the retaining of a root fragment in situ with the alveolar bone, is used as an alveolar ridge preservation technique and the implant restores the tooth offering functionality.

Materials and Methods-For this purpose a research has been done and data was obtained from on-line resources: Medline and Pubmed and books. The research was conducted between April 2018 and July 2018. A number of articles have been obtained dated between 1967 and 2018. The key words used were "socket shield", "root membrane", "alveolar ridge preservation", "immediate implant", "socket remodelling", "dimensional ridge alterations", "periodontal histology", "root submerge technique", "primary stability", "alveolar bone resorption", "alveolar ridge preservation".

Conclusion- The conclusion of the study is that the retaining of a buccal part of the root inside the socket is a very viable and successful alveolar ridge preservation technique when it is combined with colocation of immediate implant, presenting excellent survival, volumetric and aesthetic results.

Keywords: "socket shield", "root membrane", "alveolar ridge preservation", "immediate implant", "socket remodelling", "dimensional ridge alterations", "periodontal histology", "root submerge technique", "primary stability", "alveolar bone resorption", "alveolar ridge preservation".

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INDEX

RESUMO v

ABSTRACT vi

ACKNOWLEDGMENTS vii

INDEX OF TABLES x

ABBREVIATIONS xi

I. INTRODUCTION 1

1) Materials and Methods 2

II. DEVELOPMENT 2

1) Alteration of the socket dimensions in the post extraction site 2

2) Immediate Implant 4

i. Definition and benefits of the Technique 4

ii. Contraindications 4

iii. Primary stability 5

iv. Immediate implant as an alveolar ridge preservation measure 5

v. Variables to consider in order to minimize socket dimensional alterations 6

3) SOCKET SHIELD 8

i. Definition 8

ii. History 9

iii. Socket Shield Technique with immediate implant placement 10

iv. Indications and exclusion criteria 11

v. Histological and Clinical Observation 11

III. DISCUSSION 14

IV. CONCLUSION 15

BIBLIOGRAPHY 16

ANNEXES 22

INDEX OF TABLES

Table 1- Some of the contraindications and criteria for this treatment protocol are;..... 22

Table 2- General Contraindication 23

ABBREVIATIONS

Ncm – Newton per centimetre

mm - Milimetre

PRGF.PRF - Platelet rich growth factors - Platelet rich fibrin

SST – Socket shield technique

I. INTRODUCTION

After tooth extraction an inevitable cascade of bone resorption and reduction of the dimensions of the socket takes place. This reduction seems to affect the vertical ridge height buccally more than lingually. (Araújo and Lindhe, 2005) causing an aesthetic compromise especially while restoring teeth in the anterior aesthetic zone.

Immediate implant placement that was described in the past as an alveolar ridge preservation method presents great survival results but does not seem to affect this biological reaction of bone resorption. (Botticelli *et al*., 2004; Araújo and Lindhe 2005). Regenerative materials and atraumatic extraction of the hopeless tooth have also been combined with the immediate implant placement as well as the conventional implantation protocol showing results but without being able to avoid the dimensional alterations of the socket in an extent to give a predictable, satisfactory aesthetic result. (Araújo et al 2015; Fickle *et al*., 2009)

Hurzeler *et al*. (2010) after noticing the excellent results of ridge preservation with the decoronation of ankylosed tooth first seen by Malmgren *et al*. (1984) and the osseointegration of implants in contact with ankylosed tooth fragments (Davarpanah and Szmukler-Moncler, 2009), as well as other animal and clinical trials developed the socket shield technique. The socket shield is a technique where the buccal part of the root of a hopeless tooth destined for extraction is preserved intact in situ with the buccal part of the alveolar bone in order to avoid the pronounced post-extraction dimensional alterations that would normally occur and acquire a more aesthetic result. This technique is always combined with the placement of an immediate implant in the lingual part of the socket. (Hurzeler *et al*., 2010)

It is a very new technique only having its first animal trial in 2010 although the remarking results that have been documented have created a great interest for this technique resulting in many clinical trials the last years. In this study they are examined the results, benefits and limitations of this technique after histological and volumetric studies as well as clinical and animal trials found on the internet.

1) Materials and Methods

The bibliographic review of this study was realized between the months of April and July 2018.

References 1969 to 2018 were accepted in this study

Criteria of inclusion were: Index articles relevant to the theme of dissertation, articles written in English that were of scientific interest.

Criteria of non-occlusion were: irrelevant to the theme of dissertation articles that by further inspection provided no further insight to the theme, and articles that did not provide conclusions.

Keywords used for the research of this review were: “socket shield”, “root membrane”, “alveolar ridge preservation”, “immediate implant”, “socket remodelling”, “dimensional ridge alterations”, “periodontal histology”, “root submerge technique”, “primary stability”, “alveolar bone resorption”, “alveolar ridge preservation”.

II. DEVELOPMENT

1) Alteration of the socket dimensions in the post extraction site

As dentistry has evolved and implant supported restorations have become a routine procedure the success is not measure by its survival rate but by its aesthetic result. The physiological biologic cascade that occurs in the post extraction site is causing alterations in the alveolar dimensions affecting not only the aesthetic but also the functional result. That’s why the understanding of the healing process of the socket following tooth extraction as well as the prediction of dimensional alterations has become a very important topic. (Araújo *et al*., 2015; Pagni *et al*., 2012; Fickle *et al*., 2008)

The process of biological, histological and volumetric changes that takes action in order to close the wound and restore tissue hemostasis is called socket healing. This process is consisted by three different biological phases. The inflammatory phase where the socket

is filled with a blood clot that is gradually giving place to a granulation tissue, which by its turn will give place to a provisional connective tissue rich in collagen fibers. The proliferative phase is following where fibroplasia is occuring and a provisional matrix rich in blood vessels and bone forming cells are formatting and the connective tissue starts to be replaced by immature bone called woven bone. The third and last phase is the bone modelling and remodelling phase where the woven bone is substituted by lamellar bone and the bone resorption that takes place in the alveolar walls leads to the evident dimensional changes in the socket. (Amler, 1969)

The alveolar process is defined as the tissue surrounding the fully erupted teeth. The volume and the shape of the alveolar process is determined by form of the teeth, their axis of eruption and eventual inclination. (Weijden *et al*., 2009). It's also constructed by two histological different bones, the bundle bone or lamina propria which occupies the inner part of the socket and its in direct contact with the cementum of the teeth and the alveolar bone which is the remaining hard structure. (Araújo and Lindhe 2005; Araújo *et al*., 2015)

The bundle bone which is in direct contact with the tooth through the Sharpey's fibers that penetrate the cementum of the tooth and are in contact with the dentin is a tooth dependent structure. The extraction of the tooth will cause complete reabsorption of this bone structure.

Bundle bone is mostly situated in the buccal part of the alveolar process and tends to consist a big part of the existing bone in the already thin bone lamella of the anterior teeth. All these factors cause a far more pronounced buccal bone resorption rather lingual. Also following tooth-extraction a greater horizontal than vertical ridge resorption is going to occur. This horizontal resorption it can reach up to 50% of the original width of the buccal plate. As the alveolar ridge of the buccal plate is many times consisted mostly by bundle bone this extent horizontal resorption can cause a great vertical alteration in the dimensions of the socket and even in some cases a complete collapse (Botticelli *et al*., 2004; Sun *et al*., 2013).

Most dimensional changes seem to take place the first 3 months following tooth extraction while reorganization of the alveolar ridge can continue for up to a year. (Schropp *et al.*, 2003). There are several factors that can affect this bone resorption including, surgical

trauma, lack of stimulus on the alveolar wall, lack of vascularization of the periodontal ligament and resorption of bundle bone. (Araújo *et al*., 2015)

2) Immediate Implant

i. Definition and benefits of the Technique

The protocol of immediate implant was first introduced by Schulte in 1976 as an alternative to the original implant protocol described by Branemark where the implant was placed only after a healing period of the post extraction site of 3 months and the restoration was collocated 3-6 months later when secondary stability was achieved. This alternate protocol revolutionized modern implantology including all the steps of the previous protocol in a one stage surgery: immediate implant placement after extraction of a failed tooth and subsequent immediate implant restauration. (Khzam *et al*., 2013; Lee *et al.*, 2014; Clementini *et al*., 2015)

A technique with many benefits, as less treatment time is required, there is a reduction in surgical interventions and in the majority of cases it is possible to have an immediate aesthetic result with a provisional fixed restauration, also the healing process is faster while the healing of the post extraction socket occurs at the same time with the implant osseointegration (Khzam *et al*., 2013; Clementini *et al*., 2015), .Furthermore clinical trials have shown great results of this technique demonstrating survival rates similar to the original protocol and up to 97.6%, which means that this is a technique which seriously minimizes treatment time without losing any predictability (Slagter *et al*., 2014).

All these advantages, the improvement of implant design (tapered, platform switch implants) and surface technology as also the evolving society and the necessity for faster results have created the tendency for bigger demand on this procedure, making it almost a routine procedure the last years. (Kan *et al*., 2015; Altintas *et al*., 2015)

ii. Contraindications

Besides its popularity this is a very sensitive technique which requires a skilled and experienced surgeon and a meticulous case selection in order to avoid any risks of failure or other adverse effects like anaesthetic results due to excess buccal resorption. (Table 1 in Annexes).

The healing pattern of Implants placed in the extraction socket was termed ‘Type 1’ implant installation at a consensus conference (Hammerle *et al*., 2004; Del Fabbro *et al*., 2013).

iii. Primary stability

Primary stability is important to osseointegration. In immediate implant placement primary stability is even harder to be achieved as the post extraction socket has limited bone availability (bone quality and quantity are compromised in comparison to a healed site) and mostly derives from the apical bone nevertheless it’s of even greatest importance especially when in cases where we proceed with immediate provisionalization. Implant insertion torque seems to greatly affect primary stability and studies have shown that an implant insertion torque of 20-60 Ncm is ideal to achieve an optimal result. (Kan *et al*., 2015; Khzam *et al*., 2013)

iv. Immediate implant as an alveolar ridge preservation measure

It had been suggested that immediate implant placement preserves alveolar dimension (Lazzara, 1989; Denissen *et al*., 1993; Watzek *et al*., 1995; Paolantonio *et al*., 2001), however more recent preclinical studies and clinical trials have proved this concept wrong, as dimensional alterations have been observed in the implant surgical site (Covani *et al*., 2004; Ferrus *et al*., 2010; Sanz *et al*., 2010; Botticelli *et al*., 2004; Huynh-Ba *et al*., 2009)

This bone recession that occurs normally in the post extraction site seems to be more pronounced in the buccal wall rather than the lingua/palatal affecting the pink aesthetics outcome the position and function of the implant. (Slagter *et al*., 2014). And it consists a rather common complication following immediate implant, and once the soft tissue is following the underlying bone a similar more apical shift of the mucosal margin position is going to occur compromising aesthetic results especially in the anterior zone of the maxilla and in patients with high smile line, recent clinical trials have demonstrated. Extensive bone loss can even affect osseointegration. (Clementini *et al*., 2015)

Botticelli *et al*. (2004) and Schropp *et al.* (2003) demonstrated a horizontal bone resorption in post extractions sites up to 56% of the buccal wall and up to 30% of the lingual/palatal.

Khzam and colleagues demonstrated in a 4 year follow up that in the first year follow up the mesial and distal volume of the papillae was significant lower compare to the 4th year follow up while the buccal gingival level had a continuous volume reduction. Which actually means that papillae height has the possibility to improve or regenerate while the level of mid facial gingiva tends to deteriorate with time. (Khzam *et al*., 2013)

v. Variables to consider in order to minimize socket dimensional alterations

This pronounced bone resorption in the vestibular wall of the alveolus can be partly attributed to the extense presence of bundle bone in this area which reabsorbs completely after the tooth extraction due to lack of supporting function of the tooth which results most of the times to a more vertical rather than horizontal reduction of the socket dimensions. With the majority of the studies showing mean 0,6 mm vertical mid facial bone recession following single tooth implant within the first year of placement. (Araújo *et al*., 2015; Lee *et al.*, 2014)

Although all the factors affecting bone recession are unknown there are some variables to consider in order to minimize dimensional alterations of the alveolus. These are:

- Implant position relative to the wall socket

Paolantonio et al. (2001) and most recently Chen *et al*. (2009) demonstrated that a gap between the socket bone wall and the implant of approximately 1,5-2 mm can heal without compromising the degree of secondary stability however some vertical resorption of the midfacial wall cannot be avoided.

- Thickness of buccal wall of the socket

The definition between thin and thick alveolum wall has been described in literature with 1mm or more threshold. There are numerous studies that have associated the thickness of the vestibular wall with vertical and horizontal dimensional alterations of the socket. Interestingly it has been observed that the thicker the buccal wall is the more horizontal bone resorption will present and less vertical although extremely thin buccal plate in an immediate implant site might also be related with a significant buccal horizontal resorption. Thinner buccal walls seem to undergo a premature and more severe vertical resorption (Qahash *et al*., 2008; Tomasi *et al*., 2010). In a clinical studies of Spray *et al*., 2000 and Belser *et al*. (2007) it was determined that the necessary thickness of the buccal

wall in order to avoid excessive bone loss and maintain vertical dimension is around 2mm, the same result was supported in a dog model clinical report by (Qahash *et al*., 2008). Although present studies indicate that only (2.6%) of the canines and incisors present this 2 mm width which indicates that in the anterior aesthetic zone regenerative technique must be used to maintain a stable buccal wall and acquire an aesthetic result when performing immediate implantation. (Huynh-Ba *et al*., 2009; Lee *et al.,* 2014)

- Residual bony defect in the socket

Discrepancies between the anatomy of the root and the implant morphology can lead to a lack of congruence between the implant bed and the socket of a post extraction site causing a more surgically challenging situation. This kind of situation can be also caused by a periapical inflammation or any other situation where bone resorption is happening prior to extraction causing bone defects. (Tomasi *et al*., 2010; Lee *et al.,* 2014)

Botticelli *et al*. (2004) reported from experiments in dogs that mechanically produced defects between 1.25-2.25 mm of width and up to 5.5 mm of depth in the marginal portion of the implant site would heal and be filled with new bone 4 months after the surgery.

- Reasons for tooth extraction

A socket where a tooth is extracted for vertical fracture might behave different from a socket that a tooth is extracted due to periodontal lesion. (Botticelli *et al*., 2004)

- Effect of different surgical techniques (Barone *et al*., 2008)

Atraumatic extraction and flapless technique seem to help to reduce the amount of bone resorption by preserving bone vascularization. (Del Fabbro *et al*., 2013)

- Use of regenerative techniques

Alveolar ridge preservation techniques seem to be offering a positive effect in bone remodelling, decreasing the amount of bone resorption and offering a better functional and more aesthetic result (Lekovic *et al*., 1997/1998; Iasella *et al*., 2003; Vignoletti *et al*., 2013). Several regenerative techniques such as grafting the socket with xenografts, allografts or alloplasts, incorporation of autologous blood derived products and bioactive agents (PRGF.PRF), guided bone regeneration with absorbable or non-absorbable

membranes have been proposed in the literature and although showing promising results not one of these techniques have managed to eliminate completely this bone remodelling process .It worth also to mention that the use of regenerative materials and particularly barriers can cause post- operative complications such as membrane exposure that could lead to an infection of the site and a possible loss of the implant. (Avila-Ortiz *et al*., 2014; Del Fabbro *et al*., 2013; Clementini *et al*., 2015)

3) SOCKET SHIELD

i. Definition

It is well documented that tooth extraction leads to bone resorption, a physiological process that is determined by plenty biological mechanisms but most importantly by the loss of vascular support from the periodontal ligament. This inevitable bone resorption causes alterations in the dimensions of the socket that seem to be more pronounced in the buccal rather the palatal/lingual bone plate (Schroop *et al*., 2003; Araújo and Lindhe 2005). The more extent buccal bone resorption can be explained by the vast presence of bundle bone in the area which completely reabsorbs following tooth extraction due to loss of the periodontal ligament and the collagen fibers embedded within it. Causing aesthetic and functional problems especially in the anterior zone.

Biomaterials, atraumatic techniques and even immediate implant placement have been used over the years in order to avoid bone resorption of the post extraction site, showing results but never accomplishing to prevent completely bone remodelling. The incapacity of these alveolar ridge preservation techniques to avoid any volumetric changes in the post extraction socket has driven the authors in the research for other innovative techniques permitting them to acquire a perfect aesthetic result especially in the anterior zone of the maxilla where is more desirable.

One of the techniques surfaced during this attempt to achieve this seemingly impossible task is Socket Shield. A technique first described by Hurzeler *et al*. (2010) where during extraction a part of the root is left intact to the socket maintaining a natural and healthy attachment with the bone and preserving its periodontal ligament. This root submerge technique has shown excellent results permitting to eradicate or at least minimize any bone resorption subsequently providing excellent aesthetic results. Although promising more research and extensive inquiry needs to be done to warranty these results.

ii. History

The concept of socket shield emerged as an evolution of clinical and pre-clinical studies based on the idea of root retention for alveolar ridge preservation beneath removable prostheses.

The root submergence technique was first developed to preserve the periodontal attachment complex, in order to increase the retention and stability of removable prostheses. Several studies have reported the successful preservation of periodontal tissue with vital or endodontically treated roots covered by hard or soft tissue. Malmgren *et al*. in 1984 described the decoronation technique of ankylosed teeth a method that demonstrated not only preservation of the existing bone volume but even a vertical bone growth which could be observed coronally of the root. (Gluckman *et al*., 2018)

O'Neal *et al*. (1978) presented histological and radiographical evidence of new formatted cementum and connective tissue between the dentin of the amputated tooth and the new formatted bone. Bowers *et al*. (1989) submerged teeth with bony defects in 9 patients and observed that after 6 months no resorption, ankylosis or pulp death had occurred.

In the 90s Buser *et al*. experimented with implant placement surrounded by periodontal ligament and although the results weren't good enough it was observed a close attachment between implant and remaining part of the roots. Filippi *et al*., (2001) showed that the decoronation procedure is an excellent solution for maintaining the volumetric dimensions of the alveolar process when dealing with ankylosed tooth. Although in contrast with what we currently know for the socket shield technique the ankylosed part of the root would eventually completely absorb giving form to new bone.

Salama *et al.*, (2007) reported that with root submerged technique they were able to retain the vital periodontal tissue around the root and develop pontic site with little or no collapse creating aesthetic results in cases were multiple adjacent restoration were needed (fixed partial dentures). Davarpanah and Szmukler-Moncler (2009) observed in a five-case report study that after collocating implants in contact with ankylosed root fragments, osseointegration of the implants occurred without any problems and the sites did not appear to present any pathology. (Hurzeler *et al*., 2010; Baumer *et al*., 2017)

iii. Socket Shield Technique with immediate implant placement

Firstly the patient is given prophylactic antibiotics, amoxicilin with clavulclanic acid 1 hour prior to surgery, the patient is administrated with local anesthesia and is asked to rinse with 0.12 clorhexidine, then the coronal part of the problematic tooth is removed and it's levelled in the gingival level using a conventional chamfer diamond bur with irrigation. Subsequently the implant bed is prepared in the palatal/lingual part of the remaining root while also using the long axis of the root as a guide. This osteotomy/dentinotomy helps to separate the palatal from the buccal part of the root while also serving as a perfect natural guide for the implant position.

The remaining part of the root is separated from the wanted buccal part with lindeman surgery bur for more precision and then and then its retrieved with root tip forceps leaving intact and situ the buccal part. This most wanted part of the root is then reduced until its subgingival but subcrestally 0,5 to 1 mm and its thinned out to a 2-3 mm thickness using round diamond burr and it's also bevealed toward the implant so there is more space for sort tissue to grow between abuntment and dentin.

If during any moment of this procedure the buccal fragment of the root is loosened or fractured it has to be removed. On the inside of the root segment where dentin is exposed an enamel protein matrix can be applied in order to initiate cementum formation which potentially can help to avoid root resorption.

Now that the shield and the implant bed are ready a conventional tapered implant is placed immediately 2 mm below the bone crest while trying to avoid any pressures exerted in the root segment in situ. Augmentation procedures can be used between the implant and the root segment to additionally help osseointegration. A titanium temporary abudment with a non-occlusal provisional restoration can be placed, while it must be checked that is discharged from occlusion during lateral and protrusion movements.

The patient is prescribed antibiotics and analsegic medication, he is also advised to oral rinse with chlorhexidine 3 times a day for 14 days and not to brush the area for the same amount of time. In the regular check-up implant mobility, presence or absence of exudate, perimplant soft tissue swelling, presence or absence of symptomatology, alterations in sensibility and presence or absence of pain need to be evaluated as well as the marginal

bone level, the degree of resorption of the shield, and the pink aesthetics. (Mitsias *et al.*, 2015; Baumer *et al*., 2017; Bramanti *et al*., 2018).

Although there is not yet a consensus in the recommended step by step procedure, with the increase use and experience of the authors a step by step protocol procedure will arise. (Mitsias *et al.*, 2015)

iv. Indications and exclusion criteria

The socket shield is a technique best applied and indicated in the anterior aesthetic zone, where the pink aesthetic score is of great importance to have a satisfactory aesthetic result. (Saeidi Pour *et al.*, 2017). Anterior irreversible damaged teeth with neighbouring healthy teeth are best indicated for this procedure. (Baumer *et al*., 2017). However it's a very sensitive and challenging technique that's why cases should be selected carefully, always regarding the excluding criteria. (Mitsias *et al.*, 2015). (Table 2 in Annexes)

v. Histological and Clinical Observation

Although socket shield is a relative new technique (Hurzeler *et al*., 2010) we already have a respected number of animal and clinical trials showing positive results of its use. In a recent case evaluation of 128 cases with 4 years follow-up (biggest case series till now) it was observed that 123 out of 128 implants were osseointegrated showing a survival rate of 96.1% a similar survival rate to immediate implant and conventional implant protocol. The longevity of this technique is not yet tested though so we cannot be certain of its long-term viability. (Gluckman *et al*., 2015).

The most common complication observed in the same study was socket-shield exposure that could be determined as external when the exposure was toward the oral cavity or internal when the exposure was toward the restoration. Out of 128 cases 12 internal (9.4%) and 4 external exposures (3.4%) were observed. The possible cause for this exposure could be the lack of space between the coronal aspect of the shield and the subgingival part of the restoration. So with this knowledge the original protocol of this technique where the shield was prepared 1 mm supra coronal has been modified in order to create more space between the restoration and the shield and avoid this complication. Best results where observed when the shield was reduced to bone crestal level and

additionally thinned out 2 mm coronally, creating a chamfer and giving 2-3 mm of additional prosthetic space for soft tissue infill. (Gluckman *et al*., 2018).

One of the biggest questions right now regarding this technique is how osseointgration is achieved between the exposed dentin of the remaining root and the implant surface as well as what kind of tissue is forming. (Schwimmer *et al*., 1994).

While the osseointegration of the implant in the lingual part of the alveolar bone is successful and it is observed to be the same in all histological evaluations, as also the root fragment in situ seems to maintain its periodontal ligament with the buccal alveolar bone and no resorption is observed in the buccal remaining root. There is a contradiction in the histological evaluations about what tissue is formed between the implant and the shield. (Hurzeler *et al*., 2010; Baumer *et al*., 2015; Schwimmer *et al*., 1994).

In the first animal trial by Hurzeler it was observed that osseointegration can be achieved with this technique. More specifically it was observed new cellular and acellular cementum in the exposed dentin and healthy connective tissue with occasionally new formation of woven bone in the space between shield and implant. The spaces between the threads of the implant were filled with connective tissue and an amorphous mineralized tissue. (Hurzeler *et al*., 2010).

In another animal histologic evaluation (Baumer *et al*., 2015) and the first human histologic evaluation (Schwimmer *et al*., 1994) bone formation was observed in the space between shield and implant. Bone tissue was intimately apposed in the dentin and the threads of the implant and matured remodelled bone was present demonstrating complete osseointegration but there was no presence of cementum.

These different histologic results could be explained from the use of enamel matrix. As in the first animal study it was applied in the inner dentin layer after the preparation of the shield and in the other two it wasn’t. The benefits of the presence of cementum in the osseointegration process are yet uncleared as well as if the cementum helps to avoid resorption of the root fragment. A comparative study needs to be completed in order to clarify the role of enamel matrix and presence of cementum in this method. (Baumer *et al*., 2017).

These histological results are not enough to know how in the long term the remaining part of the root is going to act and if it's going to be integrated by healthy tissue or slowly reabsorb giving place to a bone. Further histological investigation is needed. (Baumer *et al*., 2017)

Tooth extraction is followed by an inevitable bone resorption more pronounced in the buccal part. A resorption that can reduce up to 2 mm the vertical dimensions of the socket creating an anaesthetic result. (Baumer *et al*., 2015). The majority of dimensional changes in the alveolus occur the first trimester and resorption can be witnessed in a slower pace for up to a year. (Saeidi Pour *et al.,* 2017). The maintenance in situ of the buccal part of the root seems to stop the normal remodelling process as the blood supply arriving form the periodontal ligament is maintained and there is no buccal bone resorption. (Tan *et al*., 2018).

In an animal study a mean resorption of 0.66 in labial direction was found 5 months later after the removal of the healing abutment while the resorption was more pronounced in the middle of the area and was decreasing distally and mesially. An extra 0.22 mm resorption was detected after the placement of the final restoration. According to this publication the shape of the abutment and the final restorations of great importance while they will serve as support for the marginal soft tissue and they will allow a smaller resorption. (Baumer *et al*., 2015)

A 5 year follow up of 10 cases showed a tissue resorption in orofacial direction with an average of 0.37 mm after 5 years. It is very interesting to notice that there was a similar tissue resorption in the neighbouring teeth. (Baumer *et al*., 2017).

Bramanti *et al*. (2018) showed the same survival results with the conventional technique but with far superior aesthetic results. In this comparison study of conventional protocol versus SST in the aesthetical region it was demonstrated an average marginal bone resorption of 1.115+-0.131 with the conventional protocol and 0.605+-0.06 with the SST. (Bramanti *et al*., 2018).

Another comparative study between conventional immediate loading with regenerative techniques and Socket Shield Technique with 2 years follow up showed a considerable bone resorption of up to 5 mm with the conventional technique and an impressive low bone resorption equal to 0.8 mm with the Socket Shield Technique. These impressive

results highlight the importance of natural vital tissues for the acquisition of an aesthetic result. (Abadzhiev *et al*., 2014).

In a recent human histologic evidence the buccal bone was preserved without any resorption while osseointegration was achieved. (Mitsias *et al.,* 2017).

Modified versions of the techniques have also shown very good results. For example Gluckman *et al*. (2015) had pleasing aesthetic results using the technique for two adjacent implants.

III. DISCUSSION

Socket shield following placement of immediate implant is a technique that although very new in the scientific world seems to be already quite predictable presenting by authors same implant survival results as the immediate and conventional implant protocol while aiding for a significant preservation of the alveolar ridge contour, far superior from the two latest techniques referred.

The retaining of the buccal part of the root permits preservation of periodontal vascularization reducing socket resorption without the need of use of any grafting materials or other regenerative methods and thus reducing the cost and the possible number of surgical interventions while providing a minimal invasiveness and giving a best possible aesthetic result. This can only highlight the power and significance of preservation of natural biologic structures. (Saeidi Pour *et al.,* 2018)

Although all these benefits we are still unsure about how the full osseointegration of the implant is achieved and what tissue is apposed between the implant and the socket shield. Authors have noticed difference in the histological results with the use of enamel matrix showing a layer of cementum interposed between the dentin of the retaining root and the implant with its use and the absence of this cementum layer when it was not used. (Baumer *et al*., 2017). These results although, are unclear and a further comparative investigation needs to be made.

Also, it is unknown what is occurring in the long term with the remaining part of the root. It cannot yet be concluded as there are no long-term follow-ups, if the retained part of the root is going to slowly reabsorb giving place to bone or it is just going to stay in vivo unabsorbed and covered with connective tissue.

In general there is need for further investigation in order to know the long-term effects of this technique.

IV. CONCLUSION

Nowadays the clinical success of an implant is not measured by its osseointegration but by its long-term aesthetic result. This new principle in implantology that has occurred due to the very high survival rate of implants has lead the authors in the search for new approaches in order to maintain the dimensions of the socket and acquire the much desired aesthetic result. Socket Shield has managed to show with consistency in many clinical and animal studies the same survival results showing that osseointegration and formation of bone between root fragment is possible while also showing excellent aesthetic results.

We can conclude from this study that the retaining of a buccal part of the root inside the socket is a very viable and successful alveolar ridge preservation technique while combined with colocation of immediate implant. Showing excellent survival volumetric and aesthetic results. Although it is important to notice the difficulty and sensitivity of this technique as well as the lack of longer follow-ups to really know and understand the long-term results of this very promising technique.

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ANNEXES

Table 1- Some of the contraindications and criteria for the immediate implantation protocol are;

CONTRAINDICATIONS

- Presence of infection at the extraction site
- Diabetes
- Uncontrolled periodontitis
- Smoking
- Poor oral hygiene
- History of drug or alcohol abuse
- Medically compromised patients
- Inadequate tissue profile
- Insufficient bone apical to the socket in order to achieve primary stability
- History of radiotherapy in the neck or head region
- Biphosphonate medication

(Atlintas *et al*., 2015; Slagter *et al*., 2014)

Table 2- Contraindication for SST

- General contraindication for oral surgery
- Contraindications for Immediate implant as previously referred

Local Contraindication

- Teeth with vertical root fracture affecting the buccal aspect
- Teeth with horizontal fracture at or below crestal bone level
- External or internal resorption of the root
- Any other possible pathologies affecting the buccal portion of the root, except apical pathology

(Baumer *et al*., 2017)