Partial Extraction Therapy in Implant Dentistry

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Editors

Springer

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Dear Meenakshi and Bhakti,
We wish to express our gratefulness for everything you remarkable women have done to enhance our lives.

Udatta & Ali

Foreword

As dentistry evolves, it takes pioneers and trendsetters to look into the future. Tooth replacement strategies are among the most critical of all dental procedures. Patients rely upon dental professionals to be able to minimize destruction and maximize the effect and esthetics of these artificial replacement teeth.

This book highlights a more minimally invasive approach developed over the past 2 decades and how "Partial Extraction Therapies" can be implemented into a modern dental practice. The authors have concisely adapted this technique as a routine protocol and have clarified the key factors of success in a systematic blueprint.

I hope that this book helps lead the next generation of dentists to look more closely at these modern-day tooth replacement procedures.

Maurice Salama, DDS
Team Atlanta Dental Clinic,
Atlanta, GA, USA
Scientific Editor Dentalxp.com

Foreword

The loss of a tooth sets off a cascade of events that ultimately lead to bone and soft tissue loss. Many techniques have been developed over the years to try and deal with this phenomenon. Most of these techniques have occasional success, and we are striving to find a technique that is more predictable and reproducible—predictable in that we can achieve the best result possible more often than not and reproducible in that it is not just a technique that is limited to highly skilled clinicians but one that can be achieved across the board. This book is an important milestone in helping practitioners with a step-by-step protocol in a technique that has slowly become a predictable and reproducible way to maintain the bone and soft tissue both in the short and long term.

I have no doubt that this book will help anyone wanting to get involved in these treatment protocols, thereby benefitting our patients and giving them the ideal treatment options they expect from us as practitioners.

These techniques are not easy and require a fair amount of surgical skill. Learning how to do them by reading up on the protocols will go a long way in giving you the necessary confidence to try this technique. Reading in itself is not enough, and I encourage everyone who wants to attempt this technique to get adequate training from an accredited institute or trainer and secondly to ensure that you have the correct instruments to carry out the procedure. Failure to follow these protocols may lead to increased failure and frustration.

These techniques will change the way you do implantology, and the improvement in the results you achieve will be staggering.

Howard Gluckman, BDS, MChD (OMP), PhD
Director, Implant and Aesthetic Academy,
Cape Town, South Africa

Preface

Leaving a part of the root behind intentionally when extracting a tooth prior to implant placement would seem unthinkable for most clinicians. When Narayan first introduced the concept of the socket shield technique to us in 2012, we instinctively dismissed it. The procedure sounded like a violation of the basic principles of implant dentistry.

Some cutting-edge work on Dental XP (one of the largest portal for online education) by Maurice Salama, Howard Gluckman, Snjezana Pohl and Jorge Campos Aliaga inspired us to warm up to the idea of placing an implant in close proximity to a partially extracted root.

The results we witnessed in the first few cases were spectacular and surpassed the outcomes of our earlier cases in every aspect. This motivated us to pursue the socket shield technique more frequently in our practices. Unfortunately, there was limited literature on the subject. We depended on the experience of the originators of partial extraction therapies (PET), Howard and Maurice, to guide us through the protocols.

In the past 5 years, PET procedures have gained immense popularity the world over. With the growing enthusiasm among clinicians, the time was ripe to introduce a set of guidelines for clinicians to follow in order to achieve consistently successful outcomes, minimize errors, and manage complications.

This guidebook on PET covers all aspects of treatment modality with an emphasis on case selection criteria and step-by-step demonstration of the technique. All three PET modalities—the socket shield procedure, pontic shield procedure, and root submergence technique—are described in the book. The restorative phase of the treatment involving the art of fabricating the interim and definitive restoration is described in great detail.

The contributors to the book, Sudhindra Kulkarni, Tarun Kumar, and Payal Kumar, have been early adopters of the PET procedure and bring their wealth of experience to the book. Fittingly, Narayan, who has been one of the earliest experts of the socket shield technique, has scripted the chapter on biological rationale for PET.

Any new technique needs several rounds of fine-tuning and establishing protocols. The newly developed technique should also be duplicable, in that any clinician anywhere in the world should be able to achieve comparable results if the methodology is followed. We acknowledge the contribution of the *PET Research Group* comprising selfless clinicians and researchers from all over the world who are teaching the right method of executing this technique and also contributing towards forming a consensus on certain contentious issues.

The introduction of any novel treatment protocol should be aimed at reducing morbidity, treatment duration, and overall cost, without any compromise to the final result. The PET is a patient-centric treatment approach, which apart from fulfilling all the above criteria also provides results that are superior to existing techniques. With evidence in favor of the technique increasing by the day, it is a matter of time before PET become part of mainstream implant practice. This book will provide a thorough understanding of all aspects of the technique while assisting clinicians in incorporating the procedure in their daily practices.

Mumbai, India Udatta Kher
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Biologic Rationale for Partial Extraction Therapies

1

T. V. Narayan and Sudhindra Kulkarni

Abstract

Partial extraction therapies (PET) are a group of clinical procedures carried out wherein a part of the tooth is left behind in the alveolar socket at the time of extraction and the implant is placed either at the same time or later. This technique makes the body believe that the tooth is in the bone and makes it behave as such. The procedure relies on the concept that, the alveolar bone resorption is a consequence of loss of bundle bone and the only way to preserve the bundle bone is to retain the periodontal ligament attachment to it. This chapter will cover the biology of the periodontal tissues and the evolution of PET.

1.1 Introduction

Partial extraction therapies denote a collective term used to describe the maintenance of a root or a part of the root with the aim of preserving the natural contours of bone and soft tissue around implant-retained restorations. These include the root submergence technique [1], the socket-shield technique [2], the pontic-shield technique [3], and Glocker's technique [4] for ridge preservation. Details of each will be described in the further chapters of this book. The key to the rationale for partial extraction therapies lies in understanding alveolar bone development, bundle bone, and the dimensional changes associated with tooth loss, which will be discussed in the following sections.

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1.1.1 Alveolar Bone

Alveolar bone is one of the three supporting tissues of teeth. Along with periodontal ligament and cementum, they are collectively called the periodontium. Alveolar bone is composed of two structures—the alveolar process and the alveolar bone proper. Tooth buds of developing teeth are housed in the alveolar process during organogenesis and subsequently the roots of the teeth. The alveolar process of the jawbones is unique, since it develops for the teeth and along with the eruption of the teeth and is dependent on the presence of teeth for its maintenance, undergoing atrophy, once the teeth are lost. Alveolar bone consists of two plates of cortical bone separated by cancellous bone. In some areas the alveolar bone may be thin and have no cancellous bone (Figs. 1.1 and 1.2).

The spaces between the trabeculae of cancellous bone are filled with marrow (Fig. 1.2a), which is hematopoietic in early life and fatty later in life. The surface of the trabeculae of bone is lined by osteoblasts, which are responsible for bone formation. These osteoblasts get incorporated within the matrix of bone as it is laid down to form osteocytes, which lie in lacunae and communicate with each other via canaliculi to maintain the homeostasis of bone. Cells responsible for resorption of bone are the osteoclasts and are seen in resorption bays known as Howship's lacunae. Bone is a dynamic tissue and is continually forming and resorbing in response to

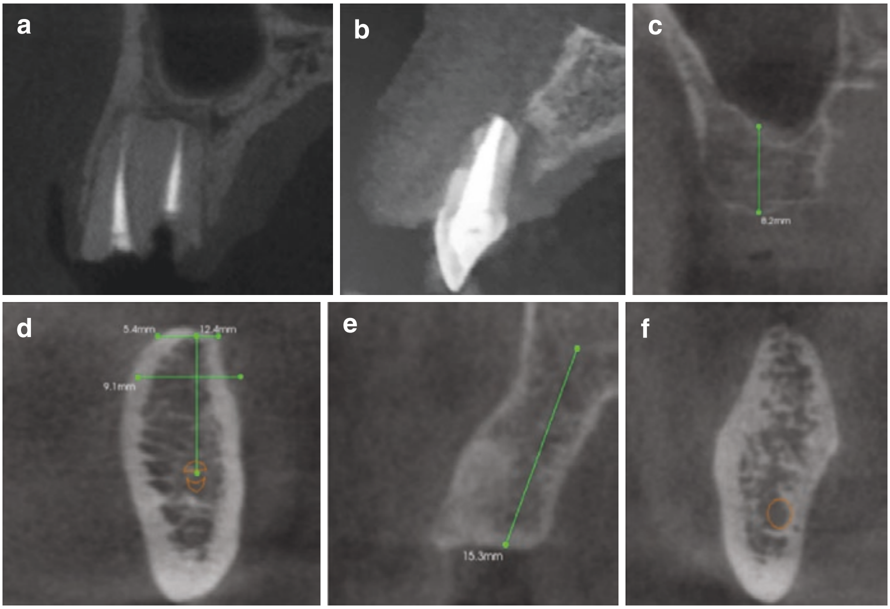

Fig. 1.1 (**a**–**f**) Different patterns of alveolar bone: (**a**) absence of cancellous bone between the cortical plates. (**b**) Loss of alveolar bone due to periodontal disease. (**c**–**f**) residual alveolar ridge with a cortical perimeter and a cancellous core in different areas of the maxilla and mandible

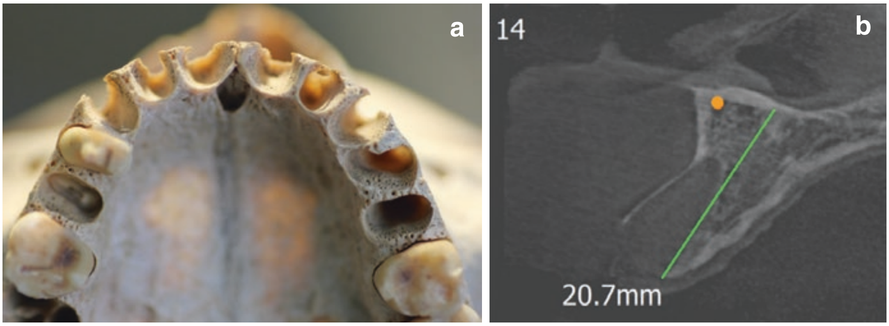

Fig. 1.2 (**a**) The alveolar bone proper can be visualized in the images. It is delicately thin and is easily destroyed by faulty extraction techniques. The marrow spaces appear as perforations giving the name cribriform plate. (**b**) The cone beam computed tomography (CBCT) section of a recently extracted tooth depicts the thinness of the labial plate

functional needs. While bone metabolism is under hormonal control, it is easily resorbed in response to inflammation, ischemia, and trauma.

Alveolar bone proper is that part of alveolar bone which actually lines the socket of the roots. It provides the attachment for the periodontal ligament fibers and is cortical in nature with perforations for nutrient channels, hence also known as cribriform plate. While the full length of the alveolar bone proper is available for periodontal ligament fiber attachment, in certain areas, the periodontal ligament fibers are embedded in the cementum and bone and undergo calcification. These are known as Sharpey's fibers, and this bone is known as bundle bone. The subsequent sections describe the bundle bone in greater detail.

1.1.2 Development of the Alveolar Bone

The alveolar bone development starts prenatally, concomitant with the membranous portions of the mandible and maxilla and strictly coordinated with the developing primary dentition and is based on molecular signaling as well as mechanical forces. The cells that participate in this event are the osteoblasts and osteoclasts. Interestingly, the osteoblasts that are responsible for the intramembranous ossification that produces the alveolar bone are derived from the ectomesenchymal cells that are present in the dental sac, also responsible for development of periodontal ligament and cememtum. This implies that ontogenically, the three structures of the periodontium have a common origin and that the alveolar bone belongs to the tooth. This is amply demonstrated by alveolar bone loss as a result of tooth loss.

The mandible develops in membrane around the Inferior alveolar nerve. This results in a bony trough in which the nerve lies, and the walls of which extend superiorly to form the alveolar process. This alveolar process will also house the developing tooth buds. While the development of the maxilla is more complex, the alveolar process, that will enclose the developing tooth buds, develops in much the same fashion as the mandible. Over time, these tooth buds will be separated by bony partitions, thereby creating sockets. This has been described in a very elegant paper by Kjaer and Bagheri [5].

1.1.3 Alveolar Bone Proper

The alveolar bone proper starts developing with the erupting tooth. After crown formation is complete, the complex interactions between the Hertwig's epithelial root sheath and the dental follicle, initiates cementogenesis with the differentiation of cementoblasts from the ectomesenchymal cells. Simultaneously, other ectomesenchymal cells differentiate into fibroblasts to form the periodontal ligament and another population differentiates into osteoblasts to give rise to alveolar bone proper, forming sockets for the roots. The fact that all these events occur synchronously allows for the embedding of PDL fibers into the cementum and alveolar bone proper.

As root formation progresses, the PDL continues to extend itself as does the alveolar bone proper continue to remodel. Bone is deposited apically and coronally, increasing the depth of the socket, remodeling and filling in around the root as the tooth erupts. It should be obvious now that the development of alveolar bone proper is purely a function of tooth formation and eruption and in cases of anodontia or lack of eruptive force, this will not develop.

1.1.4 Bundle Bone

Alveolar bone proper provides the attachment for Sharpey's fibers from the PDL. These are arranged in bundles and get calcified within the bone to provide a firm attachment. This part of the alveolar bone proper is referred to as bundle bone. Bundle bone merges with the adjacent lamellar bone which comprises the alveolar process. Bundle bone has an important role to play in tooth movement and periodontal disease progression. Understanding bundle bone is the key to understanding the rationale for partial extraction therapies, hence we will delve a little in-depth here.

Several papers have reported loss of bundle bone as the first event in the dimensional changes that take place after extraction and the explanation seems to lie in the fact that after tooth extraction, the bundle bone becomes non-functional through loss of its periodontal blood supply and undergoes complete resorption in the first few weeks [6–9]. Al Hezaimi and co-workers [9] analyzed the blood supply to buccal bone in monkeys and established that the blood supply to the buccal plate came mainly from the socket side of the alveolus i.e. via the periodontal ligament, the adjacent interdental bone, and supraperiosteal vessels emanating from the gingiva (Fig. 1.3). They also found that the buccal bone was composed of bundle bone and cortical bone, and that while the thickness of this bone was not uniform corono-apically, the thinnest area was at the coronal portion.

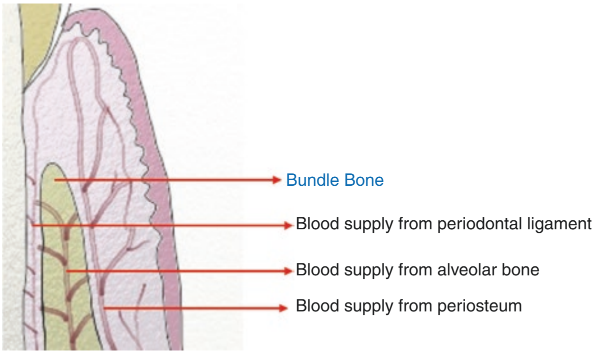

Fig. 1.3 Blood supply to the bundle bone

This implies that the periodontal ligament is a key player in maintaining the viability of the bundle bone as well as the outer cortex, and loss of a tooth will compromise this blood supply Fig. 1.3 and lead to a loss of bone.

One of the most cited pieces of published dental literature in the English language is the works of Araujo and Lindhe group [6–8, 10, 11], on the dimensional alterations of the alveolar ridge. Ridge alterations following tooth extractions in mongrel dogs described the phases of resorption after extraction as occurring in two phases: Phase one which occurred from within the socket and involved bundle bone. According to these authors, since most of the buccal crests of these sockets were made up of bundle bone, the dimensional loss was severe. In phase two, there was resorption from the surface of both bone walls.

The dimensions of bundle bone are reported to be 0.2–0.3 mm in width (apico-coronal) on the lingual plate, and at the buccal crest, 2 mm on the buccal crest, sometimes spanning the whole mesio-distal dimension of the crest. As a consequence, they found that following extraction, the buccal bone shows a vertical loss and the crest lies on an average 1.9 mm apical to the lingual crest. This may not be truly representative of what happens clinically in humans, but does offer a plausible explanation (Fig. 1.3).

In a 2009 systematic review, Van der Weijden and co-workers found only one article by Nevins et al. that corroborated these findings in humans. Their principal findings were a loss in width of 3.87 mm and a loss in height of 1.67–2.03 mm [12, 13].

In another systematic review from 2012, Niklaus Lang's group found that in human hard tissues, horizontal loss was 3.79 ± 0.23 mm and vertical reduction was 1.24 ± 0.11 mm on the buccal at the end of 6 months. Proximal bone loss was 0.84 ± 0.71 mm [14].

Chappuis [11] and co-workers, in an detailed CBCT based clinical study in humans, found that patients with a thin facial wall phenotype (<1 mm), showed a rapid vertical bone loss on the facial plate of (Median—7.5 mm), whereas those which had a facial plate thickness of greater than 1 mm, showed a median vertical

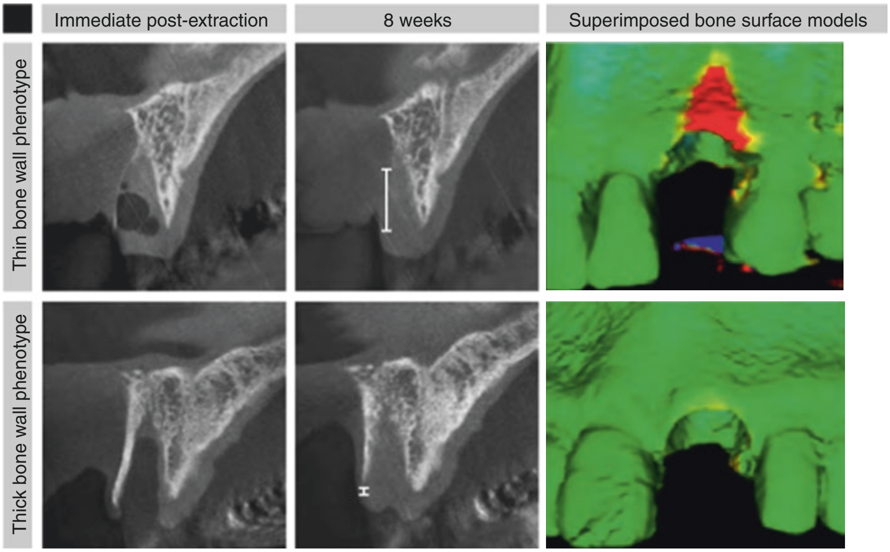

Fig. 1.4 Thin bone wall phenotypes with a facial bone wall thickness of 1 mm or less, revealed a progressive bone resorption pattern, leading to median vertical bone loss of 7.5 mm or 62% of the former facial bone height after 8 weeks of healing. This is in contrast to thick wall phenotypes, showing a facial bone wall thickness of more than 1 mm, displaying only a median vertical bone loss of 1.1 mm or 9%. The dimensional alteration pattern in single extraction sited with healthy neighboring dentition occurred mainly in the central area of the socket wall, whereas the proximal areas remained nearly unchanged after flapless tooth extraction at 8 weeks of healing [11] Printed with permission from Chappuis et al. [12]

bone loss of 1.1 mm. This implies that in facial plates that are greater than 1 mm thick, only part of it is bundle bone, and the loss of the tooth results in an early loss of this bundle bone on the socket side, without loss of the surface bone (Fig. 1.4).

With this background information, it is clear that the *bundle bone*, and the rest of the alveolar bone proper, *belongs to the tooth* and tooth loss will result in an obligatory loss of bone, starting with a rapid loss of bundle bone and continuing gradually to the rest of the alveolar bone over the long term.

The resorption of the alveolar ridge is more pronounced on the buccal than on the lingual aspect of the extraction socket [15, 16] and it is the loss of buccal tissues that is more prominent and compromises the outcomes in the esthetic areas [6, 7].

Howell et al. showed in 1970s that when endodontically treated submerged roots were left in the alveolar bone under complete dentures, hardly any resorption was seen at 10 years.

To prevent and/or minimize the resorption and mitigate the effects of bone loss after the removal of the teeth various treatment modalities such as immediate implants [10, 17, 18], use of graft materials to augment the socket [8, 19–22], and use of barrier membranes [18, 19] have been tried. Of the multitude of procedures tried above, none of them have been effective in achieving the said goal [7, 19–23] and thus complete preservation and/or entire regeneration of the extraction socket has not been achieved.

The loss of the periodontal ligament attachment to the buccal bone and loss of the bundle bone due to the extraction of the tooth/root has been determined as the principal factor in the loss of alveolar bone. This led to the emergence of the concept that, if a part of the root is retained, then it may be possible to retain the corresponding part of the bone.

With this background, Filippi et al. [24] showed that an ankylosed tooth retained bone, submerged roots allowed to form bone and cementum on top of them.

Salama et al. [1], in 2007, reintroduced root submergence in preserving alveolar bone width and height in the aesthetic zone under pontics between implants and teeth, for optimizing aesthetics.

Davarpanah and Szmukler-Moncler [25] published an alternative to extraction of deeply placed, impacted teeth that were not communicating with the oral cavity, clinically and radiographically healthy teeth that come in the pathway of implant placements. They suggested that, instead of removing the roots with invasive surgery it may be prudent to place the implants directly in contact with them. In small sample size of six patients with seven implants, they placed implants in contact with root fragments. They reported good success rates with some bone loss in one of the cases. Although the sample size was small, the paper was a positive step retaining healthy roots around implants and was an important milestone in the history of PET.

In 2010, Hurzeler et al. [3] conducted a beagle dog study to demonstrate that the retention of root helped in holding the alveolar volume. They used an enamel matrix derivative to fill the gap between the implant and the retained root. They reported, histologically, the formation and maintenance of supra-alveolar connective tissues, the formation of cementum along the root surface, but no-epithelial down migration between the root and the bone. The authors then depicted the first clinical case of the socket-shield technique, wherein the authors' placed the implant after preparing the shield in a manner depicted in the Fig. 1.5. The study showed that retaining the buccal aspect of the root did not interfere with osseointegration and that it may be beneficial in maintaining the buccal bone contour. This proof-of-principle study sets in motion the use of socket shield/PET as a treatment modality for the prevention of buccal tissue loss.

In 2013, Baumer et al. [26] published the first histological, clinical, and volumetric data of implants placed in beagle dogs after vertical separation of the buccal fragment. In their study, they removed the palatal portion of the root and then also split the buccal root into two parts. They placed the implants without any enamel matrix derivative and euthanized the animals at 4-months and conducted the histological evaluation. The implants had all integrated with new bone formation between the implant and the root fragment. They found that root fragment was well attached to the buccal bone with no signs of resorption. Clinically, too there were no visible signs of inflammation as all sites had healed well. Volumetrically, in one case that was reported, they showed good maintenance of buccal bone contours. Thus, this came to be a significant step in the evolution of PET techniques, as now it was proven that bone forms between the implant and the root fragment with no adverse effects on both, the implant as well as the root fragment.

In the same year, Kan et al. published the use of proximal shield to maintain interdental soft tissue in the aesthetic zone. Although it was just a case report, it did

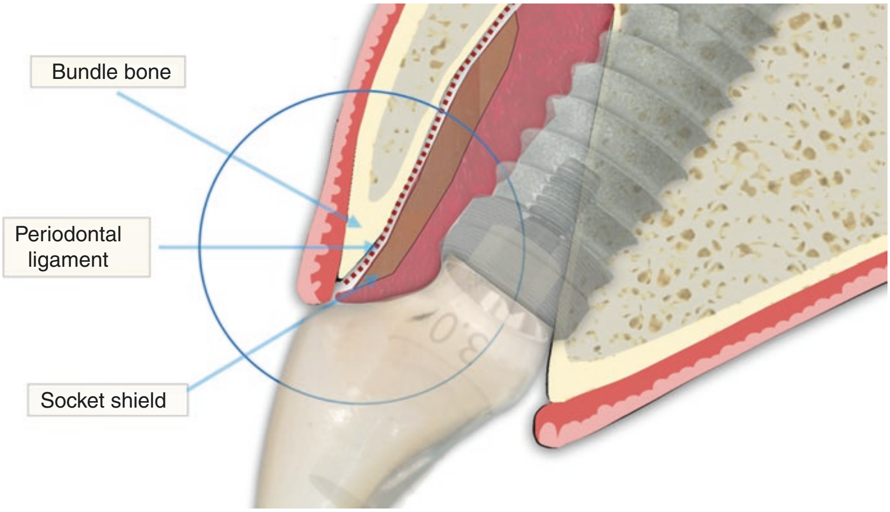

Fig. 1.5 Preservation of the bundle bone with a socket shield

open up newer possibilities in the management of the shield to harness the aesthetic potential of biologic entities around the implant with root fragments, intentionally prepared and left in the socket.

In 2014, Glocker et al. published a modified socket shield technique in three cases, in which they prepared the shield, but did not place an implant immediately in the alveolar socket. Implants were placed 6-months later. They concluded stating that the complete preservation of the buccal lamellar bone was observed intra-operatively in all three cases. This technique now became a viable alternative in cases where implant placement was not possible immediately after partial extraction.

In the same year, Siormpas et al. coined the term “root membrane technique” for cases in which there is an intentional retention of buccal root fragment to prevent buccal bone loss. The difference between the root membrane technique and the others was that, in this technique the implant deliberately touches the root fragment. They published clinical results and radiographic data of 46 patients followed up to 5 years post loading, with a success rate of 100% as far as implant integration was concerned and loss of one root to resorption that did not affect the implant.

In 2016, in a significant technique article, Gluckman et al. coined the term “Partial Extraction Therapy” that included various different terminologies under one name. Root submergence technique, socket shield technique, and pontic shield technique were collectively called partial extraction therapies. Figure 1.5 demonstrates the meaning of the various terms. Gluckman et al. then followed up with part 2 of the article in 2017 where they described the various procedures and technical aspects of partial extraction therapy.

At this point in literature it was well established that intentional retention of a part of the root on the labial side of the socket is indeed a good way to prevent buccal bone loss and thereby provide excellent tissue contours. It was also clear that the apex of the root should be totally removed and that no residual endodontic filling material must be retained behind on the shield.

In 2017, Gharpure and Bhatavadekar in a systematic review of the available literature on socket shield doubted the long-term outcomes of the procedure. It takes years, if not decades for a new technique to get refined in procedure and gain acceptance, and their review of the very limited literature at that point may have been premature. As clinicians we believe that the procedures under the umbrella of PET have very sound scientific basis as shown in animal and histological studies, as well as long-term case series. It is only a matter of time that the PET becomes a staple procedure in the surgical inventory for replacement of teeth with implants and we will start to see controlled clinical trials as well as histological studies happening in different part of the globe to substantiate the benefits of the same.

Sirompas et al., in 2018, published up to 10 years of retrospective data on clinical results of the root membrane technique for periodontal ligament-mediated immediate implant placements. A total of 182 patients received 250 immediate implants (230 maxilla, 20 mandible) after the root membrane concept and followed-up for a mean of 49.94 months. Overall, five implant failures were recorded. Ten-year cumulative implant survival rate of 97.3% (implant-based) and 96.5% (patient-based), respectively, was reported in this study. This by far is the most recent long-term data of the patients that have been treated with PET and is significant in its findings. Various other articles, mainly in form of case reports, have been published since 2018 till date.

As practitioners of this science and art, we the authors of this book feel that there is a very high amount of clinical evidence to support PET, and hence this book has been authored detailing every aspect of the PET procedure in a manner that is clinically relevant, technically reproducible, and evidence-based for the reader to incorporate it into their daily practice.

1.2 Partial Extraction Therapies

Root submergence technique (RST): A healthy root is left submerged below a fixed partial denture or an implant-supported fixed bridge (Fig. 1.6a).

Socket shield technique (SS): A part of the root is left attached to the labial bone, which aids in maintenance of the labial bone and soft tissue architecture. The labial root fragment is referred to as the 'shield' through all the chapters. An implant is placed in the palatal part of the socket in the same surgical appointment to support a restoration (Fig. 1.6b).

Pontic shield (PS): A part of the root fragment is left attached to the labial bone like the socket shield technique. Natural bone fill with or without a bone graft material is allowed to occur in the remainder of the socket. The purpose is to prevent the collapse of alveolar ridge below future pontic sites (Fig. 1.6c).

The timeline for the PET is described in a chart below (Fig. 1.6).

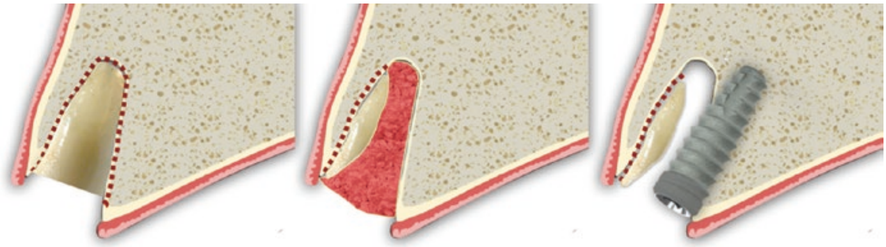

Fig. 1.6 Depiction of the various partial extraction therapies: (**a**) Root submergence. (**b**) Pontic shield. (**c**) Socket shield

1.3 Histological Evidence in PET Describing the Fate of the Root Fragment

Hürzeler et al. [3] in a proof-of-principle study done in animal models showed that, leaving behind the root and treating the dentine side of the root with enamel matrix protein derivative (Emdogain, Straumman, Basel, Switzerland) did not influence osseointegration. They found that there was no epithelial down growth, a 0.5 mm area coronal to the implant had connective tissue and a biological Junctional epithelium. Cementum had formed on the dentine surface, also visible were cemetoid, cementoblasts and there was absence of any osteoclasts. Even in those sites where the implants were placed close to the tooth there was presence of cementum and in gaps between the threads an amorphous mineralized tissue was observed.

Bäumer et al. [26] conducted a similar study in animals, but did not apply any EMD and found that new bone had formed in the gap between the implant and the dentine and the lingual side showed osseointegrated implant. The gaps between the threads showed bone fill, and in sites where the implant touched the tooth, no resorptive process was observed.

Zhang et al. [27], in a study done on dogs with four groups, extraction, extraction with socket graft with Bio-Oss collagen, SS only and SS with Bio-Oss collagen, found that in sites with SS in comparison to no SS shield sites, there was a good bone fill and better trabecular pattern.

Human histology for socket shield was found accidentally by three authors, Guarnieri et al. [28], Schwimer et al. [29] and Mitsias et al. [30].

Guarnieri et al. [28] found cellular cementum and cementocytes in an implant failure case where the implant was placed accidentally touching the fractured root and not the socket shield technique as we know it. They attributed the cementum formation to the inflammation and the extrusive action of the root fragment, possibly on account of it being luxated. This is not what we would expect around a socket shield, where only a stable fragment is left behind.