



## **Techniques for Preservation of Post-extraction Alveolar Bone Loss: A Literature Review**

**Shejali Jana<sup>1</sup>, Rucha Shah<sup>2\*</sup>, Raison Thomas<sup>2</sup>, A. B. Tarun Kumar<sup>2</sup>  
and D. S. Mehta<sup>2</sup>**

<sup>1</sup>*Private practitioner, Hyderabad, Telangana, India.*

<sup>2</sup>*Department of Periodontics, Bapuji Dental College & Hospital, Davangere, 577004,  
Karnataka, India.*

### **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/JAMMR/2021/v33i1030907

Editor(s):

(1) Dr. Rui Yu, The University of North Carolina at Chapel Hill, USA.

Reviewers:

(1) Benjelloun Laila, Ohammed V University, Morocco.

(2) Pedro Henrique Cossu Vallejo, Barretos Cancer Hospital, Brazil.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/67017>

**Received 12 February 2021**

**Accepted 17 April 2021**

**Published 30 April 2021**

**Mini-review Article**

### **ABSTRACT**

Sequelae to too the extraction includes progressive loss in the vertical and horizontal dimension of alveolar ridge. These lead to changes in the alveolar process in a 3 dimensional fashion causing hard and soft tissue deficiency which may affect the ability to restore the site. Preservation of the alveolar crest after tooth extraction is essential to maintain the vertical and horizontal dimensions of the alveolar ridge. Several techniques and materials have been introduced to minimize crestal bone loss. There is a broad consensus that ridge preservation procedures are efficient in limiting the post extraction dimensional loss of the ridge. However, the key to successful outcome is proper treatment planning according to the case and prognosis.

**Conclusion:** The aim of this literature review is to discuss the several bone preservation techniques and materials to minimize post-extraction loss of hard and soft tissues.

*Keywords: Alveolar ridge; bone loss; bone preservation; implant; post extraction socket.*

\*Corresponding author: E-mail: [srucha2k@yahoo.com](mailto:srucha2k@yahoo.com);

## ABBREVIATIONS

ARP	: Alveolar ridge preservation
PET	: Partial extraction therapies
IL	: Immediate loading
PL	: Provisional loading
CBL	: Crestal bone loss
IFL	: Immediate functionally
INFL	: Non-functionally loaded
PS	: Platform switching
MBL	: Marginal bone loss
PM	: Platform matched
NS	: Non submerged implant
IIP	: Immediate implant placement
GTR	: Guided tissue regeneration
$\beta$ -TCP	: Beta-tricalcium phosphate
NCHA	: Nanocrystalline hydroxyapatite
DFDBA	: Demineralised freeze dried bone allograft
FDDBA	: Freeze dried bone
KM	: Keratinized mucosa

## 1. INTRODUCTION

Alveolar process is a tooth-dependent structure and its development is associated with tooth eruption. The tooth is anchored to the jaws via the bundle bone where the periodontal ligament fibres invest [1]. Several dimensional changes occur after tooth extraction which include the loss in height and width of the alveolar bone as the extraction socket heals. This loss occurs as a result of the destruction of the bundle bone-periodontal ligament complex.

The size of the residual ridge is reduced most rapidly in the first 6 months, but bone resorption continues throughout life at a slower rate [1]. A recent systematic review showed mean loss of 2.6–4.5 mm in width and 0.4–3.9 mm in height of healed sockets.<sup>2</sup>Resorption of the alveolar ridge after 3 months of healing, results up to 56% loss of the residual ridge. Sufficient alveolar bone volume and favourable architecture of the alveolar ridge are essential to obtain optimal functional and aesthetic prosthetic reconstructions [1,2].

To counteract the early tissue changes after extraction, different therapies have been proposed. They aim in preserving the hard and soft tissue dimensions of the alveolar ridge that are lost after tooth extraction. A recent systematic review showed positive effect of alveolar ridge preservation (ARP) as compared to unassisted healing of the extraction sockets. These interventions aim at minimizing the post

extraction bone loss however they completely eliminate it. Hence, the objective of this review is to discuss the various bone preservation techniques and methods to prevent the bone loss after tooth extraction.

## 2. MATERIALS AND METHODS

For writing this article, Medline, Embase and Cochrane databases were searched under the following key terms: Alveolar ridge, Bone loss, Bone preservation, Implant, Post extraction socket. Manual searches were carried out in Journal of Periodontology, Journal of Periodontal Research, Journal of Clinical Periodontology, International Journal of Periodontics and Restorative Dentistry, Periodontology 2000, Journal of Oral Implantology and Journal of Maxillofacial Implantology for past 10 years. The initial screening was done based on titles and abstracts. Those found suitable were accessed for full text and then a literature review was drafted based on the available information. Articles not found suitable upon reading abstract or full text, those not in English and those whose full texts were not available were excluded from the review.

### 2.1 Literature Review

#### 2.1.1 Partial extraction therapies (PET)

PET represent a subgroup of pre-collapse interventions that collectively use the tooth itself to offset the loss of alveolar tissue. They mainly preserve the ridge form by retaining the tooth root and its attachment to bone, maintaining the buccal bone periodontal ligament complex and its vascular supply and hence prevent the bone resorption [3].

#### 2.1.2 Buccal socket Shield

Buccal socket shield entails the preservation of the buccal part of the tooth during extraction, which functions like a shield to preserve the buccal cortical plate from resorption and hence, the name 'socket-shield' [4]. Hurzeler et al. in 2010 were the first to histologically assess partial root retention in combination with immediate implant placement with the aim of avoiding tissue alterations after tooth extraction [4]. Tooth indicated for extraction is de-coronated approximately 1mm apical to the gingival margin. The coronal facial root segment is separated from the rest of the root and the remaining pieces of the root are removed atraumatically.

Consecutively, the osteotomy is performed through the lingual aspect of the root. The implant is then inserted and positioned in close proximity to or in contact with retained roots. Histologic evaluation showed no resorption of the root fragment and new cementum with fibrous capsule formation around the implant surface. Buccal tissue preservation with successful osseointegration of the implant was observed.<sup>4</sup>Bäumer et al. in 2015 found that socket-shield technique provides a promising treatment to preserve the post-extraction tissues in aesthetically challenging cases [5].

### 2.1.3 Proximal shield

Buccal root retention fragment does not compensate for papilla retraction following multiple adjacent tooth extraction therefore Joseph and Kitichai in 2013, reported a modified concept of socket shield technique by preservation of interproximal root fragment. In this technique the tooth is sectioned, with a cervical root extension approximately 2mm coronal to the distal marginal bone. Subsequently, the remaining distal root fragment is hollowed out using a high speed diamond bur. Implant osteotomy is then performed and bone graft materials are placed into the gaps between the implant and bony socket. Eventually, it results in normal peri-implant soft tissue formation, good papilla fill and intimate contact between the implant and root fragment [6].

### 2.1.4 Pontic shield

In their study Abadzhiev et al modified the socket-shield technique, by preserving the entire attachment apparatus for complete preservation of the alveolar ridge for pontic site development. This technique involves decoronation of the tooth at the bone crest or, preferably, 1 to 2 mm above the crest to preserve the supracrestal fibres with epithelial and connective tissue attachment [7]. Preservation of supracrestal fibres developed better pontic sites by papillae preservation [7]. Gluckman et al in 2016 developed the Pontic sites in each patient by preparing a pontic-shield with augmentation within the extraction sockets. The socket can be sealed with a soft tissue graft and was left to heal for minimum 3 months and gradually the pontic pressure is applied. Final restorations are placed once the extraction site is fully healed without clinical evidence of pontic shield exposure. This technique can be used for development of pontic sites and results in a good tissue bulk and positive contour [3,8].

### 2.1.5 Glockers technique

In socket shield technique the intentional preservation of the coronal buccal root portion ensure the physiological preservation of labial and buccal bone structures if the implant is placed in contact to the shield. However, this approach was associated with certain risks, such as the formation of a peri-implant periodontal membrane or the development of peri-implant infections, as well as resorption associated with the long-term complications [9]. These occur especially in the presence of pre-existing or developing periodontal or endodontic infections or inflammations of the retained tooth fragments [9]. Therefore this technique was modified where in the first stage a buccal shield is left followed by a healing period and implant placement in the second stage. In this technique, the root is separated vertically in a ratio between 1:3 and 2:3 and the smaller, buccal root fragment is retained and the larger lingual root fragment is removed in a manner that spares bone and soft tissue to the greatest possible extent.<sup>9</sup> The gingiva overlying the retained buccal root fragment is tunnelled by 2 mm to allow the insertion of the collagen cone into the tooth socket and placement of the membrane part of the collagen cone under the buccal mucosa [9]. Finally, the collagen cone is secured with a criss-cross suture. Thus, delayed implantation was considered as an alternative approach to preserve the buccal lamella over a prolonged period of time and to reduce the risks and complications [9]. The clinical outcomes of this technique essentially meets the expectations for an ideal method for preventing alveolar ridge resorption and minimal material requirements [9].

## 2.2 Immediate Implant

Traditionally, a load-free healing period of 3 months is recommended to allow the implant to osseointegrate, develop connective tissue interface between implant surface and bone and minimize the risk of implant failures [10]. The immediate loading (IL) protocol prescribes that the implant be loaded on the day of placement thus results in less disturbance of the peri-implant soft tissues (Fig 1). The provisional restorations are adjusted to a light centric contact and free from eccentric contacts with the opposing teeth [11]. In their meta-analysis Zhang and co-workers concluded that there were no significant difference between IL and non-immediate loading for implant restoration in implant success and stability [10]. IL resulted a

significantly less marginal bone loss change and mid-facial recession and stimulates the formation of mature, compact, lamellar bone in response to occlusal load, increases the bone-implant contact percentage, and decreases the risk of fibrous connective tissue at the interface [12]. The enhancement of bone density is a result of the dynamic relationship between loading and positive bone modelling response according to Frost's "Mechanostat theory" [13]. But, although IL stimulates the formation of mature lamellar bone, it might represent greater crestal bone loss (CBL) resulting in decreased alveolar bone density [12]. Hence, the concept of provisional loading (PL) was introduced (Fig 1). In their clinical study Ramachandran et al assessed the radiographic changes in alveolar bone density around immediate functionally (IFL) and non-functionally loaded (INFL) implants and found greater crestal bone loss, accompanied by a greater degree of crestal bone demineralization occurring with IFL implants [12]. The micro motion of immediately provisionalized implants differ depending on whether they are functionally or non-functionally loaded [12]. Another school of thought suggests that the occlusal forces should be applied in a progressive pattern to avoid excessive stress at the osseous periphery of the implant [13]. The rationale of applying forces in a gradual manner on the implant will allow a positive bone modelling response, increases peri-implant bone density and ability to withstand the occlusal load (Fig 1). This helps the bone to tolerate more efficiently the greater forces from mastication and helps to adapt to the new loading conditions by activation of the mechanism of modelling and remodelling [14-16]. In an experimental study Podaropoulos et al demonstrated that the application of progressive loading by controlled orthodontic force on osseointegrated implants provoked significant increase in the percentage of bone to implant contact [17]. Also the addition of threads or microthreads in the cervical region positively contribute to BIC and improve the preservation and stabilization of crestal bone by transmission of functional loads to the adjacent bony structures, i.e. the cortical bone supporting the formation of trabecular bony structures. (Fig 1) [18]. This design has been found to be more effective in reducing shear stress under off-axis loading, which dominates in the oral cavity [18].

A systematic review demonstrated that implants with a rough surface and a micro-threaded neck design improve the preservation and stabilization of crestal bone and result in significantly lower

CBL as compared to machined surface [18]. The abutments used with conventional implant types are generally flush with the implant shoulder in the contact zone resulting in the formation of a microgap between the implant and the abutment (Fig 1). This may cause bacterial contamination of the gap which adversely affects the stability of the peri-implant tissue [19]. In Platform switching (PS) the diameter of the abutment is less by 0.5-1 mm than the diameter of the implant, resulting in a horizontal offset at the top of the implant that separates the crestal bone and the connective tissue from the interface, therefore the microgap is placed away from the implant shoulder and closer to the axis [19]. This ensures that the distance of the microgap from the bone is increased and delivers a measure of protection for the marginal bone.<sup>19</sup>PS is indicated, especially in the aesthetic reconstruction zone, so that intact papillae and stable inter-implant bone can be obtained [19]. The original 2 stage concept is a "submerged" technique as described by Branemark and comprises two surgical stages: In the first, the implant is inserted in the bone and after a period of osseointegration, the (trans-mucosal) abutment is attached in a second stage [20]. But recent studies have explored a single-stage non-submerged surgical procedure in which, the implant and the trans-mucosal abutment are placed in a single procedure and this abutment remains exposed during the osseointegration period [21,22]. This technique has various advantages including that it requires a single surgery and minimizes the changes in coronal direction of the mucogingival junction [23,24]. In their clinical study Sanchez-Siles et al have demonstrated that NS implants compared to submerged implants with a PS and tapered abutment show less CBL. Hence, the success of non-submerged technique varies depending on the morphology of the healing abutment used [25].

### 2.2.1 Tissue augmentation

Tissues with a thicker biotype respond more favourably to wound healing and flap management as they have a higher volume of extracellular matrix, collagen and increased vascularity [26]. In their systematic review Kinaia & co-workers, compared the immediate implant placement (IIP) in thick and thin biotypes and they concluded that IIP in thick biotype and with immediate provisionalization resulted in less mid-facial recession and better papillary height than those in thin biotype [27].

### 2.2.2 Post extraction socket grafting

Post extraction alveolar preservation using placement of bone grafts (Fig 1) with or without simultaneous implant placement are the most common method used to prevent significant post extraction bone loss [28]. Ridge preservation can be performed with autologous bone, alloplastic bone substitute material or a combination of both. In this, atraumatic extraction is followed by placement of graft materials then covered by GTR membranes and closure with sutures. Various graft materials which have been used for preserving the socket. Autogenous bones the gold standard with its biocompatibility and potential to form bone by osteogenesis, osteoinduction, osteoconduction properties but its use is limited by amount of material available and donor site morbidity [29]. Other substitutes which have been assessed with considerable success include biomimetic composite bone substitute, Dentin, Beta-tricalcium phosphate ( $\beta$ -TCP), Nanocrystalline hydroxyapatite (NCHA), Demineralised freeze dried bone (DFDBA) and FDBA, Calcium sulphate hemihydrate, xenografts. No single technique appears to be superior and the choice of materials depend on the individual clinical situation and the restorative treatment plan.

In their systematic review Ortiz et al determined the effect of socket filling with a bone grafting material on the prevention of post-extraction alveolar ridge volume loss as compared with tooth extraction alone in non-molar teeth [30]. They found that alveolar ridge preservation is effective in limiting physiologic ridge reduction as compared with tooth extraction alone.<sup>30</sup> Also, flap elevation, the usage of a membrane, and the application of a graft materials are associated with superior outcomes, particularly on mid-buccal and mid-lingual height preservation [30]. Recently, a new polypropylene membrane has been used which used a flapless intentionally exposed method of placement and resulted in good tissue formation with low morbidity risk and no second surgery for removal [31]. Also, Barone et al in their study compared clinical and histological changes after ridge preservation procedures with those of spontaneous healing and demonstrated that vertical bone changes at the grafted sockets were significantly lower when compared to non-grafted sockets [32].

### 2.2.3 Soft tissue augmentation

Recent research suggests that an inadequate width and thickness of peri-implant keratinized

mucosa (KM) may lead to more plaque deposition, increased mucosal inflammation, higher risk of peri-implant alveolar bone loss, as well as increased soft tissue recessions [33]. In their systematic review Poskevicius et al reviewed the changes in mucosal soft tissue thickness and KM width after soft tissue grafting around dental implants [33]. The outcomes demonstrated that connective tissue grafts enhanced keratinized mucosa width and soft tissue thickness [33]. In another systematic review Rotundo et al evaluated the stability of height and volume of soft tissues and peri-implant bone levels around dental implants after soft tissue augmentation and observed a mean gain of  $1.65 \pm 0.01$  mm 1 year after implant recession coverage procedures. Hence, at least in cases of thin biotypes, and cases with an increased risk of post-operative recession, simultaneous soft tissue augmentation with connective tissue graft should be considered to prevent tissue collapse [34].

### 2.2.4 Hard tissue and dual zone grafting

This technique proposed grafting in two zones (Fig 1) following immediate implant placement to preserve the bone and soft tissue volume [35]. This serves as a scaffold as well as maintain the blood clot for initial healing [35]. Following atraumatic extraction with a flapless technique, osteotomy is initiated in a palatal direction, a standard diameter implant is immediately inserted with at least 3mm of space from the buccal wall and 3mm apical to the free gingival margin. The space between the bone and implant is the bone zone [35]. A small pouch is then created facial to the buccal bone in a full thickness manner in the middle area of the socket extending beyond the mucogingival line in a mesio-distal direction with a periosteal elevator. This is the tissue zone [35]. The bone graft is placed in both the bone zone and the tissue zone up to the soft tissue level [35]. Rosa & co-workers stated that the 3mm space from the implant surface to the outer buccal wall, provides better placement and compaction of grafting material [35]. It has been demonstrated histologically that placement of graft in the space created modified the process of hard tissue healing, and improved the level of marginal bone-to-implant contact preventing soft tissue recession [35]. This technique also minimized the ridge collapse to -0.1 mm and increased peri-implant soft tissue thickness by +0.5-1.0 mm. However, it can be performed only when the buccal plate is intact after extraction [35].

### 2.2.5 Buccal bone preservation

In this technique, a pouch is created surgically between the buccal plate and buccal soft tissues and the grafting material is placed (Fig 1) in this pouch [36]. This approach is aimed to improve generation and maintain or improve labial/buccal contours without interfering with the natural healing capability of the alveolus after extraction [36]. The rationale is that slowly resorbing particles of graft prevent recession and enhance the appearance and contours of soft tissue appearance of the edentulous ridge [36]. This technique may only be applied when the buccal plate is present. In a study Slagter et al concluded that buccal bone thickness at dental implants in the aesthetic zone appears to be stable for immediate and delayed placed implants after placement of the definitive crown, independent of the size of buccal bone defect [37].

### 2.2.6 Role of atraumatic extraction

Conventional tooth extraction with forceps or elevators is often associated with higher tissue trauma and increased post extraction tooth loss. It may also lead to other complications such as fracture of bony wall, poor healing due to compromised blood supply and soft tissue damage. Recently, focus is shifting to atraumatic tooth extraction techniques which preserves the ridge dimension. Using instruments such as periostomes, periodontal ligament knives, special forceps and twisting elevators to sever the fibers, the force is applied more apically than buccolingually and dislodging the tooth atraumatically. Several studies have demonstrated the eventual bone loss is significantly higher in atraumatically extracted teeth as compared to conventional and it also results in superior patient outcomes such as pain, swelling and aesthetics [38].

## 3. DISCUSSION

Several factors affect optimal long-term treatment outcomes of implant therapy [39]. These include various host factors such as the bone quality and quantity, soft-tissue biotype, condition of the adjacent teeth, distances to the adjacent teeth, biologic width, patient compliance, oral hygiene, smoking, nutrition, and regular follow ups. Other factors include platform-switching, implant and abutment design, augmentation procedures, type of procedures, materials and membranes used, surgical procedures, including soft tissue management, the insertion depth and time of implant insertion,

loading and restoration, prosthetic procedures used and frequency of secondary component replacement, provisional and definitive restorations. The tooth extraction trauma, with its associated loss of periodontal ligament and vascularization results in unpredictable socket remodelling.

A systematic review by Ortiz et al demonstrated that alveolar ridge preservation (ARP) is effective in limiting physiologic ridge reduction as compared with tooth extraction alone [30]. Heggeler & co-workers also assessed the benefit of socket preservation therapies in patients with a tooth extraction in the anterior or premolar region as compared with no additional treatment with respect to bone level and they concluded that socket preservation may aid in reducing the bone dimensional changes following tooth extraction [2]. The graft materials provide osteogenic, osteoinductive, and/or osteoconductive properties, which maintains the space and promotes bone growth, however they do not prevent bone resorption completely. A flowchart summarizing the different treatment protocols and their indications for preservation of post-extraction alveolar bone loss is given in Fig. 2.

In a systematic review, Tan et al demonstrated that the horizontal dimensional reduction was more than vertical reduction on buccal, mesial and distal sites [40]. Horizontal bone loss was more substantial comprising of 29–63% than vertical bone loss of 11–22% after 6 months of tooth extraction [40]. This occurs rapidly in the first 3–6 months followed by a more gradual reduction in dimensions thereafter [38]. Overall, the buccal aspect of the socket generally displayed more resorption than the lingual/palatal aspect [40].

In a study, Albrektsson & co-workers observed that the amount of MBL is an important criterion to evaluate the implant therapy outcome and to predict the prognosis of the implant rehabilitation [41]. CBL around dental implants of 1.5mm during the first year followed by 0.2mm in the subsequent years has been generally considered acceptable [41]. Studies have suggested that CBL may be the result of biomechanical stress due to incorrect occlusal design [42]. The rationale behind this physiological bone resorption is the re-establishment of the peri-implant biological width [25]. PET preserve the supracrestal fibres and support the peri-implant tissues. These are cost effective, minimally

invasive and help maintain aesthetics [5]. More recently, complications of infection and bone loss have been demonstrated when implants were placed in contact with unnoticed retained root pieces at the time of extraction [5]. Thus, there is a possibility that the socket shield may pose a remote risk of infection to implants placed in

close proximity [5]. Also, loss of the socket-shield either by resorption or due to extraction following infection, would ultimately lead to loss of the buccal bone it preserves [5]. This is a promising technique that needs proper case selection and a skilled operator [5].

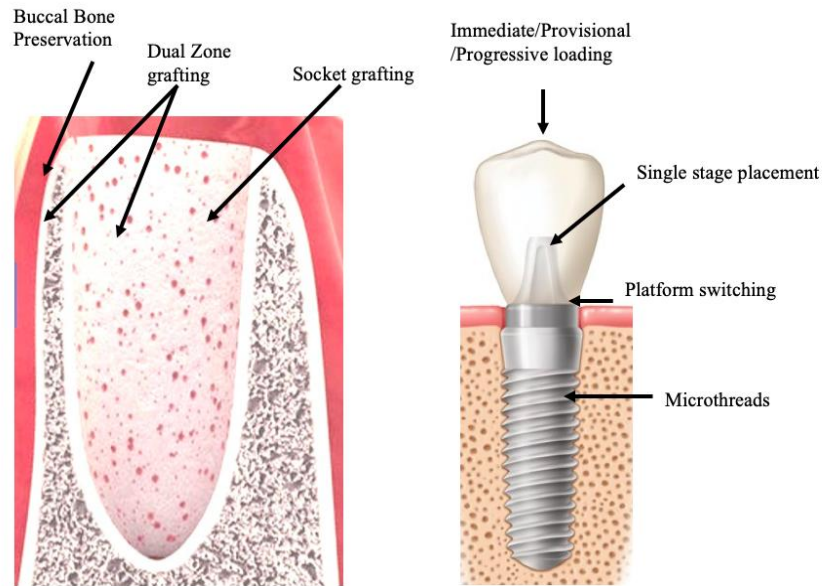


Fig. 1. Various techniques that can be utilized for preservation of post-extraction alveolar bone loss

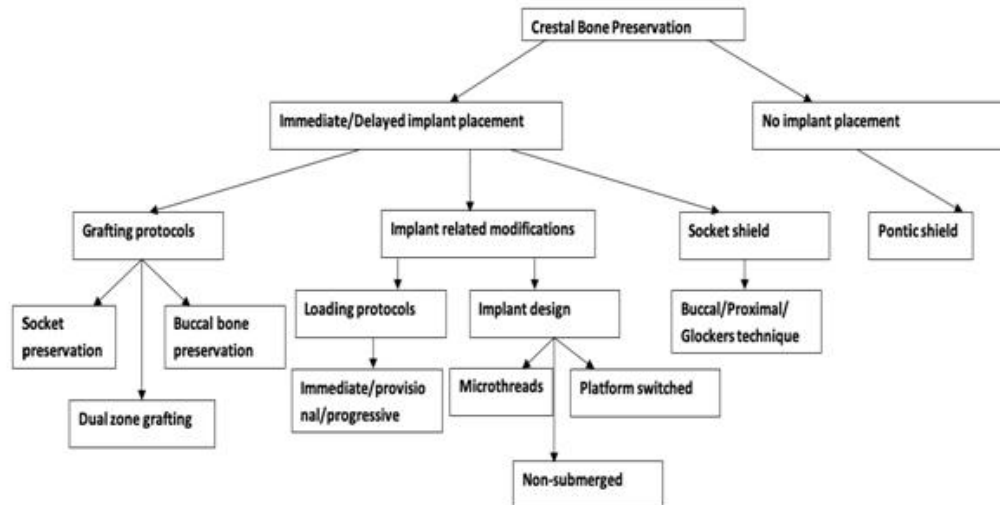


Fig. 2. Flowchart illustrating the different treatment protocols and their indications for preservation of post-extraction alveolar bone loss

Several implant features can also be modified to achieve minimal CBL. Microthreads in implant affect the distribution of stress forces around the implant [19]. They lead to lower dissipation of stresses to crestal bone hence help in preserving [19]. Platform switching causes reduction of the loading stress at the bone-implant interface and is more resistant to bacteria as well as yeast colonization [19]. APS implant platform provides both vertical and horizontal mismatch and offers a larger surface useful for the osseointegration and for the biological seal [19]. This has shown to reduce the CBL significantly over non PS cases [19].

The use of immediate or early implant procedures was proposed with the aim of limiting the ensuing bone resorption. Alternate loading protocols such as delayed and progressive have demonstrated better papillary fill and reduced CBL [43]. However, it has been reported that occlusal overload on implants could increase the MBL [43]. Therefore, loading of implants with low primary stability should be avoided to reduce the risk for failures. Results based on loading protocol showed a 95.1% success rate in the IL group, a 97.1% success rate in the early loading group, and a 96.7% success rate in the delayed loading group [44]. Also there may be chance of recession of the buccal/facial gingiva of at least 1 mm following immediate implant placement, with the recession to possibly worsen in thin gingival biotypes and in maxilla due to presence of low bone density [17].

#### 4. CONCLUSION

Several clinical techniques and a variety of biomaterials have been introduced over the years in an effort to overcome bone remodelling and resorption after tooth extraction. Currently, there is no accepted gold standard for preservation of crestal bone loss. Through this review we have attempted to summarize the commonly used techniques for the same. The obtained results, at present could not indicate which is the type of surgical procedure or biomaterial most suitable for this clinical indication, although the use of barrier membranes, a flap surgical procedure and full flap closure demonstrated better results. There is limited data, however, on the possible influence of these the rapieson the long-term outcomes of implant therapy. The eventual decision for the technique to be used should be based on the present clinical scenario, the pros, cons and indications of the technique to be performed, the

magnitude of alveolar bone changes as well as the skill of operator. Nonetheless, all existing literature points that the preservation of the alveolar crest after tooth extraction is essential to maintain the vertical and horizontal dimensions of the alveolar ridge.

#### CONSENT

It is not applicable.

#### ETHICAL APPROVAL

It is not applicable.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

#### REFERENCES

1. Van der Weijden F, Dell'Acqua F, Slot DE. Alveolar bone dimensional changes of post-extraction sockets in humans: A systematic review. *J Clin Periodontol.* 2009;36:1048-58.
2. Ten Heggeler JM, Slot DE, Van der Weijden GA. Effect of socket preservation therapies following tooth extraction in non-molar regions in humans: a systematic review. *Clin Oral Implants Res.* 2011; 22:779-88.
3. Gluckman H, Salama M, Du Toit J. Partial Extraction therapies (PET) part 1: maintaining alveolar ridge contour at pontic and immediate implant sites. *Int J Periodontics Restorative Dent.* 2016; 36:681-7.
4. Hürzeler MB, Zuhr O, Schupbach P, Rebele SF, Emmanouilidis N, Fickl S. The socket-shield technique: a proof-of-principle report. *J Clin Periodontol.* 2010; 37:855-62.
5. Bäumer D, Zuhr O, Rebele S, Schneider D, Schupbach P, Hürzeler M. The socket-shield technique: first histological, clinical, and volume trical observations after separation of the buccal tooth segment – a pilot study. *Clin Implant Dent Relat Res.* 2015;17:71-82.
6. Kan JY, Rungcharassaeng K. Proximal socket shield for inter implant papilla preservation in the aesthetic zone. *Int J Periodontics Restorative Dent.* 2013;33:24-31.



7. Abadzhiev M, Nenkov P, Velcheva P. Conventional immediate implant placement and immediate placement with socket-shield technique – Which is better. *Int J Clin Med Res.* 2014;1:176-180.
8. Gluckman H, Du Toit J, Salama M. The pontic-shield: Partial extraction therapy for ridge preservation and pontic site development. *Int J Periodontics Restorative Dent.* 2016;36:417-23.
9. Markus Glocker, Thomas Attin, Patrick R. Schmidlin. Ridge preservation with modified “socket-shield” technique: A methodological CASE series. *Dent. J.* 2014;2:11-21
10. Zhang S, Wang S, Song Y. Immediate loading for implant restoration compared with early or conventional loading: A meta-analysis. *J Craniomaxillofac Surg.* 2017;45:793-803.
11. Gjølvdal B, Kisch J, Chrcanovic BR, Albrektsson T, Wennerberg A. Clinical and radiographic outcome following immediate loading and delayed loading of single-tooth implants: Randomized clinical trial. *Clin Implant Dent Relat Res.* 2017;19:549-558.
12. Ramachandran A, Singh K, Rao J, Mishra N, Jurel SK, Agrawal KK. Changes in alveolar bone density around immediate functionally and non functional loaded implants. *J Prosthet Dent.* 2016;115:712-7.
13. Misch CE, Hoar J, Beck G, Hazen R, Misch CM. A bone quality based implant system: A preliminary report of stage I and stage II. *Implant Dent.* 1998;7:35-44.
14. Roberts WE, Turley DK, Brezniak N, Fielder PJ. Implants: Bone physiology and metabolism. *Calif Dent Assoc J.* 1987;15:54-61.
15. Rice JC, Cowin SC, Bowman JA. On the dependence of the elasticity and strength of cancellous bone on apparent density. *J Biomech.* 1988;21:155-168.
16. Misch CE. Density of bone: effect on treatment plans, surgical approach, healing and progressive bone loading. *Int J Oral Implantol.* 1990;6:23-31.
17. Podaropoulos L, Veis AA, Trisi P, Papadimitriou S, Alexandridis C, Kalyvas D. Bone reactions around dental implants subjected to progressive static load: an experimental study in dogs. *Clin Oral Implants Res.* 2016;27:910-7.
18. Al-Thobity AM, Kutkut A, Almas K. Microthreaded implants and crestal bone loss: A systematic review. *J Oral Implantol.* 2017;43:157-166.
19. Girolamo M, Calcaterra R, Di Gianfilippo R, Arcuri C, Baggi L. Bone level changes around platform switching and platform matching implants: a systematic review with meta-analysis. *Oral Implantol (Rome).* 2016;9:1-10.
20. Branemark PI. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *J Plast Reconstr Surg.* 1977;16:1-132.
21. Ferrigno N, Laureti M, Fanali S, Grippaudo G. A long-term follow-up study of non-submerged ITI implants in the treatment of totally edentulous jaws: part I: ten-year life table analysis of a prospective multicenter study with 1286 implants. *Clin. Oral Implants. Res.* 2002;13:260-273.
22. Romeo E, Lops D, Margutti E, Ghisolfi M, Chiapasco M, Vogel G. Long-term survival and success of oral implants in the treatment of full and partial arches: A 7-year prospective study with the ITI dental implants system. *Int J Oral Maxillofac Implants.* 2004;19:247-59.
23. Buser D, Mericske-Stern R, Bernard JP, Behneke A, Behneke N, Hirt HP et al. Long-term evaluation of nonsubmerged ITI implants. Part 1: 8-year life table analysis of a prospective multi-center study with 2359 implants. *Clin Oral Impl Res.* 1997;8:161-72.
24. Mellati E, Chen S, Davies H, Fitzgerald W, Darby I. Healing of Bio-Oss grafted marginal gaps at implants placed into fresh extraction sockets of incisor teeth in dogs: a study on the effect of submerged vs. non-submerged healing. *Clin Oral Implants Res.* 2015;26:553-62.
25. Sanchez-Siles M, Munoz-Camara D, Salazar-Sanchez N, Camacho-Alonso F, Calvo-Guirado JL. Crestal bone loss around submerged and non-submerged implants during the osseointegration phase with different healing abutment designs: a randomized prospective clinical study. *Clin Oral Implants Res.* 2016;1-5
26. Chappuis V, Araújo MG, Buser D. Clinical relevance of dimensional bone and soft tissue alterations post-extraction in aesthetic sites. *Periodontol* 2000. 2017;73:73-83.
27. Kinaia BM, Ambrosio F, Lamble M, Hope K, Shah M, Neely AL. Soft tissue changes around immediately placed implants: A systematic review and meta-analyses with at least 12 months of follow-up after

- functional loading. *J Periodontol.* 2017;88:876-86.
28. Horváth A, Mardas N, Mezzomo LA, Needleman IG, Donos N. Alveolar ridge preservation. A systematic review. *Clin Oral Investig.* 2013;17:341-63.
29. Herford AS, Nguyen K. Complex bone augmentation in alveolar ridge defects. *Oral Maxillofac Surg Clin North Am.* 2015;27:227-44.
30. Avila-Ortiz G, Elangovan S, Kramer KW, Blanchette D, Dawson DV. Effect of alveolar ridge preservation after tooth extraction: a systematic review and meta-analysis. *J Dent Res.* 2014;93:950-8.
31. Esch T, Barbirato D, Fogacci M, Magro O, Barros M. Tissue healing with polypropylene membrane used as conventional guided bone regeneration and exposed to the oral cavity for post-dental extraction: a case report. *Revista Científica do CRO-RJ.* 2018;3:52-56
32. Barone A, Toti P, Quaranta A, Alfonsi F, Cucchi A, Negri B, et al. Clinical and histological changes after ridge preservation with two xenografts: preliminary results from a multicentre randomized controlled clinical trial. *J Clin Periodontol.* 2017;44:204-14.
33. Poskevicius L, Sidlauskas A, Galindo-Moreno P, Juodzbaly G. Dimensional soft tissue changes following soft tissue grafting in conjunction with implant placement or around present dental implants: a systematic review. *Clin Oral Implants Res.* 2017;28:1-8.
34. Rotundo R, Pagliaro U, Bendinelli E, Esposito M, Buti J. Long-term outcomes of soft tissue augmentation around dental implants on soft and hard tissue stability: A systematic review. *Clin Oral Implants Res.* 2015;11:123-38.
35. Ghabban WA. A combination of buccal plate preservation and dual zone therapeutic technique in immediate implants: A one-year follow-up. *J Oral Implantol.* 2016;42:484-9.
36. Caiazzo A, Brugnami F, Mehra P. Buccal plate preservation with immediate post-extraction implant placement and provisionalization: preliminary results of a new technique. *Int J Oral Maxillofac Surg.* 2013;42:666-70.
37. Slagter KW, Raghoobar GM, Bakker NA, Vissink A, Meijer HJ. Buccal bone thickness at dental implants in the aesthetic zone: A 1-year follow-up cone beam computed tomography study. *J Craniomaxillofac Surg.* 2017;45:13-19.
38. Misch CE, Perez HM. Atraumatic extractions: A biomechanical rationale. *Dent Today.* 2008;27:98, 100-1.
39. Bhat PR, Thakur SL, Kulkarni SS. The influence of soft tissue biotype on the marginal bone changes around dental implants: A 1-year prospective clinico-radiological study. *J Indian Soc Periodontol.* 2015;19:640-4.
40. Tan WL, Wong TL, Wong MC, Lang NP. A systematic review of post-extraction alveolar hard and soft tissue dimensional changes in humans. *Clin Oral Implants Res.* 2012;5:1-21.
41. Albrektsson TO, Johansson CB, Sennerby L. Biological aspects of implant dentistry: osseointegration. *Periodontol* 2000. 1994;4:58-73.
42. Rungsiyakull C, Rungsiyakull P, Li Q, Li W, Swain M. Effects of occlusal inclination and loading on mandibular bone remodelling: a finite element study. *Int J Oral Maxillofac Implants.* 2011;26:527-37.
43. Ghozeizi R, Alikhasi M, Siadat MR, Siadat H, Sorouri M. A radiographic comparison of progressive and conventional loading on crestal bone loss and density in single dental implants: a randomized controlled trial study. *J Dent (Tehran).* 2013;10:155-63.
44. Kohen J, Matalon S, Block J, Ormianer Z. Effect of implant insertion and loading protocol on long-term stability and crestal bone loss: A comparative study. *J Prosthet Dent.* 2016;115:697-702.

© 2021 Jana et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

*Peer-review history:*

*The peer review history for this paper can be accessed here:*  
<http://www.sdiarticle4.com/review-history/67017>