REVIEW ARTICLE

Socket Preservation Vis-a-Vis Natural Healing: Literature Review

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ABSTRACT

Aim: To discuss the extraction socket preservation techniques and their relevance in present day clinical practice.

Summary: Tooth extraction leads to typical bone deficiency of ridge width and height of alveolar crest and reduces the possibility of placing dental implants. Socket preservation is the procedure undertaken at the time of or following an extraction that is designed to minimize external resorption of the socket and maximize bone formation within the socket. Many procedures have been suggested including minimally traumatic tooth extraction, soft and hard tissue grafting, concomitant use of barrier membranes and immediate implant placement.

Keywords: Extraction socket, Bone graft, Socket preservation

INTRODUCTION

Alveolar bone seems to play a key role in providing support to the teeth, which are anchored to the bone by periodontal fibers. The alveolar bone that supports the teeth is particularly fragile and labile and it is in a constant state of change, since replacement of old bone by new bone is a normal physiologic process. It is a tooth-dependent structure that develops in conjunction with eruption, and the topography is determined by the form of the teeth and their axis of eruption.[1] Healing of extraction socket usually occurs with substantial reduction of the original height and width of the alveolar bone, which in some cases may aesthetically compromise an implant supporting prosthesis.[2] Several studies have examined the dynamics of tissue alterations after tooth extraction.[3-8]

To reduce or eliminate potential problems after the tooth extraction, socket preservation can be commonly employed to improve the aesthetics and function of the final restoration. Socket preservation of extraction site has been proposed as a means of controlling alveolar ridge degradation, preserving crestal buccal plate integrity, improving vital bone fill, and reducing the need for future ridge augmentation.[9-13] This ultimately provides stability of the hard and soft tissues at the level of the marginal gingiva post extraction by preventing soft tissue collapse. Present paper is intended to discuss the extraction socket preservation in comparison to natural healing, and its relevance in present day clinical practice.

METHODS

The PubMed database was primarily searched upto January 2011 and MESH words used were "Extraction socket" and "socket preservation". Abstracts and full text of the pertinent articles were scrutinized and included. Further a search was conducted for printed literature from the cross-references. Relevant literature in common textbooks, bibliographies of papers and review articles of suitable peer reviewed journals were also analyzed for additional information.

LITERATURE REVIEW

Natural Healing

Complete healing of the extraction socket is generally accomplished in about 100 days after the removal of a tooth (Fig. 1). Tissue modelling following multiple as well as single tooth extractions apparently resulted in more pronounced bone loss in the buccal than in the lingual/palatal portions of the ridge. In an examination of healed sockets in dried skulls showed that from the occlusal aspect, the crest of the residual ridge shifts lingually, and from the lateral aspect, the ridge formed a concavity or flattened to form a wall running straight between the alveolar crests of the adjacent remaining teeth.[14] The effect of a single tooth extraction of premolar or molar

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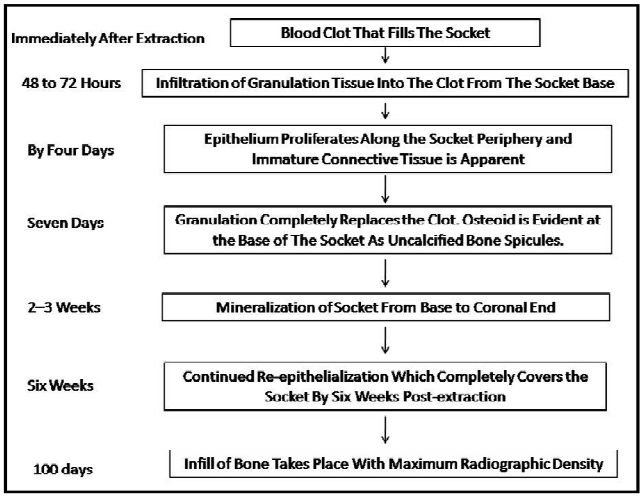

Figure 1: Healing of Extraction Socket.

teeth on bone healing and soft tissue changes using clinical and radiographic measurements as well as digital subtraction radiography revealed that it would be advantageous if this loss of bone dimension could be prevented.[15]

It has been shown in experimental studies that the coronal part of the buccal bone wall of the extraction socket is often comprised solely of bundle bone. The bundle bone loses its function after tooth extraction and is resorbed due to osteoclastic activity, resulting in a substantial vertical and horizontal reduction of the buccal crest. As the buccal wall of the tooth socket is partially or completely resorbed more frequently, the consequent collapse of the buccal soft tissue leads to marked bucco-oral alterations. It can be speculated that similar procedures occur in humans after tooth extraction, leading to these pronounced tissue alterations.[1]

Tooth extraction leads to typical bone deficiency of ridge width and height of alveolar crest and reduces the possibility of placing dental implants. It is well documented that following *multiple tooth* extractions and the subsequent restoration with removable dentures, the size of the alveolar ridge will become markedly reduced, not only in the horizontal but also in the vertical dimension; in addition, the arch will be shortened.[16-20]

Socket Preservation

Socket augmentation is the procedure undertaken at the time of or following an extraction that is designed to minimize external resorption of the socket and maximize bone formation within the socket. Many procedures have been suggested including minimally traumatic tooth extraction, soft and hard tissue grafting, concomitant use of barrier membranes and immediate implant placement. A recent consensus report suggested that minimal dimensional change occurs within six to eight weeks of an extraction[21] and that may provide the basis for immediate socket preservation techniques.

Atraumatic tooth extraction: One way to reduce trauma to adjacent bone during tooth extraction is via use of periotome. Periotomes are exraction instruments that employ the mechanisms of wedging and severing to facilitate tooth removal.[22] Periotomes are composed of very thin metallic blades that are gently wedged down the periodontal ligament (PDL) space in a repetitive circumferential fashion.[23] In addition to minimal invasive luxation, the periotome blade severs Sharpey's fibers that secure the tooth within the socket.

Elastics were first used for bloodless extraction of teeth in hemophilic patients by Dalitsch[24] in 1934 and by Birch and Snider[25] in 1939. According to them, the technique was suggested first by Wentworth in 1870 after an accidental loosening of a tooth by a rubber band. Orthodontists using elastics are fully aware of the iatrogenic extraction potential when they are used improperly.[26-28] The mechanism of the slow extraction method is based on the principle of the inclined plane. The granulation tissue that is formed around the root pushes it out of the socket while at the same time maintaining unexposed bone.

Hard Tissue Graft (Table 1): Autografts are thought of as the ''gold standard''. Xenografts bone grafts consist of deproteinized cancellous skeletal bone tissue that is harvested from one species and transferred to the recipient site of another species.[29] Being from different species, it may cause even more pronounced immunological problems.[30] The major drawback of the material is its slow resorption, with graft particles present 44 months after placement. Allograft which is bone from an individual of the same species is considered more effective and more widely available compared to xenografts.[31] Alloplasts are synthetic materials that have been developed to replace human bone. The alloplasts are osteoconductive materials[32] and biocompatible. Tricalcium phosphate is similar to hydroxyapatite (HA) with a different stoichiometric profile. Tricalcium phosphate has been formulated into pastes, particles or blocks, which have demonstrated an ability to be biocompatible and biodegradable.[33-35]

One of the first materials investigated as a substitute for bone graft was Plaster of Paris, the alpha hemihydrate form of calcium sulfate. The primary advantage of calcium sulfate bone substitutes includes ease of handling, resorption by osteoclasts and attachment and deposition of osteoid by osteoblasts.[36] With their outstanding biocompatibility and variable degradability,[37] polylactones such as polylactide (PLA), polyglycolide (PGA) and polycaprolactone as well as their copolymers are becoming one of the most commonly used synthetic biodegradable polymers in medical field. The PLA has many physical advantages, such as good mechanical properties, transparency, thermal stability, oil resistance and gas impermeability, as well as easy processing.[38] Combinations

of PLA and PGA have been successfully used in the form of bioresorbable sutures for many years, [39] and as bioresorbable fixation materials eg. clips, plates and screws.[40] Giant cell reactions were presented as a problem with earlier combinations of this material.[41] Polylactide and polyglycolide acids are considered to be suitable matrices for bone and soft connective tissue.[42]

Coverage of the Socket by Soft Tissue (Table 1): The literature is divided over whether soft tissue coverage of the socket at the time of extraction is necessary for optimum healing of the socket and aesthetics. Soft tissue coverage procedures may be considered to retain, stabilize and protect grafting materials. It is a critical step when using non-resorbable membranes. Many techniques have been suggested like displacing neighbouring tissue to cover the socket, such as coronal

Table 1: Studies related with socket preservation techniques

Year	Author	Materials and techniques used for socket preservation
1991	Block and Kent[59]	Hydroxyapatite-coated implants were placed in fresh extraction sockets in 34 patients.
1993	Gelb[60]	3-year retrospective evaluation of 50 consecutive implants placed in fresh extraction sockets.
1994	Becker *et al.*[17]	Compared demineralized freeze dried bone against autogenous bone.
1996	Nemcovsky and Serfaty.[61]	Hydroxyapatite was used. They achieved primary closure by rotating split thickness flaps and were followed for 24 months.
1997	Lekovic and Kenney[4]	Polytetrafluoroethylene (ePTFE) membranes.
1998	Lekovic *et al.*[62]	Bioabsorbable membrane was placed over the extraction socket..
1999	Misch and Dietsh-Misch[20]	Using free gingival or subepithelial connective tissue grafts.[27]
2000	Camargo and Lekovic.[63]	Sockets were filled with bioactive glass and covered with a layer of calcium sulphate.
2000	Artzi and Tal[64]	Common porous bovine bone graft (Bio-Oss)
2000	Fowler and Breault[65]	DFDBA and an acellular dermal graft
2000	Nemcovsky and Artzi[66]	Evaluated a surgical approach based on rotated full thickness palatal flap (RPF) to obtain and maintain primary soft tissue coverage and crestal bone gain after placement of 26 implants into extraction sockets.
2000	Nemcovsky *et al.*[67]	Evaluated the use of rotated palatal flap (RPF) procedure to achieve primary soft tissue closure over fresh maxillary extraction sockets prior to delayed immediate implantation combined with regenerative procedure carried out 5-7 weeks post extraction in 21 patients.
2001	Paolantonio and Dolci[68]	Early implantation may preserve the alveolar anatomy and that the placement of a fixture in a fresh extraction socket may help to maintain the bony crest structure.
2003	Serino and Biancu[69]	Sponge of Polylactide-Polyglycolide
2003	Sclar[45]	Anorganic bovine bone graft (Bio-Oss) protected by a resorbable collagen sponge
2003	Iasella *et al.*[70]	Tetracycline hydrated freeze-dried bone allograft and a resorbable membrane (Bio-Mend).
2003	Zubillaga *et al.* [71]	Demineralised freeze-dried bone allograft (DFDBA) and bioabsorbable membranes was done. Tacked membranes demonstrated less loss of augmented bone width than non-tacked sites.
2004	Guarnieri *et al.*[72]	Calcium sulphate
2004	Botticelli and Berglundh[73]	Implants had been placed immediately following single tooth extraction, the buccal as well as the lingual bone walls during healing underwent marked re-modelling and resorption.
2005	Joseph *et al.*[74]	The randomized, multi-center, doubleblinded human clinical trial using combination of rhBMP-2 and a commonly utilized collagen sponge had a striking effect on de novo osseous formation for the placement of dental implants.
2008	Neiva *et al.*[75]	Putty P15 was applied to extraction sockets, suggesting that it may be useful for alveolar ridge preservation prior to dental implant placement.
2008	Geurs *et al.*[76]	PGA/TMC barrier membrane, used in conjunction with an allograft, provides lateral alveolar ridge augmentation comparable to that achieved with other materials.
2009	Fotek *et al.*[77]	Grafted with a mineralized bone allograft that was covered with an ADM or PTFE membrane and found that both membranes are suitable for alveolar ridge augmentation.
2010	Baeyens et al [56]	Suggested the use of platelet concentrates: platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) in bone reconstruction prior to dental implant surgery

advancement of a buccal flap, rotating grafts from tissue adjacent to cover the defect, or using free gingival or subepithelial connective tissue grafts.[20] The surgical site may be left for six to eight weeks to allow healing and regeneration of mucosa over the socket. The added volume of soft tissue at this stage may facilitate optimum closure over the socket when ridge preservation procedures are undertaken. In a similar manner, procedures allowing spontaneous soft tissue proliferation could be considered prior to extraction to increase soft tissue coverage, such as removing the crown and burying the remaining root.[43]

Mobilization of tissue can be a difficult procedure, but splitting the periosteum at the base of a flap is fairly straightforward and as a result may be the technique of choice. However, coronally advanced flaps need to be undermined and advanced a relatively great distance to completely cover an extraction socket. This may cause complications such as altering the mucogingival line and creating a shallow vestibule, either of which may require subsequent surgery to correct.[44]

Guided Tissue Regeneration (GTR)/ Guided Bone Regeneration (GBR): It is possible to cover the socket to prevent ingress of soft tissue, thereby promoting maximal bony healing. Generally, there are two types of membrane used, resorbable and non-resorbable. Collagen materials have been utilized in dentistry because of their proven biocompatability and capability of promoting wound healing. Although these membranes are absorbable, collagen membranes have been demonstrated to prevent epithelial downgrowth along the root surfaces during the early phase of wound healing.

Combinations and Advanced Reconstructive Procedures: The placement of wound dressing over the grafted extraction socket is critical in preventing bone graft loss. Numerous bioabsorbable and non-resorbable materials, along with various grafting techniques, have been used; they showed varying degrees of success with regard to graft retention. Some of the popular techniques include the mineralized bone allograft–plug socket augmentation technique, the Bio-Col technique, and socket seal surgery using a free gingival graft and its modification using the connective tissue. The Bio-Col technique involves the placement of an anorganic bovine bone graft (Bio-Oss) protected by a resorbable collagen sponge (Collaplug) and then allowing spontaneous epithelialization of the socket under a denture tooth or bridge pontic.[45]

Bone Morphogenetic Proteins (BMPs): Bone Morphogenetic Protein has been shown to have osteoinductive properties.[46] BMPs belong to a group of proteins called TGF-á superfamily[47] that regulate many different biological processes including cell growth, differentiation and embryonic pattern formation.[48] While recombinant BMP molecules are extremely potent, they are difficult to use clinically in powder or solution, hence, many different carrier vehicles have been used to deliver BMP including other noncollagenous proteins, DBM, collagen, HA, PLA and or PGA combinations, calcium carbonate, calcium sulphates and fibrin glue.[35,49] More recently biodegradable gels, collagen sponges impregnated with BMP and silica glass have been used as carriers.[50]

Growth Factor: Platelets are known to contain a number of different growth factors which are released into the tissue after injury. These include Transforming Growth Factor (TGF-á), Platelet Derived Growth Factor (PDGF), Insulin Growth Factor (IGF) and Fibroblast Growth Factor (FGF) which act as differential factors on regenerating periodontal tissues.[51] Platelet Rich Plasma (PRP) is one potential source of concentrated platelets that could be used in bone regeneration.[52] This gel can then be used in conjunction with bone regeneration materials such as HA or DBM as a source of autogenic growth factors.[53]

Bioactive Polypeptides: Bioactive polypeptide may act as osteoinducers or osteoenhancers.[54] Enamel matrix protein (EMD – Emdogain) consists of a group of proteins isolated from the tooth germs pigs.[55] Baeyens *et al*.[56] suggested the use of autologous platelet concentrates [Platelet-Rich Plasma (PRP) and Platelet-Rich Fibrin (PRF)] for rapid wound healing and bone regeneration that may be considered as a new therapeutic adjuvants for bone reconstruction prior or concomitant to implant procedures, and for dental extraction socket preservation.

Stem cell: Human mesenchymal stem cells (MSCs), obtained from the adult bone marrow, are multipotent cells capable of differentiating into various mesenchymal tissues.[57] The most particular interest for oral rehabilitation and orthopaedics is the ability of these cells to differentiate into osteoblasts or bone-forming cells. From a small volume of bone marrow, MSCs can be isolated and culture expanded into a large number due to their proliferative capacity maintaining their functionality after cryopreservation. MSCs can be combined with porous, biphasic calcium phosphate ceramics (hydroxyapatite/ *á*-tricalcium phosphate – HA/TCP).[55-58]

Immediate Implant Placement as Socket Preservers (Table 1): The third International Team of Implantologists (ITI) consensus report showed that immediate implants are a very successful form of therapy. Immediate implantation is accepted treatment modality in implant dentistry for the rehabilitation of the completely or partially edentulous mandible or maxilla. Most of the available studies concerning immediate implantation describe their use in the anterior and premolar region. However, few others reported that implants do not ''preserve'' the ridge in which they are placed.[21]

DISCUSSION AND CONCLUDING REMARKS

In order to preseve the gifts of nature, man is presently trying to be positively constructive and conservative, and thus from forest to fuel, all forms of energy are being judiciously utilized. The survival rate of human life has itself increased and hence oro-maxillofacial structures, including natural teeth, are being preserved in an attempt toward this goal.[78] Alveolar ridge resorption following tooth removal is a physiologically undesirable and possibly avoidable phenomenon. Significant knowledge exists of the healing process of extraction wounds, including contour changes caused by bone resorption and the cascade of histologic events in both animals and humans. The resorption of the alveolar process following tooth extraction in both jaws is significantly greater on the buccal aspect than the lingual or palatal, so that the reduction in width of the maxillary alveolar ridge is greater than the loss of height.[1,8,79]

Studies on extraction socket preservation have shown that atraumatic tooth extraction is a prerequisite in socket preservation. Various socket preservation techniques have been employed and it can be prudent to decipher from numerous studies, that socket preservation is a validation for management of extraction site and future prosthetic rehabilitation. Studies have claimed gain in alveolar crestal width and height after socket preservation procedures, and also lesser resorption not only in horizontal but also in vertical dimension. Most grafting materials have been used as filling materials in fresh extraction sockets and to avoid collapse of the membrane. Increased mineralization was seen in socket preservation sites especially in the apical area of the socket.[69] This proved that bone formation initiated from the old bone of the lateral and apical sockets walls toward the centre of the wound.[8]

The use of grafting material in any stoichometric form is recommended as it leads to lesser resorption of alveolar crest. Additional advantage of grafting the socket with sponge form showed biopsies having structured bone with no signs of ingrowth of tissues other than bone. This may be related to the presence of sponge functioning as a barrier to the ingrowth of surrounding tissue that could have impeded the process of bone regeneration. Apart from this, graft materials available nowadays, eg PLA-PGA sponge and calcium phosphate, have faster degradation rate, and are not identified in histological analysis.[80,69,72] The successful introduction of osseointegrated implants into dental treatment planning requires an astute evaluation of the site that will receive the implant. Significant considerations begin with the preservation of the alveolar process that houses the roots to be extracted, and decisions as to whether it is advantageous to preserve these areas to protect the morphology of the proposed implant site. The shift in the paradigm towards the implantology has thus placed new emphasis on management of the extraction wound than considered previously.

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