SOCKET PRESERVATION USING BOVINE BONE WITH AND WITHOUT DENTAL IMPLANT PLACEMENT

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SOCKET PRESERVATION USING BOVINE BONE WITH AND WITHOUT DENTAL IMPLANT PLACEMENT

by

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Ali Abdul Qader Al Qabbani

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LIST OF ABBREVIATIONS

2D	Two-dimensional
3D	Three-Dimensional
β - TCP	Beta-tricalcium phosphate
BBM	Bovine bone mineral
BMP-2	Bone morphogenetic protein -2
Bio-oss	Inorganic bovine bone - Geistlich Biomaterials
BC	Blood clot
BM	Bone marrow
CBCT	Cone beam computed tomography
CaP	Calcium phosphate
CT	Computed tomography
CEJ	Cemento-enamel junction
DBBM	Deproteinized bovine bone mineral
DFDBA	Demineralized freeze-dried bone allograft
DFDBX	Demineralized freeze-dried bone xenograft
FDBA	Mineralized freeze-dried bone allograft
G.T	Granulation tissue
HA	Hydroxyapatite
II	Immediate implant
KV	Kilovolts

LM	Lamellar bone
OMF	Oral maxillofacial surgery
Mm	Millimeters
Mg-HA	Magnesium–enriched hydroxyapatite
PM	Provisional matrix
RFA	Resonance frequency analysis
TMJ	Temporo-mandibular joint
UDHS	University Dental Hospital Sharjah
USM	Universiti Sains Malaysia
USA	The United States of America
TGF-β	Transforming growth factor beta
SEM	Scanning electron microscope
SP	Socket preservation
μSv	Microsievert
μm	Micrometer
WB	Woven bone
KHZ	Kilohertz

APPENDICES

PEMELIHARAAN SOKET MENGGUNAKAN GRAF TULANG BOVIN DENGAN IMPLAN DAN TANPA IMPLAN

ABSTRAK

Objektif: Penyelidikan intervensi ini bertujuan untuk menganalisa penyembuhan, menilai dimensi tulang dan kadar penyerapan soket cabutan gigi menggunakan tulang bovin dengan implan dan tanpa implan di kalangan soket cabutan gigi yang dirawat dan tidak dirawat. Tujuan utama tatacara ini adalah untuk melindungi atau mengurangkan jumlah kehilangan rabung tulang alveolar selepas cabutan gigi dengan prosedur pembesaran rabung tulang alveolar.Kajian ini juga menilai kadar osseointegrasi antara permukaan implan segera dan tulang alveolar.

Kaedah: Kajian intervensi ini di lakukan keatas 30 orang pesakit di Universiti Dental Hospital Sharjah, Emiriyah Arab Bersatu. Pesakit yang diambil kira adalah berumur di antara 18hingga 40 tahun, yang memerlukan rawatan cabutan gigi biasa untuk satu atau kedua-dua gigi premolar dan sihat tubuh badan. Projek ini telah diluluskan oleh jawatankuasa etika Universiti Sains Malaysia dan Universiti Sharjah, Emiriyah Arab Bersatu dan persetujuan termaklum pesakit telah diperolehi. Pesakit di bahagikan secara rawak kepada tiga kumpulan. Kumpulan pertama menjalani rawatan cabutan gigi dan luka cabutan di biarkan pulih secara semulajadi. Bagi kumpulan kedua soket cabutan gigi diisi dengan granul xenograf tulang bovin kering beku bersaiz 1 mm. Membran perikardium mudah serap digunakan untuk menutupi kecacatansupaya granul tulang kekal di dalam soket dan luka soket disutur dengan

Vicryl. Bagi kumpulan ketiga, cabutan gigi tanpa trauma dilakukan dan implan serta merta diletakkan ke dalam soket dan ruang lilitan juga diisi dengan granul tulang dan dilitupi dengan membran perikardium. Tulang bovin dan membran perikardium mudah resap di perolehi dari Bank Tisu Universiti Sains Malaysia. Kumpulan ini juga juga di uji dengan ujian RFA mengunakan mesin Osstell untuk mengukur dan menilai tahap kestabilan sekunder pada jangka waktu sembilan bulan selepas pembedahan.

Rawatan susulan selepas pembedahan dijalankan untuk menilai tahap penyembuhan di peringkat 1 minggu, 3 dan 9 bulan. Semua kumpulan menjalani ujian CBCT untuk penilaian radiologi sejurus selepas pembedahan dalam peringkat 3 dan 9 bulan mengunakan Sirona CBCT dilakukan pada 3 keratan iaitu koronal, sagittal, dan axial yang melibatkan pengukuran selari soket tulang alveolar. RFA direkod untuk kumpulaan ketiga pada bulan ke sembilan.

Hasil: Tiada perbezaan klinikal dalam penyembuhan di antara semua kumpulan. Terdapat perbezaan ketara penyerapan tulang alveolar dari segiketinggian dan kelebaran di dalam kumpulan pertama, 1.84 mm (CI 95%, 0.57 – 3.10) dan 1.91 mm (CI 95% 0.64 – 3.14) pada jangka masa hari mula hingga bulan ke sembilan. Tidak terdapat perbezaan ketara diantara kumpulan kedua dan ketiga.

Perbandingan di antara kumpulan pertama dan ketiga menunjukkan perbezaan ketara ke atas penyerapan kelebaran tulang alveolar pada bulan ketiga, 2.56 mm (CI95% 4.22 – 0.90) $p \leq 0.001$, dan pada bulan yang kesembilan 3.22 mm (CI 95% 4.70 –

1.62). Perbezaan ketara penyerapan kelebaran tulang di antara kumpulan kedua dan kumpulan ketiga 1.9mm (CI 95% 3.43 – 0.34) ($p \leq 0.001$). Didapati tiada perbezaan ketara didalam penyerapan menegak tulang alveolar diantara ketiga-tiga kumpulan. Kumpulan ketiga menunjukkan penghasilan nilai RFA yang tinggi di bulan kesembilan.

Kesimpulan: Penggunaan implan serta-merta didalam luka cabutan gigi berserta dengan penggunaan geraf tulang bovin di ruang lilitan di antara dinding tulang soket dan permukaan implan dengan granul tulang bovin dapat menghindar masalah penyerapan tulang alveolar selepas cabutan gigi jika dibandingkan dengan luka cabutan yang dibiarkan tanpa sebarang rawatan. Tulang baru yang terhasil di sekeliling implant adalah bermutu tinggi yang akan menjurus kepada osseointegrasi yangkuatdi antara permukaan implan dan permukaan dalaman bahagian labial tulang alveolar. Kami dapati bahawa tulang bovin (FDBBX) yang di hasilkan di USM mengalami proses penyerapan sepenuhnya dan diganti dengan tulang baru diantara permukaan implan dan tulang alveolar bukal didalam kumpulan ketiga di bulan yang ke sembilan.

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ABSTRACT

Objectives: The aim of this interventional study was to assess healing, evaluate bone dimension and the resorption rate of the extraction alveolar socket using bovine bone with and without dental implant placementamong the treated and non-treated tooth extraction sockets. The goal of these approaches was to preserve or minimize the ridge volume loss following tooth extraction by ridge augmentation procedures. The study also evaluates the degree of osseointegration between the immediate implant surface and the alveolar bone.

Methods: This interventional study was carried out on 30 patients at the University Dental Hospital Sharjah, Sharjah, United Arab Emirates. The patients aged between 18 and 40 years, who needed non-complicated tooth extraction of only one or both mandibular premolar teeth, and being fit and healthy, were included. The project has been approved by UOS and USM ethical committees, and informed consent was obtained. Patients were randomly divided into three groups. In group I, simple extraction was done and the empty extraction socket left untreated and allowed to heal in a conventional way. In group II, extraction sockets were filled with freeze-dried bovine bone xenograft (FDBBX) granules of size 1mm. A resorbable pericardium membrane was placed to cover the defect to secure the bone granules within the socket and wound closure done with Vicryl suture. In group III, atraumatic

extraction was done and an immediate implant placed into the sockets, and the circumferential gap was also filled with FDBBX bone granules and covered with pericardium membrane. This group was additionally subjected to resonance frequency analysis (RFA) by employing Osstell machine for measuring and evaluating the degree of secondary stability at nine months.

The patients were followed-up clinically for healing assessment at 1 week, 3 months and 9 months post-operatively (PO). All groups were subjected to cone beam computed tomography scan (CBCT) for radiological evaluation immediately after the surgical procedure at three months and nine months intervals using Sirona Dental Systems, GALILEOS SIDEXIS. CBCT was performed in three different views; coronal, sagittal and axial which involve linear measurements of the socket alveolar bone. RFA was recorded for group III at nine months.

Results: There were no clinical differences in healing between the groups. Significant difference of bone resorption was evident in alveolar ridge width and height reduction within control group I, 1.84 mm (Confidence Interval (CI) 95%, 0.57 to 3.10) and 1.91 mm (CI 95%, 0.64 to 3.14) respectively at the intervals of day 0 to nine months. No significant alveolar bone resorption was observed within group II and III. Comparison between group I and III showed a highly significant difference of bone resorption in ridge width at three months 2.56 mm (CI 95%, 4.22 to 0.90) $p \leq 0.001$, and at nine months interval 3.2 mm (CI95%, 4.70 to 1.62). Between group II and III, there was a significant difference of bone resorption in ridge width of 1.9 mm (CI95%, 3.43 to 0.34) ($p \leq 0.001$). There was no significant

vertical ridge resorption observed among the groups. High RFA values were observed in group III at nine months postoperatively.

Conclusion: The insertion of immediate implants in fresh extraction sockets together with grafting the circumferential gap between the bony socket wall and the implant surface with bovine bone granules were able to preserve a greater amount of alveolar ridge volume when compared to leaving an extraction socket to heal alone in the conventional way or socket preservation with bovine bone graft only. The peri-implant new bone formation developed is of superior quality which led to successful osseointegration between the implant surface and inner surface of the buccal plate. We observed clinically that the USM manufactured FDBBX has completely resorbed and replaced by new bone in the area between the implant and the inner surface of the buccal plate in group III at nine months post-operative.

CHAPTER ONE

INTRODUCTION

The alveolar bone is a highly dynamic bone supporting the tooth and its surrounding structures. It is physiologically resorbs when the tooth is lost. Every day, thousands of teeth are extracted from the oral cavity leaving a residual defect following the loss of the alveolar bone that led to difficulty in prosthetic rehabilitation. Dental implantology has revolutionized the prosthetic replacement of artificial teeth by providing a high-quality artificial tooth replacement that mimics natural tooth structure and function. Unfortunately, the unavoidable circumstances of losing the volume of alveolar bone following tooth extraction pose a challenge to a successful dental implantology rehabilitation process.

1.1 Background

Several studies have concerns regarding the morphological alterations occurred in the alveolar process as a consequence of tooth extraction, both in the vertical and horizontal defects of the residual bone. Following tooth extraction, the alveolar ridge will undergo structural, dimensional and functional changes. The resorption rate is a factor of time since extraction. The contour loss occurs at a more significant rate during the early post-extraction period, especially within the first six months, changes in the buccal alveolar bone plate results in a collapse of the alveolar process, especially in the maxillary bone (Tan *et al.*,2012).

Tooth extraction results in an alveolar bone loss due to resorption of the edentulous ridge. An average of 40% to 60% of original height and width is expected to be lost after tooth extraction, with the greatest loss happening within the first two years. This can negatively influence bone volume that is needed for future planned dental implant placement (Cardaropoli *et al.*, 2003).

The consequences of exodontia include alveolar bone resorption and ultimately atrophy to the basal bone of the edentulous ridges. Ridge resorption proceeds quickly after tooth extraction and significantly reduces the possibility of placing implants without the need for grafting procedures.

Bone grafting in dentistry nowadays is still the key to success to bony defects reconstruction when restoring the anatomy and function of the bone. Although bone tissue exhibits a large regeneration potential and may restore its original structure and function completely, bony defects may often fail to regenerate to provide adequate functionality. In order to facilitate and promote healing, bone graft materials have been placed into the bony defect and providing variable results depending on the type of graft materials and host bone characteristics.

Furthermore, through understanding the biomechanical and biological properties of bone, we understand what type of bone grafts or bone substitute could be best used to reconstruct large bony defects. The processed graft material cannot exert its biological activity in isolation; it depends on the surrounding environment of cells to respond to its signals and in most cases for the blood supply. It is very important to

study and compare the results of each graft since the principles and indications of each type are different (Stevenson, 1998).

A recent systematic review evaluated the dimensional changes in the hard and soft tissues of the alveolar process following tooth extraction. They concluded that after 3 months of healing, the horizontal resorption of the alveolar bone was 2.2 mm at the crest. After 6 months of healing, the vertical resorption of the alveolar bone was 11–22%, whereas the horizontal resorption of the alveolar bone was 29–63% (Tan *et al.*,2012).

At twelve months of healing, the vertical resorption of the alveolar ridge was 0.8 mm. The horizontal resorption of the soft and hard tissue together was 3.8 mm and 1 mm after 3 and 12 months of healing, respectively (Figure 1.1). These numbers give us an indication that the amount of resorption is highly significant (Farina & Trombelli, 2011).

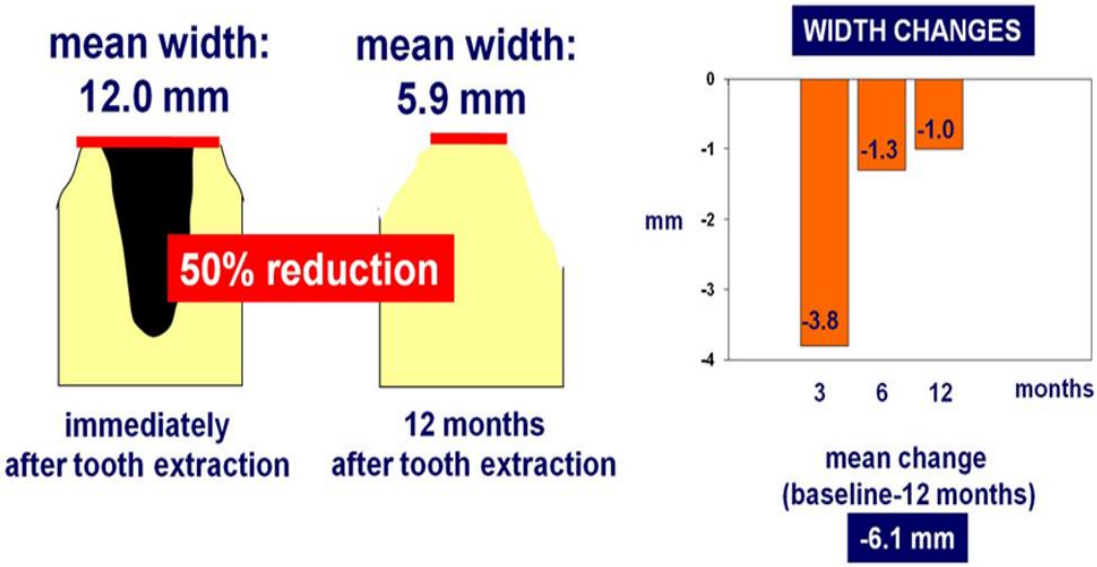

Figure 1.1 Mean changes of the bucco-lingual ridge width as assessed on cast models over a period of 12 months following tooth extraction (Farina & Trombelli, 2011).

1.2 Statement of the problem

In every tooth extraction, the amount of alveolar bone volume loss is unpredictable. We need to maintain the socket dimension following tooth extraction by inserting bone graft material or dental implant placement or both.

1.3 Objectives

1.3.1 General Objectives

To evaluate the efficacy of socket preservation using bovine bone graft with and without immediate implant placement.

1.3.2 Specific Objectives

1. To assess the healing of the alveolar sockets using bovine bone with and without immediate implant placement.
2. To evaluate the bone dimension of the alveolar sockets using bovine bone with and without immediate implant placement.
3. To evaluate the resorption rate of the alveolar sockets using bovine bone with and without immediate implant placement.
4. To assess the degree of osseointegration between the immediate implant surface and alveolar bone.

1.4 Null Hypothesis

Placement of bovine bone graft with immediate implants into extraction sockets will not preserve the alveolar bone socket dimensions.

CHAPTER TWO

LITERATURE REVIEW

2.1 Wound healing

Healing of alveolar bone following tooth extraction takes place in 4 stages which include: hemostatic phase, inflammatory phase, proliferative phase and remodeling phase. The extraction of a tooth initiates a series of reparative processes involving both hard tissue (i.e. alveolar bone) and soft tissues (periodontal ligament, gingiva). The biological events occurring during the healing of an extraction socket and their chronological sequence have been studied in different animal models, which helped to characterize the tissues involved in the healing process of extraction sockets. According to the existing literature, classification of these tissues can be the following: blood clot; consisting of erythrocytes and leukocytes embedded in a fibrin network, granulation tissue; rich in newly formed vascular structures, inflammatory cells as well as erythrocytes, provisional matrix; presenting densely packed mesenchymal cells, collagen fibers and vessels but no or only scattered inflammatory cells, woven bone; consisting of finger like projections of immature bone embedded in a primary spongiosa, lamellar bone and marrow; i.e. lamellae of mature, mineralized bone harboring secondary osteons surrounded by marrow spaces rich in vessels, adipocytes, mesenchymal cells and inflammatory cells (Farina & Trombelli, 2011).

Changes in extraction sockets were amply demonstrated with histological observations in dog studies (Cardaropoli *et al.*, 2003). At day one after extraction, the socket was occupied by a coagulum; this coagulum comprised mainly of erythrocytes and platelets that were trapped in a fibrous matrix. Immediately adjacent to the hard tissue wall was the "bundle bone", and principal fibers from periodontal ligament (Sharpey's fibers) could be found invested in the bundle bone. These were also in direct contact with the coagulum. At day three, the coagulum had been replaced by a richly vascularized granulation tissue. At day seven, newly formed blood vessels were evident in the primary matrix. Various types of leukocytes and collagen fibers had taken the place of the residual periodontal ligament as well as the granulation tissue. At day 14, most of the bundle bone had disappeared, and instead, adjacent to the newly formed blood vessels, "woven bone" started extending from the old bone of the socket walls toward the center of the socket. At day 30, woven bone underwent resorption, suggesting that the remodeling process had begun. At two months, hard tissue bridges separated the marginal mucosa from the socket, and bone marrow replaced woven bone at the center of the previous socket. At three months, woven bone was replaced by lamellar bone. At four and six months, most of the woven bone had been replaced by lamellar bone.

The role of bundle bone in the dimensional change in the alveolar ridge was investigated in several dog studies (Cardaropoli *et al.,* 2003). At 1 week after extraction, the buccal bony crest was 0.3 mm coronal to the lingual bony crest, but at 2 weeks after extraction, the buccal crest became 0.3 mm apical to the lingual crest.

This relative distance decreased to 0.9 and 1.9 mm below the crest at four and eight weeks after extraction, respectively. It was also observed that the crestal region of the buccal bone wall was made up exclusively of bundle bone, whereas the corresponding region of the lingual bone was made of a combination of bundle bone and lamellar bone. Obviously, the function of bundle bone is to anchor the tooth to the alveolar bone through the invested periodontal ligament. As the tooth is extracted, the bundle bone will lose its function, and subsequently, will resorb. This may explain the more pronounced resorption of the buccal than the lingual bony crest. These vertical as well as horizontal dimensional changes of the alveolar ridge, may complicate the subsequent restorative procedures when dental implants are chosen.

The previous sockets of the roots have been completely filled with new alveolar bone which has subsequently undergone maturation and remodeling. However, the original level of the bony housing of the extracted roots has not yet been reached. The further coronal growth of alveolar bone occurs, but never to its original height again, and the morphology of the bony trabecular pattern completely matures to match the appearance of the surrounding bone. Understanding and appreciating the repair phenomena associated with both extraction socket healing and the osseous integration of dental implants suggest that the condition with the repair of an extraction socket may be favorable for integration of dental implant at the same time.

2.2 Classification of extraction sites

Immediate implant placement is only indicated when the major part of the labial cortical wall is still intact (Figure 2.1 and Table 2.1). The implant survival rate may be severely impaired if there is insufficient labial bony support and implants are placed without additional measures (Funato *et al.*, 2007).

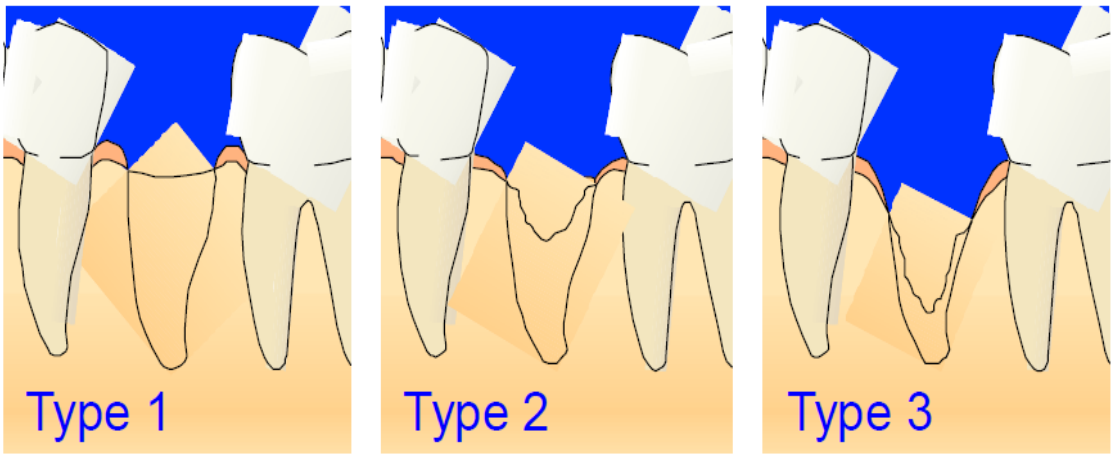

Figure 2.1 Classification of the extraction sites according to the availability of the labial bony wall (Funato *et al.*, 2007)

Table 2.1 Classification for extraction sockets with immediate implant placement (Funato *et al*., 2007)

Class	Buccal Bone	Implant Placement Technique	Expected Result	Indication for Immediate Case
Class 1	Intact with thick gingival biotype	Immediate - flapless	Optimal	Yes
Class 2	Intact with thin gingival biotype	Immediate with CTG or staged CTG (conventional tissue grafting)	Good	Yes
Class 3	Deficient but possible to place the implant	Simultaneous implant with GBR and/or followed	Acceptable	Limited
Class 4	Deficient but implant may deviate from the alveolar	Delayed	Unacceptable	No

2.3 Factors influencing the healing of extraction socket

There are many reasons why dentist preferred tooth extraction, which include but not limited to insufficient crown to root ratios, remaining root length, periodontal attachment levels, status of furcations, periodontal health of teeth adjacent to the proposed implant site, unrestorable caries, root fractures with large endodontic posts, root resorption and questionable teeth in need of endodontic retreatment. Teeth requiring root amputations, hemisections or advanced periodontal procedures may have a questionable prognosis and patients should be given reasonable options before these procedures are implemented (William Becker & Goldstein, 2008).

After the tooth is extracted, the dentist should observe the healing of the extraction socket and the factors which may affect the healing of the extraction socket. A provisional connective tissue seems to form consistently within the first week of healing; the interval during which mineralized bone is laid down is much less predictable. This variability in the wound healing process is also paralleled by a large variation in the dimensional alteration of the healing socket. The reason for this variation is presently not understood but may be linked to a different factor which may be at least in part related to patient and site characteristics as well as surgical variables (Farina & Trombelli, 2011).

2.3.1 Smoking

According to the results of a 6-month prospective study, smoking may negatively affect the extent of the dimensional reduction of alveolar ridge occurring after tooth extraction. Based on the study done by Farina & Trombelli in 2011, they observed an additional reduction of 0.5 mm in bone height may be expected following tooth extraction in smokers compared to non-smokers. However, the mechanisms by which tobacco smoke interferes with post-extraction wound healing are presently not understood. In another immunohistochemical study conducted by Ozkan A and his team in (2014) about the effect of cigarette smoking on the healing of extraction sockets, they concluded that the healing process of the tooth extraction socket is negatively affected by cigarette smoke which impairs type I collagen fibers, granulation tissue and new bone trabecular formation (Ozkan *et al*., 2014).

2.3.2 Flapless tooth extraction

It is well established that the elevation of a full thickness flap (muco-periosteal flap) may cause loss of attachment and resorption of bone. The reported crestal bone loss after a full thickness flap elevation is approximately 0.6 mm. In a dog model of post-extraction healing, an additional volumetric shrinkage of 0.5–0.7 mm was observed two months after flap elevation and tooth extraction compared to flapless tooth extraction, mostly due to an increased resorption of the buccal wall of the socket. At 4 months, the observed differences were substantially unaltered. Recently, however, a study by Barone and his group in (2014) reported that both flap and flapless groups

showed similar post extraction dimensional alterations when compared with the corresponding tooth site, thus suggesting that the difference between a flap and flapless procedures may disappear after 6 months healing period (Barone *et al.*, 2014). In terms of dental implants, both techniques with or without flap elevation achieved good success rates, though the flapless procedure did so with less discomfort for the patients. Flapless implant placement procedures may be indicated in properly selected and planned cases (Cannizzaro *et al.*, 2011).

2.3.3 Single versus multiple extractions

In a study conducted on a large sample of dried skulls, a more pronounced concavity and depression were frequently observed in multiple adjacent edentulous sites compared to the single tooth edentulous site (Crismani *et al*., 2006).

2.3.4 Location of the edentulous site

When an intra-subject comparison of the extent of vertical ridge resorption was performed between dentate and contralateral edentulous maxillary posterior sextants on computerized tomography scans, second premolar, and second molar edentulous sites showed a more apical position of the alveolar crest compared to dentate sites. This observation seems to suggest that vertical ridge resorption may occur with a different pattern depending on the location of the extraction site. Consistently with these findings, data obtained from a large cohort of subjects reported that the alveolar crest resorption (calculated as the distance from the alveolar crest to an ideal line passing through the CEJ (cemento-enamel junction) of the missing teeth was

different among posterior maxillary edentulous sites. A statistically significant effect of edentulous site on alveolar resorption was observed, with second molar sites showing a higher resorption compared to first and second premolar sites (Farina & Trombelli, 2011). When the changes in the height of the alveolar crest occurring after tooth extraction were measured on soft tissues, however, height loss was not significantly different in premolar compared to molar post-extraction sites (Schropp *et al.*, 2003).

2.4 Healing of extraction sockets following immediate implant placement

History of immediate implant placement is related to immediate tooth transplant when humans have attempted to replace missing teeth with root form implants for thousands of years and some found to have transplanted human teeth. The concept of immediate implant placement was introduced first by Schulte and his group in (1978) from Germany on animal dog studies. Since then, many follow-up studies examining different variables have been completed, supporting immediate implant placement. Placement of implants at the time of tooth extraction is called "immediate implant placement". Then Lazzara and his group in (1989**)** gave a major contribution to the immediate implant placement in human studies which consist of the insertion of an implant into a fresh extraction socket. Immediate implant placement has been proposed primarily to reduce the number of surgical interventions needed to perform an implant-supported rehabilitation and shorten the treatment time. In addition, it was previously advocated that immediate implant placement could potentially reduce the extent of alveolar bone resorption after tooth loss. Immediate implant placement

have been repeatedly shown to have success and survival rates similar to implants placed into a healed socket (Gökçen-Röhlig *et al.*, 2010).

Placement of an implant into a fresh extraction socket usually results in the direct bone-to-implant contact in the apical, narrowest part of the alveolus, providing the apical osseous anchorage to ensure a high degree of primary mechanical stability while resulting in a circumferential gap in the most coronal portion (Figure2.2).

Several authors have reported placement of implants into extraction sockets and augmentation of these sites with a barrier (Becker *et al.*, 2005; Lazzara, 1989). The rationale for this procedure is to decrease the restorative time, to promote bone-to-implant contact and to preserve alveolar bone height. A prospective clinical multicenter study by Becker and his group in (2005) evaluated implants which were placed into extraction sockets and augmented by guided tissue regeneration membranes (GTR). Out of 49 implants, three were lost prior to loading. These implants had premature membrane exposure. At 3 years, 93.9% of the implants remained functional.

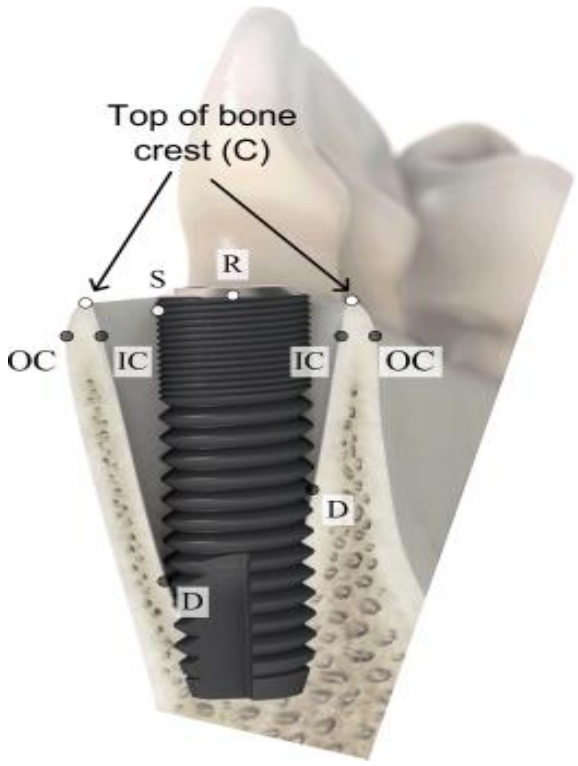

Figure 2.2 Diagram illustrating immediate implant placement into extraction socket. Landmarks used to describe the dimension of the ridge as well as the size of the gap between the implant and the socket walls. The surface of the implant(S), the center of the implant (R), top of the bone crest (C), outer border of the bone crest (OC) at 1mm apical of C, Inner border of the bone crest (IC) at1mm apical of C, base of the defect (D) (Ferrus *et al.*, 2010)

The bone formation adjacent to the implants was related to the barrier membrane retention. Sites where the barrier remained unexposed, had greater amounts of bone fill in the sockets (average of 4.8 mm) when compared with sites where the membranes became prematurely exposed and were removed (average of 4.0)(Becker & Becker, 1997).

Rosenquist and Grenthe in (1996) conducted a study whereby Nobel Biocare implants immediately placed into extraction sockets and was evaluated up to five and a half years (average were 2.5 years) following the treatment. The survival rate was 94% and the success rate was 92% (Rosenquist & Grenthe, 1996).

Even though implants immediately placed into extraction sockets have been reported to have predictable healing in a submerged environment, the non-submerged placement of an implant into an extraction socket would offer a number of advantages, but recent studies showed that an amount of resorption which is very similar with the resorption at human alveolar ridges after extraction reported recently in a systematic review (Tan *et al*., 2012). This, in turn, means that implants immediately placed into extraction sockets, do not prevent the resorption of the alveolar bony ridge. This study was conducted in both animals and humans without using a bone graft substitute.

A series of methodological reports and clinical studies evaluated the healing of immediate trans-mucosal implants which show positive results and significant osseointegration. Placement of implants into fresh extraction sites allows the surgeon to idealize the position of implants since implants are placed into a location previously occupied by a tooth rather than an altered ridge position and this should result in a better restorative result, since the screw access opening can be located through the occlusal or cingulum area of the final restoration. In addition, it allows a more normal contour to the facial aspect of the final restoration since the implants

can be placed in a more buccal position relative to the adjacent teeth and opposing occlusion (Wilson *et al.,* 1998; Favero *et al.,* 2013).

Furthermore, preservation of the existing bone is a major goal, allowing the clinician to place a longer implant, and this should result in a more normally sized clinical crown in the final restoration. Normally, unrestorable teeth are extracted; followed by a maturation period of up to 1 year. After ridge maturation, implants are placed and approximately 6 months is permitted for osseointegration.

Following the integration period, second-stage surgery is performed and then final prosthesis construction is begun after healing from second-stage surgery. This is of much time and money consuming, and multiple surgical stages need to be performed. Utilizing the immediate extraction technique, the period of ridge healing and osseointegration is accomplished concurrently, thereby reducing treatment time for the patient. This can be a major psychological benefit as well as time reducing where the patient must wear a transitional prosthesis (Cannizzaro *et al*., 2011).

Adequate bone volume and density have long been recognized as crucial components of any implant restoration case. When implants are placed into fresh extraction sockets, inconsistencies between the implant diameter and the tooth root diameter at the crest of the alveolar ridge create the potential for a significant space between the residual bone and the implant surface. Successful integration of the implant requires bone to be deposited in these areas for implant support. A continuous attempt at fixing the appropriate implant size into the corresponding alveolus has led to the use

of many osteoconductive materials and grafts, in a fashion so as to support the implant fixture and enhance peri-implant healing (Huber *et al.,* 2012).

2.5 Factors affecting healing of extraction socket after immediate implant placement

There are factors which affect the procedure of the immediate implantation placement. Some of these factors can be dealt with immediately and some are due to local properties of the extraction socket.

2.5.1 Presence of peri-radicular infection at the time of tooth extraction

Periodontitis and non-periodontitis sites showed a similar pattern of healing in terms of horizontal ridge reduction and horizontal gap fill (Ferrus *et al.,* 2010). Overall, these results seem to indicate that the presence of a chronic infection into the extraction socket is not an absolute contraindication for immediate implant placement. Immediate implant placement can be considered as a safe, effective and predictable treatment option for the restoration of fresh post-extraction infected sockets when appropriate preoperative procedures are taken to clean and decontaminate the surgical sites.

In a systematic review of more than 28 studies done in (2013) by Montoya-Salazar, concluded that the findings should be interpreted cautiously because of a great variability among the studies in terms of the type of implant used, the area of implant placement, type of infection present, criteria for patient selection, and loading

protocol. However, the high survival rate and the normal marginal bone changes obtained in several studies support the hypothesis that implants may be successfully osseointegrated when placed immediately after extraction of teeth presenting with endodontic and periodontal lesions, provided that appropriate clinical procedures are performed before the implant surgical procedure (Montoya-Salazar *et al*., 2014).

2.5.2 Implant location (Anterior/Posterior)

Anterior and posterior sites did not differ significantly in terms of resorption from the outer aspect of the ridge and vertical gap-fill. Overall, these results seem to indicate that the implant location (anterior/posterior) is a healing determinant of extraction sockets implanted immediately after tooth removal, with a tendency of anterior sites to show a greater resorption of the buccal wall and a greater horizontal defect (Ferrus *et al.,* 2010).

2.5.3 Thickness of the socket bone walls

A substantial degree of gap fills occurs at sites where the buccal bone wall was thick (> 1 mm) after a 4-month period of healing. Thick bone walls (>1 mm) favor a greater defect fill when compared to thin (≤ 1 mm) bone walls in sites where immediate implants have been placed. These findings seem to be of clinical relevance when considering that a thickness (≤ 1 mm) of the buccal and/or palatal socket wall is a rather common clinical condition, especially at the anterior and premolar region. If the buccal bony wall was initially 1 mm thick, the buccal bone resorption was as high as 52%. However, when the buccal bone wall was initially 2

mm thick the buccal bone resorption was significantly reduced to 33% (Figure 2.3)(Ferrus *et al.*, 2010).

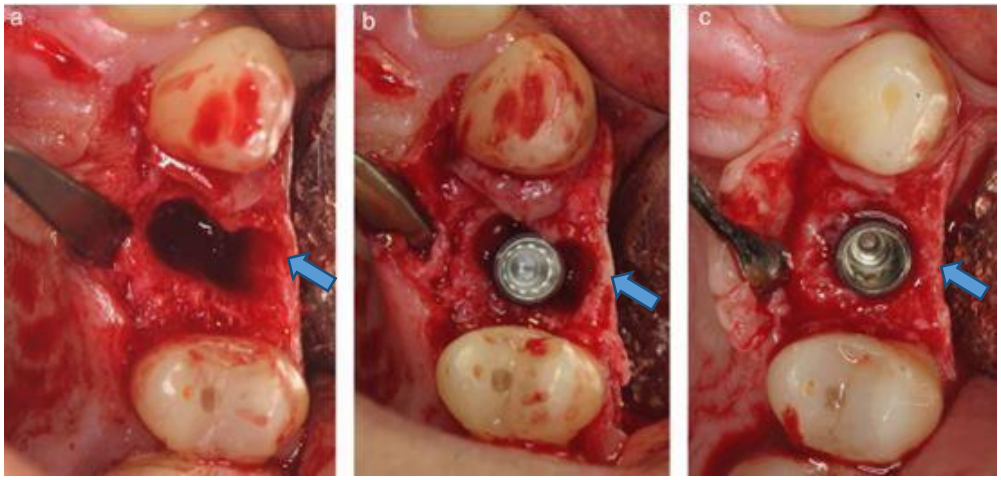

Figure 2.3 Thickness of the buccal plate when placing the lower immediate implant in tooth number #45 (Ferrus *et al.*, 2010)

2.5.4 Gingival biotype

In a retrospective study conducted on patients treated with immediate implants placed with a flapless approach, recession of more than 10% of the length of the central incisor crown occurred at 6 over 25 thin biotype sites compared to 2 over 19 thick biotype sites. In a recent prospective study, immediate implants placed in patients with a thin periodontal biotype showed more mucosal recession than implants placed in cases of thick periodontal tissues (Evans & Chen, 2008). They have also studied the soft tissue alterations following Type I single-tooth implant placement and related treatment outcomes to tissue biotype. They reported that at 18 months after implant placement, there was a 1mmrecession of the soft tissue margin,

but also that the soft tissue recession was most pronounced at sites belonging to a thin biotype.

2.5.5 Flap versus flapless surgery

A study conducted on beagle dogs suggested that immediate implants insertion without flap elevation (flapless procedure) may significantly reduce the extent of bone resorption at the buccal aspect when compared to flap surgery and concomitant implant placement (Blanco *et al*., 2008). In another study conducted by Villa and her group in (2007) where thirty-three patients with teeth extracted for endodontic or periodontal lesions and replaced with immediate implants or early implants, a tendency towards lower mean bone loss was observed with the flapless protocol versus flap protocol -0.74 mm and -1.02 mm respectively.

2.6 Socket preservation technique

Several authors have reported the use of socket preservation technique; the consequences of exodontia include alveolar bone resorption and ultimately atrophy to the basal bone of the edentulous site/ridges. Ridge resorption proceeds quickly after tooth extraction and significantly reduces the success of placing implants without grafting procedures (Araújo & Lindhe, 2011; Perelman-Karmon *et al.*, 2012)

After severance of the supra and subcrestal fibrous attachment using scalpels and periotomes, elevation of the tooth frequently allows extraction with minimal socket wall damage. Extraction sockets should not be acutely infected and be completely

free of any soft tissue fragments before any grafting or augmentation is attempted. Socket bleeding that mixes with the grafting material seems essential for success of this procedure.

Various types of bone grafting materials have been suggested for this purpose, and some have shown promising results. Coverage of the grafted extraction site with wound dressing materials, coronal flap advancement, or even barrier membranes may enhance wound stability and an undisturbed healing process. Crespi and his team in (2009) evaluated two new materials were evaluated in the split-mouth clinical trial, Mg-enriched HA and calcium sulfate, in 15 patients. Three months later, they found significant differences in ridge height reduction; 0.48 mm in Mg-enriched HA and 2.48 mm in calcium sulfate groups and 3.75 mm for the controlled group respectively. Based on this study, Mg-enriched HA was found to be more useful in alveolar ridge preservation than calcium sulfate, and it can be concluded that Mg-enriched HA is a suitable material for socket preservation and ensures early angiogenesis and early osteogenesis (Crespi *et al.,* 2009).

In another recent split-mouth design study, sockets were treated with anorganic bovine bone matrix (ABM) and synthetic cell-binding peptide P-15 and compared with a controlled group. The sockets in both groups were covered with acellular dermal matrix (ADM). No statistically significant differences could be found between the groups (1.5 mm and 1.2 mm) respectively, but the ridge width resorption was significantly greater in the control group (3.4 mm) compared with test group (2.52mm)(Novaes *et al.,* 2012).

Whereas allograft material was also tested in (2012) by Brownfield & Weltman, by a randomized controlled clinical trial, 20 patients selected for the two groups using demineralized bone matrix and cancellous bone chips. No significant difference on ridge resorption was found between the two groups (LA Brownfield *et al.*, 2012).

A randomized controlled study conducted masked clinical trial in 24 patients. Subjects received either extraction alone or socket augmentation using tetracycline hydrated freeze-dried bone allograft (FDBA) and a collagen membrane. Histological analysis demonstrated greater bone formation in augmented sites after a 6-month healing period (Iasella *et al.*, 2003).

However, some reports have shown negative results when alveolar ridge preservation was attempted, possibly as a result of the use of inadequate techniques and/or materials. For example, Zubillaga and his group in (2003) evaluated a combination of demineralized freeze-dried bone allograft and a bio-absorbable membrane for socket augmentation. The negative results observed were attributed to the slow resorption of the gelatin carrier of the graft material (Zubillaga *et al.*, 2003).

Many bone grafting materials have been suggested for socket augmentation. These include autogenous bone, demineralized freeze-dried bone allograft (DFDBA), mineralized freeze-dried bone allograft (FDBA), bovine hydroxyapatite (HA), alloplasts and demineralized freeze-dried bovine bone xenograft.

After placement of the bone graft material, a membrane should be sutured and cover the augmented area to secure the bone particles from being scattered. Evaluation of