Aesthetic Approach for Post-Extraction Alveolar Socket in the Anterior Maxilla: Literature Review and Clinical Evidence

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Abstract

When we treat patients with dental extractions needs in the anterior maxilla, previously it is important to understand the process of bone remodeling after perform that procedure, the different types of bone, gingival biotype, types of smile, age and systemic condition of our patients in order to choose the correct treatment plan. A dental extraction results in changes of horizontal and vertical dimensions of hard and soft tissue, the magnitude of these changes are important in decision-making, elaboration of treatment plans to avoid aesthetic and functional complications during prosthetic rehabilitation. The modern dentist (oral surgeon, periodontist, prosthodontist or general dentist) must have diagnostic criteria that makes him choose the best therapy based on scientific evidence, knowing how the tissues respond to different techniques of reconstruction: bone grafts of different types, soft tissue grafts or dental implant placement. The purpose of this article is to create diagnostic criteria through clinical evaluation, 3D tomography and photography. Classify the initial clinical condition of the anterior maxilla. Understand the physiological and biological healing processes that occur with each treatment and biomaterials. Select with scientific criteria the treatment plan that represents the most predictable result aesthetically and functionally.

Keywords: Alveolar Socket; Diagnosis; Bone Graft; Dental Implant; Anterior Maxilla; Soft Tissue Augmentation

Introduction

Missing teeth and supporting oral tissues have traditionally been replaced with dentures or bridges permitting restoration of chewing function, speech and aesthetics. Since dental implants were stablished as a first option of replacing missed tooth, offer an alternative to prevent horizontal and vertical tissue loss.

A tooth extraction results in horizontal and vertical changes of hard and soft tissue dimensions. After this procedure in to the empty alveolar socket its promoted a blood clot formation and posterior clot resorption, bone remodeling and new bone formation (bone modeling) [1]. Bone resorption is considered a normal healing phase in this cases with bone loss horizontally and vertically, this resorption pattern will make hard a succesfull implant placement for a dental rehabilitation in the anterior maxilla [2], that is why as a clinicians we must be trained in the management of the esthetic zone from tooth extractions, a single tooth replacement, multiple tooth replacement, hard and soft tissue reconstruction techniques.

The periodontium is an important structure that supports the tooth, provide blood supply to alveolar bone by the periodontal ligament and is affected by changes after the extraction. The Alveolar Process is a tooth-dependent tissue, the shape and volume is influenced by tooth form as well as direction of eruption. The presence or absence of the teeth will change the bundle bone and gingival tissue [3,4].

Tooth extraction is one of the most widely performed dental procedures, will generally result in some alveolar bone loss and soft tissue. The horizontal buccal bone resorption has been shown reach as much as 56% while lingual bone resorption has been reported to be up to 30% [4,5]. This also affects the overlying soft tissues of the alveolus. Immediately following an atraumatic tooth extraction (flapless technique), there is an absence of soft tissue covering over the socket entrance and hence the socket defect is left to heal by secondary intention initiated with a blood clot formation. In the subsequent weeks, cell proliferation will result in an increase of soft tissue volume and soft tissue covering will seal the socket entrance. The mucosal contours are dependent on the corresponding changes in the external profile of alveolar bone surrounding the extraction site. The magnitude of these dimensional changes are important in the decision-making and comprehensive treatment planning, always thinking in avoid prosthetic complications.

If we understand this healing process of hard and soft tissue, we will be able to evaluate the biological behavior of the anterior maxilla structures after the extraction, in order to choose the correct treatment plan for each patient before any intervention. It is important to mention that in the last decade we have seen the increase on the emphasis of the aesthetic satisfaction beside the correct functional aspect. For this reasons, the study of dimensional changes patterns of the alveolar ridge after tooth extraction it is crucial.

After 6 month of dental extraction, we can appreciate an average of the buccal plate horizontal reduction of 3.79 mm and vertical reduction of 1.24 mm, which means an vertical dimensional changes between 11 - 22% after 6 months and horizontal dimensional changes of 32% after 3 months and 29 - 63% after 6 to 7 months respectively in the hard tissue. Overall, the observed horizontal resorption of the hard tissues (29 - 63%) is far greater than the resorption in the vertical dimension (11 - 22%) over an observation period of 3 - 7 months. It can be appreciated that the bulk of the resorption occurs in the first 3 months post-extraction [6].

Also, the soft tissue changes are important, 0.4 - 0.5 mm gain of soft tissue thickness at 6 months, measured at buccal and lingual sites 3 mm from alveolar crest. Occlusally, soft tissue with thickness of 2.1 mm developed after 6 months to complete soft tissue coverage of the wound [6]. We can appreciate the conclusions on the figure 1.

![Figure 1: Horizontal and vertical, hard and soft tissue percentage change.](image-url)
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With this information we can conclude that should not be a treatment option, perform a dental extraction in the anterior maxilla leaving an empty alveolar socket healing by itself even more if we are planning to restore the tooth esthetically and functionally. Our main goal should be replace the lost tooth with a dental implant if the hard and soft tissue condition allows it, as some study indicates as a tooth replacement therapy [4].

When a tooth is already missing and restoration with a single implant is planned, the diagnostic phase differs from the clinical scenarios previously describe. Hard and soft tissue defects are often present, either from bone loss due to periodontal disease or from traumatic extraction. Therefore, a classification of the partially edentulous alveolar ridge to diagnose a possible dental implant placement or bone defects and plan which augmentation technique may be utilized [7].

The UCLA classification of the partially edentulous alveolar ridge is a diagnostic tool that describe the anterior maxilla residual bone in 6 grades, if we modify in a 4 different categories it should be easier to understand and apply. Type I which demonstrate no vertical or horizontal deficiency, either at the crest or at the apical portion of the ridge showing enough bone for a dental implant. In a Type II ridges horizontal deficiencies are seen without any vertical bone defects, showing not enough bone in the half portion of the body implant. Type III demonstrate only horizontal deficiency at the crest with normal vertical bone levels, a knife shape alveolar ridge. Type IV reveal vertical deficiency of bone level, not enough for a dental implant placement [7,8].

The maxilla is composed by several anatomical structures with a proper function, composition and physiology: basal bone that develops together with overall skeleton and forms the body the maxilla, alveolar process that develops following tooth eruption and contains the tooth alveolus, the bundle bone that lines the alveolar socket, extends coronally forming the crest of the buccal bone and makes part of the periodontal structure. After tooth extraction, bundle bone appears to be the first bone to be absorbed whereas alveolar is gradually absorbed throughout life. As we can appreciate in the figure 2, anatomical changes and physiological processes taking over tooth extraction, the remodeling process results in a ridge morphology reduced in vertical height and more palatal in relation to the original tooth position [1].

![Figure 2](image)

Figure 2: Horizontal and vertical, hard and soft tissue percentage change.

We already know the biological healing process that occur after an atraumatic tooth extraction in the anterior maxilla and the dimensional changes which result in a residual alveolar crest well described in the figure 2. Dental implants are today considered as reliable treatment option to replace missing teeth for esthetic and function. Implant placement in the anterior maxilla area is challenging because of esthetic concern and unfavorable bone topography. The success of an implants restoration depends in the accurate diagnostic criteria.
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Before to replace a tooth with a dental implant it is really important to establish an alveolar socket classification using the Cone Beam CT as radiographic examination option, prior to perform any treatment choice. This technology gives the clinician exact details of the hard and soft tissue structures necessary for proper diagnosis and accurate treatment planning. CBCT create real time images in axial, coronal, sagittal, and oblique planes, known as multiplanar reformation that provides accurate 3D information [9].

The CBCT has become the most trusted technique in treatment planning and diagnosis in implant dentistry. It gives accurate images of highly contrasted structures and is useful in bone analysis. It generates 3D images of oral structures, soft tissues, nerve pathways and bone quality and quantity of the facial region that can be measured for dental implant size selection and positioned by the use a surgical/ radiographical splint, everything in a single scan [10].

The use of the CBCT and the proper clinical examination are key factors which determine the quality of the socket (the presence or absence of the buccal hard and soft tissue). Therefore, a new simplified classification system for various types of extraction sockets in the anterior maxilla and is divided in three types [11]:

1. **Type I Socket:** The facial soft tissue and buccal plate of bone are at normal levels in relation to the cementoenamel junction of the pre-extracted tooth and remain intact post-extraction socket walls.
2. **Type II Socket:** Facial soft tissue is present, but the buccal plate is partially missing following extraction tooth or before the surgery.
3. **Type III Socket:** The facial soft tissue and the buccal plate of bone are both markedly reduced which usually requires regenerative procedures to restore [11]. This classification can help to determine which clinical therapy will be the best option [11].
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An alveolar socket Type I could be the less complicated and the most predictable to treat with dental implants. Intraoral key factors as a soft tissue biotype (thin or thick/scalloped or flat), relation cementoenamel junction with the soft and hard tissue, thickness of buccal plate, size of gap (distance between buccal plate and dental implant), implant position and type of occlusion are the most important intraoral aspects to study before any intervention.

The type of smile is an extraoral important factor to keep in mind every time when we evaluate a patient with this kind of requirement. A dental photography can help us to quantify the visual presence or absence of gingival zenith’s and interdental papillae during maximum smile.
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**Extraoral photographic evaluation**

We can classify this aspect in 3 categories: 1. Low gingival smile line, 2. Medium gingival smile line, 3. High gingival smile line. Using this information, it is more important the preservation of the natural contour of gingiva around dental implants restorations, because in more than 91% of the patients, we can found a visual display of the interdental papillae when smiling [12].

![Figure 7](image)

In these cases the soft tissue biotype can also affect the implant success therapy. The establishment of the concepts of both gingiva characteristic could make a major difference result [13] (Table 1).

<table>
<thead>
<tr>
<th>Soft tissue thickness</th>
<th>Thin biotype</th>
<th>Thick biotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2 mm</td>
<td>&gt; 2 mm</td>
<td></td>
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| Biologic width       | < 3 mm       | > 4 mm       |

<table>
<thead>
<tr>
<th>Immediate implant placement</th>
<th>+ Gingival recession</th>
<th>- Gingival recession</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ Loss of papilla</td>
<td>- Loss of papilla</td>
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**Table 1:** Parameters that establish the difference between both soft tissue biotypes.

Once evaluated the clinical and radiographically conditions of the anterior maxilla (soft and hard tissue, intraoral and extraoral aspects), it is time to analyze the tooth replacement technique of our choice. Titanium dental implants with the concept of osseointegration and successful placement of implant-supported restorations in edentulous and partially edentulous patients has been well documented [14]. A single or multiple tooth implant supported restoration in the anterior maxilla remains as the most esthetic and functional challenge. The requirements during a surgery intervention as a bone regeneration, soft tissue preservation or augmentation and proper dental implant position are the main factors in creation of an optimal emergence profile of implant supported prosthesis.

In order to recreate a natural soft tissue contour with the papillae and the gingival outline shape with the adjacent dentition, some main factors could directly affect the esthetic outcome of anterior implant-supported restorations: extraction technique, dental implant design, implant placement, soft tissue management, bone grafting considerations and prosthetic considerations [14,15].

**Extraction technique**

There are several ways to perform an atraumatic tooth extraction without compromise the hard and soft tissue that can predict part of the success of immediate implant placement in the anterior maxilla. Using a flapless technique in the alveolar socket type I, produce less trauma because the periosteum is not removed from the alveolar bone without compromise part of the blood supply of buccal plate. Some authors indicate the fact that keeping the buccal portion of the dental root retain after the extraction, can preserve the periodontal ligament and bundle bone around the implant to prevent a hard and soft tissue resorption, this technique apparently shows good results but needs sufficient data to confirm a long term success treatment [17,18].

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Dental implant design

Implant form, surface and connection are the key elements that we need to keep in mind when we choose a dental implant. In the anterior maxilla the conical shape of the implant looks more like a tooth root, is more convenient than cylindrical shape implants, which also works great but the potential of bone fenestration during the drilling process or placement make more accurate and safety in order to prevent threads exposures. Also, a self-tapered implant provide more initial stability. The reduced diameter in the coronal part of the implant will let a gap between implant and buccal plate that will help to avoid a soft tissue recession, complication after the inevitable bone resorption during the first phase of the healing process after a tooth replacement. A roughness surface will provide the proper condition for biologic stabilization, facilitating the bone cells proliferation around dental implant body, known as osteogenesis, which means early percentage of bone-titanium contact. Many surface types are available in the market like machined surface, acid-etched and titanium plasma sprayed are the main surface treatments to achieve this roughened state. Implant thread shape and the distance between them has also been found to influence the type of force transferred to the surrounding bone.

Initial implants introduced had V-shape design. With the understanding of stress patterns, the variants of V-shape thread design came into existence. Presently available thread designs include; V-shape, square shape, buttress, reverse buttress and spiral shape. Some implants combine more than one types of threads in a same implant, distributed from the apex to the body and neck, which make more interesting the different applications of those dental implants for many clinical scenarios [15].
The implant-abutment connection is believed to play an important role in the outcome of the implant therapy and almost each dental implant manufacturer developed its own unique connection. These connections are subjected to an aggressive marketing campaign with many manufacturers and clinicians claiming the superiority of one connection over the others. The difference in neck design and platform switching between External Connection and Internal Connection implants, did not show any statistically significant differences between the two connection types [16], therefore the clinical use of the implants, from a cross arch hybrid protheses or a single tooth replacement will make us choose the right implant and abutment option.

Implant placement

Gingival esthetics around dental implants have become a main focus in the anterior maxilla, the proper 3D positioning of the implant will determine a final soft tissue shape including the interdental papillae.

Positioning involves four planes: the apico-occlusal, mesio-distal, labio-palatal planes and vertical depth of implant head.

1- Apico-occlusal positioning

Positioning of the implant in an axial direction must be 2 to 3 mm above an imaginary line connecting the cementoenamel junction of the adjacent teeth. Less than 2 mm will lead to a short crown (which is impossible to correct), and more than 3 mm will hinder proper hygienic maintenance because of increased pocket depth around the transmucosal insert. Also, it’s important to mention that the biologic width around an implant is apical to the abutment implant connection. In the anterior maxilla, the implant is usually placed approximately 4mm apical to the height of the buccal tissue of the adjacent teeth.

2- Mesiodistal positioning

An implant positioning in a mesio-distal dimension that has a proper relationship between the teeth can be achieved. The middle orientation in a mesio-distal direction is mandatory to avoid placing the implant in the interdental papillary position and subsequent approximation of the neighboring roots. To prevent the absence of interdental papilla between implant-tooth, the ideal mesiodistal position, should be 1.5 mm from implant-tooth to avoid bone loss and maintain the support for soft tissue. Less than 1.5 mm will make a greater contact point surface between tooth and implant restoration, showing an square and not triangular crown that mask the deficient papilla. If the distance is more than 2 mm, the compromise of vertical soft tissue will be more critical, because the patient will show a black space instead a gingival papilla with a less esthetic result.

3- Labiopalatal positioning

Placing the implant too far palatially will result in a “ditched-in” restoration and placing the implant too far labially will result in an esthetically bulky crown that is impossible to correct, even with the use of angulated abutments. Keep a minimum of 1mm of buccal bone is mandatory to ensure a restoration with a flat emergence profile.

4- Vertical depth of implant head

The platform of the implant should be located 2 to 4 mm below the midfacial aspect of the free gingival margin, with the extended long axis directed slightly lingual to the incisal edge of the definitive restoration. When the long axis of the implant is inclined labially and projects beyond the incisal edge of the definitive restoration, the result is that the subgingival contours of the abutment or restoration will tend to deflect the gingival margin apically, resulting in an unharmonious esthetic profile.

In screw- retained anterior restorations, the implant is generally placed slightly lingual or palatal to the long axis of the crown, different that cemented restorations where the implant should be located exactly in the center of long axis of the crown.
Bone grafting (gap management)

In the case of atraumatic extraction with immediate implant placement, an implant should be placed lingually; this position create a gap between the implant and buccal plate, maintaining the space for bone remodeling. Tarnow and Chu study demonstrate that the size of the gap doesn’t matter; even if it is left the gap empty or it is filled with a bone graft material [23]. It is really important to understand the biology concepts. After that, we can conclude that we are not going to replace the lost tooth with a exactly a new tooth. The main goal should be recreate "not create" the original condition of the tissue (dental/gingiva/bone) for an optimal esthetic outcome and how this titanium screw will work after loaded with a prosthetic restoration, that shows a total different behavior than natural dentition.

Soft tissue management

The incorrect classification of the periodontal biotype and his considerations before the treatment, are related with the protentional risk of gingival recession. The patient with thin gingiva and thin alveolar bone has the highest risk of gingival recession, opposite that the patient with thick gingival biotype has more coronal level of gingival margin, with greater predictability than thin biotype [17].
Sometimes a connective tissue graft may be necessary to reduce soft and hard tissue compromise, but not to change the gingival biotype because this is directly related with patient’s own natural conditions. The quality and quantity of soft tissue architecture should be noted in addition to the periodontal probing depths. The thickness of fibrous connective tissue, amount of keratinized tissue and the degree and symmetry of the gingival scallop [20].

Flap or Flapless technique, definitely flapless should be the gold standard to prevent bone exposure and avoid more resorption, but if a flap is the case, a vertical incision should be made, allowing the optimal mobilization of the mucoperiosteal flap with preservation of the interdental papillae.

**Dental implant loading**

With the increase of patients for more natural and immediate restorations in the aesthetic zone, the potential for the immediate implant loading is already proved and it is interesting to mention every loading protocol.

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First, conventional loading in the anterior maxilla with a 6 months of healing process before to restore the implant with a crown, which consist in a two stage or surgeries, using a cover screw, healing abutment or temporary restoration and the final restoration [20].

Delayed loading on two adjacent implants in the anterior maxilla

Another way is a one stage surgery using the healing screw or a temporary cylinder positioned with composite placed in the soft tissue socket to preserve the gingival contour, then a temporary restoration and finally the ceramic restoration [20].

Delayed loading with a soft tissue contour preservation

Finally, immediate load that require the proper case selection, could be performed with a temporary or final restoration in an occlusion, with controlled of forces and valid prosthetic design. An a good anterior guidance could help to avoid excessive lateral loads. Patients with parafunctional habits are contraindicated for an immediate implant loading or a complete tooth replacement in one phase [20].

Immediate loading with provisional crown
Prosthetic considerations

A multidisciplinary approach is needed in this cases, the communication between the multiple dentist, laboratory technician and patient it’s important to achieve success. After that, we need to considerer a few prosthetic important aspects, like the abutment selection if an immediate provisional is the case, or the plastic cylinder with a non-rotational connection and composite placed on it to copy the alveolar soft tissue shape and cervical contouring if we just want to preserve the original soft tissue shape. For provisional or final restoration an abutment for a cemented retained or screwed fixed crown doesn’t show any statistical difference, the proper choice will depend of the experience of the dentist, and which one is better option for him. If a soft tissue graft is used to seal the socket an ovoid pontic connected to a removable partial prosthesis must be the option to push and form the soft tissue scalloped to achieve the most natural emergence profile of the final restoration. Because the implants in the esthetic zone are placed more lingual than the axis of the natural tooth, the occlusion of the restoration it is a key factor. The concept of group function will allow a more favorable allocation of forces over the implant. This kind of restoration tend to accommodate axial loads better than non-axial loads because they are ankylosed to the bone, different than natural tooth which have a periodontal ligament that shows a level of resiliency. Personally, I remeber Dr. Thomas Ford G. from ICOI (international Congress of Oral Implantology) “Pre Prosthetic and surgical Planing, Prevents Prosthetic Problems and increasing the predictability of restorations”.

When two adjacent implants are placed in the esthetic zone, clinicians should proceed with great caution. After analyzing the occlusion, the hard and soft tissue condition, the distance between implants is a crucial aspect to keep the height of the interdental papilla. The presence or absence of the papilla between two natural teeth are related to the distance from the crest of bone to the contact between the teeth [21]. When the distance was 5 mm or less, the papilla completely filled this space almost 100% of the time. If the distance was 6 mm, the interdental space filled about 55% of the time and at 7 mm, the interdental space was completely filled about 25% of the time. On dental implants this measurement from contact point to the alveolar bone crest between implants will be determined by contact point manipulation, which can be placed at any height at the discretion of the clinician [22], with this information we establish a relationship between the height of the interdental papilla, the biologic width around each implant and the residual interimplant bone crest.

**Figure 18**

If the interimplant distance is 3 mm and 1.5 mm between implant -tooth, an additional interproximal bone loss is prevented, because the enough horizontal space for the proper biologic width is kept. Also, it is important to remember the physiological bone remodeling around the neck of the implant after a one year of loading, because the biologic width around them is apical to the implant abutment connection, different than a healthy tooth, because biologic width is form supracrestally [22].

**Figure 19**

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In most cases, if there are natural healthy teeth with normal shape papilla adjacent to these two implants, then the height of the papilla between those implants will almost always be more apical in position than the adjacent healthy teeth. Try a periodontal surgery to increase the papilla will not be successful because around the implants the biologic width is apical to the crest of bone and the connective tissue and the epithelial attachment will not be supportive to the papilla. The soft tissue have a totally different behavior when we replace a tooth with an implant between two natural healthy teeth. A flapless technique not only seems to have a reduced horizontal and vertical component but may also have the potential to create improved maintenance of interproximal bone peaks adjacent to the implant [24].

With this information we can conclude some clinical criteria’s to select the patient for an immediate tooth replacement in the anterior maxilla with an alveolar socket type 1:

1. Hard and soft tissue without compromise (no infections and no fenestrations).
2. Proper distance between implants and natural tooth.
3. Free gingival margin of 3 mm.
4. Flapless and atraumatic extraction.
5. Adequate condition for a proper implant placement based in a correct prosthetic planification.

When a dental implant is placed in a post-extraction alveolar socket and bone dehiscence’s or fenestrations around some threads are exposed on the buccal plate, a minor augmentation procedure is necessary. The sandwich bone augmentation technique is a simple a non-traumatic solution without compromise a secondary surgical wound or donor site, reducing morbidity and recovery time [45].

This technique appears to enhance the outcomes of bone augmentation around the implant exposed threads using autogenous bone graft harvested from the osteotomy site. Mineralized cancellous bone allograft was layered on, followed by a layer of mineralized cortical bone allograft. A collagen membrane was trimmed and used to contain the bone grafts as well as to exclude unwanted cells, such as epithelial cells and connective tissue fibroblast [45]. Tension-free primary closure was subsequently obtained to avoid complications during the recovery phase. After six month of healing, a mature regenerated bone allows to load the implant with the final restoration.
There are three different timing protocols for implant placement after tooth extraction: immediate, immediate-delayed or delayed implants. Which one should be the best option? The first is the implant that we place in a post-extraction site, the second is the implant that we place around 8 weeks after the extraction and the third is the implant that we place around 3 months after the extraction.

Using this classification, Esposito M and coworkers evaluate the success, complications, aesthetics and patient satisfaction of each of this clinical situation after one, two and five years of loading [25]. They conclude that immediate and immediate-delayed implants may be at a higher risk of implant failure and complications than delayed implants, on the other hand the aesthetic outcome might be better when placing implants just after tooth extraction [25]. This is a valuable information that confirm the biological process we studied previously at the beginning of this article, because when a tooth extraction is performed, a cellular activity it's initiated and seems to be a good moment to place a dental implant if we have the perfect conditions. In an immediate delayed implant, the biological process that was already initiated during a previous extraction and the implant surface is not going to be in contact with a mature bone, making less predictable an esthetic outcome and implant survival. In the other hand a delayed implant have higher implant survival rate with more esthetic compromise, because the alveolar bone suffered the natural resorption after the process of bone remodeling and modeling.

If after the clinical evaluation, the alveolar classification is a socket type 2 or type 3, the approach it’s going to be different and a dental implant is not the best treatment choice in the anterior maxilla. In this types of alveolar sockets, where alveolar bone it’s partially or totally resorbed, the need for horizontal or vertical augmentation is mandatory prior to implant placement.

The biological principles of bone structure, metabolism, physiology and bone graft healing process are concepts necessary to know for design a correct treatment plan or choose the ideal bone graft and technique for every specific clinical situation. Bone grafts were developed due the need to reconstruct atrophied maxillary bones, to restore function and aesthetic of the patient.

Bone is a unique complex living tissue that serves two primary functions, structural support and calcium metabolism (primary reservoir), this tissue is compound of an organic matrix collagen type 1 and inorganic matrix of hydroxyapatites. Three different types of cells, osteoblast, osteocytes and osteoclast are related to bone metabolism and physiology and those three are closely related to each other and derived from similar precursors [26,27].

Osteoblast, are associated with the process of osteogenesis, are located in two general areas next to bone surfaces where they deposit bone matrix. There are two different types of osteoblast, endosteal and periosteal. When osteoblast become embedded in bone matrix,
they transform into osteocytes, which are mature osteoblast encased in a mineral matrix. The union of the adjacent osteocytes create a network of metabolic and biochemical messenger exchanges between the bloodstream system and the osteocytes. This mechanism allows the osteocytes to remain alive, regardless of the calcified intercellular substance that surrounds them. Osteoclasts are responsible for bone resorption and begin the bone renewal process, which is often termed “bone turnover” or “bone remodeling” [26,27].

The bone renewal or remodeling can be an anabolic process with a position of bone on the surface or it can be a catabolic process with resorption of the surface. Bone remodeling is a specific phenomenon that occurs during growth as part of wound healing, like a fracture or during the stabilization of an endosseous implant and the response to loading. This process can be explained as a cell interactions starting with existing bone. Bone is normally inhibited from resorption by osteoprotegerin, which is a protein secreted by osteoblasts to regulate the rate of resorption an inhibitory signal to the osteoclast. The osteoblast matures into an osteocyte loss gradually the ability to secrete osteoprotegerin and becomes vulnerable to normal osteoclastic resorption. Osteoclast arise from mononuclear precursor cells of the macrophage lineage in bone marrow. They mature rapidly under stimulation of macrophage colony stimulating factor and interleukin-1 and 6. The osteoclast only begins active bone resorption in response to the overriding signal of circulating parathyroid hormone and locally secreted receptor activator nuclear kappa-b ligand (RANKL). RANKL binds to RANK receptor on the osteoclast cell membrane to initiate the resorption, it is also secreted by normal osteoblasts to increase bone resorption. Normal osteoblasts also secrete OPGs as a false ligand that competes with RANKL to inhibit bone resorption by occupying the RANK receptor on the osteoclast cell membrane. This gives the osteoblast up-regulation and down-regulation control of the osteoclast and either limits the rate and amount of local bone resorption or increases it. Osteoclast-mediated normal bone resorption begins the bone renewal/bone turnover process [26,27].

Bone grafts only regenerate and heal bone through three mechanisms knowns as osteogenesis, osteoconduction and osteoinduction. Grafts may develop bone from one, two or three of these mechanisms.

Osteogenesis is the formation of osteoid by osteoblasts, in this case the new bone formation will depend of the numerous of surviving endosteal osteoblasts, mainly from cancellous marrow of its extended surface area and marrow stem cells are the sources of new bone formation, that is why the autogenous bone graft is the only type with this capabilities.

Osteoconduction is the formation of new bone from adjacent bone or from periosteum through a matrix that acts as a scaffold. This matrix must bind the cell adhesion molecules fibrin, fibronectin and vitronectin or consist in collagen itself like the healing process of a tooth socket after the extraction.
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Osteoinduction is the formation of new bone by the biochemical transformation and stimulation of stem cells (like osteoprogenitor cells) into bone producing cells (osteoblasts).

There are four types of bone substitutes to reconstruct maxillary defects named depending of their source autogenous graft, allograft, xenograft and alloplastic grafts [28].

Autogenous grafts comes from the same individual, taken from adjacent site or remote site. Adjacent donor site in most cases in oral implantology like mandibular ramus and symphysis, 100% biocompatible, combine the osteogenesis-osteoconduction-osteoinduction properties, they are biologically compatible as they are from the same patient and provide a scaffold into which new bone may grow. For these reasons is known as the gold standard. All of these require surgery at a second site and therefore the morbidity must be considered.

Allografts, these are bone grafts harvested from cadavers and processed by methods such freezing or demineralising and freezing. The grafts are then sterilised and supplied by specially licensed tissue Banks in bone particles or bone blocks. They are resorbable and have the osteoconduction properties.

Xenografts, these are graft materials derived from animals such as cow or coral. Is processed to completely remove the organic component and have a high osteoconduction potential.

Alloplastic grafts are synthetic bone substitutes including calcium phosphate and bioactive glasses, provide a physical framework for bone ingrowth. Can be totally resorbed, partially resorbed or not at all with time. Have an osteoconductive potential.

A numerous alternative techniques are currently used to augment bone (horizontal or vertical dimension) prior to dental implant placement in the anterior maxilla, planified to be performed immediately after the tooth extraction or in the residual alveolar bone crest:

• Alveolar preservation.
• Alveolar reconstruction/Shell technique (Khoury).
• Onlay grafting.
• Inlay grafting.
• Ridge expansion/Ridge splitting.

Alveolar preservation

In the alveolar socket type 2, when the buccal plate is partially resorbed. After the extraction the new bone formation is naturally occurring event as long as surrounding alveolar walls remain intact. However, the alveolar ridge volumetric contraction may impair implant placement. To reduce alveolar bone loss or increase the buccal plate partially resorbed to an acceptable level to achieve aesthetic outcome, a surgical technique limiting the trauma without flap elevation is essential for success, known as alveolar preservation. This technique involves bone substitutes and soft tissue management [31]. The clinical advantage of bone fillers in alveolar ridge volume preservation and prevention of additional bone grafting procedure are largely in the available literature [1,2].

There are two different approaches (Classic and Esthetic) for the alveolar preservation in the anterior maxilla when we are planning a delayed implant.

The classic technique: when after the extraction the alveolar site is filled with a particulate bone graft and later a mucoperiosteal flap is raised with one or two vertical releasing incisions on the adjacent teeth, the graft can be covered with a collagen membrane and the flap is advanced coronally to achieve primary closure [29]. Maintain the esthetic profile in this case it’s really difficult, there are so many possible complications as loss of interdental papilla height once the attachment has been removed, recession of the adjacent teeth, inability to achieve primary closure for inadequate coronal displacement of the flap, scar tissue formation along the vertical incisions (compromising the esthetic during the smile) and coronal displacement of the keratinized tissue, which reduces the amount of keratinized attached tissues on facial aspect of the alveolus [29].

A flapless esthetic technique: during this procedure after the atraumatic extraction, the empty socket is filled with a particulate bone graft, and deep epithelialization of the internal coronal borders of soft tissue it’s done with the scalpel blade to induce a blood clot formation.

in the area to receive the soft tissue graft and help on the healing process of this autogenous free gingival graft used as socket seal taken from palate [29,30,36]. This FGG socket seal is sutured and secured in place over the graft of the socket seal.

This approach will increase the volume of tissue particularly the keratinized. The FGG must be free from rugae to prevent future problems with texture of tissue in the alveolus site. After this procedure when the tissue heals, the use of an ovoid pontic with a low pressure can make the shape of the gingival zenith, contour and papilla [30].

This procedure shows a successful result and excellent soft tissue stability, minimizing the soft tissue contraction, optimizing aesthetic results of implant restoration and prevention bacterial infections, preparing the hard and soft tissue to receive a dental implant and fixed restoration.
The extraction socket graft material should be osteoconductive, acting as a scaffold for growing bone and allowing bone formation to be distributed more efficiently within a given space. The particulate allograft have the potential to be replaced with new bone while keeping the space maintained until the bone fill is complete. The selection should be based on above criteria and the planned time of entry for implant placement, if dental implant if going to be placed around four or six month after the extraction, materials with more rapid resorption pattern should be utilized. In the other hand, if a dental implant is not planned initially in an extraction socket, alveolar preservation should still considered to reduce bone resorption, and the graft materials with slow resorption pattern should be considered [7].

This treatment can be done in combination with immediate implant placement if the hard tissue conditions are optimal, the implant can be uncover with a simple U-SHAPE incision on the crest of the ridge and de-epitheliased and rolled back on itself under the labial gingiva [1,30,36].

When the alveolar socket it’s classified as type 3 or the residual alveolar bone crest volume in partially edentulous patients it is not enough to an optimal implant placement, the surgical approach is different, more traumatic and sometimes include a hard tissue donor site, which means an extra wound and healing phase, knows as alveolar reconstruction/Shell technique (Khoury), onlay graft, inlay graft, ridge expansion/ridge splitting are a few techniques available to analyzed as a reconstructive treatment choice which shows a high success rate.

**Alveolar reconstruction/Shell technique**

This technique involve the use of a thin cortical plates harvested from ramus to recreate the buccal plate or palate, fixed in a sandwich type manner; interposing these plates with cancellous bone harvested from the same site or particulate allograft. This technique suffers from similar disadvantages of most harvesting techniques, the need for a second surgical or donor site, but has shown success and a less complication rate [33,34].
Onlay grafting

When the graft material is laid over the defective area to increase width, height or both of the alveolar bone. The host bed is usually perforated with a small bur to promote the formation of a blood clot between the graft and recipient bed. The block of bone graft is fixed with non-resorbable screws that should be removed in a second surgical moment. In this kind of cases, choose a donor site it's important, the extra-oral sites like iliac crest shows less implant survival rate than intra-oral sites like ramus or symphysis, the morbidity is important to considerer as the bone volume needed to reconstruct the alveolar defect [37,38].

There are two keys to succeed, first the graft should be stable without micro movement and second, the friction between the fixation screws, the bone graft and host bone must be not excessive to avoid osteonecrosis and bone resorption.

Onlay bone graft from mandibular symphysis, case 1
Onlay bone graft from mandibular symphysis, case 2

Figure 31

Inlay grafting

This technique consists of a section of maxilla surgically with a bone saw, creating a line of fracture that will separate the bone into two sections, and graft material must be placed like a sandwiched between them, like Le Fort I osteotomy and interpositional block of bone graft is fixed between the maxillary segments. This procedure is limited to severe maxillary relationship that might lead to an inadequate final prosthetic outcome from a functional and esthetic viewpoint [38].

Ridge expansion/Ridge splitting

This procedure consists of perforating a narrow ridge (minimum ridge width of 3 mm is recommended) with a small bur, and split longitudinally and parted to widen it and allows placement of an implant or graft material or even both at the same time with the use of osteotomes, sometimes the use of a bone saw can help to separate the ridge in a new buccal and palate plate [41]. This approach is also named as Ridge Splitting, bone spreading, or ridge expansion. The 3 mm of minimum width are preferred to avoid complications like bone fractures and resorption. This technique is more applicable in the maxilla than the mandible because the quality of the bone. It is recommended make a crestal incision and minimal mucoperiosteal reflection to expose the ridge crest to leave the periosteum intact [38,42,43].

Ridge expansion

Figure 32
An alternative to an autogenous graft is the guide bone regeneration or GBR. It is the least invasive of all the bone regenerative techniques and often involves using a barrier membrane to isolate the grafted zone from the surrounding soft tissue. This allows the slower growing bone regenerative cells to penetrate the defect without interference from surrounding tissues [35]. The use of barrier membranes also have disadvantages like the exposure even is a collagen or titanium mesh, compromising the clinical results with high infection potential after the barrier membrane exposure.

The literature review and clinical evidence has demonstrated that a wide range of surgical procedures can be used to correct atrophied alveolar ridges in the maxilla (horizontal or vertical defects). Every technique can be performed in combination with a multiple grafts materials and the success rate is demonstrated with the survival or lost of dental implants on each case [39,40]. Analyze every clinical...
Aesthetic Approach for Post-Extraction Alveolar Socket in the Anterior Maxilla: Literature Review and Clinical Evidence

aspect, the systemic condition and the expectation of the patient can make you decide the adequate reconstructive treatment choice. Many researchers in their investigations and mainly the systematic reviews like Agaloo TL and Moy PK, Which Hard Tissue Augmentation Techniques Are the Most successful in Furnishing Bony Support for Implant Placement? Make us understand the fact that the survival rate of dental implants in grafted sites it’s related with the contact between implant surface and native bone (residual crest) and also with the compatibility of the embryonic origin of the graft and the host. This compatibility will help in the adaptation of the block of bone graft or even in the new blood vessels formation.

After the clinical evaluation and conversation with the patient about their expectations, the understanding of limitations of the hard and soft tissue augmentation, and the healing time needed for the treatment plan with multiple surgery’s, an alternative is suggested to a surgical reconstruction to replace the missing tooth with an individual implants. A fixed gingival restoration in the anterior maxilla screw retained it can be planned like any other implant surgery, from clinical photography, impressions for study models, bite registration, dental gingival diagnostic wax-up and CBCT tomography using a radiographic stent created from diagnostic wax-up to be evaluated the 3D positions of implants that are needed and the numbers of implants required.

The ideal position and tooth size, gingival zenith’s, balanced occlusion, palate screw retained restoration and a short treatment time compared with the vertical and horizontal soft and hard tissue augmentation, reaching the desired functional and esthetic outcome is the main goal with this predictable technique. The limitation is the necessary complex oral hygiene that is required for maintenance [45,46].

In any of this treatment options, if the planification is poor, complications will occur later of the treatment process or in a short period of time after the installation of any prosthetic restoration on dental implants. Curiously in implant dentistry every restoration have a period of success of five years after the day one, then our restorations are under the survival period, if everything is going well [47]. All this when a treatment is planificated from the initial evaluation to the installation of prostheses.

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As an oral surgeons, prosthetist, periodontist or general dentist with a high level of oral implantology training and experience, is our duty to serve our patients with responsibility and commitment. The knowledge means everything and is everywhere around us, is on the books, on the articles, professor experience, classrooms or training programs. In oral implantology the margin for error is so small, 1 mm more subcrestal or supracrestal can mean a difficult hygiene with bacteria’s proliferation and inflammation with the subsequent periimplantitis or a threads exposure with a non-esthetic result. Every time we are with a patient, we are doing science. Also, it is important to realize the fact that we just have one chance to do things right. It is easier to be planned and avoid complications than to have to solve complications with each patient.

We receive patients with functional and esthetic complications in my office from other practices every month, that deserve to be shown to encourage a dentist which desire an oral implantology practice, to get a formal training, because in my opinion it is a privilege to help people to achieve their demands and expectations.

Here a few examples of some wrong and terrible diagnosis without prosthetic and surgical planning.

**Figure 37**
Aesthetic Approach for Post-Extraction Alveolar Socket in the Anterior Maxilla: Literature Review and Clinical Evidence

At the beginning of this review, the major importance of the final prosthetic design of the implant restoration was mentioned, but is not available enough scientific evidence or systematic reviews that can relate the implants prosthetic restoration design with the success of the dental implants placed in a previous grafted sites and the different techniques and materials. For this reason, further investigation is needed to establish which augmentation technique and which graft material is indicated for every single restoration design.

Conclusion

The main reason of this paper is to create the idea that get a formal training is to develop the diagnosis criteria who will make you design treatment plans in order to avoid complications and achieve clinical success. As an oral surgeon, prostodontics, periodontics or general dentist is our commitment to establish a responsibility with our patients and perform any clinical treatment based on literature evidence. In the oral implantology field, more than 50 years of clinical evidence make us easy the proper selection of the adequate treatment plan in challenging clinical cases. There is not enough data that can relate the success of the implant supported restorations with dental implants placed in previous grafted sites, describing which augmentation technique and materials were used. That is why further information is needed to improve our clinical protocols.

Bibliography


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