Management of Extraction Site for Implant Placement

Bach Le, DDS, MD, FICD, FACD
F. Kyle Yip, MS, DDS, MD

Healing of the Extraction Site

Early histologic studies in the mid-20th century of human and animal extraction sockets by Mangos, Christopher, Amler, and Boyne, explored in detail the early and late phases of socket healing. Evian further characterized socket healing between four and 16 weeks in 1982 utilizing biopsies of sockets and core biopsies. The following sequence was generally seen in healthy sockets:

1. Day 1 – Clot formation
2. Day 2-7 – Granulation tissue fills socket
3. Day 4-20 – Connective tissue replaces granulation tissue; spindle cells, collagen fibers, and early vascularity is seen
4. Day 7 – Bone formation begins with uncalcified spicules and osteoid at the socket base and periphery
5. Day 20 – Mineralization begins
6. Day 40 – two-thirds socket filled with immature bone, lamina dura becomes lost
7. Day 50-90 – Bone matures into trabecular pattern resembling alveolus
8. Day 100 – Socket density comparable to surrounding bone, minimal residual osteogenic activity

Socket Epithelialization

Proliferation of epithelium at the periphery of the socket was noted by Amler to begin at day 4. Amler and Mangos found complete fusion of the overlying epithelium around day 20-30, although some sockets were noted to remain incompletely covered at day 35. Amler noted that epithelialization was delayed by sloughing epithelium at edges of ragged and traumatized native epithelium, but minimal sloughing was found at the edges where clean incisions were made.

Dimensional Changes of the Socket and Ridge

The alveolar process is comprised of both cortical and bundle bone. The term bundle bone is used because of the insertion of Sharpey’s fibers from the periodontal ligament (PDL). It comprises a thin layer surrounding teeth, while the remainder of the alveolus is cortical bone. Al-Hezaimi et al. demonstrated in monkeys that the blood supply to the alveolar process surrounding teeth comes from the PDL, interdental bone, and overlying supraperiosteal vessels. During tooth extraction, loss of the PDL and damage to
the interdental bone and vasculature results in resorption of the bundle bone. Araujo demonstrated in dogs that the bundle bone is replaced by woven bone, resulting in significant vertical reduction of the buccal crest. The outer surfaces subsequently resorb on both buccal and lingual aspects, resulting in horizontal bone loss. In single extraction sites or small areas, up to 50% reduction in width may occur in the first year, with the majority occurring in the first 3 months. The buccal plate resorbs at a greater degree than the lingual plate, resulting in a lingual migration of the alveolar crest. In multiple extraction sockets, damage to interdental vasculature and loss of PDLs results in proportionally more width and height reduction than single sites. A systematic review in 2009 of 11 papers reported a mean reduction in alveolar ridge width of 3.87 mm after tooth loss.

Atraumatic Tooth Extraction

Tooth extraction should involve as minimal injury as possible to the surrounding bone and soft tissue. Damage to the labial plate can exacerbate horizontal and vertical resorption, while damage to the interproximal bone can result in loss of papilla. Unnecessary flap elevation should be avoided to minimize devascularization of the labial plate and exacerbate labial bone loss. Flap elevation during tooth removal has been reported to increase bone resorption by 16%. Sectioning of teeth and the judicious use of peritomes, proximators, and luxators will aid in expansion of the PDL space and tooth removal while limiting trauma to the surrounding alveolus. Once the tooth is removed, the socket should be inspected in all dimensions for integrity of the surrounding bone.

Socket Preservation and Augmentation

Adequate crestal bone and ridge thickness is a prerequisite for implant placement. Alveolar bone loss after extraction may result in compromised implant position or angulation. Since buccal bone is more susceptible to resorption than other areas of the alveolar ridge, techniques to maintain or correct existing defects are necessary for ideal implant placement.

Socket grafting for ridge preservation has been advocated to decrease the amount of bone loss following tooth extraction. Socket grafting, socket augmentation, and ridge preservation also are commonly used terms to describe grafting of the socket. Controlled animal and clinical studies have demonstrated a significant reduction in bone loss after tooth extraction when socket grafting is performed. This may obviate the need to undergo more invasive bone augmentation procedures, thereby shortening treatment duration. Some opponents of socket grafting claim that placing foreign material may hinder bone growth and become “osseo-obtrusive.” Histology from these studies have demonstrated a decrease in vital bone formation with retention of graft particles up to four years after placement. Stavropoulos studied xenograft compared to no graft in a guided tissue regeneration (GTR) rat model and found interference of new bone formation with xenograft. Utilizing a Teflon capsule for space maintenance, xenograft was compared to empty space. Histology at one year after grafting showed that bovine bone xenograft resulted in only 23% volume of newly formed bone compared with 88% in the empty capsule control group. Nevertheless, the presence of residual graft materials at four months after socket augmentation has not been
shown to affect the osseointegration of implants.  

**GRAFT MATERIALS**

*Autogenous bone*

Araujo demonstrated histologically in a dog model that autologous bone chips in a fresh extraction socket were almost completely resorbed (2% residual non-vital bone chips) at the 3-month mark. Overall, the autologous bone chips did not stimulate or retard bone formation, but failed to prevent ridge resorption after tooth extraction. However in a human study with iliac crest bone graft, Pelegrine demonstrated no statistically significant change in the amount of mineralized bone after 6-months (42% vs. 45%), but did show a reduction in ridge resorption compared to untreated controls (1.14 mm vs. 2.46 mm horizontal, 0.62 mm vs. 1.17 mm vertical). These limited studies show autogenous bone may be a viable graft material, but will require an additional surgical site and increased morbidity.

*Allograft*

Allografts also have been studied for socket preservation. Histologic analyses of sites grafted with allograft have shown adequate bone formation for implant osseointegration. Mineralized human allograft has demonstrated a range from 27-68% vital new bone formation, 4-15% residual graft particles, and 38-58% non-bone connective tissue in various histologic studies taken at four to six months. This appears to demonstrate greater vital new bone formation and decreased residual graft particles compared to bovine-derived bone material (xenograft) (33.3-46.3% vital new bone formation, 26-36% residual graft particles at eight to nine months).

The timing of implant placement after socket grafting has had limited study. Beck and Mealey compared biopsies at the 3-month and 6-month post-operative time point after ridge preservation with mineralized allograft. They demonstrated similar new bone formation (45.8% vs. 45%) and residual graft material (14.6% and 13.5%) at the 3-month and 6-month post-operative periods respectively.

There is some debate between the use of mineralized and demineralized variants of allograft. Mineralized bone retains more structural integrity, while the decalcification of demineralized bone is thought to expose bone morphogenetic protein BMP and increase osteoinduction. Wood and Mealey demonstrated at the 4-month mark after augmenting intact sockets that demineralized bone allograft had a significantly greater percentage of vital bone (38.4% vs. 24.6%) and significantly lower percentage of residual graft particles (8.8% vs. 25.4%) when compared to mineralized bone. Neither showed any significant difference in alveolar ridge changes. However, sockets with buccal wall defects or atrophic ridges may not be adequately treated using demineralized graft material due to its lack of structure. Mineralized grafts have been shown to produce comparable results to autogenous bone for augmentation in atrophic alveolar ridges, and long-term structural stability.

*Xenograft*

Xenograft is bone material derived from animal sources such as bovine or porcine bone. Bovine bone matrix has been reported to preserve the alveolar ridge with adequate bone formation and enable successful implant placement. Histologic analysis of bone retrieved nine years after sinus augmentation and implant placement revealed that bovine graft remnants persisted (16%), and newly formed bone accounted for only 46% of the biopsy specimens. This persistence of graft materials is consistent with other
reports taken after implant loading from six months to four years. These authors noted that the bovine graft material was in intimate contact with newly formed bone, and that newly formed bone was in intimate contact with implant surfaces. While the graft material may remain, its slow resorbing qualities may aid its function in space maintenance. There were no differences in vital bone to implant contact when comparing sinus augmentations with xenograft vs. autogenous bone.

While certain graft materials, xenografts in particular, demonstrate very slow resorption rates, it is not conclusive whether this affects vital bone formation or if any effect is clinically significant with respect to implant success. The success of integration and initial implant survival is dependent on two aspects of bone quality; the density and rigidity of bone and hence its ability to establish primary stability, and the availability of vital bone for bone-to-implant contact at the microscopic level. It has been shown that bone-to-implant contact around osseointegrated implants ranges from 42% to 96%, but it is unknown what absolute minimum is required for long-term success. Studies comparing autografts to xenografts with histologic analysis of bone-to-implant contact have shown similar degrees of osseointegration, and residual graft particles incorporated in direct contact with newly formed bone. This is consistent with systematic reviews that have demonstrated no decrease in survival rates with implants placed in GBR-treated sites and augmented sinuses.

**Alloplast**

The term alloplast encompasses bone substitute material that is synthetic in nature. This can include a variety of materials including but not limited to hydroxyapatite variants, bioactive glass, calcium sulfate, and collagen. Advantages for using synthetic material include eliminating the risk of disease transmission, and the avoidance of biologic materials that patients may refuse for personal or religious reasons. Clinical and histologic studies have shown that various alloplasts demonstrate improved vital bone formation and reduced residual graft material to allografts and xenografts, and are appropriate for socket grafting. However, a recent systematic review of randomized controlled clinical trials of various graft materials revealed that while histologic outcomes were better with alloplasts, there was no decrease in ridge dimension loss compared to sockets with no grafting. However, sockets grafted with allografts and xenografts showed significant reduction in loss of ridge dimensions. This suggests that while alloplasts demonstrate good osteoconductive properties, they may not have the structural stability needed to maintain or augment ridge dimensions.

**Particle size**

In selecting particulate graft material, particle size is an important consideration. In a controlled animal study, cortical allograft with particle sizes between 90-300 microns produced rapid healing by direct ossification when placed into critical-sized defects, while particles larger than 300 µm healed more slowly, and those that were too small were not osseoconductive. Although graft materials of different types and sizes are capable of bone formation when used for socket preservation, a thorough understanding of the material of choice and its handling properties is important for successful ridge preservation and subsequent dental implant placement.
TECHNIQUE

*Sockets with intact labial walls*

Various techniques have been described for ridge preservation after tooth extraction. One technique involves partially filling the socket with graft material and then occluding the top of the socket with a collagen plug to protect the graft. No flap is elevated, and a figure-of-eight suture is utilized to help retain the collagen dressing.

Other authors suggest utilizing a free gingival graft taken from the palate, while others do not use any occlusive dressing. Another technique involves raising a mucoperiosteal flap to secure the bone graft with a membrane. For socket defects with an intact labial plate and normal crest level, the senior author prefers to place a small-particle cancellous allograft without a barrier membrane (Figure 1A-D).

Several recent systematic reviews have been unable to demonstrate superiority of one ridge preservation technique over another, although two suggested that flap elevation and membrane usage might improve results.

Furthermore, although these reviews demonstrate socket grafting can minimize ridge resorption, there is no conclusive evidence that these procedures improve the ability to place implants. Further study focusing on long-term esthetic outcomes of implants after socket augmentation is needed.
Sockets with labial wall defects

Teeth with periapical radiolucencies, labial fistulas, or lost as a result of trauma often have compromised labial walls (Figure 2A-N). These defects can lose as much as 40%-60% of the alveolar ridge width within 1-year. 20, 74, 75 Different techniques to address labial wall defects using guided tissue regeneration have been described. Although adequate clinical documentation is still lacking, a flapless approach has been described, which involves positioning a barrier membrane within the socket and packing mineralized allograft into the socket.

Fig. 2A

Fig. 2B

Fig. 2C

Fig. 2D

Fig. 2E

Fig. 2F
Teeth with labial wall defects require socket augmentation using guided tissue regeneration with an open flap to overcorrect the alveolar ridge to achieve ideal contours.
While a flapless surgery may be technically easier to perform, this technique inherently limits bone regeneration to the confines of the socket, and likely resorbs past the confines of the original labial wall during the healing process. Anatomical contours may not be achieved, necessitating further augmentation procedures.

Augmentation with an open-flap approach is recommended for sockets with labial wall defects, yielding predictable peri-implant tissue, bone stability, and contour. Opening extraction sockets with labial defects facilitates access for removal of tenacious granulation tissue and fibrous scar tissue that is often associated with chronic long-standing infection. On occasion, teeth with labial bone defects may also be accompanied by overlying soft tissue loss and recession (Figure 3). The senior author prefers to use the “open book” flap for augmentation of these defects, particularly in sites where there is loss of labial attached tissue.
**Fig. 3D**  C-D Open Book Flap incision design

**Fig. 3E**  
Mineralized cancellous allograft placement with overcorrection and collagen membrane coverage

**Fig. 3G**  Soft tissue closure; note slight exposure of membrane left to heal by secondary intention

**Fig. 3H**  
Healing at 4 months post-operative with flapless implant placement

**Fig. 3I**  
H-I Healing at 4 months post-operative with flapless implant placement
The open book flap is developed with a crestal incision made slightly lingual to the ridge midline to preserve an adequate amount of keratinized tissue in the flap. This is followed by a distal, curvilinear, vertical incision that follows the gingival margin of the distal tooth. A wide subperiosteal reflection is made to expose 2 to 3 times the treatment area, and then the papilla is reflected on the mesial side of the edentulous site.

(Figure 4A-B) Raising a flap for correction of the anatomical defect allows for flap release and tension-free expansion of the soft tissue matrix. Secondary bone augmentation may still be required in larger defects with multiple missing walls. Tenting screws may be used for overcorrection of the defect and support of the overlying tissue.47 Because most bone graft procedures inherently result in secondary remodeling and resorption,79 it is important to factor in the amount of anticipated resorption by overcorrecting the defects so that the critical 2 mm threshold of labial bone is achieved in the final result (see Figure 2E).

**Fig. 4A** Open Book Flap Design. The open book flap design should be utilized for large defects to improve visualization and access to the graft site.
Barrier membranes

Ridge preservation may be performed with or without the use of membranes. Recent systematic reviews have suggested that the use of membranes improves graft stability. As a socket heals, bone healing progresses at a slower rate than the overlying soft-tissue, resulting in loss of dimension. Membranes function by preventing soft-tissue ingrowth and allowing the bone matrix to mature. Non-resorbable membranes predictably prevent epithelial ingrowth, but are more susceptible to exposure and have higher rates of infection compared to bioresorbable membranes. Some studies have shown the higher exposure rate does not always equate to graft resorption. One randomized controlled study compared non-resorbable polytetrafluoroethylene (PTFE) membranes to resorbable collagen membranes for ridge preservation without primary closure. The authors did not find any significant difference in clinical or histologic outcomes between the two interventions. Both groups resulted in keratinized tissue covering the exposed membrane by secondary intention.

Barone et al., in a clinical study on socket augmentation with healing by secondary intention, reported secondary soft tissue healing over grafted sockets did not compromise bone formation and soft tissue level and width of keratinized tissue were improved (see Figure 2G-H). Other studies have demonstrated better tolerance with exposure of resorbable membranes.

Immediate implants

Although immediate implants have been shown to integrate with high success rates similar to implants placed with a delayed approach, studies have shown that implants placed into extraction sockets do not necessarily prevent alveolar ridge changes, and may often be subject to some labial gingival recession.

(Figure 5) In a retrospective analysis of 42 single-tooth implants placed in the esthetic zone, Evans et al. found a highly significant change in crown height due to marginal tissue recession of approximately 1 mm, with no difference seen between implant systems. Thin tissue biotypes showed slightly greater recession than thick-tissue biotypes.

![Labial Gingival Recession](image)

Various technical advances have improved marginal bone loss and soft tissue recession after immediate implant placement. These differences are due to a number of important advances, including the introduction of platform-switch designs, immediate provisionalization, and advanced understanding of implant positioning.

Platform-switching

Recent short-term studies have reported diminished crestal bone loss and better peri-implant maintenance when the implant-crown margin is moved away from the outer circumference of the implant and repositioned inward, closer to the center of the implant’s restorative platform. This technique is now commonly known as platform-switching. Platform switching has been shown to reduce marginal bone loss in a proportional...
manner to the abutment-implant discrepancy. Canullo followed 22 patients with immediate implants and provisionalization for two years, and demonstrated less facial recession and more papilla height in platform switched immediate implants compared to controls. One study reported that this restorative technique allows implants to be placed closer together with less crestal bone loss.

As long-term documentation becomes available, utilizing the platform-switching concept may enable esthetic outcomes with the placement of multiple adjacent implants.

**Immediate provisional restoration**

Immediate placement of dental implants into fresh extraction sockets with immediate delivery of a provisional restoration in the esthetic zone is a concept first reported by Wöhrlé in 1998. A recent systematic review by Slagter demonstrated that immediate provisionalization at the time of immediate placement in sockets with intact bony walls minimizes bone level changes to <0.5 mm without affecting survival rates.

(Figure 6A-J) Block *et al.* found no statistically significant differences in crestal or interproximal bone levels when comparing immediate or delayed implant placement with immediate provisionalization in the anterior maxilla.
Immediate implant placement with immediate provisionalization.
The authors concluded that immediate implant placement with provisionalization resulted in approximately 1 mm less facial gingival recession compared with that in the delayed group.

DeRouk also found in a 1-year single-blind randomized study that submerged implant placement followed by delayed restoration had significantly more midfacial recession (0.75 mm additional) compared to immediate provisionalization. This is consistent with observations from previous studies that demonstrated immediate and delayed changes in peri-implant tissue after restoration delivery, indicating that adaptive responses to provisional contours may help maintain tissue levels.

**Buccal plate integrity and thickness**

An implant placed into an intact extraction socket, has been shown to osseointegrate and form bone as long as a stable blood clot can be maintained. Fresh sockets with a thick labial plate >1 mm will respond more favorably to treatment with immediate implants with less facial recession. The flapless approach for immediate placement should be the preferred technique in these cases to reduce loss of buccal bone width and height. Thin labial plates (< 1 mm thickness) demonstrated increased labial resorption and decreased gap fill. Januario et al. reported that over 50% of maxillary anterior teeth have labial plate < 0.5 mm. In these cases, an open flap approach with with external grafting of the socket wall for overcorrection of ridge contours should be considered. (see Figure 2A-N)

**Immediate implants with buccal wall defects**

Controversies exist in the literature regarding the proper management of extraction sockets with a buccal plate defect. Historically, the literature does not recommend immediate implants if the buccal plate is compromised due to the increased risk of labial marginal recession. However, multiple authors have demonstrated predictable implant survival with simultaneous GBR of facial wall defects with immediate implant placement. Le et al. assessed the outcome of single stage (non-submerged) implant placement and simultaneous augmentation of 156 sites with vertical buccal defect using a mineralized particulate allograft covered with a collagen membrane. The vertical buccal defects were classified as small (less than 3 mm in depth), medium (3 – 5 mm in depth), and large (greater than 5 mm in depth). The initial vertical buccal wall defect was recorded by measuring the amount of vertical implant platform’s rough surface exposure after implants were placed. Sectional CBCT scans were used at 36 months after graft healing. The site of the original vertical bone defect was evaluated for the presence of any residual vertical bone defect. The results showed the presence of bone in 100% and 79.3% of small and medium size vertical defects, respectively. Large size defects showed only partial improvement without any complete correction. Single-stage implant placement with simultaneous bone grafting to support the soft tissue margin showed promising outcomes in correcting vertical buccal wall defects of less than 3 mm.
(Figure 7A-I) Kan studied twenty-three patients with immediate implant placement with facial wall defects and guided bone regeneration, and found that the defect morphology was highly correlated with gingival recession after one year. In patients with a V-shaped defect where the interproximal boundaries of the defect were intact, only one out of 12 patients demonstrated greater than 1.5 mm recession. In U-shaped or Ultra-U-Shaped defects however, where either or both sides of interproximal bone was compromised, >1.5 mm recession was found in 43% and 100% of cases. This emphasizes the concept that graft material must have some amount of "housing" by native bone in order to adequately consolidate and regenerate new bone.
Single-stage Implant Placement with Simultaneous Bone Grafting.

Open book flap design with aesthetic contour graft and non-submerged closure around healing abutment.

A 3-walled defect, after immediate implant placement, effectively leaves a 2-walled defect or zero or 1-walled defect. This is dependent on the condition of interproximal bone and the buccal-lingual positioning of the implant. Interestingly, Zitzmann et al. suggested that immediate or early (within 6 weeks to 6 months but after soft tissue coverage of the socket) implant placement and GBR allows for improved defect correction compared to delayed placement and GBR. The authors found that more ridge resorption had occurred in the delayed group, resulting in 92% of these defects demonstrating zero or a 1-wall defect, and poorer defect correction compared to immediate and early groups.

In the case of apical facial wall defects, where the crestal aspect of the buccal bone is intact and sufficiently thick, the implant can be placed in a flapless manner to minimize ridge remodeling. The apical dehiscence can then be addressed with a small flap through the mucosa and guided bone regeneration.

Biotype
Patients exhibit differences in their gingival phenotypes, often termed “gingival biotypes.” Most patients fall into two categories: slender teeth with thin gingiva and scalloped periodontium, or square teeth with thick gingiva and blunted periodontium. 

(Figure 8A-B) In a study of 100 volunteers, De Rouck et al. demonstrated that approximately one-third of the patients exhibited thin biotype, which was usually associated with females. Two-thirds were thicker biotypes usually associated with males. They classified the two biotypes by using the translucency of the gingiva on probing as a marker for thickness: if the probe was visible through the facial gingival tissue, this was considered a thin biotype. Much consideration has been given to the thickness of the gingiva related to implant dentistry. The thinner biotype is more prone to recession and loss of interdental papilla. While objective data studying esthetic outcomes with anterior implants are limited, some clinicians advocate the routine use of connective tissue grafts to transform thin biotypes into thicker tissue for enhanced esthetic outcomes. If an implant site exhibits a thin biotype, a connective tissue graft or bone augmentation should be considered prior to or simultaneously with implant placement.

Peri-implant marginal gap (Jumping gap)

When placing implants into fresh extraction sockets, a marginal defect around the implant may result, referred to as the jumping gap. (Figure 9) Many practitioners have been placing bone grafts or bone substitutes into these defects, based on previous animal studies showing that a gap of more than 1 mm may lead to incomplete marginal bone formation and apical migration of the bony crest.

Fig. 8A  Gingival Biotype. Most patients will fall into two categories: slender teeth with thin gingiva and scalloped periodontium or square teeth with thick gingiva and blunted periodontium.

Fig. 8B  Gingival Biotype. Most patients will fall into two categories: slender teeth with thin gingiva and scalloped periodontium or square teeth with thick gingiva and blunted periodontium.

Fig. 9  Peri-implant Marginal Gap (Jumping gap).
Conversely, a more recent animal study showed that defects larger than 1 mm eventually led to complete bone formation with a rough-surfaced implant, and no clinically detectable change in bone height. The same authors subsequently found in a human study of 21 implants that gaps ranging from 1-3 mm healed predictably with new bone formation without the use of graft material or membrane. This result was again confirmed in a split-mouth study with dogs and lingual positioning of implants, with or without grafting of a 1.7 mm gap. No loss of bone height or difference was seen between groups. Another prospective study in dogs comparing buccal gap sizes of 1 mm, 2 mm, and 3 mm with Laser-Lok (Biohorizons) implants showed a direct relationship between increasing gap size and bone volume and soft tissue volume at 2-months. Furthermore, the authors demonstrated that a 3 mm gap was resistant to resorption at four months in comparison to the 1 mm and 2 mm groups.

(Figure 10) The authors concluded that 3 mm is the critical size for optimal buccal bone and soft tissue thickness to form. Tarnow, in a recent retrospective cohort study, evaluated 49 immediate implants in the esthetic zone without flap elevation, and compared groups +/- grafting of the gap and +/- provisionalization based on study casts measuring horizontal changes compared to contralateral control teeth. They found that groups without grafting or provisionalization had an average of 1 mm buccal-palatal dimension change at 6 months to 4 years.

Provisionalization reduced this to 0.6 mm change, and bone grafting reduced this to 0.3 mm change. A group with both provisionalization and grafting demonstrated only 0.1 mm change. These data suggested that provisionalization and grafting together most predictably maintain esthetic contours. Further comparative research in humans to determine the effect of gap size and grafting the gap on implant survival and esthetic outcomes still is needed.

Implant position

Dental implant therapy should be prosthetically driven and not primarily bone-driven. To this end, the implant must be accurately placed in a 3-D (mesiodistal, labiobuccal, and apicocoronal) position with the goal of achieving a proper emergence profile for the final restoration. When the implant position is not accurate, the esthetic result is often compromised. Implants placed too deep apico-coronally or too labially often result in an unnaturally long restoration.
(Figure 11A-B) In addition, implant position has been shown to have a direct influence on bone and soft tissue thickness related to the implant. Le et al. studied the relationship between crestal labial soft tissue thickness and implant bucco-lingual angulation.

The bucco-lingual angulation was recorded as cingulum, incisal, or labially-angled based on the position of the screw access hole of the provisional restoration. The implant labial bone thickness was measured at the crestal and mid-implant levels using sectional cone beam computed tomography scans. Of implants with cingulum, incisal, and labial angulations, 3.4%, 20%, and 53.3%, respectively, demonstrated crestal labial soft tissue thickness of < 2 mm. Implants with cingulum angulation had a mean crestal soft tissue thickness of 2.98 mm, while those with incisal and labial angulation had decreased mean tissue thickness of 2.24 and 1.71 mm, respectively.

(Figure 12) A significant association between crestal labial soft tissue thickness and implant bucco-lingual angulation was noted when implant labial bone thickness at crestal level was < 2 mm (P < 0.01). The investigators concluded that implants with labial angulations carry a higher risk of soft tissue complications when the crestal implant labial bone thickness is < 2 mm.
Soft tissue grafting

Several authors suggest concomitant connective tissue grafting to compensate for anticipated loss of labial tissue volume at the time of immediate implant placement in the maxillary anterior area.\textsuperscript{131, 132} Grunder reported an average tissue collapse of 1.06 mm in the horizontal dimension without connective tissue augmentation, as compared to 0.34 mm gain with connective tissue grafting six months after surgery.\textsuperscript{131} Rungcharassaeng noted an increase in tissue thickness after immediate implant placement in both grafted and non-grafted cases, but that grafted cases were significantly thicker than non-grafted cases.\textsuperscript{132} Non-grafted cases demonstrated an increase from 1.1 mm to 1.4 mm, but grafted cases demonstrated an increase from 1.2 mm to 2.6 mm.\textsuperscript{132}

A minimum of 2 mm thickness is suggested to conceal zirconia, and 3 mm for all other restorative materials in the prosthesis.\textsuperscript{133} In contrast, Le et al.\textsuperscript{130, 134} demonstrated that proper implant positioning, angulation, and maintenance of buccal bone thickness led to facial soft tissue thickness without the need for connective tissue grafting.

(Multiple immediate implants)

Single-tooth implant restorations are more likely to have predictable soft tissue anatomy whereas multiple implants often have compromised soft tissue anatomy.\textsuperscript{135} Loss of the interproximal bone and vasculature after multiple-tooth extraction results in a greater degree of bone loss and ridge remodeling than does single-tooth extraction.\textsuperscript{10}

Sufficient distance must be present between implants in order to avoid inter-implant bone loss and shortened papilla height,\textsuperscript{136} with 3 mm reported as the minimum to maintain an optimal papilla height. Although the type of implants used was not specified, some advocates of newer implant designs and surfaces have reported significantly less bone loss than older traditional implant designs. Novaes\textsuperscript{137} demonstrated in a dog model with platform-switched implants that there was no difference between 1, 2, and 3 mm distances and papilla formation was established in all groups.

If an adjacent central and lateral incisor is planned for implant-supported replacement, the lateral incisor site may be considered for substitution with a pontic.\textsuperscript{138, 139} Soft tissue height between an implant and pontic has been reported to be as high as 5.5 mm,\textsuperscript{140} and may allow for increased papillae height. Pontic site development has also been advocated in selected cases by using the root submergence technique\textsuperscript{139} in order to maintain the underlying alveolar dimensions.

When multiple teeth are indicated for extraction, a staged approach utilizing strategic extractions of selected teeth and fabrication of either a tooth-borne or implant-borne temporary fixed partial denture (FPD) will help to decrease bone loss and maintain the supporting bone and tissue architecture.\textsuperscript{12, 141}

Table 1  Labial Soft Tissue Thickness and Labial Bone Thickness.
Linear correlation between labial crestal soft tissue thickness and underlying bone thickness.
(**Figure 13A-H**) In a controlled animal study, Favero *et al.* demonstrated that tooth extraction next to a socket into which an immediate implant is placed caused more bone loss in both bucco-lingual and mesio-distal dimensions compared with sites adjacent to a maintained tooth. ¹⁴¹

---

**Fig. 13A**

**Fig. 13B**

**Fig. 13C**

**Fig. 13D**

**Fig. 13E**
Socket shield technique

A recent technique for alveolar ridge preservation, dubbed the “socket shield” technique,\textsuperscript{142} has been proposed\textsuperscript{139, 143-146} whereby the buccal remnant of the root is intentionally retained to maintain the buccal bundle bone. Davarpanah\textsuperscript{147} demonstrated successful implant placement and loading with implants in contact with ankylosed root fragments. Utilizing these principles, Hurzeler et al.\textsuperscript{142, 148} placed immediate implants with an enamel matrix derivative (Emdogain) into hemi-sected roots of a dog, while maintaining a thin buccal veneer of the root. After four months, histology revealed that the alveolar crest was free of any resorptive process. The root fragment also demonstrated newly-formed cementum between areas of clinically direct contact with the implant threads. The implant body demonstrated mineralized tissue deposition and cementum between it surface and the root dentin. This concept was applied in a case study involving a central incisor with a root fracture,\textsuperscript{142} and was subsequently adapted by Kan and Rungcharassaeng\textsuperscript{149} with interproximal root fragments for maintenance of interproximal bone
**Figure 14A-C** Root fragments were maintained 1 mm coronal to the bone crest in order to maintain support of dentogingival tissue

(Figure 14A-C)

(Figure 14D), and implants were placed in an immediate fashion

(Figure 14D)

**Figure 14E**. After implant healing and restoration, peri-implant bone and tissues were well maintained

(Figure 14E)
One additional retrospective study of 46 patients demonstrated 100% survival rate, with only 0.2 mm average bone loss over 2 to 5-year follow-up. One patient in their study demonstrated apical root resorption of the residual fragment, but this did not affect implant survival. Further study is needed on this technique to evaluate its efficacy and utility.

Current literature suggests that immediate implant placement in molar sites demonstrates high survival rates from 89-100%. While prospective, controlled clinical trials are limited, a recent systematic review (2016) and meta-analysis of 768 implants demonstrated a cumulative survival rate of 98% with no difference between the maxilla and mandible. Meta-analysis of marginal bone loss after at least 1 year was estimated to be 0.57 mm. This is
consistent with a previous systematic review of 1,013 immediate implants demonstrating a cumulative survival rate of 99%. If sufficient primary stability is achievable, some authors also have demonstrated success with immediate occlusal loading. 

Immediate implant placement in molar sites presents a few unique challenges. A pre-operative CBCT is critical to assess the position of the maxillary sinus for maxillary implant placement and the IA canal for mandibular implant placement. Considering molar prosthetics, a wider platform implant (5 mm) should be placed into the center of the socket for ideal axial loading and restoration. Wider bodied implants also may help engage the walls of molar extraction sites and contribute lateral enforcement to primary stability. However, a recent systematic review has shown that ultra-wide implants (>6 mm) demonstrate a significantly higher failure rate (3.67 vs. 1.45%) than wide (4-6 mm) implants in molar extraction sites. This suggests that an optimum implant width exists, larger than which may increase failure rates. Regardless of implant size, the molar site’s multi-rooted void limits the amount of remaining bone for engagement and primary stability. To address this, some authors advocate sectioning of the crown and drilling the implant osteotomies prior to root removal in order to guide and stabilize the osteotomy position. They reported a success rate of 19 out of 20 implants with one early failure and no late failures. If lateral stability is insufficient, apical bone may be engaged for primary stability if at least 5 mm of apical bone exists, but this is often precluded by the position of the sinus floor or inferior alveolar nerve. Grafting vs. non-grafting of the residual socket gaps does not appear to change implant survival or marginal bone levels. 

Maxillary extraction sites are unique due to tri-rooted sockets that may reduce available horizontal bone, and also may be limited vertically by sinus pneumatization. A CBCT study of 95 patients demonstrated the mean distance between the sinus floor and maxillary first molar mesio-buccal, distal-buccal, and palatal root apices as -0.36 mm, 0.32 mm, and -2.2 mm respectively.

The mean distance from the maxillary first molar furcation to sinus floor was 6.51 mm (SD=2.94 mm). Forty-six percent of patients demonstrated >5 mm apical bone and 68% of patients demonstrated >5 mm horizontal bone between root apices sufficient for implant placement. If sufficient horizontal bone and a minimum of 4 mm vertical native bone exists, an osteotome sinus elevation may be performed simultaneously with immediate implant placement. With less than 4 mm native bone, a lateral window sinus elevation is recommended either in a simultaneous or staged approach.

**Immediate implants in localized infections**

Immediate implants placed into sites with localized infection such as periapical radiolucencies have shown equal survival to non-infected sites. Chrcanovic, in their systematic review, evaluated immediate placement of implants into infected sites. Although a cumulative survival was not calculated, all twenty-one human studies demonstrated over 90% survival, with the vast majority over 97%. This is consistent with earlier systematic reviews demonstrating high success of immediate placement of implants into infected sites.

**Risk Assessment**

Procedures with a high level of predictability will have a small number of esthetic failures defined by significant tissue recession or exposure of the abutment margin. Based on the many important factors that may affect the esthetic outcome of immediate implant
treatment, we recommend a thorough risk assessment analysis when considering immediate implant as a treatment option.

(Figure 15)

<table>
<thead>
<tr>
<th>Biotype</th>
<th>Low Risk</th>
<th>Moderate Risk</th>
<th>High Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buccal crest</td>
<td>&lt; 3 mm</td>
<td>3-5 mm</td>
<td>&gt; 5 mm</td>
</tr>
<tr>
<td>Buccal bone thickness</td>
<td>&gt; 1 mm</td>
<td>0.5-1 mm</td>
<td>&lt; 0.5 mm</td>
</tr>
<tr>
<td>Buccal gap</td>
<td>&gt; 3 mm</td>
<td>1-3 mm</td>
<td>&lt; 1 mm</td>
</tr>
<tr>
<td>Position of implant</td>
<td>Cingulum</td>
<td>Incisal</td>
<td>Labial</td>
</tr>
</tbody>
</table>

Fig. 15 Risk Assessment of Critical Factors Affecting Immediate Implant Success.

CONCLUSION

It is reported that up to 16% of single implant restorations in the esthetic zone fail for esthetic reasons, with gingival recession and a lack of interdental papilla being the most common complications. Esthetic outcomes are predictable with a thorough understanding of bone and soft tissue physiology and implant principles. Most complications can be avoided with proper treatment planning and execution.

REFERENCES


