Immediate Maxillary Molar Implant Placement with Simultaneous Crestal Approach Maxillary Sinus Bone Graft and Flapless Extraction

Jone Kim, DDS, MS

INTRODUCTION

P.I. Bränemark introduced the idea of osseointegration when he noticed the incorporation of titanium with bone tissue.¹ The concept of osseointegration revolutionized the replacement of missing teeth with dental implants. Greater understanding in bone and soft tissue physiology, accelerated by technological advances, has resulted in significant improvements in dental implant surgery; enabling a reduction in the number of surgeries with less invasive surgical techniques, optimized esthetics, and decrease in the length of total treatment time from extraction to final restoration. Contemporary implant surgeons employ less traumatic surgical techniques, place implants immediately, and combine multiple surgical techniques with fewer surgeries.

The posterior maxillary molar site is particularly challenging due to reduced alveolar bone and the presence of the maxillary sinus. A ridge preservation bone graft and/or a maxillary sinus bone graft is often required prior to implant placement, complicating immediate implant placement. Simultaneous flapless extraction, crestal sinus lift, immediate implant placement and ridge preservation can be combined into one surgical visit for the reconstruction of posterior maxillary molars with appropriate preoperative evaluation and meticulous surgical technique.

EXTRACTION

There is a theoretical advantage to flapless extractions in decreasing bone resorption. Canine studies comparing flapped versus flapless extractions of second, third and fourth premolars without bone grafting or implant placement demonstrate no significant difference in horizontal and vertical bone loss.²⁻⁴, ⁵ However, canine studies comparing flapped versus flapless extraction of more anterior first and second premolars demonstrates a significant difference with less bone resorption with the flapless technique. ⁶ A plausible explanation for this difference between the two studies may be that the stripping of the periosteum in areas of thinner buccal bone in the more anterior portion of the maxilla causes greater bone resorption. Studies have shown that thin buccal bone (< 1 mm) has more bone resorption compared to thicker bone (> 1
In addition to alveolar bone resorption, full thickness flap may lead to marginal recession at the adjacent teeth, defective papillae and loss of keratinized mucosa.\(^\text{13}\)

Flapless surgery makes it simpler to bone graft the socket than flapped surgery. The flapless extraction socket is basically an empty cavity where bone grafting particles can be placed with ease and with less mobility. In addition, since no incisions are made, a flapless extraction results in less surgical trauma, shorter surgical time, no need of suturing and decreased swelling and pain. Because of these advantages, the flapless extraction technique should be considered for all teeth that require an extraction, even if the extraction site is not for socket management or immediate implant placement.

However, the most important aspect of the extraction, in the author’s view, is not whether the flap is made or not but rather minimizing removal of bone. Therefore, the extraction technique should focus on preserving the alveolar bone, especially the buccal and interradicular bone. Among the socket bony walls, buccal bone is the thinnest and will, therefore, resorb more than other bony walls, and the preservation of interradicular bone is critical for immediate molar implant placement after the extraction.\(^\text{7,9,14,15}\) If the flapless extraction is too difficult, it is better to make a minimal flap and remove less bone than to do a flapless extraction with more bone removal. If the flapless extraction can be achieved with no bone removal, then this should give the best clinical outcome.

### RIDGE PRESERVATION BONE GRAFT (RPBG)

After extraction, the surrounding alveolar bone goes through stages of remodeling resulting in alveolar dimensional changes.\(^\text{16-18}\) Cardaropoli et al.\(^\text{17}\) and Araujo and Lindhe,\(^\text{18}\) demonstrate horizontal and vertical bone resorption is from loss of bundle bone within two weeks after extraction. The crestal part of the buccal bone is solely made up of bundle bone, whereas lingual bone is comprised of lamellar and bundle bone. After extraction, since the crestal part of the buccal bone is made primarily up of bundle bone, increased bone resorption is observed in buccal bone compared to lingual bone.\(^\text{17-24}\)

Immediate bone grafting is performed after the extraction to preserve the alveolar ridge, to minimize future bone grafting, and increase the success of the implant surgery. There is horizontal bone reduction of 32% at three months, and 29-63% at six to 12 months after extraction.\(^\text{18,19,25-30}\) There is 11-22% vertical bone resorption observed at six months post-extraction and increasing vertical resorption with multiple extractions.\(^\text{19,22,31,32}\) Ridge preservation bone grafting (RPBG) is a predictable surgical modality to preserve the alveolar bone after the extraction and allow for wider and longer implant placement.\(^\text{19,33-37}\)

In a recent randomized controlled clinical trial, 48 implants were placed into either RPBG sites or spontaneously healed extraction sites four months after tooth extraction. All implants survived at the one year follow up, but during surgery, 14/24 (58%) spontaneously healed extraction sites required additional bone grafting,
whereas only 1/24 (7%) needed additional bone grafting in RPBG sites. There is an inverse correlation, resulting in thinner buccal bone showing a two-fold increase in horizontal bone loss compared to thicker buccal bone in spontaneous healed sites. Whether there is thick or thin buccal bone, without bone grafting there is an average of 4.04 mm horizontal reduction. There is no correlation between the thickness of the buccal bone and alveolar bone loss in RPBG sites. In an RPBG site there is an average of 0.71 mm horizontal bone reduction. RPBG is able to compensate for alveolar bone contraction for both thin and thick buccal bone plates. Therefore, what is important is not the thickness of the buccal plate, but rather whether or not RPBG was performed after the extraction.

RPBG ideally should be performed in a flapless manner to prevent horizontal bone loss and maintain keratinized gingiva. In a prospective randomized clinical trial that compared flapped and flapless RPBG, horizontal bone loss was 3.5 + 0.9 mm and 1.7 + 0.6 mm for the flapped and flapless approach, respectively. In addition, the flapless technique showed an increased width of keratinized gingiva compared to pre-operative measurement, whereas the flapped approach showed decreased width. However, the flapped group had a slightly less vertical buccal bone reduction compared to flapless (-0.6 + 0.7 vs. -1.1 + 0.9 mm), which was statistically significant.

Even though autogenous bone is the gold standard for bone grafting, many bone graft alternatives such as xenograft, allograft, alloplast, and bone morphogenetic protein have been used in RPBG. Currently, there is no consensus on one bone graft material being superior to the others. No matter which bone grafting material or surgical technique is utilized, the ultimate goal of RPBG is to preserve the alveolar bone for future implant placement reducing the need for additional bone augmentation at the time of implant placement.

IMMEDIATE IMPLANT PLACEMENT

In the beginning stages of implant surgery, implants were primarily placed in a delayed manner. Extraction sockets healed for several months prior to implant placement. Implants placed in a delayed approach have a high success rate. The first clinical study of immediate implant placement was published in 1978. Surgical techniques have evolved along with increased knowledge of bone healing in the extraction site to improve the immediate placement of dental implants with predictable results. Short term survival rates and clinical outcomes are similar in both immediate and delayed approaches. Advantages of immediate implant placement include the reduction in the number of surgeries and treatment time, preservation of alveolar height and width, optimal gingival esthetic, ideal implant placement and patient’s convenience. There is more favorable bone healing and improvement in soft tissue contour with immediate placement.

One of the major concerns with immediate implant placement is the presence of infection at the extraction site. Successful outcomes have been demonstrated with placement of implants placed into extraction sites with periapical lesions. A retrospective study of 418
immediate implants placed into extraction sites with periapical lesions demonstrated a 97.8% survival rate with mean follow up of 67 months. Immediate implant survival rates are similar for extraction sites with or without perapical lesions.

There are several factors that are important to ridge alteration and survival after immediate implant placement: thickness of buccal wall, horizontal bone gap and initial primary implant stability.\textsuperscript{7,57,63,78} Thicker bone in the buccal wall resulted in less resorption of the buccal wall, which will decrease the chance of dehiscence and other implant complications.\textsuperscript{7,9,39,78,79} In the posterior maxilla there will frequently be a horizontal gap after immediate implant placement due to the fact that the dimension of the socket is larger than the diameter of the implant.

For maxillary first molar, the average mesio-distal and bucco-lingual measurement is 10.4 and 11.5 mm, respectively.\textsuperscript{80} If the gap is within 2 mm, after implant placement, spontaneous healing without bone grafting can occur.\textsuperscript{57,81} If the gap is wider than 2 mm, bone grafting is recommended for immediate implant placement after extraction in order to minimize bone resorption.\textsuperscript{63} Adequate primary stability is another critical factor for a successful clinical outcome in an immediate implant placement and loading of the implant.\textsuperscript{82,83} Currently, studies demonstrating that primary stability is not crucial with implants with special types of surface treatment have only been done on delayed implant placement not on immediate implant placement.\textsuperscript{84,85}

Pre-operative and post-extraction evaluation of the socket and bone is important for determining if primary stability of the implant can be attained. For immediate molar implant placement after extraction, besides vital structures such as the maxillary sinus, adequate dimensions of the alveolar bone, particularly of interradicular bone, are crucial for achieving primary stability of the implant.\textsuperscript{15,86} Primary stability of the implant is achieved by placing the implant in the interradicular bone. Anatomical dimensions of the interradicular bone will depend upon tooth and trunk length and root morphology;\textsuperscript{80} the more divergent the roots are the wider the interradicular bone. Vertical length of the interradicular bone can be limited by pneumatization of maxillary sinus. The location of interradicular bone is usually the ideal site for implant placement. When there is an absence or inadequacy of interradicular bone for immediate molar implant placement, the surgeon may attempt to place the implant in one of the root sockets. However, placing the implant at an off-angle will increase the magnitude of force to the implant and surrounding bone.\textsuperscript{87} In addition, an implant that is placed in a compromised position may lead to difficulties with abutment and crown placement and hygiene. Therefore, good extraction technique to preserve the socket wall and interradicular bone is vital to the successful outcome of immediate implant placement after an extraction.
MAXILLARY SINUS BONE GRAFT

Maxillary sinus bone graft (MSBG) was first introduced by Tatum in 1976. Subsequently, Boyne and James published the first study of maxillary sinus bone grafting using autogenous bone grafting in 1980. Ever since then, a lateral window approach, derived from the Caldwell-Luc procedure, has been the surgical choice to treat vertically deficient bone in the posterior maxilla. Even though autogenous bone is the gold standard, different bone grafting materials have been used in the lateral approach MSBG with predictable results.

The obvious indication for MSBG is inadequate vertical alveolar bone in the posterior maxilla for implant placement. As long as the bone grafting does not extend to block the ostium, bone grafting in the sinus is not contraindicated and is generally a benign procedure. Contraindications for MSBG can be categorized into two groups: patient (medical) and sinus (local) factors. Some of the patient or medical contraindications include chemotherapy or radiotherapy of the maxillary region, immunocompromised status, medical conditions affecting bone metabolism, pregnancy, uncontrolled diabetes and alcohol or drug abuse. Sinus or local contraindications include inadequate transverse dimension of the sinus, intranasal acute or chronic sinusitis, unrepaired oroantral fistula, recent nasal or sinus surgery, cysts or tumors of the sinus, and ostium in the surgical site.

In addition to these contraindications, there are factors that may predispose certain patients to implant failures in the maxillary sinus. One of the predictors of implant failure in the posterior maxilla is smoking. Studies have shown that smoking is a relative risk to implant failures. In regards to effects of smoking in MSBG, a retrospective study by Zinser evaluated 1,045 implants placed in the grafted maxillary sinus and concluded that smoking doubled the relative risk of implant failure. In contrast, a review of implants placed in maxillary sinus lift sites by Pjetursson, et al. did find higher failure rates for smokers compared to non-smokers (3.5% vs. 1.9 %, respectively), but this difference was not statistically significant. Other predictors of implant failure in the posterior maxilla that were mentioned are bone quality, time lapse from extraction to implant placement, residual alveolar bone height, augmented compared to non-augmented sinus and membrane thickness.

After Tatum first introduced lateral approach MSBG, Summers published the first crestal approach (also known as transalveolar) to the sinus, using a set of tapered osteotomes with increasing diameter. Since then, MSBG has evolved over the years from lateral window opening to various crestal approach techniques, including using piezoelectric surgery, trephines, osteotome, hydraulic lift/pressure, press-fit bone block, drills specifically designed for crestal approach and modifications of these techniques. Studies comparing crestal versus lateral approaches to MSBG revealed that both techniques showed similar success in clinical results.

The main advantages to the crestal approach MSBG is that it can be done without a flap, with less post-operative
swelling and pain, minimal bone grafting materials and with reduced surgical time. The most common crestal approach MSBG technique is condensing and tapping of the bone with various diameter osteotomes to lift the sinus membrane, which was first described by Summers.

The crestal approach is simpler than the lateral approach MSBG in the immediately extracted molar sites. This is due to the fact that the unevenness of the maxillary sinus floor often occurs from molar roots protruding into the sinus, which can make a lateral approach MSBG more challenging. In addition, the lateral approach will require making a buccal bony window above the mesio-buccal and disto-buccal roots (approximately 12 mm in length) and continuously elevating the membrane inferiorly to the sinus floor, at which the lowest point is at the trifurcation of the roots. These factors can make the lateral approach sinus lifting more challenging immediately after the extraction.

In the crestal approach MSBG in immediately extracted molar sites, the opening into the sinus is through the interradicular bone, which is usually the most inferior part of the sinus floor in the maxillary molar. Elevating the membrane from inferiorly to superiorly, will result in uniform and “tent” like sinus elevation. Also, the crestal approach sinus lift is completed after a sufficient elevation and, thereby, reducing the overall sinus lifting. Whereas in the lateral approach, a much larger area of the sinus has to be elevated due to the inability to form “tent” like membrane elevation.

In addition, it is the author’s opinion that better stability of the implant can be achieved with a crestal approach due to “tent” like lifting of the maxillary sinus membrane. This “tenting” effect of the maxillary sinus membrane, via crestal approach, allows firmer condensing of the bone grafting particles within the elevated membrane space than the lateral approach, which usually has a much larger membrane elevated space that can allow more movement of the bone grafting particles.

In 2000, Cosci and Luccioli, published a study introducing a new sinus lift technique with the use of lifting drills to perforate, not fracture, the sinus floor and lift the membrane. This technique is referred to as the Cosci’s technique. The tip is specially designed so that it will not perforate the sinus membrane even if the drill tip makes contact with the membrane. There is no use of osteotomes. In this six year retrospective study, 265 implants were placed in a one stage crestal approach MSBG, in healed sites, with eight implant losses, resulting in a 97% survival rate. One study even compared Cosci’s technique to Summers’ technique. This study showed that both techniques displayed predictable results but Cosci’s technique required less surgical time, less intra- and postoperative morbidity and was preferred by patients. In another study, 134 implants placed in a multicenter retrospective study using Cosci’s technique, showed implant survival rate of 96.3% with average follow-up time of 48.2 months. In this study, the average preoperative alveolar bone height was 3.46 mm ± 0.91 mm, which further shows that implants can be successfully placed with simultaneous crestal approach MSBG in alveolar bone height of less than 5 mm.
INDICATIONS AND RATIONALE FOR IMMEDIATE MAXILLARY MOLAR IMPLANT PLACEMENT WITH SIMULTANEOUS CRESTAL APPROACH MAXILLARY SINUS BONE GRAFT AND FLAPLESS EXTRACTION

Reduced vertical alveolar ridge due to inherent bone remodeling is one of the challenges of an implant placement after the extraction of maxillary posterior teeth. In addition to anatomic limitations, maxillary sinus pneumatization, which ends normally at age 20, will continue to progress after the extraction with loss of vertical alveolar bone. Clinicians should consider preserving the alveolar bone height by immediate implant placement and/or immediate bone grafting to decrease the sinus pneumatization and alveolar bone loss. In addition, time lapse from the extraction to implant placement is one of the predictors of implant failure in posterior maxilla.

Immediately after the extraction the best treatment for posterior maxillary teeth may be an implant placement with simultaneous MSBG, if indicated. In a retrospective analysis, 391 implants were placed immediately after the extraction of maxillary molar teeth and 156 out of 391 implants required simultaneous MSBG due to inadequate alveolar bone height. Overall survival rate was 99.5% (389/391) after 75 month follow-up, showing that immediate maxillary molar implant placement at the time of extraction with simultaneous crestal approach has a high survival rate.

One of the drawbacks for crestal approach, as with the lateral approach, is achieving adequate primary stability of the implant at the time of MSBG. Most studies indicate that less residual alveolar bone results in increased implant failure rate. Therefore, studies have shown that ideal residual alveolar height, for immediate implant placement with simultaneous crestal approach MSBG, should be 5-6 mm to achieve primary stability of the implant. However, Gonzalez, et al., compared the success rate of immediate implant placement with simultaneous crestal approach MSBG, in healed extraction sites, with residual alveolar bone height of < 4 mm and > 4 mm, which showed 100% and 98.51% success rates, respectively. Simultaneous crestal approach MSBG and implant placement can be achieved in vertical alveolar bone of less than 5 mm with a high success rate.

The requirements for maxillary molar implant placement, immediately after the flapless extraction, with simultaneous crestal approach MSBG are: 1) adequate horizontal dimension for diameter of planned implant; 2) no major soft tissue defect, such as buccal or lingual fistula; 3) no oroantral communication (OAC) greater than 3-5 mm after the extraction; 4) no purulent discharge from socket and/or maxillary sinus after the extraction; 5) no major periapical and maxillary sinus infection and/or pathology; 6) no more than one alveolar wall defect; and 7) no symptomatic maxillary sinusitis. If any of the mentioned criteria are not met, the implant should be placed in a delay approach. Comprehensive pre-operative
clinical and radiographic evaluations to select an ideal surgical candidate for this technique are paramount to a successful clinical outcome.

Pre-operative radiographic evaluation for maxillary molar extraction should include the following: 1) horizontal and vertical dimensions of interradicular bone; 2) evaluation of maxillary sinus, such as infection, thickness of membrane and pathology; 3) presence of periapical radiolucency, such as bone loss, infection and lesion; 4) presence of OAC; and 5) evaluation of alveolar wall, such as wall defect, thickness of buccal bone and vertical and horizontal dimensions of the socket wall. It is possible to perform the surgery with a panoramic radiograph but a cone beam CT (CBCT) is highly recommended for pre-operative radiographic evaluation. (Figure 1A, B) Clinical evaluation for maxillary molar should include the following: 1) status of adjacent teeth; 2) soft tissue evaluation (such as keratinized tissue, gingival recession, swelling and fistula); 3) inter-occlusal and mesio-distal space; 4) clinical signs of parafunctional habits; and 5) occlusion.

Figure 1A. Cone beam CT of maxillary molar tooth.
A. Maxillary molar tooth with divergent roots with adequate interradicular bone for an immediate implant placement. Sinus is within-normal-limit (WNL).

Figure 1B. Maxillary molar tooth with inadequate interradicular bone for an immediate implant placement due to convergent roots. Notice the roots are protruding into the sinus. Sinus is WNL.

This technique is a preferred implant treatment plan for many, if not all, of the patients that desire an implant after the extraction when they are given delayed vs. immediate surgical options.

If the extraction, RPBG, MSBG, and implant placement are done in 2 or more surgeries, the patient may select a non-implant treatment option, due to increased treatment time, cost, and number of surgeries, even though an implant may be the best treatment option and the patient’s preferred plan. The added benefit for the surgeon is less operative procedures with less office visits.
SURGICAL TECHNIQUE FOR IMMEDIATE MAXILLARY MOLAR IMPLANT PLACEMENT WITH SIMULTANEOUS MAXILLARY SINUS BONE GRAFT AND FLAPLESS EXTRACTION

Pre-operative Regimen

The patient is given the following pre-operative antibiotic regimen: 1) If the patient has no allergic reaction to penicillin, the patient takes 2 grams of amoxicillin 1 hour prior to surgery and then 1 gram bid for 5 days; 2) If allergic to penicillin, the patient takes 600 mg clindamycin 1 hour prior to surgery and then 150 mg qid for 5 days. Just prior to surgery, the patient’s mouth is rinsed with chlorohexidine gluconate for approximately 15-20 seconds.

Flapless Extraction

As mentioned previously, the most important aspect of the extraction is not whether the flap is made, but rather that it is focused on minimizing the removal of bone. Therefore, the extraction technique should concentrate on preserving the alveolar bone, especially the buccal and interradicular bone.

After local anesthetic is administered, the first step is to gently free up the crestal gingival tissue away from the tooth without stripping off any of the periosteum from the alveolar bone. To do this, a 2/4 molt curette (Hu-Friedy, Chicago, Ill.) is placed into the gingival sulcus, including the interdental gingival tissue. The soft tissue is then gently pushed away from the tooth. Freeing up the crestal gingival tissue slightly allows for reduced trauma to the soft tissue from any instruments that will be in close contact during the extraction. A perioosteal elevator can also be used to free up the crestal gingival tissue. No incision is made and interdental papilla is not detached from the bone during the extraction.

Next, a periotome (Dowell, Rancho Cucamonga, Calif.) is used to separate buccal bone from mesiobuccal to mesiodistal and palatal bone from the trunk and root of the tooth. Use of a periotome will reduce the incidence of alveolar bone fracture and, more importantly, can be used to preserve the buccal bone in the socket, instead of having the buccal bone attached to the root during the extraction. Then a straight elevator or slightly curved elevator is placed into the sulcus to gently subluxate the tooth. After adequate subluxation, if there is enough tooth structure, an attempt is made to extract the tooth by using a modified upper forcep (Karl Schumacher, Linden N.J.). Using a modified forcep that has smaller and narrower beaks will reduce trauma to the alveolar bone and soft tissue, compared to a conventional upper forcep.

During the extraction, with a forceps or even with an elevator during subluxation, the crown of the tooth can fracture, leaving part of the crown, trunk or roots in the socket. If part of the crown or trunk is in the socket, it is sectioned to separate the multi-rooted maxillary molar tooth into multiple single roots. The goal is to section the multi-rooted maxillary molar tooth and remove the roots individually. However, during sectioning, be cognizant
to avoid removal of the buccal and interradicular bone, which is located just below the root trunk. Trunk length is approximately 4 mm.\textsuperscript{15}

Since maxillary molar teeth have 3 roots, section the remaining crown or trunk into 3 parts: mesiobuccal, distobuccal and palatal root.

(Figure 2) To accomplish this, a ½ or #2 round bur (SS White, Lakewood, N.J.) is used with a surgical handpiece. During trisecting of the roots, it is not necessary to touch the bone with the round bur. Preserving the interradicular bone is crucial for an immediate implant placement because this may be the only source of bone for the primary stability of the implant.

![Figure 2](image.png)

Figure 2. Multi-rooted maxillary molar tooth is sectioned into 3 separate roots, mesio-buccal (MB), disto-buccal (DB) and palatal (P) roots.

After trisecting the roots, a small elevator or 2/4 molt curette can be used to complete the separation of the roots and then, using the same instrument, subluxate and extract the roots. A thin periotome or root tip pick can also be used to loosen and remove the roots. If the roots are firmly embedded in the socket and difficult to extract, a ½ round bur can be used to section the roots, mesio-distally or bucco-lingually, and then remove the sectioned roots using appropriate instruments. All 3 roots can be removed in this manner.

After extraction of the three roots, the socket needs to be carefully examined for any potential complications. The following should be evaluated: sinus floor and membrane, socket wall, interradicular bone and presence of infection. If the sinus floor is difficult to visualize, the Valsalva maneuver can be gently performed to check for oroantral communication. After a thorough examination, the socket is gently curetted to remove any granulation tissue and periapical lesion. However, this step should be done with caution if the sinus membrane is exposed or perforated.

After careful curetting, thoroughly re-evaluate the socket. Depending on the clinical findings, the surgeon will decide at this time whether or not to continue with the next step, modify the treatment plan or abort the surgery. Whether to continue, modify, or abort the surgery will depend upon several factors: 1) sinus membrane perforation and size of perforation; 2) vertical and horizontal dimensions of interradicular bone; 3) size and location of bony wall defect; and 4) presence and extent of periapical and sinus infection. Based on these factors and clinical findings, the final decision will depend on whether the alveolar ridge can be preserved, the implant can attain primary stability, and a sinus bone lift can be predictably performed. If the decision is made to continue with the surgery, the next step is the crestal approach MSBG.
Crestal Approach to the MSBG

From the pre-operative CBCT and socket evaluation, approximate vertical and horizontal dimensions of the interradicular bone are estimated. Ideal bucco-lingual and mesio-distal position of the implant is usually the mid-crest of the interradicular bone. The author’s crestal approach maxillary sinus bone grafting technique is similar to the technique that was described by Cosci and Luccioli, where “lifting” drills are used to perforate the sinus floor without perforating the sinus membrane.

The first drill used in the crestal approach MSBG is a 1.3 mm pilot drill (Salvin, Charlotte, N.C.) at 800 RPM, with copious normal saline or sterile water irrigation. The depth of the drilling is approximately 1-2 mm short of the estimated vertical dimension of the interradicular bone. During drilling with a pilot drill, the sudden feel of denser bone may indicate that the drilling depth is at or close to the sinus floor, which is composed of cortical bone. Cortical bone will feel denser compared to medullary bone and the surgeon’s tactile sensations should be able to differentiate between cortical and medullary bone during drilling. The next drill used is a 2.0 mm twist drill, again 1-2 mm shy of estimated vertical length of the interradicular bone. After each drilling sequence, measure the depth of the drill site with a depth gauge or probe. It is important not to drill through the sinus floor with the twist drill, as this will increase the likelihood of sinus membrane perforation. After using the 2.0 mm twist drill, specially-designed crestal approach sinus (CAS) drills (Hi-Ossen, Fairless Hills, Pa.) (Figure 3A, B) at 600-800 RPM will be used to approach the sinus floor and enter the maxillary sinus without perforating the sinus membrane. These CAS drills come in various diameters (2.8, 3.1, 3.3, 3.6, 3.8, 4.1 mm) and the drill tip is specially designed to minimize sinus perforation even if the tip of the drill touches the sinus membrane.

![Figure 3A. Crestal approach sinus drill (CAS drill). A. 4.1 mm CAS drill.](image)

![Figure 3B. 4.1 mm CAS drill with a stopper.](image)

To further reduce the chance of sinus membrane perforation, drill stoppers are used during the drilling sequence to better visualize the depth of the drill, and to prevent entering the sinus too quickly. Drill stoppers come in various lengths and they
can be “snapped” into place at the junction of the drill and shank. Stoppers come in different lengths, in increments of 1 mm, which will indicate the length of CAS drill that will be entered into the drill site. A stopper will hit the ridge and prevent the drill from entering deeper once the appropriate length is reached.

The first CAS drill used is a 2.8 mm with a stopper that will give a slightly longer drill length than the last measured drilled depth. Then, sequential CAS drills with increasing diameter and shorter stoppers, to increase the length of the drill by increments of 1 mm, are used until the sinus floor is perforated. Drilling should be done gently and slowly to minimize sinus membrane perforation. In addition, all CAS drills do not need to be utilized for every case. During the drilling sequence, CAS drills that are close in diameter can be skipped, depending upon the “softness” and amount of the bone present. As soon as the sinus floor is felt, there should be a sudden “soft” feel with no resistance.

After the sinus floor is felt, carefully examine the site for any perforation of the membrane. If a visual evaluation of the sinus membrane cannot be achieved, the Valsalva maneuver can be performed gently to check for OAC. If the sinus membrane is not perforated, the next step is the hydraulic lifting of the membrane.

(Figure 4A, B) The purpose of this step is to gently elevate the membrane using sterile liquid, such as normal saline (NS), which will reduce the risk of sinus membrane perforation while elevating the membrane.

The hydraulic lifting is done using a NS filled 3 cc syringe that is connected to a rubber hose, which also has a broader rubber tip connected at the other end. The broader rubber tip will be placed right up against the crestal drill site and approximately 0.5 – 1.0 cc of NS will be slowly injected into the sinus cavity to elevate the membrane. After injecting NS into the sinus cavity, draw NS back into the same syringe and then inject more NS into the sinus cavity again, like a “pumping” action. This step is done multiple times to elevate the membrane slowly. One of the drawbacks with this step is that a significant amount of NS may leak out because the rubber tip may not fit...
tightly in the drilled implant site. This can make it more challenging to hydraulically lift the membrane. A best effort should be made to lift the membrane up to or close to the desired vertical length with hydraulic lifting.

After hydraulic lifting, the bone carrier is used to carry the bone grafting particles into the crestal drill site. Then, push gently into the sinus cavity with a bone condenser. Adequate sinus bone grafting can be verified with CBCT or a blunt-ended depth gauge. After adequate MSBG, the next step is implant placement.

**Immediate Implant Placement**

Horizontal and vertical dimensions of interradicular bone will determine the diameter and length of the last CAS drill to be used, and thus, that of the implant that will be placed. As mentioned previously, a CBCT can give approximate dimensions of the interradicular bone, which will determine the approximate diameter of the implant. However, the exact diameter of the implant will be determined during surgery. The last CAS drill will be determined by dimensions of the interradicular bone and should be at least 2-3 mm away from the buccal bone. This is usually not a problem for molar sites since the average bucco-lingual and mesio-distal measurement is 10 mm. Generally, the diameter of the implant that is placed in a molar site is 4-5 mm, with 5 mm being the most common, and the length is 10 -12 mm.

After bone grafting and attaining the desired sinus elevation, the implant is placed in a routine manner, just like it is done in any other immediate implant surgery. The final vertical position of the implant is usually at or just below the crest of the interradicular bone. If much of the interradicular bone is missing or removed during the extraction, the implant is placed 3-4 mm below the buccal gingival margin, assuming primary stability of the implant can be achieved and there is no significant gingival recession and buccal bone loss.

**Ridge Preservation Bone Graft**

Due to dimensional changes after the extraction, Ridge Preservation Bone Graft (RPBG) is a routine procedure for all immediate implant surgeries. After the implant is placed into a final position, the implant is covered with a cover screw, cotton ball or sterilized polytetrafluoroethylene (PTFE) tape (also known as plumber’s tape) prior to bone grafting in order to prevent bone grafting particles falling inside of the implant. If all the socket walls are intact, freeze-dried cortico-cancellous mineralized allograft (Osteokor, Surgikor, Calif.) is loosely packed into the socket, even if the gap is less than 2 mm. For any socket wall defect, which is usually the buccal wall, xenograft (Bio-Oss, Geistlich, N.J.) is placed in the bony defect area and then allograft is placed in the remaining socket space. Bone grafting particles are placed up to the fixture level and, after removing the cover screw or material that is covering the inside of the implant, the healing abutment is then placed. The top of the healing abutment should be at or slightly above the gingival margin. One of the main advantages of placing the healing abutment is faster soft tissue healing compared to primary closure.

After the healing abutment is placed, additional bone grafting particles are placed approximately 1-2 mm above the implant fixature level. Resorbable collagen
membrane (Cytoplast, Osteogenic Biomedical, Texas) is placed above any exposed bone grafting particles. There is no undermining of the soft tissue or periosteum during placement of the resorbable collagen membrane. Even though an incision or flap was not made, non-resorbable sutures (Cytoplast, Osteogenic Biomedical, Texas) are placed bucco-lingually to provide some gingival tautness and to prevent the resorbable membrane from coming out too early during normal oral function and hygiene.

SURGICAL CASES

Surgical Case 1

A 48-year-old male presents with failing root canal treatment (RCT) and unrestorable tooth #14. (Figure 5A-C) Patient’s past medical history (PMH) is non-contributory. Pre-operative clinical evaluation showed a missing crown of tooth #14, minimal gingival recession, and severe buccal abrasions of adjacent teeth. Adjacent teeth that show severe abrasions will be restored with new restorations PFM at a later time. Cone beam CT showed mild thickening of the sinus membrane, periapical infection with possible sinus floor perforation and approximately 5-7 mm of vertical length of the interradicular bone.
After treatment options were discussed with the patient, the chosen treatment plan was immediate implant placement after the extraction, with simultaneous MSBG.

(Figure 5D-F) After treatment options were discussed with the patient, the chosen treatment plan was immediate implant placement after the extraction, with simultaneous MSBG.

(Figure 5D) Pre-operative CBCT of MB root and interradicular bone of tooth #14.

(Figure 5E) Pre-operative CBCT of DB root and interradicular bone of tooth #14.

(Figure 5F) Pre-operative CBCT of palatal root (PR) of tooth #14. Slight thickening of the membrane is noted. From the CBCT, estimated vertical length of the interradicular bone is 5-7 mm.

(Since the detailed description of the surgical technique was outlined in one of the previous sections, only the key points of the surgery will be mentioned for surgical cases.)

Since the crown was missing, tooth #14 was sectioned to extract the mesio-buccal, disto-buccal and palatal roots separately without making a flap.

(Figure 5G, H) Next, a pilot drill is used to make the initial drill site, drilling about 1 mm short of estimated minimum vertical dimension of the interradicular bone that was measured in the CBCT. Then, a twist drill (2.0 mm) is used to make the drill site slightly wider and to drill up to the same vertical depth as the pilot drill. Then, a 2.8 mm CAS drill, which is the narrowest CAS drill diameter, with a 6 mm stopper will be used to widen the drill site and to increase
the vertical depth, gradually getting closer to the sinus floor.

Figure 5G. Without a flap, tooth is sectioned into 3 separate roots, MB, DB and P roots.

Figure 5H. Roots are extracted one at a time. Interradicular bone is preserved.

(Figure 5I, J) Sequential CAS drilling is followed with appropriate stoppers to increase the length of the drill, 1 mm incrementally, until the sinus floor is met. After each CAS drilling sequence, using a blunt ended instrument, the drill site is checked for sinus floor perforation, since the sinus floor can be partially perforated, such as in cases where the sinus floor is inclined or uneven.

Figure 5I. CAS drill with a stopper.

Figure 5J. The CAS drill with a stopper being used to perforate the sinus floor.

After the sinus floor is met and the membrane is intact, a hydraulic lift is performed. Approximately 0.5 – 1.0 cc of NS is pushed into the sinus cavity to elevate the membrane. During hydraulic lifting, the goal is to lift the membrane superiorly as possible but not more than the desired vertical length. After hydraulic lifting, bone grafting particles are gently condensed into a space between the sinus floor and the membrane is lifted until the sinus membrane is adequately elevated.
This can be verified with radiograph or a blunt ended measuring instrument.

(Figure 5 K,L) Bone carrier being used to place the bone grafting materials into the elevated sinus membrane space.

(Figure 5 M) A cover screw is placed and allograft bone particles are placed into the remaining socket space, similar to RPBG technique. The cover screw is then removed and the healing abutment is placed. Resorbable membrane is placed over the exposed bone grafting particles and non-resorbable sutures are placed in an interrupted manner.

(Figure 5 N) Surgery was uneventful and there was no sinus membrane perforation. The sutures were removed in 1-2 weeks and patient is to follow-up for 5-6 months or until the implant is ready for abutment and final restoration.

After adequate sinus elevation, an implant (5 x 10 mm) is placed in the ideal position, which is at or just below the crest of the interradicular bone, or 3-4 mm below the buccal free gingival margin.

(Figure 5 L) View of the implant site after bone grafting. Notice that the implant site is within confines of the interradicular bone.
Figures 5Q & R. Five month post-operative clinical views.

Figure 5S. Five month post-operative clinical view with healing abutment removed.

Figure 5T. Five month post-operative periapical radiograph.
Surgical Case 2

A 36-year-old female presents with failing RCT of tooth #14 with poor long term prognosis. (Figure 6A) Her PMH is non-contributory. Clinical examination showed multiple missing teeth, crowding of upper maxillary teeth and normal gingival soft tissue around tooth #14. Orthodontic treatment option, along with other treatment options, was discussed but the patient decided not to go through with the orthodontic treatment. Pre-operative CBCT showed mild thickening of the sinus membrane without any other lesions, and 3-7 mm of vertical length of the interradicular bone.

(Figure 6B-D) After treatment options were discussed, the treatment plan chosen was immediate implant placement, after the extraction, with simultaneous MSBG. (The sequence of surgical steps and follow-up will be similar to the one described for Surgical Case 1.)
Figure 6B. Pre-operative CBCT of MB root of tooth #14.

Figure 6C. Pre-operative CBCT of DB root of tooth #14.

Figure 6D. Pre-operative CBCT of PR of tooth #14. Sinus membrane is slightly thickened. From the CBCT, estimated vertical length of the interradicular bone is 3.7 mm.

(Figure 6E-I) There was no sinus membrane perforation or complications during the surgery. The sutures were removed in 1-2 weeks and post-operative healing was uneventful.

Figure 6E. Fractured crown during an attempt to extract with a forcep.

Figure 6F. Without a flap, tooth is sectioned into three separate roots, MB, DB and P roots.

Figure 6G. View of the finished implant site after bone grafting. Note the implant site is within the confines of the interradicular bone.
Figure 6H. Photo taken immediately after surgery.

Figure 6I. CBCT taken immediately after surgery. Note the dome or tent shape of the elevated sinus. (Implant dimension: 4.8 x 10 mm)

(Figure 6J-Q)

Figure 6J. Facial view one week post-operative. Note that the patient has no post-operative facial swelling.

Figures 6K & L. Clinical views five month post-operative.

Figure 6M. Clinical view eight months post-operative. Final restoration was placed six months post-operatively.
Surgical Case 3

A 51-year-old male presents with retained root tips of tooth #2. (Figure 7A) The patient’s PMH is non-contributory. Clinical examination showed missing teeth #4 and 30, normal gingival soft tissue, and missing crown of tooth #2 with retained root tips.
(Figure 7B, C) Pre-operative CBCT showed a thickened sinus membrane without any other sinus lesions, periapical radiolucency extending to the sinus cavity with sinus floor perforation, and 3-5 mm vertical measurement of the interradicular bone with resorption at the furcation.

(Figure 7D-F) For this case, the major concerns were periapical lesion, and ability to achieve primary stability of the implant due to vertical interradicular bone loss. After the extraction, interradicular bone, sinus floor and membrane will need to be thoroughly evaluated.
After treatment options were discussed with the patient, the treatment plan chosen was immediate implant placement, after the extraction, with simultaneous MSBG. (The sequence of surgical steps and follow-up will be similar to the one described for Surgical Case 1.)

**(Figure 7G – L)** After the extraction, the sinus floor was perforated but the membrane was intact. There was no sinus membrane perforation or complications during the surgery. The sutures were removed in 1-2 weeks and post-operative healing was uneventful.

*Figure 7G. Roots extracted without a flap.*

*Figure 7H. Using the CAS drill with a stopper to perforate the sinus floor.*

*Figure 7I. Use of a blunt-ended bone condenser to gently lift the sinus membrane during bone grafting. Marking on the bone condenser indicates that the sinus elevation is just beyond 10 mm.*
Figure 7J. Implant is positioned and the socket is filled with bone grafting particles.

Figures 7K & L. Immediate post-operative clinical views. Here, Gelfoam (Pfizer, New York, N.Y.) was placed over the resorbable membrane. This was one of the earlier cases and, currently, Gelfoam is no longer used.

Figures 7M & N. Clinical views 10 months after the surgery. Implant was ready in 5-6 months but the patient decided to wait on the final restoration.

Figure 7O. Periapical radiograph with the final restoration 11 months after surgery.
CONCLUSION

With a thorough pre-operative clinical and radiographic evaluation, a maxillary molar implant placement, immediately after the extraction, with simultaneous maxillary sinus bone grafting is a predictable treatment modality with a successful clinical outcome in an ideal situation, even with pneumatized maxillary sinus. Combining 4 proven surgical techniques into one surgery will reduce the total treatment time, and the number of surgeries and is the treatment option preferred by the patient who wants to have an immediate implant placement after a maxillary molar extraction.
REFERENCES


