

IN BRIEF

- The most important step in treatment planning is determining the prognosis of the remaining dentition.
- There is some evidence that placement of foreign materials into extraction sockets will interfere with normal bone formation.
- Immediate implant placement when indicated provides several advantages for both practitioner and patient.

Immediate implant placement: treatment planning and surgical steps for successful outcomes

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Diagnosis and treatment planning are key factors in achieving successful outcomes after placing and restoring implants placed immediately after tooth extraction. The efficacy of immediate implant placement has been established and shown to be predictable if reasonable guidelines are followed. Some or all of the following suggestions, depending on individual circumstances, should be considered when evaluating a patient for dental implants: thorough medical and dental histories, clinical photographs, study casts, periapical and panogram radiographs as well as a linear tomography or computerised tomography of the proposed implant sites. Reasons for tooth extraction include but are not limited to: insufficient crown to root ratios, remaining root length, periodontal attachment levels, periodontal health of teeth adjacent to the proposed implant sites, unrestorable caries, root fractures with large endodontic posts, root resorption, teeth with deep furcation invasions being considered as abutments for fixed partial dentures and questionable teeth in need of endodontic retreatment.

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INTRODUCTION

Teeth requiring root amputations, hemisections or advanced periodontal procedures may have a questionable prognosis and patients should be given the implant option before these procedures are implemented. Similarly, non vital teeth, fractured at the gingival margin with roots shorter than 13 mm, should be considered for the implant option. This review will describe the steps for immediate implant placement at the time of extraction as well as the 'gap' and socket preservation. We will also discuss the concept of minimally invasive surgery when applied to implants placed at the time of extraction.

Placement of endosseous implants has made it possible to restore patients who are fully or partially edentulous.¹⁻³ Original protocols required placement of implants into healed edentulous ridges. Lizzara placed implants at the time of extraction.⁴ These implants were augmented

with barrier membranes to preserve ridge width and height and to decrease total treatment time. Becker *et al.* reported a 93.3% implant survival rate for implants placed at the time of extraction and augmented with barrier membranes after one and five years following loading.^{5,6} Over the past 16 years numerous studies have confirmed the predictability of placing implants at the time of extraction.⁷⁻¹⁰ Small osseous defects are frequently found adjacent to implants placed at the time of extraction. These defects can be implanted with small autogenous grafts taken from edentulous ridges or other sites.^{11,12} A prospective clinical trial placed implants immediately after tooth extraction.¹¹ Defects were grafted with small autologous bone chips harvested from adjacent edentulous ridges. One year after implant loading the survival rates were 93.3% with clinically insignificant crestal bone loss. Others have used various materials and methods including demineralised freeze dried bone and barrier membranes to augment edentulous ridges and small defects adjacent to dental implants.¹³⁻²³ The stability of the implant can be verified using resonance frequency analysis.²⁴⁻²⁹ This method requires placement of an electronic transducer onto the implant head or prosthetic abutment with a retaining screw, and passing a low voltage current through the transducer. The current is not detected by the patient. Resistance to vibration of the transducer to the surrounding bone is registered in a special small

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computer. The original research measurements were made in Hertz. Hertz measurements have been calibrated for each transducer and are converted to Implant Stability Quotient (ISQ) units by the computer. Measurements are recorded as ISQ values.

A recent study evaluated stability of implants placed at the time of extraction with resonance frequency analysis.³⁰ Stability measurements were taken at the time of implant placement and after healing. The average interval between implant insertion and abutment connection was 5.6 months. Two implants were lost between implant insertion and one year. At two to three years the cumulative survival was 97.2%. Resonance frequency measurements at implant placement showed a mean primary stability of 62.0 ± 9.8 ISQ and a mean secondary stability after one year of 64.0 ± 9.8 ISQ for all implants. The increase was not statistically significant. The primary stability in the maxilla was significantly lower than in the mandible, while no difference was seen for secondary stability. Initial average stability measurements were high. Measurements taken after healing were not significantly higher than those recorded initially. Studies indicate that implants with an RFA greater than 50 are stable. Sites which receive implants at the time of extraction or within a short time after extraction demonstrate slight decreases in crestal bone width.^{30,31}

It is the purpose of this paper to review the concept of immediate implant placement and to expand the indications, limitations, anatomic, prosthetic and aesthetic requirements for placement of implants at the time of extraction. The concept of 'socket preservation' for sites that might receive dental implants as well as guided implant placement will be discussed. We will also introduce the idea of minimally invasive surgery and guided implant placement for implants placed at the time of extraction.

Diagnosis and treatment planning

Diagnosis and treatment planning are key factors in achieving successful outcomes after placing and restoring implants placed immediately after tooth extraction. Following some or all of the following suggestions, depending on individual circumstances, should be considered when evaluating a patient for dental implants: thorough medical and dental histories, clinical photographs, study casts, periapical and panoramic radiographs as well as a linear tomography or computerised tomography of the proposed implant sites.

The most important step in treatment planning is determining the prognosis for the dentition, and in particular prognosis for the tooth in question. Reasons for tooth extraction may include but are not limited to, insufficient crown to root ratios, remaining root length, periodontal attachment levels, status of furcations, periodontal health of teeth adjacent to the proposed implant site, unrestorable caries, root fractures with large endodontic posts,

root resorption and questionable teeth in need of endodontic retreatment.³² Teeth requiring root amputations, hemisections or advanced periodontal procedures may have a questionable prognosis and patients should be given reasonable options before these procedures are implemented. Similarly, the option for implant placement for non vital teeth, fractured at the gingival margin with roots shorter than 13 mm should be considered as the treatment of choice.³³ If treated using traditional methods, these teeth will require crown lengthening procedures, endodontic treatment, and posts and crowns. Removal of three or more millimetres of periodontal attachment during crown lengthening results in root length with less than optimal attachment. These factors are critical when teeth are being considered for abutments for fixed partial dentures. The risk to cost benefit ratio must also be considered.

In the aesthetic zone bone morphology, scallop of the periodontium, level of crestal and interproximal bone, smile line, morphology of the gingival tissues must be considered before initiating treatment.³⁴⁻³⁷ Proposed interimplant distance as well as existing contact relationships and interproximal bone must be analysed prior to implant placement.³⁸⁻⁴⁰ Patients with a thin or moderately thin periodontium will have soft tissue recession at the implanted sites. In these situations it is advisable to use orthodontic forced eruption procedures prior to tooth removal and implantation. This allows bone and soft tissues to move coronally, thereby assuring adequate mucosal tissue adjacent to the implant. Where there is a soft tissue deficiency subepithelial connective tissue grafting can further augment tissue height and thickness, thereby enhancing the aesthetic results.^{41,42} This procedure compensates for the slight soft tissue recession which usually occurs after tooth extraction.

Radiographic evaluation should consider availability of native bone, bone shape, quality, quantity, bone width and height. A minimum of 4-5 mm of bone width at the crest and 10 mm or greater from the alveolar crest to a safe distance above the mandibular canal is recommended.⁴³ Sufficient distance must be available coronal to the maxillary sinus and floor of nose. For a satisfactory aesthetic result in the aesthetic zone, the interproximal bone height should be 5 mm or less when measured from the contact point of the adjacent tooth. As the distance from the contact point to the interproximal bone increases, the likelihood of retention of the interproximal papillae post implant placement diminishes. Patients must be made aware of potential aesthetic shortcomings if implants are placed in jeopardised aesthetic zone sites.

Once the decision has been confirmed that the patient is a candidate for immediate implant placement, a surgical guide should be used to assure proper implant placement. A provisional appliance with an ovate pontic should be available for insertion after implant placement.⁴⁴⁻⁵⁰

Tooth extraction and implant placement procedure

The patient is anaesthetised and various flap procedures can be used to gain access for tooth extraction.⁵¹ Figures 1 to 11 represent the authors' routine surgical sequence for placement of a single tooth in the aesthetic zone after immediate implant placement using a minimally invasive method. Infection was present as evidenced by the purulent exudate exuding from the palatal aspects. Many clinicians postpone treatment of sites exhibiting infection. Villa recently reported on a case series of patients where implants were installed immediately after extraction.⁵² The extracted teeth exhibited signs of periodontal or endodontic infections. At two years the cumulative survival rate was 100%. The results of this study indicate that once the infected teeth were removed and implants placed, there are no adverse results for the implanted sites. Teeth to be removed and implants placed immediately after extraction can be accessed using either an open, flapped approach or with a minimally invasive technique. With experience the surgeon can displace the marginal tissues buccal/lingually to gain access to the surgical site (Fig. 5). A Molt C2 (Hufriedy, Chicago) curette can be used to luxate the root mesial-distally. Care must be exercised not to luxate buccal-lingually. Excessive force in this direction can damage the buccal plate. After tooth removal, a curette is used to explore the location of the buccal plate and confirm that it is intact. The surgical guide is placed over the surgical site and a sharp Precision Drill (Nobel Biocare, Precision Drill, Yorba Linda, California) is used to penetrate the palatal wall of the extraction socket (Fig. 7).¹¹ This drill guides the drills used to create the osteotomy. In the maxillary anterior region it is important to avoid placing the implant directly into the extraction socket. Placement of the implant in this position will invariably cause the implant to perforate the buccal plate and jeopardise implant survival. The axis of the implant must be even with the incisal edges of the adjacent teeth or slightly palatal to this landmark. A direction indicator should be used to verify the correct angulation and trajectory of the proposed implant (Fig. 8). Standard drilling procedures are performed according to the manufacturers' instructions. In the aesthetic zone, the implant head should be a minimum of 3 mm apical to an imaginary line connecting the cemento-enamel junctions of the adjacent teeth and apical to the interproximal and crestal bone.⁵³ A healing abutment or cover screw is placed in the implant. The healing abutment should be even with or slightly apical to the adjacent marginal tissues. Interproximal papillae adjacent to the implant can be adapted with interrupted sutures under minimal tension. The provisional is then inserted, and evaluated, making certain the pontic is clear of the healing abutment. The provisional restoration should have an ovate pontic to support the adjacent tissues and help preserve soft tissue anatomy



Fig. 1 The maxillary left lateral incisor has a blunted short root with a severe palatal infection related to a non-vital tooth

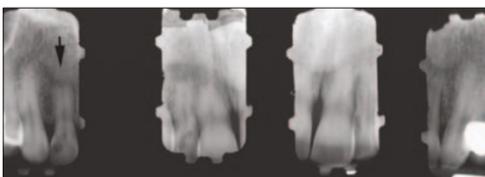


Fig. 2 Left maxillary lateral incisor (arrow) has a blunted apex, possible coronal fracture and a draining abscess



Fig. 3 Suppuration expressed from palatal aspect of maxillary left lateral incisor



Fig. 4 Extensive palatal granulation tissue

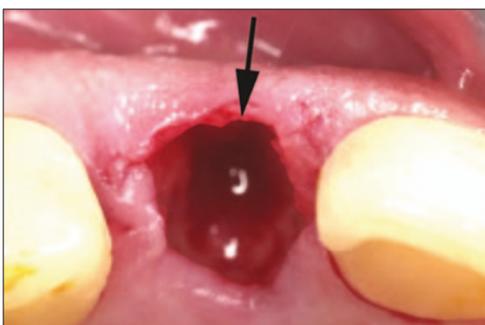


Fig. 5 Tooth has been extracted. Arrow points to socket

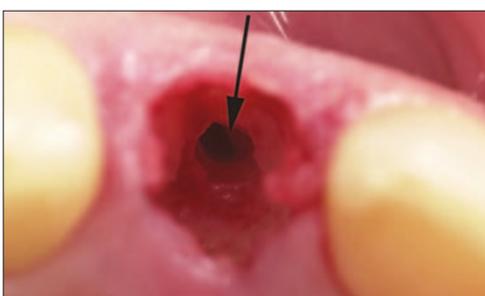


Fig. 6 Osteotomy has been prepared in palatal aspect of extraction socket

Fig. 7 Guide pin within palatal aspect of surgical guide



Fig. 8 Implant has been inserted into osteotomy and a 4 mm healing abutment has been placed onto the implant. Arrow points to gap between mucosal tissue and healing abutment

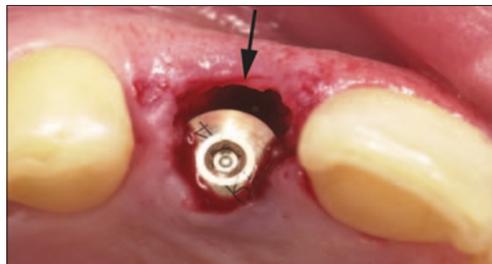


Fig. 9 Bovine bone has been layered into gap between mucosal tissue and abutment (arrow)



Fig. 10 Tissues sutured with no attempt to advance flap over bovine bone particles

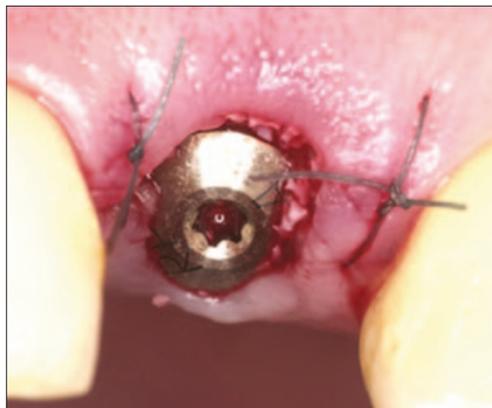


Fig. 11 Two year follow-up photograph. Note how interdental papillae fill entire embrasure spaces. There is slight soft tissue inflammation between lateral and canine



adjacent to the implant. The patient is instructed in proper after surgery care and sutures are removed in seven to 10 days. Restoration of the implant can take place once osseointegration has been confirmed (maxillary anterior region four to six months). In the event that an immediately placed implant would encroach upon the maxillary sinus, it might be prudent to delay implant placement, augment the sinus, allow for bone healing and then place the implant.

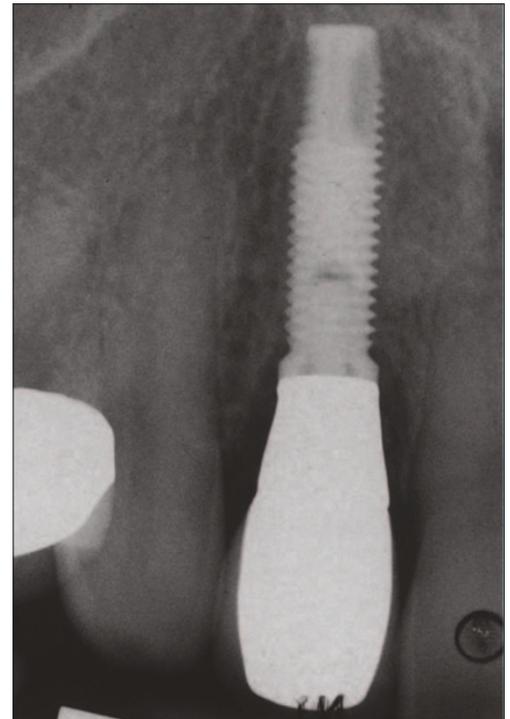


Fig. 12 Two year follow up radiograph. Note stable interproximal bone

The gap

On occasion the marginal tissues do not adapt to the healing abutment. In experimental studies, if the gap is too wide, connective tissue forms between the coronal implant aspect and surrounding bone.^{54,55} A series of animal and human studies has demonstrated that small gaps between implants and bone will fill with bone with or without grafting materials or barriers.⁵⁶⁻⁶¹ Botticelli *et al.* created 1.0-2.5 mm wide circumferential defects in dogs. At a few sites, the labial bone adjacent to the socket was reduced. Over a four month healing period the circumferential defects healed with bone. At sites where the labial bone was reduced, proper bone healing occurred at the mesial, distal and lingual defect aspects, but reduced bone volume occurred on the labial surface. The same authors repeated the study. Special implants were inserted into the defects, leaving a 1.0-2.5 mm gap between the implants and surrounding bone. Bovine bone alone or with a resorbable barrier was used to augment some sites, while others were left to spontaneously heal. It was demonstrated that at four months, all defects filled with newly formed bone and the biomaterial placed in the marginal defect in conjunction with implant installation became incorporated in newly formed bone tissue. A high degree of contact was established between the bovine bone particles and the newly formed bone. In the model used, bovine bone *did not* enhance the process of bone formation and defect closure. Recently a prospective trial was reported using various augmentation techniques at immediate implant sites.⁶² The efficacy of combinations of membranes and autogenous bone grafts at immediate implants were compared. Sixty-two

consecutively treated patients each received an immediate implant for a single tooth replacement at a maxillary anterior or premolar site. Dimensions of the peri-implant defect at the implant collar were measured as follows: vertical defect height (VDH), horizontal defect depth (HDD) and horizontal defect width (HDW). Each implant randomly received one of five augmentation treatments and was submerged with connective tissue grafts: Group 1 expanded polytetrafluoroethylene membrane only, Group 2 resorbable polylactide/polyglycolide copolymer membrane only, Group 3 resorbable membrane and autogenous bone graft; Group 4 autogenous bone graft only, and Group 5 no membrane and no bone graft control. At re-entry, all groups showed significant reduction in VDH, HDD and HDW. Comparisons between groups showed no significant differences for VDH (mean 75.4%) and HDD (mean 77%) reduction. Significant differences were observed between groups for HDW reduction (range, 34.1-67.3%), with membrane-treated Groups 1, 2 and 3 showing the greatest reduction. In the presence of dehiscence defects of the labial plate, HDW reduction of 66.6% was achieved with membrane use compared with 37.7% without membranes. Over 50% more labial plate resorption occurred in the presence of a dehiscence defect irrespective of the augmentation treatment used. The results indicate that VDH and HDD reduction at defects adjacent to immediate implants may be achieved without the use of membranes and/or bone grafts.

In practice, when the gap is present no effort is made to surgically advance the flap (Fig. 8). A small amount of allograft or alloplast is *layered* between the margin and implant abutment (Fig. 9). This material is left exposed. Within a few weeks some of the material will be exfoliated and gingival mucosa will migrate over the exposed materials and healing is uneventful.

Bovine bone has been used to augment small gaps adjacent to immediately placed implants.^{63,64} Results from these studies demonstrate that the bovine bone does not affect the survival of implants. It is important to recognise that placement of bovine bone, allografts or other substances with or without barrier membranes may support or improve soft tissue contours; however, these materials cannot be relied upon to enhance osseointegration.

Socket preservation

Socket preservation is a relatively new term to implant dentistry. It implies that placement of varying implantable materials within the sockets alone or with barrier membranes maintains socket anatomy. To date, there is inconclusive evidence this procedure maintains original socket dimensions. There is some evidence that placement of foreign materials into extraction sockets will interfere with normal bone formation.^{65,66} Iasella *et al.* compared normal socket healing with those grafted with demineralised freeze dried bone and covered with a collagen

barrier membrane.⁶⁷ Unaugmented or grafted sockets decreased in width by an average of 1.7 mm, while grafted sites decreased by 1.2 mm (difference of 0.5 mm). The quantity of bone observed on histologic analysis was slightly greater in preservation sites, although these sites included both vital and non-vital bone. Others compared ridge dimensions and histologic characteristics of ridges preserved with two different graft materials.⁶⁸ Twenty-four subjects, each requiring a nonmolar extraction and delayed implant placement, were randomly selected to receive ridge preservation treatment with either an allograft in an experimental putty carrier plus a calcium sulphate barrier or a bovine-derived xenograft plus a collagen membrane. Horizontal and vertical ridge dimensions were determined using a digital caliper and a template. At four months postextraction, a trephine core was obtained for histologic analysis. Allograft mixed with an experimental putty carrier produced significantly more vital bone fill than did the use of a xenograft with no carrier material. Ridge width and height dimensions were similarly preserved with both graft materials. Placement of materials into extraction sockets might be termed osseointerference.

There is evidence that resorbable barriers without grafting reduces alveolar ridge resorption after tooth extraction.⁶⁹ Following elevation of buccal and lingual full-thickness flaps and extraction of teeth, experimental sites were covered with bioabsorbable membranes; control sites did not receive barrier membranes. Titanium pins served as fixed reference points for measurements. Flaps were advanced in order to achieve primary closure of the surgical wound. There was no membrane exposure during the course of healing. Reentry surgeries were performed at six months. Results showed that experimental sites presented with significantly less loss of alveolar bone height, more internal socket bone fill, and less horizontal resorption of the alveolar bone ridge. This study suggests that treatment of extraction sockets with membranes made of glycolide and lactide polymers is valuable in preserving alveolar bone in extraction sockets and preventing alveolar ridge defects. Use of these materials may minimise crestal resorption, and may be indicated to minimise ridge resorption if dental implants are not part of the treatment plan. Placement of implants into these materials may limit osseointegration. Until there is sufficient evidence that these materials maintain socket anatomy, and do not interfere with osseointegration, caution should be exercised.

CONCLUSION

The purpose of this paper was to review the history, predictability, rationale and treatment planning steps for implant placement immediately after tooth extraction. Multi-centre studies have validated the predictability of placing implants at the time of extraction provided these procedures are appropriately treatment planned.

5,7,8,11,30,70,71 To date, evidence for placement of bone substitutes adjacent to small bone defects related to immediately placed implants appears safe, although these materials do not appear to predictably promote osseointegration. There is insufficient evidence that 'socket preservation' procedures predictably maintain socket anatomy without crestal resorption. Bone substitutes implanted into extraction sockets may interfere with normal bone healing and ultimately osseointegration. A minimally invasive approach offers several patient advantages and should be employed wherever possible.

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