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Review

Guidelines for Optimizing Outcomes with Immediate Molar Implant Placement

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Abstract

This paper is a follow-up to our recent literature review of outcomes with immediate molar implants and summarizes considerations used by various highly experienced clinical investigators to achieve acceptable survival rates. The surgeon's skills and experience, proper case selection and specific modifications in osteotomy preparation all are crucial in avoiding intra- and extra-operative complications and implant failure.

Key words: **Immediate, molar implant, guidelines.**

Introduction

We have recently published a systematic review and meta-analysis of patient outcomes following immediate molar dental implant (*IMI*) placement.[1] The analysis revealed that it is possible to obtain good outcomes, although many factors play a role, and the treatment is among those recognized as being difficult to undertake with success.[2] In the present paper, we have attempted to summarize key clinical factors affecting outcomes following *IMI* placement.

Discussion and Protocol Recommendations

There are some obvious advantages for patients and clinicians in providing immediate replacement of molar teeth with implants. These include fewer and potentially less invasive surgical procedures, greater patient acceptance, less chair time and lower treatment fees, shorter treatment times and potentially fewer risks. Another advantage is that IMIs may reduce maxillary sinus pneumatization following molar extraction.[3] However, not every molar site will be suitable for this treatment approach and as with all surgical procedures, operator skills and experience will affect the outcomes. Jemt et al[4] recently reported outcomes during 28 years of implant treatment in multiple centers showing that notable differences existed between surgeons and between surgeon genders, and that these differences did not change with time. While the authors were not focusing on IMI outcomes, given their level of difficulty,[2] outcomes with IMIs will definitely be affected by clinical skills and judgment.

Careful selection of appropriate patients, reason for extraction, surgical technique, socket anatomy, initial implant stability, submerged vs. non-submerged healing, and implant design will be crucial for successful IMI treatment. Ideally patients will be non-smokers, although some investigators[5,6] have ac-

cepted patients who smoked ≤10 cigarettes/day, while others[7,8] placed no restriction on smokers. Nevertheless, smoking is generally considered to be a key risk factor for implant complications/failure,[9] especially with immediate molar implants, if the patient smokes >10 cigarettes/day (×10 increased failure over non-smokers)[10] so that novices planning to use IMIs would be advised to limit their attempts to confirmed non-smokers.[11] Other contraindications include history of head and neck radiation in the previous 12 to 24 months, uncontrolled diabetes, use of anti-resorptive[12] or RANK ligand inhibiting[13] drugs and parafunctional habits such as bruxism.

Reason for tooth extraction

The reason for tooth extraction may play a role in IMI outcomes. Accordingly, the majority of IMI clinical trials did not include molars lost to chronic severe periodontitis (or aggressive periodontitis) or to apical pathology.[1] It should be pointed out, however, that there is some evidence that periapical infection and associated large bone defects may not be an absolute contraindication for immediate implantation.[14] In two recent systematic reviews[15,16] the authors concluded that the limited data available appears to indicate that immediate implants placed in sites with periapical infection may have comparable outcomes to those following immediate placement in healthy sites provided that appropriate measures are taken to manage the infection. Jofre et al[17] presented a protocol for the management of sites with acute infection using systemic antibiotics starting 3 days before extraction as well as drainage and profuse irrigation with 0.12% chlorhexidine. Others[18] have reported that good bone healing after a flapless extraction may result without removing the reactive granulation tissue present within a chronic periapical infection. Success here was likely related to the fact that most clinicians used pre-surgical systemic antibiotic for all IMIs. However, more clinical studies will be needed since pathogens can persist in bone even in apparently well-healed extraction sockets and can lead to retrograde peri-implant infections.[19]

Surgical technique

The majority of investigators[1] who have undertaken studies of IMIs have stressed the importance of atraumatic tooth removal. Molar teeth are generally first modified by coronectomy and sectioned so as to allow removal of each root separately using periotomes and/or piezosurgery tips.[20,21] Buccolingual movements of the roots should be minimized in order to avoid buccal plate damage. Alternatively, after de-coronation, the tooth may be left in situ while the osteotomy is created through the furcation area, the roots being removed only after osteotomy completion just prior to implant insertion[22,23] or even after implant placement.[5] The shoulder of the implant is ideally placed slightly (1–2 mm) apical to the buccal alveolar crest[24] to compensate for expected crestal bone remodeling, and any peri-implant defects grafted appropriately.

There also may be a benefit to making the extraction flapless as this will result in minimal disturbance of the buccal plate's periosteal blood supply, less crestal bone loss[25] and less buccal soft tissue retraction.[26] Sites with a thick buccal gingival biotype (i.e. a periodontal probe cannot be seen through the tissue when inserted into the gingival sulcus) are preferred for IMI placement, while sites with a thin biotype might not be appropriate unless soft tissue grafting, to thicken the biotype, is incorporated into the treatment. Without this grafting, thin gingiva will likely recede post-treatment, exposing some of the metal surface of the implant.[26]

Socket anatomy

Socket anatomy appears to be central to successful IMI outcomes. Firstly, intact socket walls are generally preferred in order to avoid the concomitant need and challenges/complications of guided bone augmentation grafting. In cases in which one or more socket walls are missing, IMIs may not be appropriate, making socket preservation grafting and delayed implant placement preferable.[27] Placing an IMI into an intact socket was originally proposed to reduce or eliminate the expected buccolingual alveolar ridge width shrinkage following extraction. This ridge remodeling is known to be particularly significant at the mid-buccal aspect,[28] where bone retention is critical for successful implant outcomes. However, the prevention of ridge width shrinkage was later shown not to happen with IMIs placed in dogs[29] and humans.[30,31] As a result, it is now recommended that IMIs be over-seated by up to 2 mm on the buccal aspect to compensate for the expected bone loss.[8,22,24,32] In a recent animal study, Huang et al[33] compared implants placed at the level of the bone crest to those submerged by 1.5 mm, and found the latter to have significantly less crestal bone loss after 4 months in function. Placing an implant subcrestally may also increase bone-to-implant contact.[34] If gaps remain between the coronal part of the implant and a socket wall, some clinicians suggest grafting them (e.g. with a slowly resorbing material such as Bio-0ss®) only if their widths are≥2 mm.[35,36] Others pre-

fer to graft if a mid-buccal gap of ≥1.25 mm and/or a mesial, distal or mid-lingual/palatal gap width of ≥2.25 mm remains.[37] In addition to gap widths, thickness of the buccal bone wall is crucial.[38,39] Thus, if after implant placement buccal bone thickness is estimated to be <2 mm, and certainly 1 mm or less, in addition to grafting of any peri-implant gaps, buccal wall "over-augmentation" is prudent in order to minimize crestal bone loss.[32,33,40] In a recent report on a group of immediate anterior implants for which buccal bone over-augmentation grafting had not been carried out, using CBCT scans of the implants after 7 years in function, Benic et al[41] found no buccal bone remaining with one-third of the implants studied. The mean buccal bone thickness at the remaining sites was only 0.4±0.7 mm. "Platform-switching" (i.e. using a prosthetic abutment smaller in diameter than the implant prosthetic table) also will reduce crestal bone loss with wide diameter molar implants.[42] As already noted, consideration must be given to the associated gingival biotype since thick and wide gingiva promote preservation of both soft and hard tissues, while thin narrow gingival tissues predispose to gingival recession and crestal bone loss.[43-45]

Inter-radicular septal/furcal bone (IRB) is another anatomic challenge with IMI placement. Under ideal circumstances, the buccal and lingual/palatal aspects of IRB can be maintained and used as buttresses to stabilize IMIs. Managing IRB varies in difficulty. Smith and Tarnow[46] classified molar sockets into three types based on the amount of inter-radicular septal bone remaining (Figure 1). Type A sockets were designated as those with sufficient bulk of IRB to contain the osteotomy in its entirety perhaps with the aid of osseodensification-type burs to expand rather than remove bone.[47] With this socket type, the authors recommended that an implant should be fully seated apico-coronally in IRB, and that any remaining root socket defects need not be grafted. Type B sockets were defined as those having sufficient IRB remaining to stabilize the implant, but not completely to house it. For this type (IRB <3 mm) in the mandible, Fugazzotto[48] suggested that rather than removing it or encountering bur chatter in drilling it, the first bur could be started at an angle near the base of the IRB. Once an entry point was established here in the absence of drifting or chatter, the bur could then be slowly up-righted as osteotomy preparation continued. Thereafter, each bur in sequence entered the site at a slightly less acute angle before being straightened up, so that at the end, the preparation would allow implant placement in the correct position and stabilized by the buccal and lingual bone buttresses. Others have proposed removing all or part of the IRB, for example with round burs,[49] trephines[50] or piezo surgical tips before initiating osteotomy preparation with a pilot bur. To avoid final implant positioning being too far buccal in mandibular IMI sites, Hayacibara et al[51] preferred to initiate drilling towards the lingual aspect to minimize the extent of bur drift buccally. Finally, some clinicians have favored placement of Type B IMIs into one of the mandibular molar root sockets or in the palatal root sockets of maxillary molar,[52] but this is the least favorable approach as it results in poor restoration

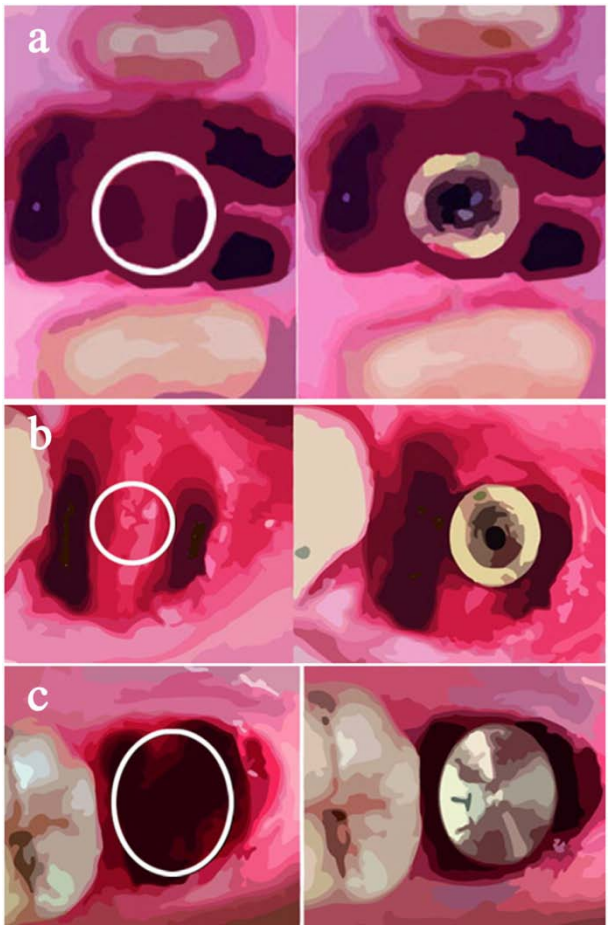

Figure 1. (a) The white circle in the left-hand drawing denotes the center of a Type A socket[46] into which an implant has been placed in the right-hand drawing. The implant is completely housed by the IRB. (b) The white circle in the left-hand drawing denotes the center of a Type B socket[46] into which an implant has been placed in the right-hand drawing. The implant could not be completely housed by the IRB. (c) The white circle in the left-hand drawing of a Type C socket[46] highlights the missing IRB. A wider diameter implant (right-hand drawing) was needed to allow it to contact as much of the socket wall bone as possible.

emergence profiles and compromised homecare (Figure 2).

Type C sockets of Smith and Tarnow[46] classification are those with insufficient septal bone to stabilize the implant without engaging the socket walls for support. With this last socket type, the IRB will generally be removed and an implant of sufficient diameter placed so as to make maximal contact with the socket walls. With socket Types B and C in the mandible, in order to achieve maximum initial stability, it was stressed that the IMI apex must engage ≥4 mm of native bone.

Investigators have used pre-op CBCT films to predict the risks of IMIs damaging the mandibular nerve or perforating the mandibular lingual bone plate. Froum et al[53] suggested that it should be safe to place an IMI if the distance from root apices to the nerve canal is at least 6 mm as measured on CBCT, accepting that up to 4 mm of apical bone must be engaged to ensure adequate IMI stability. In another study, Lin et al[54] used CBCT cross-sectional views and virtual IMI placements to predict the risk of nerve damage. In a sample of 237 subjects, the mean distances between molar root apices and nerve canal (RAC) were 7.0±2.9 mm for the first molar and 4.3±2.7 mm for second molar sites. Nerve damage was likely to occur in 69.9% of the second molar sites, but the risk reduced to 35.4% at the first molar sites. The probability of nerve damage decreased by 26% with every 1-mm increase in RAC. The investigators also found that 57.5% of first molars and 62.3% of second molars had lingual mandibular ridge concavities, increasing the risk of lingual plate perforation and arterial damage. In another computer-based simulation study of IMI placement in the posterior mandible[55] the same investigators predicted that the risk of lingual plate perforation decreased by 34% for every 1-mm increase in RAC.

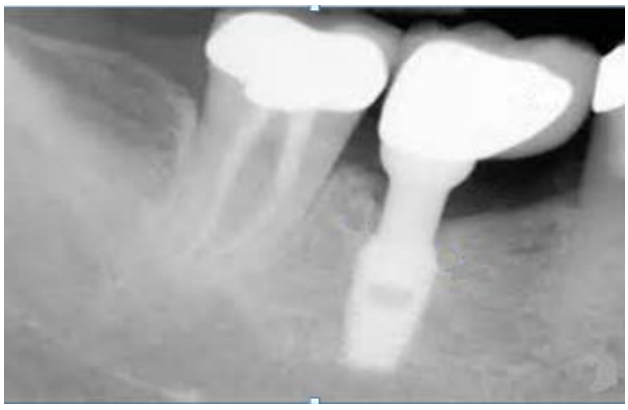

Figure 2. The implant was placed immediately into the distal root socket of the lower first molar and has resulted in a crown with poor emergence and impaired homecare.

In the case of maxillary IMIs, there might be limited bone between the socket apex and the maxillary sinus.[56] In such sites, in order to develop sufficient bone to house an IMI, osteotomy preparation can include localized indirect, sinus floor elevation using osteotomes,[5,57-60] specialized burs[61] or piezoelectric tips.[62] Most commonly, particulate allograft or xenograft particles are used in these procedures to maximize new bone formation around the implant apex as shown by Summers in his classic paper on indirect osteotome-mediated, sinus floor elevation with delayed maxillary implant placement.[63] Alternatively, if the IRB was wide, Fugazzotto used a small diameter trephine to free a plug of bone in it, and subsequently imploded the plug as an autogenous graft, elevating the sinus membrane and providing a tented space in the sinus to receive the implant apex.[59,64] In sites with adequate bucco-palatal ridge width but limited subantral bone, sinus elevation grafting can sometimes be avoided by using a short wide (≥6 mm) implant (Figure 3).[65]

Implant design

Investigators have used both cylindrical and tapered implant designs as IMIs. There may be some advantage with tapered designs in improving initial implant stability, especially in bone of low density.[66] However, excessive taper might lead to increased early failure of wide diameter implants used as IMIs in the mandible possibly due to the excessive torque needed to install them, resulting in excessive compression of crestal bone and its resorption.[49] Atieh and Shahmiri[67] studied the effect of various degrees of implant taper on crestal bone of mandibular molar implants, using a finite element analysis model, and concluded that small taper angles (e.g. 2–5º) placed less stress on crestal bone than larger ones (up to 14°) after the onset of implant function.

Implant diameter also appears to be a factor in the survival of IMIs, assuming appropriate surgical technique and initial implant stability.[68] Most investigators have used IMI diameters >4.5 mm,[1] and some have recommended diameters of ≥6 mm in order to provide a prosthetic table that will allow the proper emergence profile for a molar crown, and reduce crestal stresses generated by the high biting forces typical of molar teeth.[68] Larger diameter implants often will permit shorter implants to be used, which is particularly helpful in the resorbed posterior mandible.[69,70] However, it must be kept in mind that the implant width should never compromise the final buccal bone thickness since if this is <1.8 mm thick,

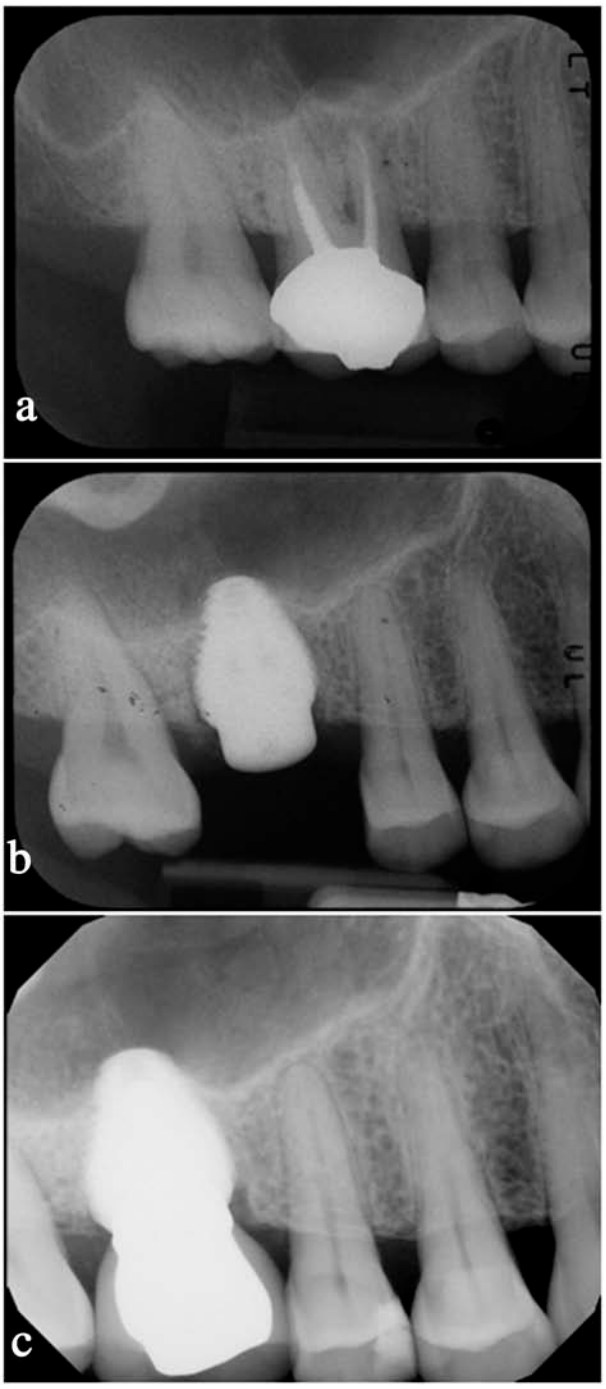

Figure 3. (a) Failed endodontic treatment necessitated the removal of the maxillary right first molar which was de-coronated and sectioned to allow the roots to be removed individually. There was extensive periapical granulation tissue around the mesiobuccal root, and this was removed using curettes. An 8-mm diameter (ultra-wide) by 8-mm long moderately rough implant was inserted at the time. (b) The immediate postoperative radiograph taken at placement of the IMI. The site was developed using hand profilers which allowed localized sinus floor elevation without adding graft material. (c) The 6-year follow-up radiograph of the restored implant.

stress on crestal bone will likely lead to loss in buccal bone height.[38,71] In order to avoid compromising buccal bone, thought should be given to using a smaller diameter implant and placing it slightly lingual.[72] In this case, it has been recommended that the implant be over-seated to a level ("running room") in bone that will allow development of an esthetically-pleasing and hygienic emergence profile.[46] Alternatively, a 4.8-mm diameter implant with a coronal shoulder diameter of 6.5 mm could be used.[48,59] Ultra-wide implants with diameters of >6 mm to 9 mm[11,49] are available in lengths as short as 7 mm. However, technical difficulties/complications can arise with these implants, especially in posterior mandible where the necessarily wide diameter burs can become locked in situ during use due to excessive friction, and where it might be difficult, if not impossible, to fully seat the implant 2 mm below the alveolar crest as recommended.[11,65]

Initial IMI stability

As with delayed implant placement, IMIs must have good initial stability to integrate. The initial stability can be confirmed easily at the time of insertion of a cover screw. If the implant turns with tightening of the cover screw, it can be removed and replaced with one of greater diameter. Otherwise, implant placement should be aborted and the procedure converted to socket preservation.

Walker et al[73] conducted a study with 174 IMIs placed in mandibular first and second molar sites of 172 patients. Implants were inserted using a drill handpiece set to torque values (ITVs) of 15 (low), 30 (medium) or 50 (high) Ncm. Five of the implants could not be stabilized, necessitating their removal. Of the remaining 169 implants, at the time of implant installation 29% (n=49) showed low ITVs, 23% (n=39) had medium ITVs and 48% exhibited high ITVs. At the 3-month follow-up visit, cumulative survival rates for the implants with initial low ITVs was 86%, while survival for medium and high initial ITV implants were 90% and 96%, respectively. Gehrke et al[74] compared ITVs for immediate vs. delayed implant placements, and reported that at all time periods (zero, 90 days and 150 days) ITVs were significantly lower with the immediately placed implants. Another finding was that ITVs in maxillary sites were significantly lower than in the mandible.

Submerged vs. non-submerged initial healing protocols

Following IMI insertion, some investigators have stressed that wound closure and submerged healing are important in achieving osseointegration.[6,40,48,59,

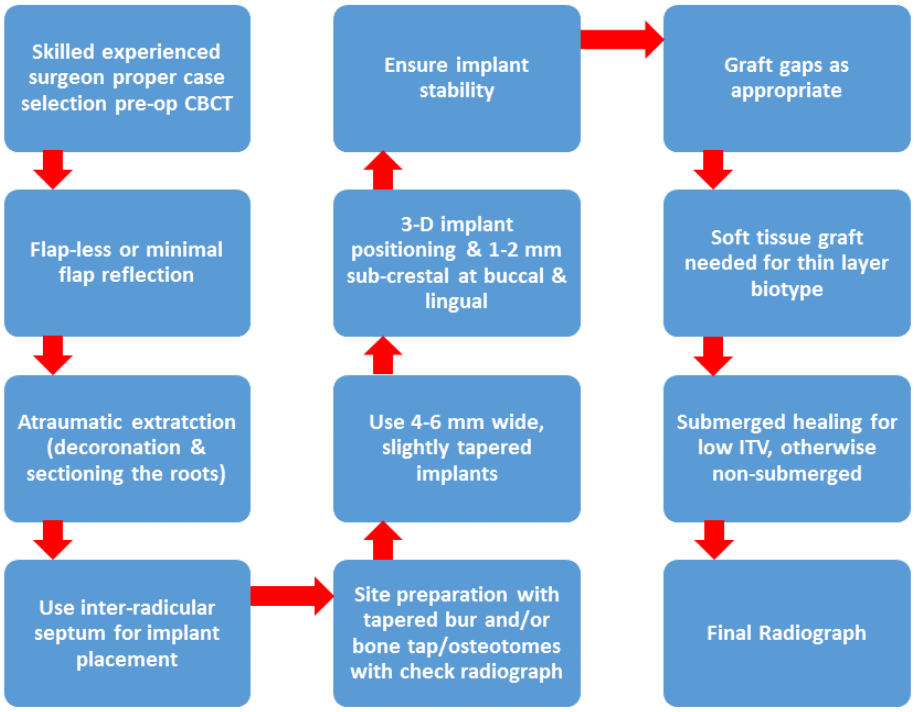

Figure 4. Summary flowchart for IMI placement.

Others made no attempt to cover the implant site relying only on soft tissue adaptation with or without gap grafting to promote site healing, thereby avoiding later re-entry.[5,22,49,60,65] Submerged healing is recommended for IMIs with low initial ITVs.

Conclusions

Installing immediate molar implants is a difficult procedure meant for skilled and experienced surgeons (see Figure 4). Proper case selection includes considering the reason for tooth extraction, the socket anatomy remaining after extraction, the dimensions of the inter-radicular bony septum, the appropriate implant shape, length and diameter, the depth and 3D positioning of implant insertion, the size of peri-implant gaps and the appropriateness of including soft tissue grafting at sites with a thin and/or narrow gingival biotype.

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