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Guidelines for Optimizing Outcomes with Immediate Molar Implant Placement

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Abstract

This paper is a follow-up to a recent systematic literature review with meta-analysis of outcomes when using immediate molar implants (*IMIs*). An attempt has been made to offer guidelines to assist clinicians in their successful use of this treatment approach. The surgeon's ability, proper case selection, socket anatomy, and specific modifications in osteotomy preparation all are crucial in avoiding errors, complications and implant failure. While long-term data are sparse, *IMIs* appear to be a viable treatment option if the offered guidelines are strictly followed.

Keywords: Tooth extraction; Dental implantation; Endosseous; Guided tissue regeneration

Introduction

We have recently published a systematic review and meta-analysis of literature published from November 2008 to May 2015 reporting outcomes following immediate molar dental implant (*IMI*) placement [1]. The search format was that recommended by the Academy of Osseointegration Workshop on the State of Science on Implant Dentistry (SSID) [2,3]. The search language used was similar to that employed in a previous review conducted by others on *IMI* data up to October 2008 [4]. Criteria for qualification of studies to be included in the analysis were: i) at least 10 *IMIs*; ii) minimum follow-up 1 year in function; iii) clearly reported/interpretable survival and/or success (based on crestal bone loss) data; and iv) use of root-form, solid, titanium or titanium alloy implants. Fifteen publications fulfilling these criteria were identified, none of which were double-blind, randomized, controlled prospective clinical trials. Recognizing this limitation, our analysis supported Atieh's earlier conclusion [4] that it is possible to obtain good outcomes with *IMIs* with the added proviso that those of diameters >6 mm may be at greater risk of failure.

There are obvious advantages for patients and clinicians in providing immediate implant replacement of molar teeth. These include fewer and potentially less invasive surgical procedures, greater patient acceptance, less chair time, lower treatment fees, shorter treatment times, and potentially fewer risks. The clinician needs to be aware, however, that achieving success with *IMIs* is affected by many factors. In the present paper, we have attempted to formulate guidelines for the successful use of *IMIs*. Considerations will include case selection, reason for extraction, quality and quantity of keratinized tissue, socket anatomy and how it impacts osteotomy preparation, implant design, and initial implant stability.

Discussion

Case selection

As with all technique-sensitive surgical procedures, not all clinicians will be capable of successfully employing *IMI* procedures because of infrequent usage of the procedure, failure to follow strict protocols, inadequately trained support staff and/or inability to manage the associated stress [5]. Likewise, not all molar sockets will be appropriate for *IMI* placement thereby making careful case selection crucial. Patients should be non-smokers since smokers have been shown to have 10x the risk of *IMI* failure as non-smokers [6]. Other patient contraindications include history of head and neck radiation in the previous 12 to 24 months [7], uncontrolled diabetes [8], use of anti-resorptive [9] or RANK ligand-inhibiting [10] drugs, and parafunctional habits such as bruxism [11].

In most situations, a pre-operative CBCT scan should be done to allow pre-treatment assessment of buccal bone thickness and proximity of vital structures [12]. In posterior mandible, Froum, et al. [13] suggested that safe placement of an *IMI* is likely if the distance from root apices to the nerve canal is at least 6 mm as measured on CBCT, accepting that up to 4mm of apical bone must be engaged to ensure sufficient initial *IMI* stability to avoid micro-movements [14]. Lin, et al. [15] used CBCT cross-sectional views and virtual *IMI* placements to predict the risk of nerve damage with mandibular *IMIs*. In a sample of 237 subjects, the mean distances between molar root apices and nerve canal (*RAC*) were 7.0±2.9mm for first molar and 4.3±2.7 mm for second molar sites. Nerve damage was likely to occur in 69.9% of second molar sites, but the risk was reduced to 35.4% at first molar sites. The probability of nerve damage decreased by 26% with every 1mm increase in *RAC*. The investigators also found that 57.5% of first molars and 62.3% of second molars had lingual mandibular ridge concavities adding the risk of lingual plate perforation and arterial damage. In another computer-based simulation study of *IMI* placement in posterior mandible [16] the same investigators predicted that the risk of lingual plate perforation decreased by 34% for every 1mm increase in *RAC*. Given all of this information, a reasonable guideline to follow is the 6 mm minimum *RAC* rule of Froum. With an *RAC* less than 6mm, it becomes safer to undertake socket preservation grafting with delayed implant placement, and clearly this is more likely to be the case for mandibular second molars.

IMI sites with a thick buccal gingival biotype (i.e., a periodontal probe cannot be seen through the tissue when inserted into the

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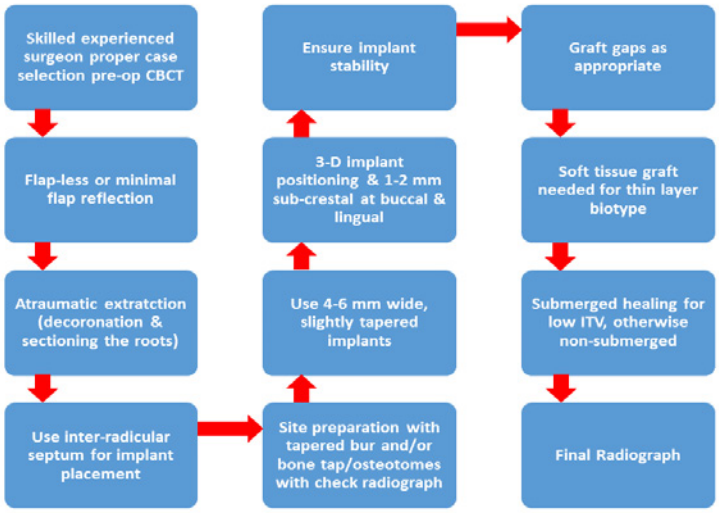

Flow Chart:

gingival sulcus) and a keratinized gingiva vertical width of ≥2 mm are preferred since thin and/or narrow keratinized tissue will predispose to crestal bone resorption and peri-implant gingival recession [17-20]. Should textured implant surfaces become exposed as a result of crestal bone loss, there is the risk of peri-implantitis and progressive bone loss [21]. As well, once restored, implants with thin, narrow keratinized tissue are more likely to be associated with bleeding on probing and brushing discomfort [22]. If adequate keratinized gingiva is lacking, a graft of palatal connective tissue can be harvested and inserted under the buccal and lingual/palatal flap margins and over the implant as one would place a membrane [23]. Alternatively, a dense PTFE membrane can be placed in a similar fashion over the implant and left exposed so as to promote healing by secondary intention with generation of new keratinized tissue [24].

The majority of recent *IMI* clinical investigations did not include molars lost to chronic severe periodontitis (or aggressive periodontitis) or to apical pathology [1], the consensus being that *IMI* placement should be for molars lost to non-restorable caries, root fracture or endodontic treatment complications. While there is some evidence that periapical infection and associated bone defects may not be an absolute contraindication for immediate implantation provided that thorough debridement and antibiotic coverage are employed [25,26] further data from randomized controlled clinical trials are required to confirm this procedure to be safe and to establish an appropriate protocol [27].

Extraction technique

The majority of investigators [1] who have undertaken studies of *IMI*s have used antibiotics (most commonly amoxicillin or clindamycin in the case of penicillin allergy) starting before or immediately after the procedure. They stressed the importance of atraumatic tooth removal, ideally with flap-less surgery to minimize disturbance of the buccal plate's periosteal blood supply [28], crestal bone loss [29] and buccal soft tissue recession [30].

Prior to extraction, molars are generally modified by coronectomy and sectioned so as to allow removal of each root separately using periotomes and/or piezo surgery tips [31,32]. Bucco-lingual 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 tooth's furcation area, the roots being removed only after osteotomy completion and just prior to implant insertion [33,34]. If the roots are removed first, the surgeon should use a surgical stent to ensure correct implant positioning, while still being aware of socket anatomy particularly buccal bone thickness and crestal height. Following *IMI* insertion, some investigators have stressed that wound closure and submerged healing are important in minimizing the risk of infection and achieving osseointegration, while others made no attempt to cover the implant site relying only on soft tissue adaptation with or without gap grafting to promote site healing and avoiding later re-entry [1]. Clearly with the non-submerged approach the quantity and quality of keratinized gingival tissue will be a factor requiring consideration. Even with submerged *IMI* placement, there can be a risk of infection if dehiscence of the overlying soft tissues occurs during site healing [6]. Most investigators do not, however, include the incidence of peri-implantitis causing *IMI* failure whether that is early or late [35].

Managing socket anatomy

Socket walls: Socket anatomy is central to successful *IMI* outcomes. Firstly, as already stated, intact socket walls are essential in order to avoid the concomitant need and challenges/complications of simultaneous guided bone augmentation grafting. Where one or more socket walls are missing or have a significant dehiscence, socket preservation grafting [24,36] and delayed implant placement are more appropriate. Since placing *IMIs* does not eliminate post-extraction alveolar ridge remodeling [37,38], it is recommended that *IMIs* be submerged by up to 2 mm on the buccal aspect to compensate for the expected buccal crestal bone loss [29,33,39]. This is particularly important if the thickness of the buccal wall is <2 mm [40,41]. Huang, et al. [42] compared implants placed at the level of the bone crest to those submerged by 1.5 mm in dogs, and found the latter to have better crestal bone preservation in relation to the implant neck after 4 months in function. Submerging the implant may also increase bone-

Table 1: Surgical management for immediate molar implantation based on socket (*IRS*) classification of smith & tarnow.

Type of *IRS*	Condition of Buccal Wall	Gingival Biotype	Surgical protocol	Healing Phase
A or B	intact &thick (≥2 mm)	thick & wide (≥2 mm)	flap-less + gap grafting as needed	1-stage if ITV35 to 50 Ncm or RFA >60
A or B	intact &thick (≥2 mm)	thin & narrow (<2 mm)	flap + gap grafting as needed + CT graft or d-PTFE barrier	2-stage
A or B	Intact &thin (<2 mm)	thick & wide (≥2 mm)	flap +subcrestal placement &lingual implant positioning to create buccal gap for grafting	1-stage or 2-stage
A or B	Intact &thin (<2 mm)	thin & narrow (<2 mm)	flap +subcrestal placement + lingual positioning to create buccal gap for grafting + CT graft or d-PTFE barrier, or socket preservation & delayed implant placement	2-stage
Type C	Intact &thick (≥2mm)	thick & wide (≥2 mm)	flap-less +*IRS* removal + wider implant &gap grafting as needed	1-stage if ITV 35-50 Ncm or RFA >60
Type C	intact &thick (≥2 mm)	thin & narrow (<2 mm)	flap + *IRS* removal + wider implant + gap grafting as needed + CT graft or d-PTFE barrier or socket preservation & delayed implant placement	2-stage
Type C	Intact &thin (<2 mm)	thick & wide (≥2 mm)	flap + *IRS* removal + wider implant with subcrestal placement+ xenograft buccal over-grafting & gap grafting as needed + CT graft or d-PTFE barrier or socket preservation & delayed implant placement	2-stage
Type C	Intact & thin (<2 mm)	Thin & narrow (<2 mm)	socket preservation & delayed implant placement	2-stage
Type A,B or C	Lack of Buccal wall		socket preservation & delayed implant placement	

to-implant contact (i.e., osseointegration) [43]. If the implant cannot be adequately submerged in sites with a thin buccal plate because of vital structure proximity, consideration can be given to placing it towards the lingual/palatal to avoid contact with the buccal bone [44]. This will leave a gap that can be grafted with a slowly resorbable material such as xenograft or mineralized allograft with or without a barrier membrane which will minimize buccal bone resorption [45]. Generally, gaps between the coronal part of the implant and any socket wall are similarly grafted if their widths are ≥2 mm [14,46-49]. Buccal over-grafting (i.e., on the outer periosteal buccal bone surface in a pouch under the flap) with xenograft can be of benefit in situations where the implant surface-to-buccal bone distance ≥4 mm as this too will reduce loss in bucco-lingual/palatal ridge width and preserve/improve anatomical contours [50].

Inter-radicular septum: Inter-radicular septal/furcal bone (*IRB*) is another anatomic challenge with *IMI* placement. Under ideal circumstances, the buccal and lingual/palatal aspects of the *IRB* should be maintained and used as initial implant-stabilizing buttresses. Smith and Tarnow [51] classified molar sockets into three types based on the amount of *IRB* remaining. Managing *IRB* will present varying levels of difficulty and vary depending on the *IRB* type, the thickness of buccal bone and the quantity of keratinized gingiva (Table 1). *Type A* sockets are designated as those with sufficient *IRB* bulk to contain the osteotomy in its entirety. With this socket type, the authors [51] recommended that an implant should be fully seated apico-coronally in *IRB*, and that being the case, any remaining root socket defects/gaps need not necessarily be grafted. This would, however, assume that they can be covered by repositioned thick keratinized gingival tissue that is adequately supported by remaining alveolus. If not, gap grafting covered with a connective tissue graft or a barrier is advisable (Table 1).

Type B sockets were defined as those having sufficient *IRB* to stabilize the implant, but not completely house it [51]. Management will depend on the buccal bone thickness and the quality/quantity of keratinized tissue (Table 1). If the buccal bone is thin (<2 mm), the implant can be submerged up to 2 mm below the buccal crest. Some clinicians have proposed removing all or part of the *IRB in Type B* sockets, for example using round burs [52], trephines [53] or piezo surgical tips before initiating osteotomy preparation with a pilot bur. In contrast, Fugazzotto [54] suggested that this *IRB* can be left and managed with a modified drilling protocol. Specifically, the first bur was started at an angle near the base of the *IRB*. Once a stable entry point was established, the bur was then 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 in the end, the preparation allowed implant placement in the correct position stabilized by the *IRB* buccal and lingual bone buttresses. To avoid final implant positioning being too far buccal in posterior mandible because of bur drift buccally, Hayacibara, et al. [55]. Initiated drilling into the *IRB* towards the lingual. Finally, some clinicians have favored managing *Type B* sockets by placing an *IMI* into one or other of a mandibular molar root sockets or into the palatal root socket of maxillary molars [56], but this is the least favorable approach as it results in poor restoration emergence profiles and compromised homecare.

Type C sockets of Smith and Tarnow [51] are those with insufficient septal bone to stabilize the implant without engaging 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 available socket walls while still respecting the buccal bone thickness. If this results in a thin buccal plate remaining, buccal over-grafting with xenograft can be added to the protocol. With socket *Types B* and *C* in mandible, in order to achieve maximum initial stability, it was stressed that the *IMI* apex should engage ≥4 mm of native bone.

In the case of maxillary *IMIs*, there may be limited bone between the socket apex and the maxillary sinus. In such sites, in order to develop sufficient bone to house the implant, osteotomy preparation can include localized indirect, sinus floor elevation using osteotomes [56-60], specialized burs [61] or piezoelectric tips [62]. Particulate mineralized allograft or xenograft particles or autogenous PRP-fibrin clots [63] often are used in these procedures to maximize new bone formation around the implant apex. Alternatively, if the *IRB* was wide mesio-distally, Fugazzotto used a small diameter trephine to

free a plug of *IRB* bone, and subsequently condensed it apically as an autogenous graft using osteotomes, elevating the sinus membrane and providing a tented space in the sinus to receive the implant apex [59,64]. In some sites with limited subantral bone, sinus elevation grafting can be avoided or minimized by using a short, ultra-wide (>6 mm) implant [39,65]. However, if the buccal bone is thin and the implant platform is not submerged 2 mm below the crest as recommended by the manufacturer, unwanted crestal resorption may be the result.

Implant design

Investigators have used cylindrical and tapered implant designs both with moderately rough surface textures (e.g. particle-blasted, acid-treated) as *IMIs* [1]. There may be some advantage with tapered designs in improving initial implant stability especially in bone of low density [66]. However, excessive taper may lead to increased early failure of wide diameter implants used as *IMIs* in mandible possibly due to the excessive torque needed to install them causing unfavorable compression of crestal bone with its resorption [52]. 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 to 5°) placed less stress on crestal bone than larger ones (up to 14°) after the onset of implant function**.** While a variety of different *IMI* implant thread configurations have been used, as yet none has proved to be superior (Chart 1).

Implant diameter also appears to be a factor in the survival of *IMI*s assuming appropriate surgical technique and adequate initial implant stability. Finite element analyses by Ormianer, et al. [68] suggested that a 6mm diameter *IMI* reduced crestal bone stresses compared to those with 3.7 or 4.7 mm diameters provided there was a minimum of 1.8 mm buccal bone thickness. Appropriately, most investigators have used *IMI* diameters >4.5 mm [1] which if need be can allow them to be used in shorter lengths [69]. Jiansheng, et al. [19] investigated the use of short (5.7 to 8 mm), wide (5 to 7 mm) implants as *IMIs*. A minimum keratinized tissue width of 2 mm was required and implants were submerged about 3 mm below the bone crest. After a mean of 2 years in function, the survival was 99.4%. However, technical difficulties/complications can arise with ultra-wide implants (>6 mm) especially in posterior mandible where the necessarily wide diameter burs can stall and become locked in place due to excessive friction. It also may be difficult or impossible to seat these implants 2 mm below the alveolar crest as recommended [52], compromising the final buccal bone thickness. In this case, thought should be given to using a smaller diameter implant (e.g. 5 mm) and placing it slightly to the lingual [70], keeping in mind that smaller diameter implants placed as *IMIs* will need to be submerged to a level in bone that will allow development of an esthetically-pleasing and hygienic emergence profile ("running room") [51]. Alternatively, a 4.8 mm diameter implant with a coronal shoulder diameter of 6.5 mm has been used [54,64].

Initial IMI stability

As with delayed implant placement, *IMIs* must have good initial stability to integrate. Traditionally, high insertion torque (*ITV*) has been considered the best indication of good implant stability. *ITVs* of 35 to 50 Ncm appear to be appropriate based on the author's (MK) experience. However, if torqueing force is excessive, despite there being good initial implant stability (i.e., avoidance of early micro-movements), there may be strain-related micro-fractures and compression necrosis in the peri-implant cortical bone [71]. Before new cortical bone can be formed around implants placed in this fashion, a resorptive phase is needed to remove the damaged bone. This will be accompanied by a temporary reduction in implant stability which could result in micro-movements sufficient to inhibit osteogenesis and early implant failures. This has led to the suggestion that a lesser torque (e.g. 25 Ncm) may be preferable, and that adequate implant stability is better verified with resonance frequency testing (i.e., axial stability) than by achieving high initial torque values (rotational stability) [72]. A resonance frequency value (RFV) of ≥60 is generally considered to be sufficient for implant integration [73].

Conclusions & Suggested Guidelines

1. Based on published literature, the use of immediate molar implants appears to be a valid treatment in the hands of skilled clinicians, although long-term performance data are limited. Given the difficulty of the procedure clinicians should follow strict guidelines to minimize the risk of complications/failures. Based on current literature, the following IMI placement guidelines are recommended:non-smokers only

2. a pre-op CBCT scan to minimize risk especially in mandible

3. thick gingival biotype and adequate keratinized tissue width (≥2 mm)

4. atraumatic extraction with flap-less surgery if feasible

5. only sites with intact socket walls after extraction

6. osteotomy preparation will vary with socket type (Table 1)

7. *IMIs* to be submerged (up to 2 mm) below the buccal bone crest if crestal buccal bone is thin (<2 mm)

8. thin buccal plate (<2 mm) may require more lingual placement of the implant with gap grafting and/or buccal over-grafting

9. gaps between implant and socket walls generally grafted if ≥2 mm in width

10. xenograft or mineralized allograft preferred

11. initial implant stability verified

12. Submerged healing if ITV<25 and/or RFV <60.

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