The Challenge of Implant Therapy in the Posterior Maxilla: Providing a Rationale for the Use of Short Implants

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Abstract

Rehabilitating patients with a resorbed maxilla presents several challenges when the desired treatment plan involves the placement of endosseous implants. Correct diagnosis requires knowledge on jaw healing patterns, systemic effects, and the impact of bone quality changes on implant success rates. Appropriate treatment planning requires an in-depth understanding of the materials and methods available to the contemporary implant surgeon. The clinician must be able to persist on evidence-based techniques and adhere to those proven methods. Successful surgical placement requires correct use of the available armamentarium and acceptance of the limitations that implant density still presents. Especially challenging is the implant treatment of maxillary molars due to the plethora of complicating factors such as limited bone availability, interarch space challenges, sinus problems, etc. These are just a few of the factors that may lead to placement of short implants in these sites. An extensive review of the literature that is available for short implants (implants <10 mm in length) indicates that although they are commonly used in areas of the mouth under increased stress (posterior region), their success rates mimic those of longer implants when careful case selection criteria have been used. The available studies and case-series offer a valid rationale for placement of short implants so long as one understands the limitations, indications, risk factors, and limited studies that actually follow-up success rates of short implants for over 5 years. This review of the literature will provide the reader an in-depth view of the evidence in using short implants as an alternative treatment modality for the maxillary molar region.

Keywords: short implants, sinus lift, maxilla, sinus augmentation, bone grafting, surface

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Introduction

Conventionally, surgeons aim for placement of the longest possible implant in any given site as long as its placement does not hinder the final prosthetic result in terms of esthetics. This was especially crucial in the past, when implants presented a machined surface and the most common way to increase implant-to-bone contact was to increase the surface area available by placing a wider or longer implant. The longer and wider implants were clearly associated with higher success rates at that time (when placed in similar intrarural sites). However, the posterior maxilla presents a uniquely challenging site for implant placement due to several complicating factors. Some of the factors that lead to difficulties in implant placement and success in the maxillary molar region are:

- Difficult and challenging access
- Limited visibility
- Commonly reduced interarch space
- Postextraction resorption that leads to extensive tissue loss over time, as well as sinus pneumatization
- Poor (type IV) bone quality (thin layer of cortical bone surrounding a core of low-density trabecular bone) associated with the least favorable success rates

To compensate for the poor bone quality, research teams have improved implants’ texture and design to facilitate osseointegration. Using different techniques (eg, acid etching, grit blasting, titanium plasma spraying, surface coating), implant companies today have replaced the traditional polished surface on implants with “rough” surfaces that have led to significantly better long-term results. These techniques result in implant surface irregularities in height, wave length, and spatial dimension. Arguments in favour of rough implant surfaces include:

- Increased contact area to offer better mechanical stability between bone and implant immediately following insertion
- Provides surface configuration that properly retains the blood clot
- Stimulates the bone healing process

An additional way to compensate for the limited bone height that is commonly present in the posterior edentulous maxilla was sinus lift augmentation using autogenous bone or bone substitutes. More experienced maxillofacial surgeons would also proceed with total or segmental bone onlays and Le Fort I osteotomy with interpositional bone grafts. The implant industry contributed to resolving the problem of bone height with the fabrication of zygomatic and short implants. Zygomatic implants are associated with some controversy and are not the topic of this paper. This article will focus on the treatment option of using short implants in the posterior upper jaw.

Sinus Augmentation With Bone Grafting

Prior to analyzing the evidence on use of short implants—as supported by the literature—it is important to mention the difficulties associated with sinus augmentation. This is the procedure of choice for surgeons that do not select to use short implants or when short implants are contra-indicated. The maxillary sinus augmentation procedure techniques of fringe osteotomy (lateral window, complete osteotomy), is a well-proven procedure that is used to increase the bone volume in the deficient maxilla. However, there are times that it is not prudent to proceed with such techniques due to chronic history of sinusitis, excessive tobacco abuse, pathologic lesions, osteoradionecrotic effects, and large prominent septa. If short implants can provide a successful alternative, then in some cases the operator will have more options when clinically judging the situation.

Current Update on Short Implants
The minimal length for predictable success was always considered that of 10 mm and thus implants of this length are commonly referred to as "standard length implants". As a result, any implant under 10 mm in length has come to be considered a "short" implant. Nevertheless, it is intere...

Advantages

There are several advantages associated with the use of short implants as a treatment option in the severely resorbed posterior maxilla (Table 1). Patients don’t necessarily need to invest in additional pro-surgical diagnostic tests such as computed tomography (CT) when perhaps “bone sounding” may prove adequate in cases where the sinus is to be avoided. Tests such as CT scans lead to additional costs, time, and radiation exposure. These scans are most commonly requested when investigating a borderline 10-mm implant case or when reassessing the option of a sinus augmentation surgery. In many cases, when the bone height is sufficient, short implants will allow the operator to avoid sinus lifts entirely, along with the complications and challenges associated with such procedures.

Disadvantages

If we take into account the advantages mentioned in Table 1, it would seem reasonable to assume that short implants would be part of mainstream implant dentistry by now. However, there is still controversy on their indications due to several challenges that have been associated with them.

Reduced Implant Surface

The area of contact is determined by 4 factors: the length, diameter, taper, and texture of the implant surface. The average surface area of roots of a maxillary first molar is 533 mm², compared to 256 mm² for a threaded 18-mm Nobel Biocare implant 43 (polished 3.75-mm diameter implant). It seems logical, therefore, to always strive for the longest possible implant. If we consider that a root form implant is approximately cylindrical, the surface is grossly estimated by 2πr², where L is the length in mm and “r” is the radius in mm. When the length or the radius increases, the surface area increases. However, in cases with compromised bone height where short implants seem to be the only solution, to compensate for a shorter length, a wider diameter implant (5 mm) can be used. In fact, the use of a 5-mm-diameter implant that is 6 mm long increases the surface area available to contact the bone similar to that of a 3.75-mm diameter implant that is 10 mm in length. To reduce the risk of failure of endosseous implants used in the posterior applications, wide-diameter implants have been suggested.

When studying the influence of diameter, length, and taper on strains in the alveolar crest with a three-dimensional finite element analysis, the authors came to several conclusions. The same force (200 N vertical and 40 N horizontal) was applied to implants of different lengths (5.75 to 25.5 mm), diameters (3.5 to 6 mm), and taper (0 to 14 degrees). They found that increasing implant diameter resulted in as much as a 3.2-fold reduction in crestal strain, increasing length creates as much as a 1.65-fold reduction, and increasing taper increases the crestal strain as much as a 1.65-fold, especially in narrow and short implants. The authors remind us that diameter sizes and lengths have to be considered together because of their interactive effects. In low-density bone, short, narrow, and taper implants should be avoided because low-density cancellous bone already increases the strains around the implants. 47, 48 It was further found that the influence of the diameter on crestal bone strains dominates over the effects of the length and taper.

In addition, the surface area increases significantly simply by altering the texture configurations on rough implants. Rough implants offer extensive surfaces for osseointegration and therefore allow the clinician to consider usage of short implants with some confidence. A rough implant has a micro-texture that increases the surface area and the anchorage of the implant to the bone during osseointegration. The literature emphasizes the importance of the geometry of the implant, especially for a short implant placed in the posterior maxilla. In fact, it has been demonstrated by Bernard et al. who studied Branemark and ITI implants, that textured implants of various lengths offer a significantly stronger anchorage compared to machined implants.

Increased the diameter of the implant in a poor quality and quantity bone would be a way to increase tolerance of occlusal forces. The crown-to-implant ratio is defined as the ratio of crown length to implant length. Surprisingly, the improvements of surfaces and implant systems, along with prosthetic occlusal adjustments, have now become evident, though, that a crown-to-implant ratio of 1:1 was extremely successful and completely acceptable. However, in the posterior maxilla, there is usually natural resorption of the alveolar ridge as a result of prolonged edentulism that leads to an amplified interarch distance. The consequent limited available bone leads the implant practitioner to consider the option of short implants. In fact, it has been demonstrated by Bernard et al. who studied Branemark and ITI implants, that textured implants of various lengths offer a significantly stronger anchorage compared to machined implants.

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It has become apparent through reviewing the literature that the one improvement that had the most dramatic effect in improving implant treatments was the evolution of implant surfaces from machined/polished to rough textured surfaces. We took this into account when evaluating the literature, and Table 3 provides some examples of implant success rates.

After studying the literature, it becomes evident that concerns regarding placement of implants under 10 mm in length have diminished due to the newly developed implant surfaces. It is reasonable to assume that with careful case selection criteria, the contemporary implant surgeon would be able to achieve long-term success rates that surpass the 95% mark. In fact, in most studies the success rates surpassed 95%, closely mimicking the success rates traditionally reserved for longer implants (although all mentioned studies had an average length of time of less than 10 years).

The aforementioned success rates become even more important when one considers the circumstances under which short implants are selected. For example, it is more likely that most of the short implants were placed in the posterior maxilla, where there commonly is less bone height available with poor bone quality. 16 Poor bone quality is strongly linked to higher failure rates in implants, although rough surfaced implants nowadays have somewhat dampened this negative effect.33 In one of the few studies where length was assessed alone (implant system, implant width, and implant position were kept constant) as the only changing factor, Bahat found short implants to present with 90.5% success rate (length of observation was 5–70 months) compared to 96.2% for longer implants.44 However, the implants used were machined/polished. In a following study, when investigating the 10-year survival of Branemark machined implants, he noted that when short (<7 mm) implants were not stand-alone in free-end situations, they had similar success rates as the longer implants.43

Discussion

Perhaps clinicians should reconsider the way they view placement of short implants. Short implants can be a very successful alternative to sinus grafting (with subsequent placement of longer implants). However, there are several guidelines/suggestions that should be stressed. The most important aspect of implant treatment with short implants is “case selection.” For example, it would seem prudent to follow a 2-stage implant surgery approach when placing short implants, since this approach has been linked with higher success rates with short implants.33 It may also prove wise to avoid placing short implants in single molar cases in free-end situations but rather split them to an additional implant (preferably longer), especially when placed in soft bone; type III or type IV. Soft bone is alone a risk factor, so complicating it with a short implant only magnifies the potential problem. Most implant failures can be attributed to poor bone quality.38 Occlusion is a crucial factor in longevity of implant treatments. Maximal occlusal forces applied and tolerated vary greatly according to implant position in the arch, parafunctional habits of the patient (bucco/lingual), and nature of the opposing dentition. Biomechanical overload can easily be rendered with high biting moments, unfavorable force distributions, and increased force magnitude regularly seen in the posterior region of the mouth. Overloading may lead to loss of osseointegration and fracture of the implant or the superstructure.65 66 When placing short implants, it has also become apparent from the literature that compensating with wider implants is the most reasonable approach. Crucial decision-making factors are summarized in Table 4. Dentists should carefully consider these—along with other factors they deem necessary—prior to making final decisions in their treatment plans.43

Conclusions

The literature seems to show that there is good reason to contemplate the use of short implants even in the posterior maxilla. It is an option we should always consider and offer to the patient. The literature is not always consistent, but many recent studies show that short implants can be quite predictable and have a success rate similar to longer implants. The research on implants is very active, and it seems that the tendency to use shorter implants will become more and more accepted. Clinicians still have to be cautious and to select their cases safely and carefully.

References


**Figure 1.** A Nobel Replace Tapered Groovy implant 8 mm in length and 5 mm wide by Nobel Biocare. The surface of this implant is “rough” (acid etched) named “Ti-Unite.” This implant has an internal abutment connection system; namely the “tri-channel” connection.

**Figures 2 and 3.** A Straumann-ITI implant 6 mm in length and 4.8 mm in width with a 6.5 mm wide neck collar. The surface of this implant is “rough” SLA (Sand blasted; Large grit; Acid etched). This implant has an internal abutment connection system; namely the “morse-taper” connection.
**Figure 4.**
A Branemark implant 7 mm in length and 5 mm wide by Nobel Biocare with a Ti-Unite surface. This implant has an external connection system; namely the "external hex."

**Table 1.**
Advantages of short implants in the resorbed posterior maxilla

**Table 2.**
Various factors that need to be considered when selecting a case for placement of short implants

**Table 3.**
Cumulative success rates of short implants vs. 10-mm (or longer) implants

**Table 4.**
Important decision making factors when treatment planning the placement of short implants suggested by the authors