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Contemporary management of the edentulous maxilla



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IMPLANTOLOGY HAS BECOME one of the main focuses of modern dentistry. The high success rate and longevity of dental implants, documented over the past 50 years, has increased awareness in both the public and professional community. Implant supported restorations provide the best alternative for the rehabilitation of the partial or completely edentulous patient. The patient satisfaction is higher than any other restorative option providing advantageous psychological outcomes. Currently, our profession has a high demand for dental implants due to an increase in the aging population and to all the benefits that this restorative option provides.

Multiple problems have been associated with edentulism and its traditional management. Edentulous patients treated with complete dentures may suffer from a 75% reduction in the normal bite force when compared to a natural dentition.¹ In consequence, their food selection is very limited, with less intake of vegetables, carotenes, and fiber, and a high tendency to consume high cholesterol and saturated fat foods. Recently, a literature review confirms that completely edentulous patients have a higher risk to develop multiple systemic disorders.² The combination of poor oral intake, compromised dental function, and malnutrition, leads to a reduction in the patient's quality of life and may lead to debilitation, illness, and potential decreased life span.

Implant therapy to address the shortcomings of traditional dentures have mostly focused on the mandibular denture as this has been the most problematic for patients. Over the last five decades, our profession has addressed the mandible in several very successful ways including the mandibular, fixed, implant supported restoration. The maxillary prosthesis, on the other hand, has proven to be more challenging for dental implant restoration. The anatomic structures, such as the nasal floor and maxillary sinuses, limit the ability to place implants in a vertical position. Many situations required the use of

sinus augmentation, increasing the morbidity, time, and cost of the treatment. Therefore, many providers do not offer, and many patients do not pursue, a fixed arch restoration of the edentulous maxilla.

Treatment options for the edentulous maxilla

Historically, the most traditional option for the edentulous maxilla has been the complete denture. It is usually the most popular due to the low cost and wide accessibility of this treatment option. Most dentists would agree that a removable denture is a poor substitute for a natural dentition but makes for an acceptable substitute compared to living without teeth. Nevertheless, few patients would opt for this type of removable prosthesis when given the choice for a fixed solution. In some cases, however, this is the best treatment option, and the patient is comfortable with the modality of treatment.

Implant-retained overdentures, using the Locator Abutment System for example, have been a good alternative for the edentulous patient. However, these prostheses are most often tissue-born and, thus, have the usual problems that come with a tissue born prosthesis. Maintenance issues increase (wear of the nylon components or the abutments themselves) when compared to a traditional denture, especially when the overdentures are incorrectly constructed to support, rather than retain, the overdenture. Treatment options typically include two to four implants, which also increase the expense of this treatment option. While overdentures have been a wonderful alternative to traditional dentures, they still are considered removable prostheses and do not compare to the patient satisfaction associated with fixed prosthetics.

Porcelain fused to metal restorations, typically in the form of fixed partial dentures supported by implants, have been used very successfully as an alternative to the traditional denture or overdentures mentioned above, with the benefit of being a fixed solution. The prostheses usually require six to eight

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dental implants for the completely edentulous arch and face the usual anatomic limitations that are inherent in the maxilla. The need for posterior support of the prosthesis typically requires attention to be paid to the maxillary sinuses, and while the literature has documented the success rate of maxillary sinus augmentation in systematic reviews to be around 90–93%,^{3,4,5} the success rate is lower when compared to implants in native bone. The fixed prosthesis is an inherently expensive prosthesis due to the number of implants and components involved and the time required by the surgeon, restorative dentist, and dental laboratory. Other limitations include an increased treatment time for the restoration because of the two stage protocol that is often followed and the inability to immediately load the prosthesis due to the lack of immediate cross arch

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stabilization. Due to these limitations, we are faced with decreased patient acceptance of the treatment modality.

What do patients want?

Most practitioners involved in treating the edentulous patient with traditional complete dentures have heard the common complaints of denture sores, a lack of stability and retention of the prosthesis, and an inability to masticate effectively. For patients contemplating implant therapy to treat their edentulism, the complaints typically revolve around treatment time, comfort during the healing phase, the number of surgical procedures, and the expense associated with it.

The tilted implants concept

Tilted implants were described shortly after the concept of osseointegration was

introduced to North America in 1982. Some of the first implants to be placed with non-axial loading were the Pterygoid/Tuberosity Dental Implants that were first described in 1985.⁶ The positioning of the dental implant was used to overcome anatomic obstacles, such as the maxillary sinus, in the posterior maxilla when bone was available in the maxillary tuberosity (see *Photo 1*). This type of implant has been used for 30 years with success well documented in the literature.^{7,8}

The Zygomaticus Implant, another non-axially loaded implant, was created by the late Professor P.I. Branemark and has been commercially available for the last 25 years.⁹ This type of implant also allows implant rehabilitation of the posterior maxilla without the need for sinus augmentation (see *Photos 2 and 3*). The approach is recommended for the severely atrophic posterior maxilla, with anterior extension of the maxillary sinuses up to the bicuspid area. Zygomaticus Implants were introduced in 1998 by Branemark and carry a high success rate reported between 94%–100%.^{10,11}

In the last decade, the concept of using tilted implants to avoid anatomic structures has eliminated the need for bone grafting procedures, while simultaneously obtaining adequate primary stability to permit immediate function and immediate fixed restoration. The concept, commonly referred to as “all-on-four,” incorporates tilted implants similar to the Zygomaticus protocol and the Pterygomaxillary implant protocol. Use of the all-on-four protocol has addressed many of the disadvantages, mentioned above, of more traditional methods used to treat the edentulous patient.

Biomechanics of tilted versus axial implants

To address the biomechanics of dental implants in human bone, the Skalak model was created in 1983 and establishes that a given number of implants distributed within a defined anterior posterior spread will follow a mathematical equation.¹² Biomechanical studies using this model involving the number of implants and their angulation were performed by Brunski.¹³ The results showed that the load on a fixed prosthesis involving

Photo 1.



Photo 2.



Photo 3.



four versus six implants was not dramatically different when the most posterior implants were placed in the same position.

Interestingly, when this model is applied to tilted implants, the stress on tilted implants is as great as with vertically placed implants. A 30 degree distal implant tilt appreciably decreases the force on the dental implants by redistributing the load. Brunski also suggested that a lower force on the tilted implant and components could reduce stresses and strains associated with the tilted position of the implant.

A study by Lambert, et. al.¹⁴ determined that it is not the number of implants but the anterior-posterior spread of the implants that is important in the distribution of stress to the implants. Other studies have shown no difference between tilted versus axial implant success.^{15,16,17}

Immediate loading

The concept of immediate loading was introduced in 1990, and the initial research pointed to suboptimal success rates compared to delayed loading protocols. In the last 15 years, however, the success has been well documented in the literature, with results showing high survival rates and a low incidence of complications in the maxilla between 94–98%.^{18,19,20,21,22} The introduction of Cone Beam Computed Tomography (CBCT) has facilitated a practitioner's ability to examine a patient's anatomy and allow a surgeon to better predict the bone density and volume when attempting implant placement and immediate loading. The advancements in imaging and the related software have allowed better planning and estimation of the results of surgery.^{23,24,25,26,27,28}

Evolution to the all-on-four concept

The benefits demonstrated with the use of tilted dental implants and in conjunction with the evidence of immediate loading evolved to the all-on-four (AO4) concept introduced by Maló, et. al.²⁹ The AO4 concept consists of rehabilitating the edentulous arch through a fixed prosthesis supported by four tilted implants. The posterior implants, placed at an angle, are used with axially placed anterior implants providing appropriate anterior-posterior spread and allowing for immediate loading under most circumstances (see Photos 4 and 5).

This concept, first popularized in 2003, was a considerable departure from the traditional concepts put forth by P.I. Branemark four decades prior. Due to the radical differences, questions about implant survival, bone resorption, prosthesis survival, and the ideal number of implants have emerged. The first studies documenting this technique had few patients and were not statistically significant. Since then, there have been more additions to the literature supporting success rates in the mandible at 97.5–99.0% and in the maxilla at 93.0–99.0%.^{30,31,32,33,34,35}

Photo 4.



Photo 5.



Advantages of tilted implants

There are multiple benefits of tilted implants when compared to our more traditional methods of axially loaded implants. Tilted implants avoid various anatomic structures and allow us to use fewer implants to support the same prosthesis. The elimination of bone grafting procedures provides a shorter total treatment time, less patient morbidity, decreased cost, and possible immediate restoration. Tilted implants also provide an increase in the anterior-posterior spread, resulting in a stronger prosthesis by eliminating or shortening distal cantilevers that are common with non-tilted implants used to supported fixed prostheses.

Risks and failures

In a recent study, Parel et.al.³⁶ described risk factors that must be considered when contemplating the use of tilted implants. The primary factors identified included a natural opposing dentition, poor bone density, bruxism, and male gender. Secondary factors, such as smoking and poor bone volume may increase

the failure rate and consideration should be given to these risks by the placement of additional implants or delayed loading.

Conclusion

The fundamental idea in today's use of titanium root forms to support prosthetic appliances is relatively unchanged when compared to the original concepts put forth by P.I. Branemark decades ago. However, use of modern implant surfaces, improved materials, different implant designs, and expansion of our knowledge and literature base have caused a change in the protocols that were used decades ago. Part of this change has led to the more common use of tilted implants and their use has allowed for a radical expansion of the surgical and prosthetic possibilities that our profession can offer our patients. The dental profession is now able to treat the edentulous maxilla with a larger arsenal of tools which now includes a fixed, implant-supported prosthesis that can be done in less time, with less cost, and with reduced surgical intervention than options we have had in the past. ●



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