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Review Article

ANGULATED IMPLANTS: A LITERATURE REVIEW

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ABSTRACT

Dr. Paulo Malo in 1993 advocated angulated placement of implants and named this concept as "All on four" in which two vertical implants are placed in anterior region and two implants in posterior region are placed at an angulation of 35-40 degrees [2]. Since then, several clinicians and researchers have reported use of angulated implants with varying degrees of success over a period of time but there is no consensus about the routine use of angulated implants for rehabilitation of patients with severely resorbed alveolar ridges

INTRODUCTION

Rehabilitation of completely edentulous patients with implants is a well-established and reliable mode of treatment. Availability of good quality and quantity of bone for implant placement is very important aspect. Patients with severe resorption of alveolar bone require prior surgical intervention in the form of bone augmentation and sinus lift procedures for its successful outcome.

Traditionally, it is well established that the masticatory forces must be directed along the long axis of the tooth or implant which increases the longevity and reduces the amount of bone resorption. Due to lesser amount of bone available in severely resorbed alveolar ridges, researchers have been trying to find a suitable alternative to bone augmentation and sinus lift procedures so that additional surgical procedures could be avoided. Dr. Paulo Malo in 1993 advocated angulated placement of implants in such cases and named this concept as "All on four" in which two vertical implants are placed in anterior region and two implants in posterior region are placed at an angulation of 35-40 degrees [2]. Since then, several clinicians and researchers have reported use of angulated implants with varying degrees of success over a period of time but there is no consensus about the routine use of angulated implants for rehabilitation of patients with severely resorbed alveolar ridges.

Advantages

Stability even in minimum bone volume: Longer implants can be used in minimum bone volume with advantage of increasing bone-to-implant contact and reducing the need for vertical bone augmentation. Good clinical results. Eliminates the need for bone grafting which is invasive with unpredictable outcome [3]. Can usually be performed in patients with various systemic conditions which are often contraindications for bone grafting [3]. The angulations allow placement that avoids anatomical structures [1]. There is a biomechanical advantage in using tilted distal implants rather than distal cantilever units [4].Reduce the length of cantilevers without performing bone grafting or sinus lifting [5]. Effective and safe alternative to maxillary sinus floor augmentation procedures [6] and to pneumatised maxillary sinus [7]. Distally tilted implants induced better loading transmission than vertical implants [8]. Excellent prognosis in short-medium term [9] as well as in long term [10]

Disadvantages

Procedure is highly technique sensitive. Surgeon need to be very skilful. Computer guided surgical stent required for implant to be placed in desired angulation. Even slight change

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in angulation may pose problem to patient and operator. Long term studies are not available.

Distance between Two Implants

A trigonometry ratio was developed to estimate a two-dimensional safe distance between a tilted implant and an adjacent vertical implant. The distance or length between the fixtures can be determined by multiplying the known length of each implant by a constant derived from the sin of the insertion angle [11]. In edentulous maxillae if inter-implant distance is increased, load distribution will be better [12].

Recommendations

The use of angulated implants should remain confined to situations of favourable bone quality (preferably greater than D3).Angulated implants should only be placed after suitable three-dimensional-planning, leading to three-dimensional treatment guidance. Greater inclinations of the implants ($>30^0$) lead to increased force levels at the implant-bone and implant-abutment-interfaces. Therefore, extreme angulations should be avoided. Inter-implant angulations should be confined to a single three-dimensional plane to simplify prosthetic restoration. Single tooth restorations and cantilever bridges on angulated implants should be avoided, and the aim should be to splint the implants.

Background

Before we proceed for discussion about angulated implants, we must take a brief insight regarding axial implant. Axial implants are those which are placed perpendicular to the bone or occlusal surface or parallel to the long axis of an adjacent tooth. Success of an implant treatment is viewed via various aspects like osseointegration, marginal bone loss around implant, effect of implant angulation and prosthesis survival. After implant is placed into bone, it gets osseo-integrated with the bone which is related to the bone quality, host response, asepsis maintenance, general health of patient, site of implant placement etc.

Success Rate

Various studies are available regarding success rate of angulated implant placement at various time intervals. Malo *et al*., [13] clinically retrospected all on Four immediate function concept in 44 patients in which 176 implants were loaded. Cumulative survival rates of 96.7% and 98.2% for development and routine groups respectively were noted with 100% prosthesis survival rate and low marginal bone resorption over period of 6 months.

Calandriello and Tomatis [14] conducted one year prospective clinical study in 18 patients to treat atrophic posterior maxilla with 60 tilted implants with cumulative survival rate of 96.7%. Penarrocha *et al*., [15] concluded after one year follow up study of tilted implants in buccolingual direction in restoration of posterior mandible with horizontal atrophy provided good results.

Graves *et al*., [16] reported good performances of this technique, in terms of implant survival rate and function in a large cohort of 276 patients, evaluated after 16 months from prosthesis placement. Malo *et al*., [17] conducted an open cohort study with mean follow up of two years for immediate rehabilitation of completely edentulous arches with four implant prosthesis concept in 142 patients who received 227 implants and concluded that this procedure in difficult conditions is a viable concept in short term. Babbush *et al*., [18] retrospectively studied 708 implants placed at an angle in 165 patients and reported cumulative survival rate of 99.6% (99.3% in maxilla & 100% in mandible) for up to 29 months of loading. Definite prosthesis survival rate was 100%.

Agliardi *et al*., [19] evaluated prognosis of immediately loaded fixed full prostheses for treatment of edentulous patients with extreme bone loss in posterior mandibular region over mean period of 30.1 months and found excellent outcome.

Butura *et al*., [20] studied mandibular all on four technique using 857 angled implants in 219 jaws over three years and stated that procedure can be carried out with high confidence. Crespi R *et al*., [21] reported 98.96% of implant survival rate after three years from loading for 24 maxillary rehabilitations without any prosthetic complete failure.

Krekmanov *et al*., [22] studied tilting of posterior implants for improved prosthesis support in 47 patients and found that there were no implant failures in mandible while cumulative success rates in the maxilla at five years were 98% for tilted implants and 93% for non-tilted implants.

Rosen and Gynther [10] evaluated retrospectively the surgical outcome of tilted implants in severely resorbed edentulous maxilla as an alternative to bone grafting. They demonstrated that such patients can be treated successfully with success rate of 97% in 103 implants of 19 patients over long term follow up of 10 y (mean).

Ata-Ali *et al*., [23] performed meta-analysis on oral rehabilitation with tilted implants and deduced that tilted implants exhibit same evaluative behaviour as axial implant. There was no evidence of differences in success rate between tilted and axial implants in either the prospective or retrospective studies subjected to review. The marginal bone loss observed with the tilted and axial implants likewise proved very similar.

Implant bone Interface

Cehreli *et al*., [24] demonstrated in them in-vitro study that angulated implants were associated with higher forces acting on the implant-bone interface during axial loading of maxillary or mandibular superstructures that were supported by four implants. Particularly high loads acting on the implant-bone interface must be expected in single tooth restorations, and these loads will become more severe with increasing length of the load arm involved (off-axis loading) [25]. Kvanc and Haldun [26] performed spiral CT study to evaluate effect of residual bone angulation on implant supported fixed prosthesis in 30 patients and found minimum angulation values at second premolar, first and second molar region were 0^0, 3^0, 9^0respectively. Average values being 4^0, 10^0, 15^0 and maximum values 11^0, 18^0, 22^0 respectively. Bone loss around an implant placed at an angle is same or less as compared to that around axial implant [10,14,19].No correlation exists between implant angulation and bone loss [27,28].

Implant Angulation

Angled implants have smaller quantity of fringes and stresses which were located mostly around apical region of lateral

implants [29]. Gulizio *et al*., [30] studied an effect of implant angulation on retention of overdenture attachment and concluded that angle had an effect upon retention of gold matrices, but not for titanium matrices. Pellizzer *et al*., [31] studied influence of implant angulation with different crowns on stress distribution and found that screwed prosthesis exhibited highest stress concentration. Higher the implant angulation, higher is the stress value, independent of crown type. Increasing the tilt of distal implant does not increase the stress significantly. Architecture of mandible plays a major role during treatment planning of complete edentulous patients [32].

DISCUSSION

The present review discusses an alternative mode of treatment in cases where there is too much of bone resorption which limits implant treatment. To avoid various invasive procedures like bone augmentation and sinus lift, this modality is gaining popularity amongst patients and surgeons. Various short-term studies are supporting this procedure strongly in terms of success rate. Axial implant placement has been accepted worldwide as a successful treatment modality for rehabilitation. When various criteria for success of implant prosthesis like osseointegration, crestal bone loss around implant neck, longevity or survival of the restoration etc. are considered along with complications associated with implants; most of the studies have demonstrated excellent success rate over a period of time (1-10 y) with an average of more than 95%. Commonly accepted criteria for assessment of implant success were proposed by Albrektsson *et al*., [33] Misch *et al*., [34] at the International Congress of Oral Implantologists(ICOI) pisa consensus conference. Based on above criteria, number of studies has been reported claiming success rate of the order of 78-100% with more than 15 y of observation time [35-37]. In case of atrophic maxilla, implant placement isn't possible without undergoing invasive procedures like bone augmentation or sinus lift procedure or both. Several types of complications may occur during and after the sinus elevation procedure like Schneiderian membrane perforation, nose bleeding, post-operative pain and swelling even though it was not described an important negative effect on implant success rates [38]. But patient may be under psychological stress and addition of burden of an extra surgery and increased cost if enough bone isn't available to carry out sinus lift and implant placement at same appointment [39].Bone grafting, though practicable now a days is dependent on many factors like type of bone graft used (autogenous, alloplastic or xenograft), host response, age of patient, various complications associated with grafting procedure, infection and most importantly time spent while graft material matures and is taken up by bone. One review revealed that there are not many studies providing data on success rate of dental implants placed in on lay graft augmented ridges and demonstrated, on average, a poor methodological quality [40]. Considering all these things, placement of an angulated implant avoiding both invasive procedures like sinus lift and bone augmentation procedure is a viable treatment option [41]. Bone tolerates the forces more favourable when those are directed vertically. Forces on axial implants are directed vertically along long axis of an implant and suggested to be more favourably as they distribute stress more evenly throughout implant [42]. This explains high survival or success rate of axially placed implants with a minimum crestal bone loss of 0-0.2mm/year [43-45]. But scenario is different in case of angulated implants. The angulated implants direct the forces at an angle and thus are associated with higher forces acting on implant bone interface during axial loading [24] which should logically induce bone resorption by disrupting bone implant interface which is supported by in vitro experiments that show that non axial loads cause stress concentration in the marginal area of bone [38-41] but this hasn't been demonstrated in vivo or in other words crestal bone around neck of an implant but this doesn't happen because all prostheses fabricated on implants placed using this technique are removable type and produces intermittent type of force on implants in contrary to fixed prosthesis. But, one study has showed excellent outcome with immediately loaded fixed full prosthesis [19]. Also, it has been proved that tilting of posterior implants improves prosthesis support [22]. Various studies carried out regarding success rate of angulated implants have shown same or less amount of crestal bone loss in comparison to axial implants [10,14,19]. Some studies have advocated that we should not place single angulated implant to replace single missing tooth since prosthesis fabricated over it will be of fixed type creating more amount and duration of load and increased off axis loading [25]. In one meta-analysis, author found no difference in success rate between tilted and axial implant [23]. This opens our thought process that tilted implants can be placed at high success rate as that of axial implant. In various studies surgeons used four implants to replace complete maxillary or mandibular denture of which two were placed at an angle and two axially. None of the researchers have used or advocated the use of all four angulated implants since load distribution will not be favourable in such case. It seems that in their opinion, placement of two axial implants is essential when two angulated implants are used in order to distribute load more favourably. In addition, most of the studies are short term ranging from 1-3 y. Though short term studies show no difference in amount of bone loss around axial and angulated implant, data available is not sufficient to predict long term success.Vertical forces applied during mastication and deglutition is supposed to cause more bone destruction than horizontal forces acting around an angulated implant. Also, stress values are directly proportional to implant angulation. Deflection and stress concentration generally increases with increase in either magnitude or angle of loading. When vertical loads are applied to vertical and angled implants, there is only apical migration in vertical implants but there is significant deflection coupled with some apical migration in angled implants [46]. Duration of force applied is more influential in bone resorption and deformation than is the amount of force [47].Therefore, long term clinical and histopathological studies are necessary and recommended to utilise this modality in routine practise. However, this procedure is a viable concept in short and medium term [13-15,17].

CONCLUSION

This technique is extremely technique sensitive, useful in patients with resorbed ridges but long term studies are required to evaluate its success rate in terms of load distribution, marginal bone loss around implant and prosthesis survival but currently many practitioners are treating patients with this modality with a great success.

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