CURRENT CONCEPTS IN OCCLUSAL LOADING OF DENTAL IMPLANTS : AN OVERVIEW

Dr. Harshitha Alva[1]*, Dr. Suresh Nagaral[2]

Reader[1], Department Of Prosthodontics, Dayananda Sagar College Of Dental Sciences, Bangalore 560011
Professor & Head[2], Department Of Prosthodontics, Dayananda Sagar College Of Dental Sciences, Bangalore 560011

Corresponding Author *
Dr. Harshitha Alva
Email: drharshitha@gmail.com

ABSTRACT:

Transfer of mechanical load across the interface between prosthesis and their supporting biological structures, play a significant role in the success of Prosthodontic rehabilitation. Over the years various concepts of loading for various types of dental implants have been put forth by different authors.
This article discusses different loading concepts considering the various types of dental implants based on different clinical situations.
Keywords: loading of implants, occlusion, Occlusal loading, Pterygoid implant, Zygomatic implant

INTRODUCTION:

Prof. P.I Branemark's concept of osseointegration has taken implant dentistry by leaps in recent years. One of the key factors that influence osseointegration of dental implants is mechanical loading. Various studies have concluded that rate and loading frequency are of prime concern amongst the numerous factors that influence the response to mechanical loading.
Bone being a living structure could adapt its mass and structure to the demands of mechanical loading. Osteocytes, buried in the bone matrix and the lacuna-canalicular porosity are believed to be the professional mechanosensory cells of bone that mediates mechanosensing. In 1981, Albrektsson and colleagues[1] identified six factors that influence osseointegration : (1) status of the bone; (2) loading conditions;(3) surgical technique; (4) implant design; (5) implant finish; and (6)implant material.

Branemark's original protocol:

The two-stage surgical protocol established by Branemark et al to attain optimum osseointegration consisted of prerequisites such as countersink the implant below the crestal bone, obtaining and maintaining a soft-tissue cover over the implant and a minimally loaded implant for 3 to 6

months. The primary reason cited for the submerged surgical approach of implant placement was to reduce and minimize the risk of bacterial infection, to prevent apical migration of the oral epithelium along the body of the implant, and to minimize the risk of early implant loading during bone remodelling[1]. A second-stage surgery was thus necessary to uncover the implant and attach a prosthetic abutment.

LOADING CONCEPTS:

Immediate loading:

Immediate loading refers to implant-based surgical technique in which the implant supported restoration is placed into occlusal loading within 48 hours after implant placement. Immediate loading of a dental implant includes a non-submerged, one stage surgery and actually loads the implant with a provisional restoration at the same appointment[2]. It is indicated when there is adequate bone quality (type I, II or III), sufficient bone height of approximately 12mm, sufficient bone width of approximately 6 mm and the ability to achieve an adequate antero-posterior (AP) spread between the implants. A poor antero-posterior spread decreases the mechanical advantage gained by splinting the restoration.

The contraindications include poor systemic health, severe para functional habits, reduces bone density (e.g. type IV), decreased bone height or width and inability to achieve an adequate AP spread.

According to Gapski et al, the following four categories of factors influence the result of immediate implant loading[3]

TABLE 1 : Factors influencing the result of immediate implant loading

1	Surgery-related factors	Primary Implant Stability Surgical Technique
2	Host-related factors	Quality and Quantity of cortical and trabecular bone Wound healing Modelling / Remodelling activity Oral Hygiene/ patient compliance
3	Implant-related factors	Implant number Dimensions of the implant Implant design Surface condition of the implants
4	Occlusion-related factors	Occlusal forces Implant position

The immediate implant-loading concept challenged the conventional protocol of no occlusal loading of the implant for 3 to 6 months before the restoration of the implant. The surgical process of the implant osteotomy preparation and implant insertion causes a phenomenon of bone repair around the implant interface. As a result of this surgical process, organized and mineralized lamellar bone becomes unorganized, less mineralized and woven bone of repair next to the implant.

The implant-bone interface is weakest at 3 to 6 weeks and at a risk of overload, after surgical insertion due to the surgical trauma that causes bone

remodelling at the interface that is least mineralized and unorganized during this time frame. One method to decrease the risk of immediate occlusal overload is to decrease the surgical trauma and the amount of initial bone remodelling during implant placement. The protocol for immediate load is to tighten the implant within the bone to 45 to 60 Ncm[3]. Although this concept helps to ensure that the implant has rigid fixation and is in good quality bone, the additional torque used to secure or evaluate fixation of an implant in bone actually may increase the strain at the interface and therefore increase the amount of remodelling, which decreases the strength of the bone-implant interface. Hence, it is prudent to minimize factors related to thermal injury and surgical trauma when considering immediate load to the implant interface.

Rationale for immediate loading is not only to reduce the risk of fibrous tissue formation which may result in clinical failure, but also to minimize woven bone formation and promote lamellar bone maturation to sustain occlusal load.

The Branemark Novum concept[4]:

The Novum Concept was conceived in 1980. This treatment modality is based on the Branemark Classic osseointegration procedure, a two-step surgical approach with varying time intervals between the steps. The distinctive feature of this procure is that it requires only 6 to 8 hours for reconstruction of the entire dentition and thus gives the patient a third set of teeth in just 1 day. There are four drill templates and eight drill guides that precisely position three implants which are totally parallel and level. A prefabricated lower bar is placed on three implants, and an upper bar fits on the lower bar. The denture teeth and vertical dimension of occlusion are previously selected by the dentist. Then the case is waxed up, adjusted, processed and fit and insertion done on the same day.

Apart from reduced cost, the advantage of this procedure is completion of the surgery and reconstruction in one day, with rigid stabilization at the time of implant placement. Disadvantages include appearance of the lower bar when the patient pulls down his or her lower lip, extensive surgical procedure demanding much more than routine implant surgery, limited patient selection due to anatomic limitations and also the surgical template might not fit all mandibles.

Early loading:

An implant supported restoration that is in occlusion between 2 weeks and 3 months after implant placement is referred to as an early loaded implant. The fundamental goal of early loading is to help improve bone formation in order to support occlusal loading at two months[5].

Delayed loading:

It refers to implant prosthesis with an occlusal load after more than 3 months of implant placement. This loading approach either uses a two-stage surgical procedure that covers the implants with soft tissue or a one-stage approach that exposes a portion of the implant at the initial surgery.

The rationale behind this approach is that premature loading of implants would lead to implant micro movement, caused by functional force around the bone-implant interface during wound healing and may induce fibrous tissue formation rather than bone contact, leading to clinical failure. In

addition, prevention of infection and epithelial down growth can also be prevented by coverage of the implant. Initial exposure or biomechanical stimuli often induce a fibrous connective tissue interface between implants and bone. Hence the submerged implants were preferable for initial rigid fixation[4].

Progressive loading:

In 1980, the concept of progressive or gradual bone loading was proposed by Branemark during prosthetic reconstruction to decrease crestal bone loss and early implant failure of endosteal implants[6]. Bone density and bone-implant interface were found to be the key factors affecting progressive loading of implants.

A review of the literature of in vivo and in vitro studies[7,8] has shown that a significant metabolic change in the bone cell population is caused by dynamic or cyclic loading. The greater the rate of change of applied strain on bone, more is the bone formation. The effect of applied strain on bone is dictated not only by the rate of the applied load but also by the magnitude and duration. Lower-magnitude loads applied for many cycles can cause the same anabolic effects of larger loads applied for a limited number of cycles. Therefore, a range of clinical conditions may equate to an increase in bone density.

The bone strength is directly related to density, with Division D1 bone being 10 times stronger than D4 bone to stresses that cause micro-fracture[9]. Therefore, increasing bone density around an implant increases the strength of bone, which in turn help to avoid crestal bone loss and implant failure.

Considering different types of implants:
Mini implants:

Mini implants may be placed in sites where there is osseous atrophy or site-length attenuation. Immediate loading of mini-implants may not be appropriate for fixed prosthesis. These prostheses apply much greater off-axial forces, which may induce micro-movement and result in the implant failure. Bone should be Misch type I or II, and an implant protective occlusal scheme should be used whenever mini-implants are the treatment option.[10,11]

A minimum of 6 implants maybe needed to retain a maxillary removable complete denture, 10 to 12 implants may be needed to support splinted fixed complete maxillary prostheses[11]. Occlusal and masticatory forces are distributed over these multiple splinted implants, thus reducing the relative load on a single implant by increasing the surface area loaded against the supporting bone. Two mini-implants can be used for certain mandibular tooth-bound molar sites to accept a splinted crown restoration[12]. Generally, mini-implants are indicated at sites where a standard diameter implant may not fit with adequate tooth-to-implant spacing. Hence two mini-implants can resist axial forces. However, rounded and narrow prosthetic teeth may be required to present a small occlusal table to minimize off-axial forces.[10,11]

Pterygo-maxillary implants:

The use of pterygoid implants was described by Tulasne[13]. Restoration of posterior atrophied maxilla with implant is a complex entity in itself[12]. Since implant placement in this area is often accompanied by sinus lift which itself is a morbid

procedure with questionable success rate, this new approach of placement of implants in Pterygo-maxillary area was explored. Literature describes two anatomic locations where implants can be placed: the Pterygoid process and the Pterygo-maxillary region[13]. Bahat et al considered it necessary to have the patient's mouth open to a minimum of about 35 mm to achieve desirable implant angulation[14].These pterygoid implants often offer immediate loading solutions as the bone present in that region is predominantly cortical (Type I-Type II). Therefore, it is observed that, given the excellent results achieved with pterygo-maxillary implants, this procedure has gradually established itself as not only a reliable treatment option but also one that offers good long-term results[15].

Zygomatic implants:

Rehabilitation of the maxillary anterior region has been far easier than rehabilitation of maxillary posterior region due to various reasons. According to Lekholm and Zarb classification system, the posterior maxillary region is characterized by factors such as: inadequate residual bone height due to maxillary sinus expansion and/or alveolar bone resorption and poor bone density (Type III or IV) [15-18]. Considering these anatomic challenges, few techniques have been put forth such as sinus lift procedures, guided bone regeneration, grafting with autogenous and allogenous grafts and later tilted implants (All-on-4) and zygomatic implants were introduced[19]. However, these procedures have complications such as sinus membrane perforation, graft displacement into sinus cavities, rejection of graft and screw loosening of tilted implants. To prevent these problems, posterior most area of maxillary tuberosity that is distal to maxillary sinus can be utilized for implant placement.

It was proposed by Tulsane in 1992 that implants placed in compact bone of the pterygomaxillary region shows osteointegration and provide retention and stability[20]. Tulasne (1989) credited Paul Tessier for proposing the idea of placing implants in the pterygoid region.

DISCUSSION:

Marginal bone resorption around dental implants can hamper the stability of peri-implant tissue which may lead to peri-implantitis or unesthetic implant restorations.

Certain studies have also evaluated the effect of loading on the success of dental implants. Henry and Rosenberg[21] used Branemark implants with bicortical anchorage and concluded that after a period of 6-7 weeks before loading the implants, success rate of 100% was obtained whereas Salama et al[22] found no difference in success rate between the randomly applied immediate and delayed loading. Scortecci[23] also studied immediate loading of implants with bicortical anchorage. They demonstrated that bicortical anchorage and the placement of a rigid prosthesis allows the immediate loading of implants, with a predictable outcome.

Horiuchi et al.[24] studied the immediate loading of Branemark implants and suggested delayed loading for the placement of overdentures, both in the maxilla and mandible. Jo et al.[25] concluded that primary stability of the implants at the time of the loading is the main factor influencing the success of immediate loading. Vercruyssen and Quirynen in their long-term study concluded that some

factors such as smoking, guided bone regeneration, the presence of dehiscence and bone quantity had a significant impact on the marginal bone loss around the dental implants[26].

Due to increase demands of shortening treatment time and reducing patient discomfort, immediate loading of dental implants has emerged. Regular maintenance also played a key role to ensure long-term success of immediately loaded implants. In addition, factors relating to surgery, host factors, implant and occlusion-related factors are also of utmost importance and should be analysed prior to initiation of treatment.

CONCLUSION:

Different loading protocols have been applied in different clinical situations over the past few decades. Immediate loading has achieved success when compared to other loading protocols, but primary implant stability is a key factor to be considered before attempting immediate implant loading along with other factors like patient's medical and psychological condition. Thorough diagnosis, treatment planning, analysis of bone quantity and quality as well as careful selection of implant size and form and application of loading concept are necessary factors for the long-term success of Osseo integrated supported prosthesis.

REFERENCES:

1. Albrektsson T, Brånemark P-I, Hansson H-A, Lindström J.Osseointegrated titanium implants: requirements for ensuring a long-lasting direct bone-to-implant anchorage in man. Acta Orthop Scand 1981; 52:155–170
2. F. Lobbezoo, J. E. I. G. Brouwers, M.S. Cune & M. Naeije. Dental implants in patients with bruxing habits. Journal of Oral Rehabilitation 2006 33; 152–159
3. L. Schropp & F. Isidor Timing of implant placement relative to tooth extraction. Journal of Oral Rehabilitation 2008 35 (Suppl. 1); 33–43
4. Engstrand P, Nannmark U, Mårtensson L, Galéus I, Brånemark PI. Brånemark Novum: prosthodontic and dental laboratory procedures for fabrication of a fixed prosthesis on the day of surgery. Int J Prosthodont. 2001 Jul-Aug;14(4):303-9.
5. Appleton RS, Nummikoski PV, Pigno MA, Cronin RJ, Chung K-H. A radiographic assessment of progressive loading on bone around single osseointegrated implants in the posterior maxilla. Clin. Oral Impl. Res. 16, 2005; 161–167.
6. Glossary of Prosthodontic Terms. Journal of Prosthetic Dentistry. July 2005
7. Misch CE. Stress factors: Influence on treatment planning. In: Misch CE (ed). Dental Implant Prosthetics St Louis: Elsevier Mosby, 2005:71-90
8. Misch CE. Force factors related to the patient. In: Misch CE (ed). Dental Implant Prosthetics St Louis: Elsevier Mosby, 2005:91-104 Schwarz, Melvyn S. Mechanical complications of dental implants. Clin Oral Implants Res. 2000;11 Suppl 1:156-8
9. Shatkin TE, Shatkin S, Oppenheimer. Mini dental implants

for the general dentist. Compend Contin Educ Dent. 2003;24(S1):26–34.
10. Flanagan D. Fixed partial dentures and crowns supported by very small diameter dental implants in compromised sites. Implant Dent. 2008;17:182–191.
11. Sato Y, Shindoi N, Hosokawa R, Tsuga K, Akagawa Y. Biomechanical effects of double or wide implants for single molar replacement in the posterior mandibular region. J Oral Rehabil. 2000;27:842–845.
12. Eugenia C, David P, Maria P. Rehabilitation of the Atrophic Posterior Maxilla with Pterygoid Implants: A Review. J Oral Implantology 2012:38(1);461-66.
13. Bahat O. Osseointegrated implants in the maxillary tuberosity: report on 45 consecutive patients. Int J Oral Maxillofac Implants. 1992;7:459–67.
14. Nocini PF, Albanese M, Fior A, De Santis D. Implant placement in the maxillary tuberosity: the Summer's technique performed with modified osteotomes. Clin Oral Implants Res 2000;11:273–8.
15. Cucchi A, Vignudelli E, Franco S, Corinaldesi G. Minimally invasive approach based on pterygoid and short implants for rehabilitation of an extremely atrophic maxilla: Case report. Implant Dent 2017;26:639-44.
16. Procacci P, Lora V, Rossetto A, Gelpi F, Marconcini S, Armani L, *et al*. Success of bone grafts in strophic posterior edentulous mandible: A Literature review. Minerva Stomatol 2014;62:59-62.
17. De Santis D, Trevisiol L, D'Agostino A, Cucchi A, De Gemmis A, Nocini PF, *et al.* Guided bone regeneration with autogenous block grafts applied to le fort I osteotomy for treatment of severely resorbed maxillae: A 4 to 6-year prospective study. Clin Oral Implants Res 2012;23:60-9.
18. Balaji VR, Lambodharan R, Manikandan D, Deenadayalan S. Pterygoid implant for atrophic posterior maxilla. J Pharm Bioallied Sci 2017;9:S261-S263.
19. Tulasne JF. Implant treatment of missing posterior dentition. In: Albrektsson T, Zarb GA, editors. The Branemark Osseointegrated Implant. Chicago: Quintessence; 1989. p. 103.
20. Henry PJ, Rosenberg I. Single-stage surgery for rehabilitation of the edentulous mandible: Preliminary results. Practical and Periodontics Aesthetic Dent 1994;6:15-22.
21. Salama H, Rose LF, Salama M, Betts NJ. Immediate loading of bilaterally splinted titanium root form implants in fixed prosthodontics: A technique reexamined. Two case reports. Int J Periodontics Restorative Dent 1994;15: 345-61.
22. Scortecci G. Inmediate function of cortically anchored disk-design implants without bone augmentation in moderately to severely resorbed completely edentulous maxillae. J Oral Implant 1999;25:70-9.
23. Horiuchi K, Uchida H, Yamamoto K, Sugimura M. Immediate loading of Brånemark system implants following placement in edentulous

patients: a clinical report. Int J Oral Maxillofac Implants 2000;15:824-30.

24. Jo HY, Hobo PK, Hobo S. Freestanding and multiunit immediate loading of the expandable implant: an up-to-40-month prospective survival study. J Prosthet Dent 2001;85:148-55.
25. Shatkin TE, Shatkin S, Oppenheimer AJ, et al. A simplified approach to implant dentistry with minidental implants. Alpha Omegan. 2003;96:7–15.