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BIOMECHANICS IN IMMEDIATE LOADING OF MAXILLARY ANTERIOR IMPLANTS- A NARRATIVE REVIEW

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Abstract

Purpose: *The purpose of this review is to analyse the biomechanics in, immediate loading of maxillary anterior implants and, to study the complications and failures in immediate loading protocol.*

Study Selection: *This is a narrative review performed through scientific articles published between the year 1981 and 2021, indexed in MEDLINE and pubmed databases. The study selected articles that focused on immediate loading and its biomechanical factors.*

Results: *Immediate loading is a very important protocol in Anterior Maxillary Implants as esthetics is an important concern for the patients in this region. But this concept comes with its own advantages and dis-advantages and for the long-term success, biomechanical factors need to be considered. Also, if any failures and complications occur so they need to be properly managed.*

Conclusion: *This narrative review explores various biomechanical factors affecting immediate loading of implants in esthetic zones and how to plan treatment accordingly. Also, common failures and complications and their management have also been discussed in this article.*

Keywords: Anterior Implants, immediate loading, biomechanics, platform switching, morse taper

Introduction

There has been an immense development in the field of implantology with respect to the implant designs, implant materials, concepts about timing of implant placement and implant loading. For years the two-stage surgical protocol given by Brånemark et al. to accomplish osseointegration was considered a gold standard for achieving osseointegration and long-term success. With advances in implant technology, the traditional protocol in implant dentistry has been revaluated, which has led to a growing interest in the immediate loading protocol. An abundance of clinical studies has shown positive outcomes and success with loading implants immediately or within a short period after implant placement.[1] One of the advantages of immediate implant placement and provisionalization is optimization of esthetics by preserving the existing osseous and gingival architecture.

To plan immediate loading, the prerequisites that are considered are, adequate bone density2[], sufficient bone dimensions[3], ideal insertion torque[4,5], ideal resonance frequency analysis

readings[6,7], ability to acquire an adequate anteroposterior spread.

Advantages of Immediate Loading protocol ranges from less discomfort for patients, faster treatment, more ideal soft tissue drape, immediate satisfaction and patient acceptance, greater bone-implant contact.[8,9,10,11,12] Whereas, dis-advantages of immediate loading are, increased requirement of skill level, longer initial surgical/ prosthetic appointment, possibility of increased implant morbidity.

It is important to study the biomechanics in immediate loading protocol of implants to understand the effect upon the implant-prosthesis system and oral cavity because of functional and para-functional forces. Therefore, this review article discusses about various factors involved in biomechanics of immediate loading of implants placed in esthetic zone.

Biomechanical Factors

Type of Bone

The type of bone often influences treatment outcome. There are variations in biomechanical behaviour between the four types of bone, influencing the ability of the bone to receive physiological loads. Bone-implant contact is much more in cortical bone in comparison to trabecular bone and hence the primary stability in cortical bone is greater and better distribution of forces is also there. In low density bone large number of implants or implants with greater bone contact can be used.

Design of the Implant

Length of the implant is important for achieving good primary stability. It has been observed in studies that coronal part of the implant supports all the tensional load.[13,14] Primary stability is increased with number and depth of implant threads due to increase in implant-bone contact.

Platform Switching

The platform-switch concept, introduced by Lazzara and Porter, consists of the use of prosthetic components of smaller diameter with respect to the diameter of the implant platform. It is observed that stress around peri-implant bone is reduced by platform switching which leads to less marginal bone resorption.[15]

Connection Type

The geometric design of implant connections affects the sealing of the implant-prosthesis interface. Internal connections and external connections are the two main types. Internal connections provide greater stability and reduce micro-movements during loading. Ribeiro et al. studied fatigue resistance in abutments with different connections: external hexagon, internal hexagon, and Morse taper. They analysed the screw fracture point and found that external hexagonal connections had lower resistance to fracture, while no significant differences were observed between internal hexagon and Morse taper designs. This suggests internal connections are generally more reliable in maintaining interface stability.[16]

Methods for Biomechanical Control

Number of Implants

When circumstances beyond our control, such as replacing a canine, low bone quality, or a porcelain antagonist, increase the tensions and forces on the implant prosthesis system, it is essential to compensate by increasing the surface area over which these forces are distributed. Surface area is hence increased by increasing the number of implants. This approach helps to mitigate

the excess stresses and enhance the stability of the implant.

Pontic Length

In fixed prosthesis rehabilitation on natural teeth, it is crucial to avoid excessively long pontics. This principle also applies to implant-supported prostheses. During biting, the pontic experiences a force that causes it to flex. For bridges over natural teeth, some flexion is absorbed by the periodontal ligament of the abutment teeth, which is not the case for implant-supported bridges due to the absence of such ligaments and their lack of intrusion capability. Increased distance between abutments and higher loads result in greater flexibility of the prosthesis material, leading to increased bending. This bending induces shear loads and tension on the abutments. The greater the flexion, the higher the risk of complications at the prosthetic component level. To mitigate these issues, an ideal treatment plan should limit the size of the pontics to the equivalent of two premolars, approximately 13.5 to 16 mm

Occlusion in Immediate Loading

For immediate loading, occlusion guidelines include: smaller occlusal surfaces than natural teeth, centered contacts, minimally angled cusps, proper distribution of chewing forces, avoidance of cantilevers, and adherence to a soft diet. These measures help ensure optimal function and longevity of the implant

Occlusal Adjustment

Conventional methods for adjusting occlusion are articulating papers, fabrics, vinyl and shim stock strips.[18] Dis-advantage with these methods is information about occlusal load depends on the experience of operator and perception of patient which need not be very accurate.[19] Due to these limitations, an accurate occlusal adjustment method, T-Scan was invented. T-Scan® which a digitized system is capable of identifying the contacts and it quantifies incident forces in absolute or relative units. It helps the operator to eliminate those contacts that prevent achieving the objective of a no simultaneity pattern by detecting the sequence of occlusal contacts.

Complications in Immediate Loading

Immediate loaded implant failures often occur between 3-5 weeks post-operatively, typically due to mobility without infection. Ensuring greater bone-implant contact and minimizing surgical trauma is essential. Preventing thermal injury and mechanical trauma that can cause microfractures is critical, as these can lead to osteonecrosis and fibrous tissue formation around the implant. Osteoblast death has been observed at temperatures as low as 40°C. Failures and complications in immediate loading of implants are categorized into surgical complications and prosthetic complications. Effective management involves careful surgical technique to avoid thermal and mechanical damage and promote optimal bone integration.

Surgical Complications

Drilling in poor quality bone

The primary intraoperative surgical complication is drilling in areas of poor bone quality, which can reduce primary implant stability and jeopardize the outcome. Using tapered implant systems and specific thread designs can enhance implant stability in poor-quality bone. Additionally, the surgeon's advanced experience is crucial. Undersizing the osteotomy and forgoing the use of final drills recommended by the manufacturer can improve primary stability. The osteotomy technique is highly sensitive and demands meticulous attention and care. Instead of traditional drills, special osteotomes (condensers) can be used to condense the bone, increasing bone-implant contact and enhancing

implant stability. Proper technique and equipment selection are vital for successful implant placement in challenging bone conditions.

Overtorquing an implant

Bone necrosis, defects and fractures can occur due to overtorquing the implants. This leads to diminished osseointegration and hinders the healing too. Management includes placing deeper implants and tapping before applying excessive implant torque.

Implants placed in fresh extraction sockets with immediate loading

Immediate bone-crest implant placement post-extraction may cause resorption and thread exposure, especially in the esthetic zone. To avoid complications, consider extraction with socket ridge preservation, conventional loading, deeper placement with platform-switching implants, and abutment-level impressions

Prosthetic Complications

Provisional restorations must be made from stable materials to prevent fractures during healing. In full-arch immediate loading, restorations should manage occlusal forces effectively. Metal reinforcement is recommended for cases with excessive loading or long-term provisionalization. If the implant-abutment connection loosens, the abutment should be tightened to the final prosthetic torque. Studies indicate higher failure rates for immediately loaded implants in patients with a history of bruxism. Proper management of these factors is essential to maintain implant stability and longevity in clinical practice.

Conclusion

Biomechanical analysis and considerations are very important when immediate loading protocol is followed in case of Maxillary Anterior implants as it leads to better implant stability and hence increased implant success and outcomes.

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