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Review of Literature: Loading Protocol in Implant Dentistry.

Dr. Kavita Kanojia[1] (Fellowship in oral implantology), Dr. Jyoti Tembhurne[2] (Head of Department), Dr. Arti Gangurde[3] (Associate Professor), Dr. Manish Chauhan[4] (Associate professor), Dr. Niraja Jaiswal[5] (Associate professor), Dr. Ruturaj Khankari[6] (Assistant professor).

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ABSTRACT: Loading protocols in implant dentistry have evolved significantly over the years, driven by advancements in understanding the biological processes of osseointegration and bone healing. This literature review aims to provide an overview of the healing phases of bone post-implantation, the various types of loading protocols, and the factors influencing the selection of an appropriate loading strategy. Special emphasis is placed on the role of bone density, and how esthetic, functional, biological, and structural considerations are taken into account when determining the optimal loading protocol.

Keywords: Implant Dentistry, Loading Protocols, Bone Healing, Osseointegration, Bone Density, Immediate Loading, Delayed Loading, Early Loading, Esthetics, Function, Biological Considerations, Structural Considerations

I. INTRODUCTION:

Implant dentistry has revolutionized the field of prosthodontics by providing a reliable solution for tooth replacement. One of the critical factors that determine the success of dental implants is the loading protocol, which refers to the timing of attaching the prosthesis to the implant after its placement in the jawbone. Over the years, various loading protocols have been developed, each with specific indications based on the condition of the bone, the implant site, and the desired outcomes. Understanding the different aspects of these protocols is crucial for optimizing implant success rates. Implants have gained the moniker "third dentition" due to their high success rates and associated benefits. When assessing cost-effectiveness, the implant prosthesis survival rate needs to be taken into account. Systemic disease, oral conditions like periodontal status, occlusion, and function/parafunction, implant size and shape, implant material and surface properties, timing and implant placement methodology, including primary implant stability, loading procedures, and long-term maintenance, have all been found to have an impact on the quality and predictability of different loading protocols. Mandibular bone is dense, while maxillary bone is porous. Implant placement in these circumstances significantly alters loading. Therefore, it is reasonable to wonder if osseointegration can only occur once this healing period has passed or if there are any situations in which a shorter healing period can be achieved without endangering long-term outcomes. Branemark et al. (1969) showed that direct bone apposition at the implant surface was possible and lasting under loading at the condition that implants were left to heal in a submerged way. To avoid waiting for healing, the traditional treatment strategy is questioned and quick loading is implemented.

Healing Phase of Bone:

The healing phase of bone, also known as the osseointegration period, is a critical determinant of the success of dental implants. During this phase, the bone undergoes a series of biological processes that lead to the formation of a stable interface between the implant and the surrounding bone tissue. Initially, a blood clot forms around the implant, which is gradually replaced by granulation tissue. This tissue is then remodeled into bone through the processes of osteogenesis and angiogenesis. The duration of the healing phase can vary depending on factors such as bone quality, implant surface characteristics, and the surgical technique used.

1. Osteophytic phase: The period following the insertion of a rough-surfaced implant into the maxillary or mandibular spongy bone or marrow. Just a tiny portion of the bone that grows from the internal marrow's trabecular bone comes into contact with the implant surface. On the implant surface, osteoid tissue is growing, and this phase lasts for one month.
2. Osteoconductive phase: This lasts for a further three months. The bone will keep being positioned on the metal's surface.

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3. Osteo-adaptive phase: The amount of bone on the metal does not grow or shrink.

Types of Loading Protocols:

Loading protocols in implant dentistry can be broadly classified into three categories: immediate loading, early loading, and delayed loading.

1. **Immediate Loading**: This protocol involves placing the prosthesis on the implant within 48 hours of surgery. It is typically used in cases where the bone quality is excellent, and primary stability of the implant is achieved during placement. Immediate loading has the advantage of reducing treatment time and improving patient satisfaction but requires careful case selection to avoid complications.

2. **Early Loading**: Early loading refers to the attachment of the prosthesis to the implant between 48 hours and 3 months post-surgery. This protocol is often used when the bone is of moderate density, and sufficient primary stability is achieved. Early loading strikes a balance between reducing treatment time and ensuring adequate bone healing.

3. **Delayed Loading**: In delayed loading, the prosthesis is attached to the implant after a healing period of more than 3 months. This protocol is traditionally considered the gold standard, particularly in cases with compromised bone quality. Delayed loading allows for complete osseointegration before functional loading, reducing the risk of implant failure.

Bone Density:

The loading time spans are unique for each type of bone density. Misch in 1988 described four bone densities found in the edentulous regions of the upper & lower jaws based on macroscopic cortical and trabecular bone characteristics.
D1 bone is primarily dense cortical bone.
D2 bone has dense to thick porous cortical bone on the crest and coarse trabecular bone underneath.
D3 bone has thinner porous cortical crest and fine trabecular bone within
D4 has almost no crestal cortical bone and fine trabecular bone composes almost all of the total volume of bone.

Additionally, Misch divided the bone density into four groups, D1 through D4, based on the clinical hardness of the bone as determined by drilling before implant implantation. It was noted that drilling and implant placement in D1 bone resembles drilling into oak or maple wood, drilling into D2 bone feels like drilling into spruce or white pine wood, drilling into D3 bone feels like drilling into balsa wood, and drilling into D4 bone feels like drilling into Styrofoam. When the bone density is D3 or D4, it is wise to wait longer before loading an implant because it has been observed that bone is 60% mineralized at 4 months following implant surgery, and the strength of bone is correlated with the degree of mineralization. For D1 and D2 bones, a duration of 3 to 4 months is sufficient, while a healing period of 5 to 6 months is advantageous for D3 to D4 bones.

Determination of Loading Protocol: Esthetic, Function, Biology, Structure:

The determination of the appropriate loading protocol is a multifactorial decision that involves consideration of esthetic, functional, biological, and structural factors:

- **Esthetic Considerations**: In esthetically sensitive areas, immediate loading may be preferred to restore the patient's appearance quickly. However, care must be taken to avoid compromising the implant's stability.
- **Functional Considerations**: The functional demands of the prosthesis, such as the type of occlusion and the presence of parafunctional habits, play a significant role in selecting the loading protocol. Implants in high-stress areas may benefit from delayed loading to ensure adequate bone support.
- **Biological Considerations**: The biological response of the bone to the implant, including the rate of osseointegration and the presence of any inflammatory conditions, must be considered. Early and immediate loading protocols are more suitable in cases where the biological response is favorable.
- **Structural Considerations**: The design and material of the implant, as well as the quality of the surrounding bone, influence the choice of loading protocol. Implants with advanced surface treatments may promote faster osseointegration, allowing for more aggressive loading strategies.

Immediate Loading:

Advantages:

- **Reduced Treatment Time:** Immediate loading significantly shortens the overall treatment duration, offering quicker functional and esthetic results for the patient.

- **Improved Patient Satisfaction:** Patients benefit from faster restoration of esthetics and function, often leaving the clinic with a new tooth or teeth on the same day as the surgery.
- **Bone Preservation:** Immediate loading may help maintain bone structure around the implant by stimulating bone through functional loading, which can prevent bone resorption.

Disadvantages:
- **Higher Risk of Failure:** The primary stability of the implant may be compromised due to early loading before osseointegration is fully achieved, leading to a higher risk of implant failure.
- **Complex Surgical and Prosthetic Planning:** Immediate loading requires meticulous planning and execution, with careful consideration of factors such as bone quality, implant placement, and prosthesis design.

Esthetic Considerations:
- **Immediate Esthetic Restoration:** Immediate loading is often preferred in esthetically sensitive areas, such as the anterior maxilla, where the quick restoration of a patient's smile is a priority.
- **Gingival Architecture Preservation:** By placing the prosthesis immediately, the natural gingival architecture can be preserved, enhancing the esthetic outcome.

Functional Considerations:
- **Early Return to Function:** Patients experience an immediate return to function, which is particularly beneficial for those with high functional demands or those who have lost a tooth in a visible area.
- **Risk of Overloading:** There is a potential risk of overloading the implant, especially if the patient has parafunctional habits like bruxism. This can lead to implant failure or complications.

Biological Considerations:
- **Osseointegration Concerns:** The biological process of osseointegration may be challenged by the immediate application of functional loads, particularly if the bone quality is not ideal.
- **Inflammatory Risk:** Any pre-existing inflammation or poor bone quality can exacerbate complications with immediate loading, leading to potential failure.

Structural Considerations:
- **Implant Stability:** Achieving sufficient primary stability is crucial for the success of immediate loading. This often requires precise implant placement, careful selection of implant design, and consideration of the patient's bone quality.
- **Prosthesis Design:** The design of the prosthetic restoration must account for the immediate functional demands, requiring stronger materials and a design that evenly distributes occlusal forces.

Delayed Loading:
Advantages:
- **Enhanced Osseointegration:** Delayed loading provides ample time for the implant to achieve full osseointegration, reducing the risk of implant failure.
- **Predictable Outcomes:** By waiting for osseointegration, clinicians can achieve more predictable long-term outcomes, particularly in cases involving compromised bone quality or complex anatomical conditions.
- **Suitability for Compromised Bone:** Delayed loading is particularly beneficial for patients with low bone density, poor bone quality, or systemic conditions that may affect healing.

Disadvantages:
- **Extended Treatment Time:** The main drawback of delayed loading is the prolonged treatment duration, which can be inconvenient and frustrating for patients.
- **Temporary Restorations Needed:** Patients may require temporary prostheses during the healing period, increasing the overall cost and complexity of the treatment.

Esthetic Considerations:
- **Gingival and Soft Tissue Management:** Delayed loading allows for careful management of the gingival tissues during the healing phase, which can lead to improved esthetic outcomes in the long term.
- **Potential Esthetic Delays:** Patients may need to wait several months before receiving the final esthetic restoration, which can be a disadvantage in cases where appearance is a primary concern.

Functional Considerations:
- **Gradual Return to Function:** Delayed loading ensures that the implant is fully integrated before it is subjected to functional

loads, reducing the risk of mechanical complications.
- **Reduced Risk of Overloading:** By allowing the implant to heal undisturbed, the risk of overloading and subsequent failure is minimized.

Biological Considerations:
- **Optimal Osseointegration:** Delayed loading supports the natural process of bone healing and osseointegration, which is particularly important in cases involving compromised bone quality or systemic conditions.
- **Reduced Inflammatory Risk:** The delay allows time for the resolution of any inflammatory conditions before the implant is loaded, reducing the risk of peri-implantitis and other complications.

Structural Considerations:
- **Enhanced Bone Support:** The waiting period allows for the regeneration of bone around the implant, leading to enhanced structural support and stability.
- **Implant Design Flexibility:** Delayed loading allows for the use of a wider range of implant designs, including those that may not achieve the high primary stability required for immediate loading.

II. CONCLUSION:

Individuals undergoing fixed prosthodontic rehabilitation who live far away gain the most from the accelerated treatment duration with instant loading. Additionally, this method almost completely removes post-operative discomfort and provides nearly immediate improvements in speech, masticatory function, and aesthetics. We can also state that it is challenging to determine which protocol is superior to another since various case studies analyze the impact of various protocols on implant success in different ways. It is emphasized to dentists and interdisciplinary teams that immediate loading increases the risk of implant failure and should only be utilized in areas that are crucial to aesthetics after carefully weighing the advantages, disadvantages, and available options. Accurate assessment is necessary like good primary stability, bone quantity and quality, bruxism, and parafunctional behaviors. To more precisely determine boundaries between immediate, early, and traditional loading of dental implants, more study is necessary and crucial. The choice between immediate and delayed loading depends on various factors, including the patient's clinical situation, esthetic demands, functional requirements, and the biological and structural considerations of the implant site. A thorough assessment and careful planning are essential to determine the most appropriate loading protocol for each individual case. Future research should continue to explore the optimization of loading protocols to enhance the success rates of dental implants across different patient populations and clinical scenarios.

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