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Review Article

Implant loading protocols

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ABSTRACT:
The replacement of missing teeth with implant-borne restorations has become a treatment modality accepted by the scientific community for fully and partially edentulous patients. However, the necessity of waiting to load an implant was not scientifically but rather clinically based. Hence; in the present review, we aim to summarize some of the important aspects of implant loading protocols.

Keywords: Implant, Dental, Protocol

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INTRODUCTION

The replacement of missing teeth with implant-borne restorations has become a treatment modality accepted by the scientific community for fully and partially edentulous patients.[1,2.] Primary stability and postponement of loading of dental implants for approximately 3 to 6 months have been considered for years the "condition sine qua non" to allow osseointegration of dental implants. However, the necessitiy of waiting to load an implant was not scientifically but rather clinically based. It is therefore justifiable to question whether this healing period is an absolute prerequisite for obtaining osseointegration , or if under certain circumstances this period can be shortened without jeopardizing osseointegration and longterm results[3.]

HEALING PHASES AROUND THE IMPLANTS[4]

Osteophytic phase – When an implant with a rough surface is inserted in the mandibular or maxillary spongy bone or marrow. Only a small quantity of the bone proceeding from trabecular bone of the interior of the marrow is in the contact with the implant surface. There is production of osteoid tissue on implant surface and this phase lasts for 1 month.

Osteoconductive phase – It is prolonged for 3 months . The bone will continue being placed on the surface of the metal.

Osteoadaptive phase – There is no increase or loss of the bone on the metal.

Branemark and Zarb listed four qualities found in the jawbone. Quality 1 comprised homogenous compact bone. Quality 2 consisted of a thick layer of compact bone surrounding a core of dense trabecular bone. Quality 3 had a thin layer of cortical bone surrounding dense trabecular bone of favourable strength. Quality 4 had a thin layer of cortical bone surrounding a core of low density of trabecular bone.

Misch defined four bone density groups, which vary in both macroscopic cortical and trabecular bone types. The surgical protocol, healing , treatment plans, and progressive loading time spans are unique for each type of bone density.[5]

INFLUENCE OF BONE DENSITY ON LOAD TRANSFER

The mechanical distribution of stress occurs primarily where bone is in contact with implant. The bone implant contact (BIC) percentage is significantly greater in cortical bone than in trabecular bone. The actual amount of bone in intial contact with the surface of the implant is related to the bone density. In D-4 bone only 25% of the implant may be in the contact with the bone,D-3 bone as approximately 50% bone contact, D-2 bone about 70% bone interface, and D-1 bone around 80%. The bone density increase is primarly reflective of local stress factors and relate to Wolff's law i.e generalized bone loss in region that lack stress . There is 15% decrease in cortical plate and extensive trabecular loss to immobilised for 3 months. Cortical bone decrease by 40% and trabecular bone decrease by 12% have also been reported with disuse of the bone. The density decrease in the jaws is related to the length of time the region has been edentulous, the original width of bone, muscle attachments, flexure and torsion, parafunction before and after tooth loss, hormonal influence, and systemic conditions[6].

The ideal bone for implant prosthetic support is the lamellar bone . it is highly organised, but takes approximately 1 year to completely mineralize after the trauma induced by implant placement. At 16 weeks the surrounding bone is only 70% mineralized and still has woven bone as a component. Woven bone is the fastest and the first type of bone to form around the implant interface; however, it is only mineralized and demonstrates an unorganised structure unable to withstand full-scale stresses. Therefore, the percentage of bone contact and the type of supporting bone both influences whether a load to the implant may remain within physiologic limits.

Multiple factors have been found to influence and/or alter the quality and predictability of various loading protocols for completely and partially edentulous arches. These factors include health of the patient, oral conditions such as periodontal status , occlusion ,and functional/ parafunction; characteristics of the proposed implant site , implant size and shape, implant material and surface properties; and timing and methodology of implant placement including primary stability, loading procedures and long- term maintainance[7-8].

DEFINITION OF TERMS (AS PER 5TH ITI CONSENSUS CONFERENCE 2014[10])

Conventional loading of dental implants is defined as being greater than 2 months subsequent to implant placement.

Early loading of implants is defined as being between 1week and 2 months subsequent to implant placement.

Immediate loading of implants is defined as being earlier than 1 week subsequent to implant placement.

Nonfunctional immediate loading and immediate restoration are used when a prosthesis is fixed to implants within 72 hours without achieving full occlusal contact with opposing dentition.

CONVENTIONAL LOADING

The principles and methods of progressive bone loading were established by Misch in 1980 on the basis of empirical information. Two surgical appointments are used for the initial implant placement and second stage uncovery; these are separated by 4 to 8 months depending on the bone density at the initial surgery. Five prosthodontic steps are suggested for reconstruction of the partially or completely edentulous patient, using an endosteal implant support system with a cemented prosthesis. Each of the five major prosthodontic appointments are also separated by a period of time related to the bone density observed at the initial time of surgery. In addition, an attempt is made to gradually increase the load to the implant at each prosthetic step.

The progressive bone loading appointment sequence for cement retained prostheses is as follows: Initial healing, stage two uncover, initial abutment selection and preliminary impression, final impression and transitional prosthesis, try-in (teeth and/or metal) and transitional prosthesis II, initial insertion and final delivery .

D-1 bone has the greatest amount of bone contact and lamellar bone at the beginning of the restoration. As a result, the prosthodontic appointments may be separated by 1 week and gradual loading of the implant interface is least important.

D-2 bone is ideal in its ability to respond to physiologic loads. The five prosthetic appointments in which the implant body is sequentially loaded are separated by 2 weeks. As a result, the longer healing time of D-1 combined with a shorter interval prosthetic time results in a similar overall time compared to D-2 bone and is approximately *6 1/2* months for the overall treatment.

D-3 bone has little cortical bone and fine trabecular bone primarily contacts the implant body. The prosthodontic appointments are separated by 3 weeks and overall treatment takes almost 10 months to complete (including the stage two uncover procedure).During this time frame the bone contact percentage can increase, the size of the fine trabeculae can increase to coarse trabeculae and the mineral content of the bone increases.

The progressive loading process is more important for D-3 bone than for D-2 or D-1 because of the decrease in initial bone contact.

In D-4 bone, the progressive bone loading program is most critical. The restorative appointments are on the side of safety and are separated by 4 weeks or more. The overall treatment time for D-4 bone is twice the period for D-1 or D-2 bone.

The macroscopic coarse trabecular bone heals approximately 50% faster than dense cortical bone. Therefore, the length of time elapsed between the initial and the second stage surgeries is 5 months for D-l bone and 4 months for D-2 bone, because the latter has a much greater trabecular component.

The D-l bone has greater bone contact, so even though it heals slower, the interface percentage is great and the histologic type is lamellar. A longer time is suggested for initial healing of D-3 and D-4 bone. Because the percentage of bone contact is less and the amount of cortical bone is decreased, the extra time permits formation of more lamellar bone with a higher mineral content.

Hence 6 month's healing is permitted for D-3 bone. A period of 8 month's healing is suggested for D-4 bone. The implant interface has minimum contact with bone, with little to no cortical bone on the crest or apex. An implant may increase the amount of bone in the region, even though it is not loaded.

Bone density	Initial healing (mo)	Reconstruction (wk)	Interval between appointments (wk)	Total time (mo)
D-1	5	6	1	6.5
D-2	4	10	2	6.5
D-3	6	14	3	9.5
D-4	8	18	4	12.5

The principles of gradual loading are best demonstrated in the cement retained prosthesis and least applicable for the screw-retained bar of a mandibular RP-5 restoration. In addition, it is difficult to gradually load a removable RP-4 or RP-5 prosthesis that uses a screw-retained superstructure bar because the transitional prosthesis often remains removable during the final reconstruction[9].

IMMEDIATE LOADING PROTOCOL

Patient Selection[14]
Several factors determine whether a patient is a candidate for immediate loading of his or her dental implants. These factors can be divided into four categories:
1. Surgery-related factors
2. Host-related factors
3. Implant-related factors
4. Occlusion-related factors
The *surgical factors* pertain primarily to implant stability and surgical technique. Host factors include not only bone quality and density but also proper healing environment. Implant factors are based on the structure and design of the implant system utilized, and occlusal factors relate to the importance of proper prosthetic design under occlusal forces.

IMPLANT SITE (WELL-HEALED EDENTULOUS SPACE VERSUS AN IMMEDIATE EXTRACTION SITE)

Malo and coworkers[15] showed 85.2% in immediate extraction sockets.

Chaushu and colleagues[16] showed survival rate of 82.4%in extraction sockets.

IMMEDIATE LOADING FOR SINGLE-TOOTH RESTORATION

Studies of single-tooth restoration and immediate loading have shown good success rates. Various studies have been done on these single-tooth restorations placed into immediate occlusion via provisionalization with success rates similar to those implants restored with light or no occlusal forces.
Comparable bone loss was seen with immediate loading versus the traditional two-stage surgeries. However, the immediate loading of a single-tooth restoration is clearly a viable option for select patients.

IMMEDIATE LOADING OF THE FIXED PROSTHESES

Immediate loading of implants supporting fixed restorations in the edentulous mandible is a predictable and well-documented procedure, provided that a relatively large number of implants are placed.
Implant-prosthetic protocols were described as

- cross-arch fixed rehabilitations with anterior-posterior distribution of five to eight implants.
- segmented rehabilitations with anterior-posterior distribution of six implants.
- full arch prostheses with anterior implants and distal cantilevers.

EDENTULOUS MANDIBLE

1. A minimum of four implants should be placed in the edentulous mandible to support an immediately loaded fixed prosthesis. This method requires the implants to be a minimum of 10 mm in length.
2. Primary stability with insertion torques up to 35 Ncm is an important factor for long-term survival of implants.
3. Good bone quality is an important factor for the long-term prognosis of implants.

EDENTULOUS MAXILLA

In the edentulous maxilla, significantly more implants must be placed to obtain primary stability of an immediately loaded prosthesis.

- four to six implants with full-arch prostheses and distal cantilevers
- five to eight implants with a one piece full-arch prosthesis and
- eight implants distributed along the edentulous maxilla to support a segmented rehabilation.

PARTIALLY EDENTULOUS MANDIBLE OR MAXILLA

For the partially edentulous posterior mandible and maxilla, existing literature supports loading of microroughened implants between 6 and 8 weeks subsequent to implant placement. Therefore, for the majority of patients, loading of dental implants for these

indications and within this time frame should be considered routine in the absence of modifying factors like:

- Fresh extraction sockets
- Augmentation
- Short implants

IMMEDIATE LOADING OF OVER-DENTURE PROSTHESES

Implant-retained overdentures proved to be a predictable and effective method in the management of edentulous patients.

1. Immediate loading of a minimum of 4 implants, rigidly connected with a bar placed in the interforaminal area of the mandible and loaded with an implant-supported overdenture, seems not to jeopardize the long-term survival and success rates of the implants, which are comparable to those obtained with standard conventional loading procedures.
2. Good bone quality and primary stability seem to be important prognostic factors for the success of the procedure.

EARLY LOADING PROTOCOL

Early loading in edentulous mandible[3]

Implant-Supported Overdentures

This approach describes mandibular implant overdentures that were functionally loaded no earlier than 48 hours after implant placement and no later than 3 months afterward.

Two implants combined with an overdenture retained by single ball-shaped or locator abutments was one of the the prosthodontic design identified .

1. Early loading of implants supporting overdentures placed in the interforaminal area of the mandible seems not to jeopardize the long-term survival and success rates of the implants, but the number of implants followed is very low.
2. Both splinted and unsplinted implants seem to withstand the biomechanical demands of early loading.
3. Good bone quality and primary stability seem to be important prognostic factors for the success of the procedure, but evaluation of these factors is quite subjective.
4. On average, survival and success rates for early loaded implants were comparable to those obtained in cases of conventionally loaded implants.

IMPLANT-SUPPORTED FIXED PROSTHESES

- Recommended implant prosthesis design is full-arch one-piece or segmented supported by four to eight implants.
- Implant survival rates range from 98.6% to 100%.

IMPLANT-SUPPORTED OVERDENTURES

This approach describes maxillary implant overdentures that were functionally loaded no earlier than 48 hours after implant placement and no later than 3 months afterward. Implant-prosthetic designs include

- four to six implants connected by a bar construction and three freestanding implants with single ball or locator attachments or
- four implants retaining an overdenture, supported by a bar connecting the implants or by unconnected implants, with implants characterized by a rough titanium surface and allowed to heal for at least 6 weeks.

IMPLANT-SUPPORTED FIXED PROSTHESES

Early implant loading with fixed rehabilitations describes a protocol in which implants have been in occlusal contact no earlier than 48 hours and no later than 3 months. Early loading of maxillary fixed implant prostheses is clinically documented (CD). Implant prosthetic protocols include five to eight implants supporting maxillary fixed implant rehabilitations full-arch one-piece or segmented supported by five to eight implants.

Implant survival rates range from 93.4% to 99%.

LOADING PROTOCOLS FOR SINGLE IMPLANTS IN PARTIALLY EDENTULOUS PATIENTS (2014)[10]

Treatment guidelines

The recommendations for immediate and early loading of single-implant crowns are limited to situations fulfilling the following prerequisites:

- primary implant stability (insertion torque $\geq$20 to 45Ncm and/or implant stability quotient (ISQ)$\geq$60 to 65.
- Absence of systemic or local contraindications (eg, parafunctional activities, large bone defects, need for sinus floor elevation).
- When the clinical benefits exceed the risks.
- For the anterior and premolar region, immediate and early loading is predictable procedure but esthetic areas should be approached with caution.
- For mandibular molar region, early and immediate loading is predictable but low amount of evidence in maxillary molar region.

LOADING PROTOCOLS FOR PARTIALLY EDENTULOUS PATIENTS IN EXTENDED EDENTULOUS SITES

- Early loading of solid screw type implants with a microtextured surface after 4 to 8 weeks is predictable approach.
- Immediate loading of posterior implants in healed extended edentulous sites is predictable.
- Immediate loading of anterior implants should be approached with caution and following criteria should be considered: primary stability,bone augmentation,implant design and

dimension,occlusal factors,habits,systemic health and clinician experience.

LOADING PROTOCOLS FOR FIXED PROSTHESIS IN EDENTULOUS JAWS

- Immediate, early, or conventional loading with one piece fixed interim prosthesis have high implant and prosthesis survival rates and recommended for mandible and maxilla.
- Primary implant stability is critical for predictable osseointegration regardless of loading protocol.

LOADING PROTOCOLS FOR IMPLANT – SUPPORTED OVERDENTURES IN EDENTULOUS JAWS

- Early loading is satisfactory modality using implants to support/ retain an overdenture prosthesis.
- Immediate loading in implant supported/retained overdenture appear predictable using insertion torque of 30Ncm or greater& ISQ value 60 or greater.Less compelling evidence in maxilla with immediate loading.

CONCLUSION

Immediate and early loading with outcomes comparable to conventional result is possible. However, a rigurously and thoroughly selected surgical and prosthetic management is of utmost important and necessity in achieving the goal. It is also compulsory for dental implants to show a very good primary stability and bone quantity and quality as well as bruxism and parafunctional habits must be correctly assessed. Immediate or early loading of dental implants is nowadays possible for carefully selected patients. All known risk factors and contraindications for osseointegeration with a standard protocol will be equally or even more important with immediate or early loading protocols. It is thus implied that successful osseointegeration with reduced loading protocols requires critical case selection and meticulous surgical and prosthetic management. A surgical technique that minimizes heat generation and pressure necrosis is of particular important with both early and immediate implant loading. It is also dependent on the quality and quantity of existing bone at the implant site and the ability to achieve and maintain adequate stability of implant so that micromotion is kept below the biological threshold. The level of skill and experience of the surgeon play a role in treatment outcomes. Biological limits in the immediate and early loading process of dental implants have not been entirely defined yet. Further researches are required and important for a more accurate setting of limits between implant immediate , early and conventional loading of dental implants[12].

Recommended loading protocols for various situations[11]:

For completely edentulous patients:

1. Mandible and maxilla:

Loading of micro roughened implants between 6 and 8 weeks subsequent to implant placement with fixed or removable prostheses in the mandible and fixed prostheses in the maxilla.Therefore, for majority of patients loading of dental implants within this time frame should be considered a routine.A lower level of evidence exists to support loading of dental implants with maxillary overdentures for this time frame(6 to 8 weeks).

2. Edentulous mandible

Immediate loading of microroughened implants with fixed prostheses or overdentures.

3. Edentulous maxilla

Immediate loading of microroughened implants with fixed prostheses.

Insufficient data exist to support immediate loading of dental implants with overdentutre prostheses in edentulous maxilla.

4. For Partially edentulous patients

- Posterior mandible and maxilla
- Loading of microroughened implants between 6-8 weeks subsequent to implant placement.

For the partially edentulous posterior mandible, immediate loading of microroughened implants can be considered a viable treatment option. But insufficient data exists to support immediate loading of dental implants in the partially edentulous posterior maxilla.

ESTHETIC ZONE

For partially edentulous sites in esthetic zone, loading of microroughened implants between 6-8 weeks subsequent to implant placement can be considered routine.

Also, immediate loading of microroughened implants can be considered a viable treatment option especially in maxillary anterior region when patients are unwilling to endure long delays. So, in such cases we can immediately load an implant if we have following factors:

- Primary implant stability.
- Insertion Torque value above 40 Ncm.
- Good quality and quantity of bone.

And, conventional/progressive loading protocol should always be the procedure of choice when:

- Stability is considered inadequate for immediate or early loading protocol.
- Specific clinical condition exist(Compromised host, heavy smoker, systemic disease, recent extraction site, type IV).

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