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Immediate Loading of Implants

The Brånemark Protocol

Brånemark described the concept of osseointegration as “a direct connection between living bone and a load-carrying endosseous implant at the light microscopic level” (2). Based on initial preclinical studies, it was concluded that following implant placement, a period of stress-free healing is essential for osseointegration to occur. Motion between an endosseous screw and bone results in the proliferation of connective tissue and subsequent fibrous encapsulation of the screw, leading to a reduction in anchorage predictability. In the presence of macromotion, bone does not grow into a porous implant, while ingrowth occurs with micromotion at the level of approximately 50 μm. The original Brånemark surgical protocol calls for implants to be submerged beneath the soft tissue during placement. A minimum healing time of 3 months in the mandible and 6 months in the maxilla is recommended for osseointegration to occur. The implants are then uncovered during a second surgery, which is followed by a healing period of 2 weeks for soft tissue healing before restorative procedures begin (7, 9, 17). Therefore, most of the earlier endosseous cylindric dental implant systems follow these guidelines in recommending an unloaded healing period of 3 to 6 months for successful osseointegration to occur (5).

Single-Stage Implant Placement and Immediate Loading

In recent years, clinicians have begun placing implants using a one-stage procedure, where the coronal portion of the implant protrudes through the soft tissue so that a second surgical exposure is not required. The cover screw is exposed and ready for removal prior to insertion of the abutment (6). This allows for immediate loading of the implant, which refers to a situation where the abutment and the fixed provisional prosthesis are attached at the time of implant placement and such, are accomplished during the same clinical visit (6). Loading an implant during the healing phase allows the bone to remodel and reorganize so that trabecular bone will displace and replace itself in relation to the forces to which it has been subjected. Thus, the healing process is accelerated and calcification of the peri-implant tissue occurs (7). Immediate loading presents the advantages of reducing the number of patient visits, improving the patients' psychological well-being, reducing morbidity with fewer surgical interventions, facilitating functional rehabilitation and restoring esthetic requirements, including the preservation of adjacent papillae following placement of the provisional restoration (2, 4, 5, 10). Attempts to preserve papillary anatomy and emergence profile following extraction can be facilitated by placing and loading implants immediately with a provisional restoration that conforms to the correct contours of the gingiva (9, 10). However, in additional to proper prosthodontic design, the maintenance of the natural gingival contours is also dependent upon the underlying osseous architecture, volume of soft tissue present and the distance from the plaque front to the surrounding bone (10).

Temporal Protocols of Implant Loading

Immediate loading should be differentiated from various other temporal protocols of loading. Early loading refers to a situation where prosthetic loading with a provisional prosthetic tooth occurs at a subsequent clinical visit prior to osseointegration, but following the onset of osteogenesis, as bone formation is enhanced by mechanical stimulation. Thus, early loading generally takes place approximately 3 weeks into the healing process. Biological considerations include ensuring the preservation of blood clot formation, cellular infiltration and the epithelialization process that occurs with initial healing (4). Early loading may be useful in situations of partial edentulism, poor bone quality or where immediate loading is not practical (5).

Conventional loading refers to the original recommendations of Brånemark for loading to occur after 3 to 6 months of healing in a submerged or non-submerged mucosal orientation. More recent suggestions of 6 to 8 weeks of healing have been proposed for implants with topographically enhanced surfaces (4).

Delayed loading refers to extended healing periods of greater than 3 months but typically ranging from 6-12 months. This protocol is indicated for cases where implants are placed without primary stability, where bone is of low density, and into extraction sockets without significant primary bone-to-implant contact or with a simultaneous bone regeneration procedure (4).

Causes of Implant Failure

Early application of uncontrolled and excessive forces to implants that have not yet osseointegrated are a significant cause of early failure. Therefore, a fixed provisional restoration may help to control occlusal forces to within a physiologic range (5). Additional causes of the failure of implants are due to luting failures, fracture of the temporary restoration during the osseointegration period or post-treatment perimplantitis (7). However, micromotion is a significant cause of implant failure.

Micromotion and Fibrous Tissue Formation

Motion of the implant surface relative to the bone is defined as micromotion and any factor that contributes to mobility of the implant during osseointegration has the potential to induce the formation of peri-implant fibrous tissue. Fibrous repair occurs rather than osseous regeneration and osseointegration with functional overload and 100 μm of micromovement has been suggested to be the critical level above which healing will undergo fibrous repair rather than osseous regeneration (7). In addition to fibrous tissue encapsulation, other adverse effects of micromotion include soft-tissue changes, bone loss and eventual implant failure and removal (6). Therefore, immobilization is the most important aspect to the success of an implant (7), in addition to minimizing lateral force application (5). Wolff's law states that there is apposition, resorption, and remodeling of trabecular bone depending on the direction of the forces applied to it (7). Primary stability is an essential biological requirement and loading should occur within hours of implant placement so that the blood clot, which is important to the early stages of healing, is not disrupted (4). Resistance to forces applied to the tooth include that from the root, the periodontal ligament and the alveolar bone. The crown acts as the fulcrum where all sources of force and resistance meet. Any force applied to the crown that does not correspond to the concentric center will move the entire tooth and if uncontrolled, can result in risk to the osseointegration process (7).

Requirements for Immediate Loading

Biological requirements for immediate loading include Type I or II bone quality, adequate bone width and height to place an implant that is between 12 and 16 mm long, adequate keratinized soft tissue and if necessary, bone grafts with the presence of only a 1 wall defect (6, 7). In addition, the muscular mass or facies of the patient, as well as the areas of the crown upon which forces applied by the muscular mass will concentrate, must be considered. The tongue is the strongest muscle per mass in the human body and is related to the genetics, sex and age of the patient. Macroglossia and abnormal swallowing can produce displacement of teeth and periodontal disease and forces originating from the tongue are a major cause of failure during osseointegration (7).

A physiologic balanced occlusal scheme where there is bilateral simultaneous anterior and posterior contact in both centric and eccentric positions helps to distribute the forces over a large surface area and should be pursued (16). The nature of the opposing dentition and the Angle's classification should also be considered in terms of occlusal force application through function and parafunction (5, 7, 8). Adjacent teeth protect the implant from excessive occlusal forces during the healing period by keeping the prosthesis out of occlusion (6).

Implant design plays an important role as an implant's resistance to movement includes the number, distribution, length, diameter and macroscopic stabilizing characteristics of the implant (5). According to Hruska and Borelli, "a given number of crowns supported by implants has to correspond to an adequate bone-implant interface measurable in square millimeters" in order to have a resistance that is proportional to the forces applied. Thus, as many implants as possible should be inserted as compared to the natural dentition. The occlusal table of the prosthesis should be reduced to a 1:3 relation to the natural teeth in regards to posterior teeth, to offer the least resistance to food during mastication (7) and the abutment should be shortened as much as possible to allow for a thicker acrylic resin occlusal width (2). The widest and longest implants possible are desirable and should be at least 12 mm long and 3.8 mm wide (2). The presence of surface topography increases primary stability, facilitates osseointegration with greater bone-to-implant contact at earlier times, increases the rate of bone formation and because of an improved blood clot retention, assures that osseoconduction will occur (4). Thus, HA-coated implants favor faster osseointegration, greater bone-implant contact and greater reverse-torque resistance when compared to non-coated implants (2).

One method of preventing movement is to splint implants together or to natural dentition with the purpose of resisting all tangential forces (7). Immediate loading through a temporary prosthesis can also act as a form of splinting (7).

In regards to the provisional restoration, it should only have one contact in centric occlusion, the angulation of the cusps should be reduced and the contacts during excursive movements should be in the areas with the longest and largest implants for the maximum bone-implant interface (7). A provisional crown with wings aids in increasing and sharing the resistance to lingual trauma (7). Finally, the ability and experience of the oral surgeon and the precision of surgical technique is necessary to allow for an atraumatic surgical technique with no detectable mobility at the time of placement and stabilization to ensure that no forces will be exerted to cause movement in function (5, 6, 7).

Immediate loading is not indicated when bone density is poor, when ridge expansion, sinus grafts or bone grafts with wall defects are required, when macroglossia or type II division 2 angle classification are present, when medical status is compromised, in posterior edentulous areas as esthetics are not required or when financial limitations are present (7).

Effects of Implant Characteristics on Osseointegration

Rough surfaces affect cell proliferation and differentiation to result in stronger osseointegration and thus, implants with a rougher surface may be better suited for immediate loading (1). Titanium dioxide grit-blasted surfaces (TPS) demonstrate a higher bone-to-implant contact and tolerate a higher removal torque than smooth surfaces (1). Sandblasted and acid-etched surfaces (SLA) have better bone-to-implant contact than TPS surfaces (1), although both show high success rates, while failures have been reported for machined-surface implants (4). An additional factor that promotes biological bonding is a hydroxylapatite coating (6).

Threaded root-form implants aim to maximize initial contact, achieve initial stability, increase surface area and dissipate interfacial stress (17) and are favorable as compared to implants with a cylindrical root form. A tapered design further enhances the initial stability (6) as they dissipate forces into the surrounding bone more uniformly to compact the bone in adjacent osteotomy walls with a more even distribution as compared to implants with parallel walls (17).

Pretapping screws requires a bone tap prior to placement and self-taping screw-type implants cut directly into the bone as the implant is threaded into place and may create stress concentration at the ridge crest, resulting in a loss of marginal bone (17). Pretapped screws also require more bone remodeling to osseointegrate (17). Therefore, self-tapping screws are recommended to avoid excess stress concentration in the hard tissues. Self-tapping displays higher friction with the bone resulting in a greater degree of anchorage such that an increase in the intimacy of the initial fit between the implant and walls of the receptor site corresponds with a greater percentage of bone apposition to the implant surface following healing (17).

Conclusion

A growing body of literature supports the success of immediate loading of implants when proper techniques are employed and patients with appropriate clinical factors are selected. Once implants that have been immediately loaded have demonstrated clinical osseointegration, they take on the long-term predictability characteristics of conventionally healed and loaded implants (5). Due to the significant advantages of reducing clinic visits and greater patient satisfaction, immediate loading of implants should be considered as an option when placing implants.

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