On Immediately Loaded Fixed Maxillary Prostheses

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Many questions remain unanswered in the field of implant therapy. A definitive understanding of the time-dependent, qualitative and quantitative nature of the induced interfacial healing process continues to elude us, in spite of the transforming therapeutic results of Brånemark's osseointegration (OI) technique. Predictably successful clinical outcomes are reported to be influenced by numerous host, clinician, and implant determinants presumed to promote, establish, and sustain the desired integrity of the healed response. It seems that if both immediate and delayed loading protocols are to be reconciled with favorable prognoses, the cited biologic principles of osseointegration must be respected. However, the range of host physiologic adaptability varies and it must be acknowledged that immediate functional loading protocols are likely to be riskier.

The aim of this commentary is to focus on likely factors that affect successful clinical outcomes when using an immediate loading protocol in implant therapy.

Published research and the professional community's shared clinical experiences are readily acknowledged. However, additional perceptions that reflect the author's personal conclusions from long-standing experience in traditional prosthodontics lend themselves to a proposed protocol whereby surgical and prosthodontic requirements are integrated for immediate loading prescriptions.[1] The protocol comprises critical points listed and discussed under the following headings.

Implant Stability, Including Implant Macrostructure, and Surgical Techniques to Enhance Primary Stability

Initial implant stability is the clinical discriminating factor used by clinicians to determine whether an immediate loading protocol is feasible or a delayed loading protocol is indicated.[2]

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The scientific literature is neither unanimous on this topic nor on the cut-off value of insertion torque. Moreover, in immediate loading procedures, the insertion torque value should be correlated with the amount of load, which will vary depending on the patient's characteristics and the implant rehabilitation design (parafunctions, type of antagonist, prosthesis design, number of implants, bone quality, etc).

The main factors affecting implant stability are bone quality and quantity, implant design, and surgical technique. The last two factors can be directly controlled by the clinician.

Cylindrical implants have been successfully used for years in the delayed loading approach, both in the mandible and in the maxilla. However, the cumulative survival rate for cylindrical implants in the posterior areas of the jaw, and especially in the maxilla, where bone quality is poorer, is reported to be lower.

The implant macro-design must be chosen on the basis of bone quality. Tapered implants (with a sharp apex and more aggressive threads) are strongly recommended in poor quality bone when underpreparation of the implant site is necessary to achieve sufficient primary stability.

The implant length is usually decided on the basis of available bone volume, patient's maximum mouth opening, and bone density. There is no doubt that short implants (< 10 mm long) can be stabilized in reduced bone volume with type I-II bone quality. However, implant length may have to be augmented in a III-IV bone quality in order to increase the bone-implant contact. In high-density bone, stresses are concentrated only on the first three implant threads. In contrast, stress is extended to a greater number of threads in low-density bone,[3] where long implants have greater biomechanical advantage. In immediate loading, long implants may prevent stress concentration in order to avoid the risk of micromotions.

The presence of the maxillary sinus usually precludes insertion of long implants in the distal areas of resorbed maxillae, whereas short implants (< 10 mm) may also inhibit high levels of initial primary stability. Bone grafting procedures to increase bone volume may be a viable treatment option, but they usually preclude the achievement of a sufficient primary stability and delayed loading protocols have to be followed. Moreover, the lengthening of the treatment time can be associated with complications, morbidity, and higher economic cost. In order to overcome such limitations, implants could be placed in specific

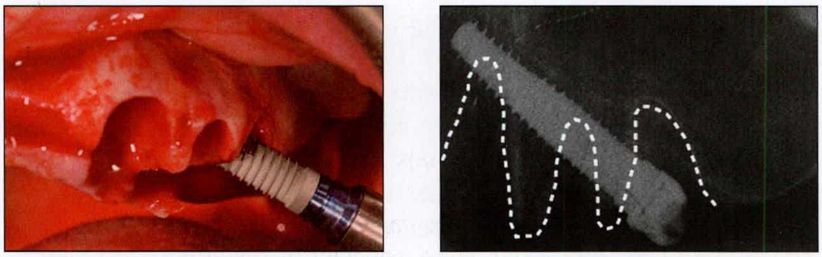

Fig 1 Insertion of a tilted implant parallel to the anterior sinus wall bypassing postextraction alveolar sockets.

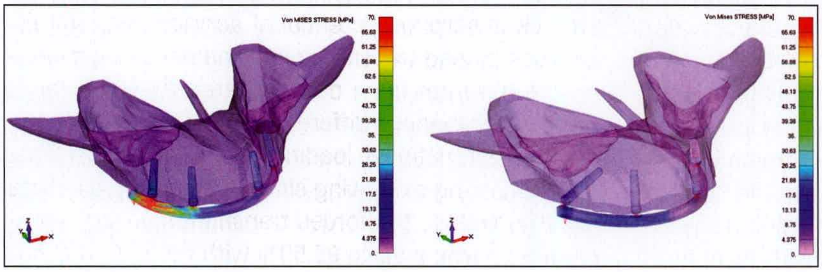

Fig 2 A finite element analysis demonstrated that distal tilted implants, splinted with a rigid framework, with short or no posterior cantilevers *(right)* decrease stress in peri-implant bone and framework when compared to shorter vertical distal implants restored with cantilevered prostheses *(left)*.[3]

anatomical areas such as the pterygoid region, the tuberosity, or the zygoma. Each of these procedures requires considerable surgical expertise and has its own risks and possible complications. Moreover, implant emergence is very often too palatal and therefore unfavorable from the prosthodontic point of view.

In recent years, several clinical studies have reported that tilting of the implants parallel to the anterior maxillary sinus wall may represent a feasible treatment option.[1,4–6] Long tilted implants (≥ 13 mm) placed in pristine bone have been advocated to obtain high levels of initial primary stability and avoid bone grafting procedures. The use of long tilted implants allows for increased interfacial area of ankylotic-like support for the implants and permits their apexes to reach the premaxilla area, where bone is denser compared to that usually found in the posterior maxilla. Further improvement in implant anchorage can be achieved by possibly engaging cortical bone of the anterior wall of the sinus and the nasal fossa when maxillary jaw rehabilitations are undertaken. This approach has the added merit of bypassing eventual postextraction sites (Fig 1).

Loading Control

While the clinician has limited means in controlling patient-related factors, the prosthodontic design that strongly contributes to stress distribution must be carefully considered and planned.

Beyond the surgical advantages of using tilted implants, significant prosthodontic advantages are gained: Tilted implants can optimize the anteroposterior spread of the implant heads to provide satisfactory molar support for a full fixed prosthesis (FFP) of 12 masticatory units (well-spread polygonal support). The "cornerstones" positioning of the implant heads (two anteriorly and two posteriorly and well spread) provides a favorable load distribution and usually more than four implants are not necessary, since the distribution of the implants plays a major role compared to the implant number. The molar emergence of the implants also eliminates or reduces the cantilever extensions, which are an unavoidable consequence to obtain the same number of masticatory units when using vertical implants.

Finite element analysis (FEA) has shown that the amount of stress at peri-implant bone is more affected by cantilever length than by implant inclination in a splinted restoration[3] (Fig 2).

Splinting of the Implants

Accuracy and rigidity of the prosthesis have been reported as fundamental prerequisites for the predictable osseointegration of implants that will be immediately loaded. In fact, splinting implants with rigid prostheses immediately after implant placement seems to protect them from overloads and micromotions.[4]

An in vitro study by Ogawa et al[7] found significantly lower bending moments for the titanium prosthesis when compared to traditional and fiber-reinforced acrylic resin prostheses. This can be explained by the higher stiffness of the metal framework prosthesis, which leads to a smaller deformation of the prosthesis at the site of load application, thereby resulting in a better distribution of the forces among all supporting implants.[7] The lower deformation for stiffer materials may also reduce risk of fatigue and eventual frequency of failure related to overloading of the prosthodontic components.

Several full-arch immediate loading protocols provide the use of immediately loaded all-acrylic prostheses.[5,6] However, to attain the required rigidity and strength, an all-acrylic prosthesis should be considerably thicker than prostheses endowed with a metal framework. From the clinical point of view, an aggressive bone remodeling is required to thicken the acrylic prosthesis when the prosthodontic space is reduced. The thicker prosthesis will reproduce both teeth and pink soft tissue, which is esthetically and psychologically disadvantageous compared to natural prostheses that do not replicate the pink soft tissue. Therefore, the presence of a rigid framework provides biomechanical and esthetic advantages avoiding bone reduction.

Passive Fitting Prosthesis

Although compelling human evidence does not exist of clinical effects on peri-implant bone during the healing phase, prosthesis misfit can induce noxious biomechanical stresses on the implants and can cause screw loosening.

To reduce errors during data transfer to the dental laboratory, in full-arch immediate loading the authors suggest the use of a plaster impression technique with pick-up impression copings and open impression trays. With this protocol, impression copings have to be screwed prior to flap closure to control perfect coupling.

Other methods for rigidly splinting impression copings have been proposed. Among these methods, the use of self-curing acrylic resins is the most frequently cited. But all acrylic resins contract during curing and this contraction may result in loss of the clinical accuracy needed.

Screw-Retained Prosthesis

The retention mechanism of the prosthesis is important in controlling occlusal load. In fact, if the prosthesis is luted with provisional cement, prosthesis misfit cannot be detected easily. Moreover, possible decementation at the level of an abutment also cannot be easily identified and may lead to unfavorable load distribution. This tends not to be the case with screw-retained prostheses, as screw preload can be checked and screws can be retightened.

Moreover, technical complications (such as chipping of the veneering material) are quite common[4] and can cause modifications of the occlusal scheme and altered occlusal load distribution. In this case, screw-retained prostheses can be easily removed and adjusted without noxious stresses on the implants.

Veneering Material

In the past, acrylic resin teeth have been recommended for occluding surfaces of full prostheses in completely edentulous patients treated with Brånemark implants because resin is a shock-absorbing material that reduces impact stresses on the implants. The shock-absorbing capacity of restorative materials is controversial nowadays. In vitro studies demonstrate a shock-absorption potential of acrylic resin, but differences in load transmission at the bone-implant interface have not been demonstrated in vivo. Clinical studies comparing different occlusal materials in immediate functional loading protocols are lacking. However, using a chewing simulator, acrylic resin was found to reduce the forces transmitted to the bone-implant interface up to 95.59% with respect to zirconia, 94.16% with respect to ceramic, and 90.36% with respect to composite resin.[8]

These findings need to be supported by clinical trials in order to investigate their clinical relevance, but it is the author's opinion that such data should be taken into consideration in clinical decision-making, especially in immediate loading protocols and, in particular, in unfavorable conditions such as parafunction when implant-bone interface loading needs to be minimized to avoid the risk of implant failure. The use of an acrylic resin provisional prosthesis or a definitive composite resin prosthesis is essential in such situations to reduce the risk of overload at a critical time for obtaining and then for maintaining osseointegration.

Occlusal Scheme

Whenever possible, occlusion objectives sought by the authors in immediate loading follows Beyron's time-proven determinants of a physiologic/therapeutic occlusion[9]:

- Acceptable interocclusal distance
- Stable jaw relationship with bilateral contacts in retruded closure
- Freedom in retrusive range of contact
- Multidirectional freedom of contact movement

On Bone Adaptability and Multifactorial Aspects Affecting the Maintenance of Osseointegration

The above-cited integration of surgical and prosthodontic requirements aims to respect the biologic principles of osseointegration. Despite variables related to site-specificity and host bed condition, the described protocol has already yielded optimal clinical results past the 5-year period of observation.[1] It is important to emphasize that developing a codified protocol is mandatory in order to add scientific relevance to clinical results and to demonstrate the predictability of a procedure.

However, it must be acknowledged that great numbers of successful outcomes continue to occur in spite of all or some of the listed key points not being respected. They include works that do not provide a rigid framework to splint the immediately loaded implants[5,6] and others that include differently applied surgical and prosthodontic protocols.[4] The published data reflect a wide range of patients' healing tolerance and adaptability irrespective of protocol differences.

It seems clear that the induction and maintenance of the osseointegrated response is a multifactorial one. Patients' general health, bone quality and quantity, surgical procedure, implant macro- and micro-characteristics, functional and parafunctional occlusal loading, medications, bacterial insult, and other biomechanical considerations potentially affect bone healing and subsequent development of peri-implant bone changes. Yet their combined role in reaching and maintaining osseointegration is not well understood.[10] In particular, site-specificity and host bed conditions are host-related factors, which are difficult for the clinician to control and can influence the treatment outcome.

The control of biomechanical aspects and the avoidance of overloading are considered particularly important in implant prosthodontics, both in immediate and in delayed loading protocols. However, there is no precise definition of "overload"; its amount is yet to be quantified. In fact, the range of physiological adaptability varies. Moreover, well-designed clinical trials to evaluate the effects of overloading on peri-implant bone are not feasible for obvious ethical reasons. Only some animal studies are available; and they report contrasting results.

In addition, prosthodontic factors possibly affecting load transmission and successful rehabilitation have been largely neglected in dental implant research. Some authors do not consider prosthodontic factors in their papers, presumably because they are unable to control them. In fact, prosthodontic design is difficult to standardize in clinical practice, and the many variables involved are difficult to isolate and evaluate by clinical trials.

It should also be noted that the individual significance of the listed key points is weak. However, considering them together is mandatory since they mutually contribute to implant stability and occlusal load control. If any one of the key points is insufficiently addressed, the contribution of other key points should not be expected to compensate.

Clinical scholars need to consider, utilize, and, whenever possible, control those surgical and prosthodontic variables that are within their operative range if they are to ensure optimal osseointegration outcomes. They should also recognize and acknowledge that natural human evolution has already provided us with a wondrous and efficient capacity of bone to heal.

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