ARTICLE

Factors Affecting Loading of Implants

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ABSTRACT

There is a growing trend in implant dentistry to decrease the treatment times associated with implant therapy. This can be achieved with immediate occlusal loading protocol. Immediate loading (IL) of dental implants is an eminent and acknowledged treatment strategy which is extensively being used for the rehabilitation of missing teeth. IL may be described as functional loading (With occlusal contacts) immediately after implantation (or within 3–4 days after surgery) without waiting for the healing period. IL has gained popularity nowadays as it includes less possible trauma to the tissues, overall treatment time is decreased, reduced patient‘s discomfort and anxiety , better patient acceptance and good function and aesthetics. The rationale of this review is to discuss the basic scientificwork performed on the concept of the factors affecting the loading of dental implants include bone quality and quantity, primary implant stability, and loading timing protocols. These elements determine whether an implant successfully fuses with the jawbone or fails under pressure.

Keywords: Immediate loading (IL) implants, Rehabilitation, Osseointegration

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Introduction :

Osseointegration or osteointegration refers to a direct bone-to-metal interface without interposition of non-bone tissue. This concept has been described by Branemark, as consisting of a highly differentiated tissue making "a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant"[1,2]. Through his initial observations on osseointegration, Branemark showed that titanium implants could become permanently incorporated within bone that is, the living bone could become so fused with the titanium oxide layer of the implant that the two could not be separated without fracture. It occurred to this investigator that such integration of titanium screws and bone might be useful for supporting dental prostheses on a long-term basis[1-2].

From this discovery in experiments focused on observing the micromovements of bone, through its laboratory development and initial application in the dental sciences, osseointeosseointegration has become a realized phenomenon of importance[2].

Currently, an implant is considered as osseointegrated when there is no progressive relative movement between the implant and the bone with which it has direct contact.[63-67]

Essentially, the process of osseointegration reflects an anchorage mechanism whereby non-vital components can be reliably incorporated into living bone and which persist under all normal conditions of loading2,3. However, the term osseointegration describes a clinical state that provides for long-term stability of a prosthesis, but this is not a biological property of any implant system or metal4,5. In other words, one can claim that a "direct bone contact" as observed histologically may be indicative of the lack of a local or systemic biological response to that surface. It is therefore proposed that osseointegration is not the result of an advantageous biological tissue response but rather the lack of a negative tissue response.

Since Branemark's initial observations, the concept of osseointegration has been defined at multiple levels such as clinically6,anatomically[2], histologically andultrastructurally[4].

In vivo and in vitro research has also been performed to evaluate the biology of the healing response to the implant surface and how the material's characteristics, such as surface preparations, chemical composition, coatings and sterilization procedures may affect the short- and long-term stability of the metallo-biological interface[7-10].

Furthermore, Brånemark_s recommendations for healing were based on empirical data that were never scientifically proven and never experimentally ascertained.[7]Nowadays, with the ever increasing demand for esthetics, the interim period of edentulousness even after implant placement can cause psychological, social or functional problems especially if the edentulous area is in appearance region.[10] Furthermore, the discomfort, inconvenience, and anxiety associated with such a long waiting period remain a challenge to both the patients and clinicians.[11] In the scientific literature it has been reported that root-form implants may osseointegrate, even though the implants extend above the bone and through the soft tissues during early bone remodeling.[12-15] This surgical approach has been termed as a 1-stage or nonsubmerged implant procedure since it discards the need for second-stage implant uncovery surgery. Thereby, eliminates the discomfort, inconvenience, and appointments of the surgery and suture removal. Consequently, immediate loading of dental implants was introduced to achieve triumph over original Branemark protocol.16 Immediate loading implant has been defined as an ―implant that carries a prosthetic superstructure which makes occlusal contact within the first 1 or 2 days after placement‖.[12] It can also be described as a situation where the superstructure is attached to the implants no later than 72hr after surgery.[17] It not only includes not submerged one stage surgery but actually loads the implant without compromising osseointegration.[5] When the occlusion is re-established within 2 weeks it is called an early loading implant but when loading is only allowed after several weeks, it should be called _delayed_ of the loading irrespective of the fact that it is a one stage - or a two-stage procedure.[18]Under these conditions, successful immediate loading of screw-type dental implants has been reported as early as 1979.1[9]Later on, many clinical & experimental studies by Chiapasco et al.[20]; Schnitman et al.[21]; Tarnow et al.[22] had been reported which acknowledged the patients the prospects of expected dental rehabilitation. These studies ultimately led to the introduction of the concept of immediate loading.[12] A key element in immediate occlusal loading protocols involves eliminating micromovements between implants and osteotomies.[23,24] The ultimate goal of animmediate loading protocol is to predictably decrease surgical interventions and to reduce the time gap between surgery and prosthesis completion,[25] but without decreasing the success rates associated with implant treatment and the unloaded healing protocol.[18-23]

The rationale of this review is to discuss the basic scientificwork performed on the concept of the factors affecting the loading of dental implants include bone quality and quantity, primary implant stability, and loading timing protocols. These elements determine whether an implant successfully fuses with the jawbone or fails under pressure.

Factors Affecting Loading of Implants;

According to the review conducted by Gapski and coworkers in 2003, [11] factors that influence in the outcomes of implant loading can be divided into 4 categories:[31]

a) Patient/Host-related factors, pertaining to bone quantity and quality (density)and proper bone healing environment;

b) Surgery-related factors, pertaining to primary implant stability and a nontraumatic surgical technique;

c) Implant-related factors, pertaining to the influence of macro- (thread) and micro- (surface coating) structure of the implant; and Patient

d) Occlusion-related factors, pertaining to the importance of occlusal forces andprosthetic design.

a) Patient/Host- Related Factors

1. BONE QUALITY & QUANTITY

A recent study has documented that the quality of bone at the implant site influences the amplitude of lateral micromovement.[32]

In type 1 bone, a force of 30N causes no detectable micromovement.

In type 2 bone, forces of 5 to 20N produce micromovements of 20 to 50 m. The critical threshold of 100 m is reached when 30N of force is exerted.

In type 3 bone, forces of 5 to 20N causes displacements on the order of 50 m. On the other hand, 30N of force produces a displacement greater than 150 m about 170 m.[32-38]

In type 4 bone, forces of 5 to 20N do not cause more than 100 m displacement, but 30N will induce a displacement of 200 m.

Histological data on immediately loaded implants have demonstrated not only a direct BIC, but also a favorable bone quality around the fixtures. Clinically, host bone density plays an important role in determining the predictability of the immediate implant loading success. An implant placed in compact dense bone is more likely to ensure initial stability and, hence, better able to sustain such immediate forces.[28-36]

Resonance frequency analysis indicated that implants are as stable at the time of placement as when measured at 3–4 months post-surgery, when placed into dense bone .[33]

Therefore, this homologous, dense bone type may present several advantages for immediate loading implant dentistry. The cortical lamellar bone may heal with little interim woven bone formation, ensuring good bone strength while healing next to an endosteal implant .[34]

In addition, its fine porosity (r10%) favors better mechanical interlocking compared to soft cancellous bone, which reaches 80–95% porosity [35].

Interestingly, few human reports have shown similar predictability regardless of anatomic location .[36] Levine et al. (1998) placed 10 implants in the maxilla (3 loaded immediately and 7 followed 2-stage protocol) and showed that all implants osseointegrated after 2 years. Horiuchi et al. (2000)[37] also reported no difference in the success rate between arches in immediate loading implants in 14 patients.

In this case series, 44 implants were placed in the maxilla and 96 in the mandibleproviding a success rate of 95.5% and 97.9%, respectively. A multicenter prospective study involving single and partially fixed prosthesis in 93 patients with 142 implants also demonstrated no difference in success rates between maxilla and mandible. [38] In this trial, a temporary prosthesis was constructed from nonheat-generating material and temporarily cemented into place. Within the limited available information, it appears that primary stability, more than the arch (anatomic) location, may be the fundamentalrequirement for immediate implant loading techniques.

2. WOUND HEALING

Metabolic diseases that directly affect bone metabolism such as osteoporosis/osteopenia or hyperparathyroidism may significantly influence implant wound healing. Osteoporosis, a pathology process leading to an absolute decrease in bone mass, has risen rapidly in the population, and poses a major public health problem.[37] Although animal research has commonly shown impairment of bone formation around implants in osteoporotic specimens ,[48,39]human trials have demonstrated that dental implant placement in patients diagnosed with osteoporosis may be successful over a period of many years if an extended healing period is advocated .[40]

So far, no attempt has been made in loading implants immediately in patients who are diagnosed with systemic diseases such as diabetes and hyperparathyroidism as well as smokers. A similar situation is also true for patients who have undergone radiation therapy. Therefore, it is strongly suggested to follow the standard 2-stage protocol or even utilize longer periods of healing in patients diagnosed with these disorders. The same standard guidelines are suggested to be used in smokers or patients under radiation therapy on the oral cavity, until future research proves otherwise.[35-40]

3. PATIENT AGE

In dental implant treatment, chronological age by itself is suggested as one of the risk factors for success, but it would not be a contraindication. In general, reserved capacity of bone and soft tissue make it possible to establish osseointegration in the long run. Rather than aging itself, the specific nature of the disease process, such as osteoporosis or diabetes, and local bone qualityand quantity at the implant site, mostly related to aging, are more important for successful dental implant treatment.[41]

4. PARAFUNCTIONAL FORCES

Parafunctional forces such as bruxism and clenching represent significant force factors because magnitude of the force is increased, the duration of the force is increased, and the direction of the force to the implant with a greater shear component. Balshi and Wolfinger reported that 75% of all failure in immediate occlusal loading occured in patients with bruxism. Moreover, parafunctional loads may increase the looseness or fracture risk of the abutments and of the temporary restorations.[41-45]

5. STATUS OF THE IMPLANT SITE[[43]

Preparation of implant sites immediately after tooth removal presents a challenge for immediate loading because the drill tends to follow the socket, and there can be deviation of planned alignment if the implant is redirected by denser bone toward the void of the socket.[43]

Another factor is the inevitable bone resorption and remodeling at the extraction site . Its unpredictability makes outcomes less certain than when implants are placed in fully healed sites. Bone and soft tissue loss occurs withsimultaneous extraction and provisional restoration, but it may be less than expected during a staged using a removable appliance. Furthermore, a wellexecuted immediate restorative strategy can minimize disruption of the bone/soft tissue complex.[41-46]

6. DIET

Diet has been known to break or loosen a transitional prosthesis in traditional prosthetics. If the immediate loaded prosthesis becomes partially uncemented or fractures, the remaining implants holding the restoration are at increased risk of overload failure. Therefore, the diet of the patient should be limited to only soft foods during the immediate load process. Pasta and fish are acceptable, whereas hard crust of some breads, raw vegetables, and fruits are contraindicated.[42-55]

b) Surgical Factors

1. PRIMARY IMPLANT STABILITY

Primary stability seems to be the most important determining factor on immediate implant loading. Functional loading placed on an immobile implant is an essential ingredient to achieve osseointegration (Roberts et al.,1984). If an implant is placed in the soft spongy bone with poor initial stability, it often results in the formation of connective tissue encapsulation, similar to the pseudoarthrosis observed in an unstabilized fracture site Micromovements of more than 100 mm are sufficient to jeopardize healing with direct BIC. This observation was also reported by Szmukler-Moncler et al., (1998), who indicated that micromotions at the bone–implant interface beyond 150 mm resulted in fibrous encapsulation instead ofosseointegration.

c) Implant-Related Factors

1. IMPLANT NUMBER

In general, two different approaches have emerged for occlusal loading with completely edentulous patients for full arch fixed restorations. The first approach involves placing several more implants than the usual treatment plan for aconventional healing period . Selected implants around the arch (three or more) are then immediately restored with a transitional fixed prosthesis Enough implants are left submerged for a healing period to allow delivery of a fixed prosthesis, even if all immediately loaded implants fail . If any ofthe implants, they are also used in the final restoration.[52-57]

This protocol was first published by Schnitman et al., in 1990, using 28 screw shaped implants in 10 mandibles to support a fixed transitional prosthesis. Schnitman et al., suggested that this procedure be used only in the completely edentulous mandible, where moderate to abundant bone was present both posterior and anterior to the metal foramina. Using this approach, 100% of the submerged unloaded implant survived, whereas three immediate loaded implants failed before 6 months and one implant failed 18 months post-surgery (84% survival) over 10 years.44 Tarnow et al. also reported a similar protocol for immediate restoration with a fixed prosthesis, using threaded implants in 10 consecutive completely edentulous cases over 5 years.45 Sixty-six of 69 implants were integrated in six mandibular and four maxillary completely edentulous arches (96% survival) using a total of 10 to 13 implants in each arch for the finalprosthesis.[56-66]

The other protocol for fixed prostheses in immediate occlusal restoration of dental implants for completely edentulous patients was published in 1999 by Scortecci and initially loaded all of the implants placed.[46] All of the implants are splinted together for an increased area of load transfer, which could decrease the stresses along the developing multiple interfaces and increases the stability, retention, and strength of the transitional prosthesis during the initial healing phase the traditional healing method, additional implants may also be used with this technique.[47, 48]

The reports in the literature on immediate loading demonstrate that the lowest percentage of survival for full arch restorations corresponded to fewer loaded implants**.** On the other hand, there are 3-year clinical reports for immediate loading with a definitive prosthesis placing only three mandibular implants with98% implant survival rates.[49] However, if even one implant fails using thisapproach, the patient treatment may require extended time for bone grafting and implant reinsertion before the fabrication of another fixed restoration.[47-50]

There are many reports where eight to 13 implants have been inserted per arch and splinted together for full arch immediate loading and an associated implant survival above 97%.[48-52] The increased number of implants not only decreases the risk of overload because of the increased implant interface but also increases the retention of the restoration and reduces the number of pontics. If fracture to a prosthesis or partially unretained restorations occur, the portion that is retained may act as a lever and overload the implants. The increased retention minimizes the occurrence of partially unretained restorations during healing, which would be another source of overload to the implants supporting the restoration.[45-52]

Decreases in pontic number also decrease the risk of fracture of the transitional, which may be a source of additional load to the remaining implants supporting the prosthesis. As a general rule, results in the literature demonstrate that more implants are inserted in the edentulous maxilla;51, 52]compared with the edentulous mandible.[53]This approach helps compensate for the less dense bone and increased directions of force oftenfound in the upper arch.[51-53]

The most common number of implants used in the clinical reports for a mandibular overdenture in the literature is four implants in the anterior mandible splinted together and dates back to 1986 with Babbush et al.[54] Reports of implants in the maxilla for overdentures are very recent and are too few to recommend a particular protocol. The clinical reports in the literature for partially edentulous patients missing multiple teeth most often suggest one implant foreach missing tooth when spacing permits[51-55].

Ericsson et al. found two out of 14 failures with immediately loaded single tooth titanium threaded implants (85%) compared with 100% for the staged healing implants.[55] In a study by Malo et al., more implant failures occurred in immediate load tooth replacement (6.3%) than with splinted implants replacing multiple teeth (1.9%).[56] In single-tooth cases, implant size, design, or surface condition may be more important, since the implant member cannot be increased. In addition, the occlusal load may be reduced by eliminating the occlusal contacts. For example, Gomes et al., evaluated HAcoated screw-type implants to replace single teeth using a nonfunctional occlusal contact scheme and showed 100% survival.[51-57]

2. IMPLANT SIZE

The surface area of implant support may also be increased by the size of the implant. For example, the length of the implant in most systems increases in increments of 2 to 4 mm. Each 3-mm increase in length can increase surface area by more than 20% for a cylinder implant design.[57] Removal torque, pushout force values, Periotest values have been highly correlated with implant size. Most of the stresses to an implant bone interface are concentrated at the crestal bone, so the increased implant length does little to decrease the stress that occurs atthe transosteal region around the implant.[58] However, because the immediately restored implant loads the interface before the establishment of a cellular connection, implant length is more relevant, especially in softer bone types. The benefit of increased length may not be found at the crestal bone interface, but rather in initial stability of the bone–implant interface. The remodeling of the interface does not occur uniformly around the implant. Instead, one region of the implant– bone interface remodels, whereas another remains stable. The

additional length may allow the remodeling in one region while the other is able to stabilize the implant. The additional implant length may also permit the implant to engage the opposing cortical plate, which also may increase initial implant stability. The cortical bone has a lower remodeling rate and further ensures astable condition during the early loading period. Schnitman et al. found a 50%

failure rate in immediately loaded implants when the length was <10 mm.[59]

Several other reports also have suggested longer implants

increase the survival rate.[67-74]

Wider root form implants for the same length provide a greater area of bone contact than narrower implants (of similar design). Occlusal stresses are the greatest in concentration at the crest of the ridge after the implant is integrated.[59-64[

As a result, width may be more important than length of the implant to decrease risk of crestal bone overload (once a minimum length has been obtained for initial fixation). Therefore, in single tooth or partially edentulous situations for immediate occlusal loading, the size of the implant is sometimes increased in width for molar situations. When a larger diameter implant is not possible without

additional augmentation surgery, more implants may be inserted (two for each molar), which also is a method to double the overall surface area in the posterior region.[67-80]

3. IMPLANT POSITION

Implant position is often as important as implant number.60 For example, in the partially edentulous patient, it is recommended to eliminate cantilevers on two implants supporting three teeth, rather than positioning the implants next to each other with a cantilever.[61] Less stress to the interface also occurs when the implants are not positioned in a straight line in an edentulous site. In the completely edentulous patient, a crossarch splint forming an arch is a very effective design to reduce stress within the entire implant support system, especially when there is an anterior–posterior (A-P) distance between the splinted implants. Hence, an implant restoration supported by the splinted arch

concept for the completely edentulous patient appears to be advantageous for the immediate load transitional prosthesis

[61-70]

The mandible may be divided into three sections around the arch: the canine to canine area and the bilateral posterior sections.[62] Several clinical reports are available in which immediate load is used in a mandible when only three implants have been considered, as long as they are positioned in the midline and bilateral posterior regions.[59] The maxilla requires more implant support than the mandible, because the bone is less dense and the direction of force is outside of the arch in all excursive movements. The maxilla is usually divided into at least four sections, depending on the magnitude of the force conditions and the shape of the arch.[63] The minimum four sections are the bilateral canine area and the bilateral posterior regions At least one implant should be inserted into each maxillary section and splinted together during the immediate loading process for

a completely edentulous patient.[58-66]

Concerns have been raised regarding crossarch splinting in the mandible because of mandibular flexure and the possibility of torsion distal to the mental foramina. However, the final restoration should be fabricated in at least two independent sections when implants are placed in both posterior quadrants andfewer than three adjacent pontics exist.[57-65]

4. IMPLANT BODY DESIGN

The implant body design should be more specific for immediate loading, because implant requires maximum stability at the time of the placement and the bone has not had time to grow into recesses or undercuts in the implant body or attach toa surface condition before the application of occlusal load.[61-66]

The functional surface area of each implant support system is primarily related to the width and the shape of the implant. Wider root form implants for the same length provide a greater area of bone contact than narrower implants (of similardesign[23-26]. Occlusal stresses are the greatest in concentration at the crest of the ridge after the implant is integrated As a result, width may be more important than length of the implant to decrease risk of crestal bone overload (once a minimum length has been obtained for initialfixation). Overload may cause early crestal bone loss in immediately loaded implants.[24-38]

A press fit implant with a cylinder design has not demonstrated bone integration with the roughed surface condition the day of implant placement. An implant body with a series of horizontal plates that is tapped or pressed into place does not have bone present between the plates the day of surgical placement.[21-29]

Macrospheres on an implant surface do not have bone present within or around the porous surfaces of the implant at the time of implant insertion.[21-31]

In general, pressfit implants may not provide optimum conditions for immediate load applications. A threaded implant body and insertion process provides a greater likelihood for initial stabilization. This is even more important for immediate load in single tooth applications or restoration replacing only a few A threaded implant design may have some bone present in the depth of thethreads from the day of insertion. Therefore, during the immediate load format.[25-28]

As a result, threaded implants present considerable advantages compared with pressfit implants for immediate load protocols, because their design features do not require integration to resist loads and they also have greater surface area to resist occlusal forces. The number, spacing, and orientation of the threads also affect the amount of area available to resist the forces during immediate loading.[28-32]

The greater the number of threads, the greater the functional surface area at the time of immediate load . Some threaded implants have a 1.5- mm distance between the threads, whereas others have a 0.4-mm distance. The smaller the distance between the threads, the greater the thread number and

corresponding surface area.[64]

the greater the functional surface area for immediate load application; The thread depth of some threaded implants is 0.2 mm, whereas the thread depth of other implant designs may reach 0.42 mm. Hence, one threaded implant may have more than 2 times the overall functional surface area, when compared with other implants of similar length and width. The implant unctional surface area is more important when the number of implants cannot be increased, for example,when less than four adjacent teeth are being replaced.[56-61]

The thread geometry may affect the strength of early osseointegration and the bone implant interface. For a “V”-shaped thread design, a 10 times greater shear force is applied to bone compared with a square thread shape. Bone is strongestin compressive and weakest in shear loading.[65-70] Compressive force transfer would decrease the microstrain to bone, in comparison to shear force type

transfers. Steigenga et al. placed 72 implants with the same surface condition into 12 rabbits and reverse torque tested the unloaded implants after 12 weeks.[66]

One third of the implants had a V- thread, one third had a reverse buttress shape, and one third had a square thread. The number and depth of threads were the same, as was the width and length of each implant. The V and reverse buttressthread geometry yielded similar values for reverse torque and bone implant contact values.[61-66]

The square thread demonstrated statistically significantly higher values for both of these evaluations. Hence, the square thread design may provide some benefit for immediate load protocols. The higher the remodeling rate (RR) of a loaded interface, the higher the woven bone ratio and the weaker the bone interface. The natural teeth have a bone RR which primarily maintains lamellar bone at the periodontal ligament-to-bone interface.The functional surface area of an implant body may affect the RR of bone during loading. In animal studies, a reverse buttress thread with a thread pitch of 0.8 mm and a depth of 0.2 mm may have a RR of 680%, whereas a Vshaped thread design with an 0.6 mm pitch and 0.30 mm depth may have a RR of 500% per year. A square threaded implant design with deeper threads is reported to have a 10-fold reduction in RR and under similar loading conditionsmay approximate 50% per year.[64-71]

A tapered implant design presents some interesting considerations for immediate load applications. The tapered implant has less overall surface area, compared with a parallel-walled, threaded implant of the same length, width, and thread number. Many tapered design implants have less thread depth near the apical portion of the implant. This feature not only reduces surface area, but it also maydecrease initial fixation.[71-79]

On the other hand, Testori et al., and Palti have both demonstrated the tapered, threaded implant design may result in greater initial stability compared with cylindered implant designs, especially when the osteotomy site is compressed during implant insertion.[67] In lower-density bone types, the smaller size osteotomy may be compressed with the tapered design, especially in the coronal region of the implant. Thus, the thread depth and tapered body may be combined to improve initial stability. This may be an advantage in lower-density bone types when fewer than four teeth are replaced, and implant position and number are less able to be manipulated.[72-79]

5. IMPLANT SURFACE CONDITIONS

When the implant surface is modified with a roughened texture, a significant increase of bone-to-implant contact is observed.[68] The shear strength of implantswith a rough surface may be 5 times greater than implants with a smooth surface.[69] Implant surface conditions may affect the rate of bone contact, lamellar bone formation, and the percentage of bone contact.[61] The coating or surface condition of the implant has been shown to be most beneficial during the initialhealing and early loading conditions. A surface condition that allows the greatest percentage of bone formation, the highest bone–implant contact percentage with the highest mineralization rate, and the fastest lamellar bone formation would be of benefit in immediate loading. The difference in implant stability of machined and roughened surface conditions of threaded implants has been measured and reported with resonance frequency values. The roughened surface significantly increased the initial stability and continued to have higher ratings of stabilization for up to 3 months.[70] There is growing evidence that the machined surface condition is less successful, especially in lower density bone types. Improved implant success rates have also been noted in immediate loading environments with hydroxylapatite (HA) coatings. HA has also been shown to decrease the RR during occlusal loading, which can increase the percentage of lamellar bone at the interface.[71] Hence, if the bone is not of ideal density for immediate loading, the surface condition of the implant body may decrease the risk of occlusal overload. On the other hand, Evans et al. stated that HA coated and noncoated screws have similar bone contact using a 2-stage surgical approach in the mandible. Sullivan et al. found peak insertion torque and resonance frequency at initial implant insertion wererelated to implant design rather than surface condition in softer type 4 bone, but similar values were observed in type 2 and 3 bone regardless of surface type.[72]Sirota et al. compared various calcium phosphate-coated implants with noncoated titanium plasma sprayed implants in immediate load applications and found a high percentage of bone implant contact after 30 days of functional loading in both groups, when in good- quality bone. It, therefore, appears roughened surfaces provide better conditions compared with machined surfaces. [72-62]

d) Prosthetic Factors

1. OCCLUSION

There are basically two types of occlusion in implants a. functional loading is when the interim prostheses are in full occlusion; it isapplied in partially and fully edentulous patients.[73] b. non-functional loading combines the advantages of a single-stage procedure with those of immediate loading. In this case, the temporary restorations are not in occlusion. They are primarily for esthetics and to guide the soft tissues during the healing period. This occlusal model (INFL) has the advantage of reducing the risk of biomechanical overloading when parafunctional habits are present and is applied in the partially edentulous patients.74 In general, all authors agree to adjust the occlusion intraorally and eliminate interferences when performing lateral movements, keeping only the centricmarkings. There is some disagreement concerning the adjustment of the occlusion in maximal intercuspal position. The range of adjustment starts from having the interim prostheses in light contact to full contacts (maximal occlusal contact in the intercuspal position with equal load distribution among adjacent teeth and the provisional crown).

Some authors prefer to have an occlusion 1 to 2 mm short of occlusal contact or 1.5 mm short of occlusal contact and 1mmshort of incisal contact. [75]

One author recommends the prosthesis to be out of occlusion by 40 µm. Finally, one authormrecommends having the occlusion out of occlusal contacts for the first2 months, in full occlusion for 6 months, and the definitive prosthesis adjusted 8 months post-surgery. [73-74-

The amount of force to the prosthesis may be dramatically decreased in partiallyedentulous patients by eliminating any occlusal contact on the restoration. Most often, the esthetic aspects of the restoration may be obtained without occlusal loading. The Non-Functional Immediate Teeth (N- Fit) concept described by both Misch and Worhle in 1998 has many biomechanical advantages and decreased risk in the partially edentulous patient. [76] Because the bridgework associated with the implants result in no occlusal contact, the risk of parafunctional forces from bruxism or clenching are eliminated. The amount of bite force during eating is less than 30 lbs/in2 and less than 30 minutes. Parafunctional forces may be greater than 500 lbs/in2 and last for several hours. The risk of prosthesis fracture, abutment screw loosening, and partially retained restorations are also reduced with this method. The completely edentulous patient may be treated to eliminate the risk of nocturnal parafunction by restoring the patient with an immediately loaded overdenture, if the patient removes the restoration during sleeping hours.[72-76]

In addition, a stress-relief system of attachment to the implants may also decrease the force transferred while the prosthesis is in function. Irrespective of the type of occlusal concept chosen, there are basic rules to follow in immediate loading:

- Interim prostheses on posterior teeth should have a narrow occlusal platform compared to natural dentition. [77]

- It is better to place the occlusal contacts inside the implant diameter.[78]

- Interim prostheses should have flat cusps to minimize lateral forces and distribute them over a large area.

- Good symmetrical distribution of the masticatory forces, especially in the initial stages of healing, is important.

- The exposure to parafunctional forces can interrupt the course of osseointegration.

- No cantilever extensions should be present to prevent the presence of nonaxial forces.

- Patients should modify their diets by avoiding hard foods during the initial healing period (about 4 weeks).

2. Controlling functional forces is one of the important factors to obtain success in immediate implant loading. It is therefore advised to start by adjusting the occlusion following the INFL model, especially in the initial stages of healing.

This is very important for avoiding complications such as fracture of the bridge and peri-implant bone loss. Switching to an occlusion in IFL later on is recommended, as the distribution of occlusal support by the remaining teeth is known to reduce the risk of overloading.[79]

3. OCCLUSAL LOAD DIRECTION

The occlusal load direction along an implant interface may affect the RR. Barbier and Schepers found an axial load along an implant body maintains lamellar bone and showed a lower RR, compared with an offset loading condition. In this animal study, osteoclasts and inflammatory cells were also observed at the interface interface for the offset-loaded implants. A crown height can be a vertical cantilever when angled forces or cantilever (mesiodistal or buccolingual) are placed on a prosthesis. Therefore, not only should posterior cantilevers be eliminated in the immediate load transitional restoration, the angle of load to the implant body should be along the long axis, especially when the crown height is greater than normal. Flat occlusal planes in the posterior regions also decrease the risk of angled loads to the implant body.[81-89]

4. CANTILEVER FORCES

cantilever on a prosthesis increases the moment loads to the implant bone interface. Cantilevers have been reported to increase crestal bone loss, increase abutment screw loosening, increase implant body fracture, and increase the risk of implant failure. Therefore, an immediately loaded transitional prosthesis should not have a posterior cantilever, because it is usually not in the esthetic zone and bite

forces are greater in the posterior segments of the mouth. This is especially noted in partially edentulous patients, who do not have a crossarch biomechanical aspect of the support system which could reduce the risk of local overload. It should be noted that partially uncemented restorations may result in a cantilever along the remaining implants. A definitive cement should be considered for the transitional restoration to decrease the risk of partially retained conditions.[86-92]

5. SCREW- OR CEMENT-RETAINED PROSTHESES

The interim prosthesis should be retrieved every 2 weeks for clinical procedures like suture removal, implant stability assessment, soft tissue healing evaluation, and modification of embrasure. These steps are critical for molding, contouring, and healing of soft tissues to have ideal esthetic outcome.80 If a cemented restoration is planned, the abutments should provide enough height for the retention of the interim prosthesis. It is advised when using this technique that these interim prostheses should not be removed during the 3 to 4 month healing period. When a screwed restoration is planned, the treatment is easier to follow up, as it is easier to remove and place the interim prostheses.[81] Taking off the screw-retained prosthesis for suture removal 10 days after surgery does not jeopardize implant stability during bone remodeling. Macromovements are not recorded, while micromovements remain within the accepted range.

In principle, a screw-retained interim prosthesis may be preferred and may have many advantages over a cement-retained one. The arguments in favor are as follows:

- Avoidance of any residual cement interfering with tissue healing,which may cause inflammation and compromise bone and soft tissue healing.

- Easy removal during the healing period, which causes lower macro movements.

- In case of divergent implants, it is easier to restore with a screw-retained prosthesis; the angle corrections with screw-retained prostheses are in the range of 40◦ to 90◦, while with the cement-retained prostheses, they are between 10◦ and 30◦.

6. CROSS-ARCH STABILITY AND MICROMOVEMENTS

Cross-arch stability is an important requirement in a rigid bilaterally splinted interim prosthesis. Splinting helps to counteract the bending effect of lateral forces, thus reducing unfavorable stresses and distributing the masticatory forces evenly on a larger area. Furthermore, cross-arch restoration with an adequate passive fit protects from excessive micromotion and gives the necessary stability for osseointegration to occur.[71-80]

When implants are splinted with an interim prosthesis, the problem of micromovement is minimized to less than 100 μm. Splinting seems to be important in conditioning the implant tissue response, as the mechanical stress acting on the implants is reduced, stability is increased, and micromotion at the interface can be maintained below the critical threshold. For immediate single implants, interproximal contacts are broad surface contact areas made to distribute the forces of mastication more evenly and provide support and good stability. In single mtooth implants the cumulative success rate (CSR) is 81.4% compared to a CSR of 94.2% for multiple implant rehabilitations.[83]The higher CSR in partial and complete arch stabilizations may be due to the rigid splinting of implants through the framework.[83-90]

7. MATERIAL FOR INTERIM PROSTHESIS

Interim prostheses are temporary crowns made from acrylic resin or a rigid framework. Acrylic resin can be fabricated and modified easily and is therefore more economical. Interim prostheses prevent the transmission of some of the load directly to the implant and provide resistance to forces in all directions.

Temporary abutments may function as a shock absorber and limit the functional forces directed toward bone. This effect appears to be a major advantage in preventing the destabilization of implants.[84] When using autopolymerizing acrylic directly after surgery, there can be many disadvantages, for example, shrinkage of the acrylic resin may compromise the accuracy of the procedure, and heat transfer to implants during polymerization and the toxicity of the monomer at the

surgical field may affect the final outcome. To reduce these disadvantages, the fabrication of interim prostheses is made using the indirect technique, and the use of a rubber dam during their placement is required. The acrylic interim prostheses can also be used to check the precision of the final impression byinserting the acrylic interim prosthesis on the final cast and checking its fit, thus confirming the correct positioning of the implant replicas.85Along with acrylic resin, the use of a rigid U-shaped metallic framework connection minimizes the rotational movements, transfers the load to the implants mostly in a vertical direction, avoids deflection or fracture that could lead to macro movements, provides stability, allows osseointegration to occur safely, and improves patient

comfort.[86] Provisionalizing immediately loaded implants can be done in different ways. A metal-free immediate provisional fixed cross-arch restoration with a continuous palatal rafter has been used and did not adversely affect the rate of osseointegration around immediately loaded splinted implants. Fiber reinforced strips have also been used to connect the temporary abutment and reinforce interim prostheses in the posterior maxilla and mandible.[86-92]

CONCLUSION

Over the past three decades, significant advances have occurred in the clinical use of oral and maxillofacial implants. Various implant systems have emerged describing various loading protocols. Thus the interaction of different factors such as surgery, host, implant-and occlusionrelated factors impact the survival of immediate loading implants Case selection is critical factor for immediate loading.

A benefit/risk ratio may be assessed for each patient condition to ascertain whether immediate occlusal loading and early implant loading is a worthy alternative. The greater the benefit or lower the risk, more likely immediate loading is considered. Majority of clinical reports reveal similar survival rates between immediately loaded and two- stage unloaded healing approaches. The biomechanical treatment approach to increase surface area and decrease forces applied to the immediate restorations is most likely the major reason for high implant survival. Until the profession has longer term evidence and more multi center studies, immediate occlusal loading will be a secondary treatment option, restricted on a case-by- case basis.

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