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Prosthetic Requirements for Immediate Implant Loading: A Review

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Keywords
Implant; immediate loading; prosthodontics; occlusion; micromotion; provisional; interim prostheses.

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Accepted June 21, 2011

doi: 10.1111/j.1532-849X.2011.00819.x

Abstract

Purpose: The aim of this article is to review the current literature with regard to prosthetic considerations and their influence on the outcome of immediately loaded implants.
Materials and Methods: A broad search of the published literature was performed using MEDLINE and PubMed to identify pertinent articles.
Results: One hundred fifty six references were selected. They were mainly descriptive, prospective, follow-up studies. They were reviewed and were categorized with respect to 6 factors that influence immediate loading: cross-arch stability and micromovements, interim prostheses, definitive restorations inserted immediately, screw- or cement-retained prostheses, occlusion, and number and distribution of implants in overdentures and fixed prostheses.
Conclusion: Immediate loading seems to be a relatively safe procedure. From the prosthodontic point of view, there are specific guidelines to follow. They are: implants should be splinted with a metallic bar and acrylic interim prostheses until full osseointegration occurs. To have a successful outcome, screw-retained interim prostheses are recommended. CAD/CAM systems can improve the placement of implants with minimum risk. Regarding occlusion, there is a disagreement on when and how to provide occlusal contacts, but all authors agree on keeping centric contacts only. Finally, concerning the number of implants required for an immediate overdenture, no conclusive evidence could be found.

Implant dentistry has become successful with the discovery of the biological properties of titanium. Previously, studies advocated a two-stage surgical protocol to ensure predictable osseointegration.[1,2] Consequently, patients were asked either to wear a removable interim prosthesis or remain partially edentulous for an extended period of time for the osseointegration to take place.[3] This was an inconvenience for the patients and remained a challenge to both patients and clinicians. Hence, the concept of loading implants immediately after placement was introduced and soon gained popularity among clinicians.[1,2] Implants were defined as "immediately loaded" if they were restored by a functional, fixed interim prosthesis at the time of the surgery[4,5] or within 48 hours after surgery.[6]

In the 1990s, the first longitudinal clinical trial results were published. They supported the immediate loading protocol in the mandible of carefully selected patients.[7] Since then and during recent years, more focus has been placed on implant treatments using single and multiple immediate loading protocols in partially and fully edentulous patients.[6,8,9] Different approaches have been reported to provide patients with interim or definitive prostheses.[6,8,9]

To be able to place implants and load them immediately, strict protocols must be followed. The immediate load concept is based on three important clinical findings:

1 Micromotion of 50 to 150 μm can be accepted at the interface between bone and implant surface.[10] Micromotion of approximately 100 μm may constitute a threshold value for implants to osseointegrate properly.[11]
2 The assumption that joining several implants together via a rigid construction will reduce micromotion, thus facilitating the healing process and the immediate loading.[12-14]
3 It is important to eliminate micromovement between implants and osteotomies. It is therefore recommended to have insertional torque values of at least 30 Ncm when placing immediate implants.[15] It is also suggested that

implant diameter is inversely related to the micromotion movement.[16]

In the mandible, the placement of implants has traditionally been easier than in the maxilla. The American College of Prosthodontists has introduced parameters to follow for maxillary implant placement. They are:

1 Adequate maxillary residual ridge (Class A).
2 Class I skeletal jaw relationship.
3 Maxilla that did not require preprosthetic surgery.
4 Adequate interocclusal space (18 to 20 mm).[17]

Survival and success rates of immediately loaded implants seemed to be similar to those of the traditional protocol (loading implants 3 to 6 months after placement).[8] Immediate loading provided several advantages such as increased masticatory function, stability to the interim prosthesis,[6] minimizing uncontrolled transmucosal loading (caused by a transitional complete denture through cross-arch stabilization), preservation of bone and stimulation of bone remodeling,[2,18-20] enhancement of gingival contours, and better esthetics.[21-25] It also resulted in improvement of the psychological impact. Before immediate loading, the psychological impact of staying denture-less for 2 weeks may have deterred some patients from seeking implant treatment.[26]

Despite several advantages of immediate loading, there is no agreement on the technique by which immediate loading can be achieved. The success of immediate loading relies on the technological advances in the texture, shape and material of the implant, on the surgical protocol followed, on the operator's skills, and finally on the prosthetic restoration.

It should also be noted that excessive loads, which often lead to excessive movement during the healing process, may cause fibrous encapsulation of the implant. To control the load on the dental implants and reduce micromotion at the bone/implant interface, various prosthetic approaches have been described.[27]

The aim of this review was to evaluate the prosthetic requirements for the success of immediate loading in complete and partially edentulous situations.

Materials and methods

MEDLINE and PubMed searches were performed for English-language articles published between 1995 and 2011 using the following terms: immediate loading, micromotion, provisional and fixed restoration, screwed, cemented, maxilla, mandible, occlusion, primary stability, and implant coated. The search led to articles with the following distribution of titles: Micromotion 17, provisional 174, protocol 202, occlusion 87, screwed 15, cemented 30, maxilla 164, mandible 251, primary stability 48, and implant coated 23.

Results

From a total of 1011 titles, 156 references were selected focusing mainly on the prosthetic requirements. They were divided into 49 clinical studies, 1 study on a cadaver, 5 randomized clinical trials, 9 clinical reports, 12 case reports, 28 prospective studies, 9 retrospective studies, 3 pilot studies, 13 literature reviews, 5 meta-analyses, 9 follow-up studies, 4 preliminary reports, 1 clinical instructions report, and 2 textbooks, included because they provide basic information still in use today. In addition, 6 animal studies were incorporated, as these had direct relevance to the topic.

Discussion

Prosthetic considerations that might affect the success of immediate loading have been classified into six sections:

(1) Cross-arch stability and micromovements.
(2) Interim prostheses.
(3) Definitive restorations inserted immediately after implant placement.
(4) Screwed or cemented prostheses.
(5) Occlusion in immediate functional loading (IFL) and in immediate non-functional loading (INFL).
(6) Number and distribution of implants for overdentures and fixed interim prostheses.

Cross-arch stability and micromovements

Cross-arch stability is an important requirement in a rigid bilaterally splinted interim prosthesis.[28-30] Splinting helps to counteract the bending effect of lateral forces, thus reducing unfavorable stresses and distributing the masticatory forces evenly on a larger area.[29-31] Furthermore, cross-arch restoration with an adequate passive fit protects from excessive micromotion and gives the necessary stability for osseointegration to occur.[28,30,32] Micromotion under a removable prosthesis during the healing phase is a major cause of fixture failure, leading to fibrointegration of the implants instead of osseointegration.[32-36] When implants are splinted with an interim prosthesis, the problem of micromovement is minimized to less than 100 μm.[28,37-42] 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.[40]

In early procedures (before 2000), immediate loading was attempted in totally edentulous arches only in order to have a good cross-arch stability.[4,43-49] More recently, research centers started to apply immediate loading for single implants and in fixed partial dentures (FPDs).[23-25,27,34,35,50-69] For immediate single implants, interproximal contacts are broad surface contact areas made to distribute the forces of mastication more evenly and provide support[27,50,70,71] and good stability.[35,58,70,71] In single-tooth implants the cumulative success rate (CSR) is 81.4% compared to a CSR of 94.2% for multiple implant rehabilitations.[59] One recent multi-center study mentions a CSR of 94.9% for 335 implants placed, of which 56% were single implants, and the rest were multiple implants.[71] This CSR is for the implants altogether and cannot be used just for the single implant units. Moreover, follow-up was only 1 year. It would be interesting to find the CSR at 5 or more years.[71] Another study in 2011 showed a clinical survival rate of 95.73% after 5 years on 164 implants placed for single-implant rehabilitation.[72] The higher CSR in partial and complete arch stabilizations may be due to the rigid splinting of implants through the framework.[59,73]

It also seems that the immediate loading of non-splinted single-tooth implants by FPDs may be a viable treatment option with a favorable esthetic outcome and may be a safe and predictable procedure with a good success rate.[51,53,61,62] It should be noted that splinting implants immediately has several effects on the outcome of osseointegration. Primary stability can be enhanced when cross-arch implant splinting is performed.[1,40,74-77]

It is also reported that bone remodeling and collagen mineralization are directly related to the strains applied.[78] The ratios of bone implant contact (BIC) in splinted implant groups were higher than in the non-splinted ones.[79] A study used the finite element method (FEM) to simulate stresses induced in bone tissue surrounding uncoupled and splinted implants in the maxilla. It showed that stress levels in bone tissue surrounding splinted implants was nine times lower than stress levels surrounding uncoupled implants.[38] However, two studies suggest that favorable implant success rates and peri-implant tissue responses can be achieved with mandibular overdentures retained by two unsplinted implants.[80,81]

Stem cells in the osseous wound differentiate and form scar tissue around the implant, thus inhibiting osseointegration when excess micromovement occurs.[36] In this respect, micromotion $<150\ \mu$m is well tolerated by the bone, as this controlled mechanical stimulation can increase bone growth and BIC.[32,82-85] Research has shown that the percentage of BIC attained in the immediate loading technique was $71.1 \pm 11.8\%$, versus $45.1 \pm 16.1\%$ in the conventional technique,[86] meaning the brief exposure to extremely low amplitude mechanical strains may accelerate bone formation.[1] Furthermore, the osteoblasts located adjacent to the implant surface displayed all signs of active cell function.[31,78,87]

In conventional loading, the biomechanical analysis of conventional implant-supported rehabilitation (2 stages) reveals that stresses introduced into the implant system as a result of prosthesis misfit may be present many years following its placement.[3,88] This misfit results in uneven force distribution and prosthesis complications (the prosthesis may become loose), resulting in increased stress on the implants with a loss of osseointegration.[85] This is due to the ankylotic character of the osseointegration phase. This problem rarely happens in the immediate load procedure, as the static stresses caused by prosthetic misfit dissipate during the first weeks of osseointegration; this is caused by the early bone resorption within the first and second weeks of healing.[3,88]

In general, a framework misfit would cause loosening of the abutment screws without affecting long-term osseointegration.[89] This is why immediate loading has proven to be beneficial, because it has to be matched in conjunction with a best possible fit of the prostheses.

Interim prostheses

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.[20] Interim prostheses prevent the transmission of some of the load directly to the implant[52] and provide resistance to forces in all directions.[90,91]

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.[92] 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.[32] 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.[32] The acrylic interim prostheses can also be used to check the precision of the final impression by inserting the acrylic interim prosthesis on the final cast and checking its fit, thus confirming the correct positioning of the implant replicas.[93] Along 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 macromovements, provides stability, allows osseointegration to occur safely, and improves patient comfort.[1,5,30,39,83,94-99]

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.[3,91] Fiber-reinforced strips have also been used to connect the temporary abutment and reinforce interim prostheses in the posterior maxilla and mandible.[92,100,101]

Final restorations inserted immediately in place

In the majority of studies, the usual recommendation is the fabrication of an interim prosthesis until its replacement by the definitive restoration once the osseointegration process is complete.[19,32,33,58,73,83,91,96,100,102-106] There are two primary systems for providing a definitive restoration at the immediate placement stage. The Branemark Novum (Nobel Biocare, Zurich, Switzerland) introduced in 1999 provided an edentulous patient with a full fixed implant-supported mandibular prosthesis on the same day. The system consisted of immediately loading three implants in the interforamina region.[2,107,108] It was necessary to prepare the definitive prosthesis according to recordings prior to surgery and to provide a pre-manufactured Ti bar screwed on the implant fixtures during the surgery; however, the system had limitations. Its usage was limited to specific patients because of the anatomic variations found in their mouth and the possible prosthetic recording difficulties.[2,107] This system had a failure rate around 13%.[109]

The Speed Master technique, introduced in 2006, had a similar protocol. It enabled the placement of four implants in the edentulous mandible using surgical guides. A permanent fixed prosthesis fabricated over a pre-manufactured Ti bar was attached to the implants on the day of implant placement, according to requirements (vertical dimension and occlusion) established during appointments prior to the surgery.[3]

From these and other studies, it can be concluded that the disadvantages of restoring immediately placed implants with definitive prostheses is greater because:

- Use of the pre-manufactured Ti bar may be difficult due to the anatomic variations in the patient's mouth. To avoid this problem, Tortamano et al fabricated the hybrid prosthesis according to the occlusal vertical dimension established prior to the surgery. They also prepared the Ti bar according to the position of implants after surgery. Despite that, they recommended inserting the prosthesis 48 hours after the surgery.[2]
- The poor control of soft tissue healing might compromise the definitive outcome of the soft tissue architecture. In the case of immediate loading with a definitive restoration (overdenture and bar) placed directly after surgery, it is necessary to reline the anterior segment of the prosthesis (that houses the bar assembly) at 3 and 6 months, as the early insertion does not allow adequate time for soft tissue healing.[2,110,111]
- If an implant fails later during the osseointegration period, the definitive prosthesis delivered at the time of the surgery will need to be replaced by a new prosthesis, thus increasing the cost.[3,88]

The introduction of precision machine milling along with the concept of immediate loading led to the use of CAD/CAM systems in implant restoration. There is a growing interest in minimally invasive implant therapy restored with a definitive fixed restoration directly. The CAD/CAM system "teeth in an hour"[36,57,102-104,112-114] was introduced to fabricate the surgical guide and prosthesis prior to the surgical procedure.

The Nobel Biocare-Procera protocol[36,57,102-104,112-114] was designed for immediate loading using a CAD/CAM fixed prosthesis milled from a block of Ti or zirconia. It necessitates a 3D virtual reproduction of the patient's jaws, occlusal bite, and actual dentures, which are reproduced from data entered on a Procera CT scan program. The information gathered gives all the necessary information to provide number, position, and location of implants to produce a final restoration that will fit onto the planned implants following their surgical placement.[114] It is essentially a flapless surgery, and the clinician provides a treatment plan that reduces the operating time, surgical trauma, and postoperative morbidity.[57,103,106,113,115-118] Time saved with this procedure is remarkable; there is no second-stage abutment connection surgery and no need for additional impressions.[103,106,113,115,116] It is claimed to aid in an accurate placement of implants with minimized risk and complication because of the use of a guided surgical template and an accurate identification of vital anatomical structures through the software.[30,114,117-121] The CAD/CAM abutments present the advantages of being specific to each patient, providing a better fit than the conventional abutments, in addition to being stronger as they employ materials such as Ti and zirconium.[104]

It is, however, recommended to provide the patient with interim prostheses rather than definitive ones, as ossoeointegration is not yet 100% predictable.[104] This technique also has disadvantages. The main early surgical complication is bony interference that could prevent complete seating of the prosthesis. Following surgery, the most common late surgical complication is implant failure with an overall failure rate of 9%.[30,112,116,118,121,122] The CT-guided surgery is not 100% accurate, as standard deviations of 1 to 2 mm between planned and actual placement of implants have been reported.[17,118,122] Finally, the guided surgery lacks visibility and tactile control during the surgical procedure.[118,122]

Another study in the maxilla applied the CAD/CAM concept using a Siemens Somatom dual-source CT scan in conjunction with OsseoSpeed implants (Astra Tech AB). Of 78 implants placed, only one failure was noted.[123] It is important to note that different software and implant systems give almost the same clinical results.

There is a trend now to reduce treatment time and simplify procedures to increase patient tolerance and reduce the probability of complications. These complications are frequently reported when combining computer-guided flapless surgery with an immediately loaded prefabricated definitive prosthesis. In fact, the immediate prosthesis should be adjusted several times during the healing phase to accommodate for tissue healing and ensure patient comfort. It is therefore better to insert an interim prosthesis during the healing period before the definitive prosthesis is fabricated.[19,32,33,58,73,83,91,94,118,122]

Screw- or cement-retained prostheses

Interim prostheses can be either screw- or cement-retained. It is important to note that each type of prosthesis has a different protocol.

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.[50,91,98] These steps are critical for molding, contouring, and healing of soft tissues to have ideal esthetic outcome.[50,91]

If a cemented restoration is planned, the abutments should provide enough height for the retention of the interim prosthesis.[85] It is advised when using this technique that these interim prostheses should not be removed during the 3 to 4 month healing period.[41,49,105]

When a screwed restoration is planned, the treatment is easier to follow up, as it is easier to remove and place the interim prostheses.[15,41,49,105] 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.[124]

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,[76,125] which may cause inflammation and compromise bone and soft tissue healing.[21,50]
- Easy removal during the healing period, which causes lower macro movements.[1,49]
- 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°.[21]

Occlusion

There are basically two types of occlusion in immediate implants:

1 Immediate functional loading is when the interim prostheses are in full occlusion; it is applied in partially and fully edentulous patients.[40,41,126,127]
2 Immediate 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.[1,40,41,55,62,74,126,127]

In general, all authors agree to adjust the occlusion intraorally and eliminate interferences when performing lateral movements, keeping only the centric markings. 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[26,51] to full contacts (maximal occlusal contact in the intercuspal position with equal load distribution among adjacent teeth and the provisional crown).[60,92,101] Some authors prefer to have an occlusion 1 to 2 mm short of occlusal contact[41] or 1.5 mm short of occlusal contact and 1 mm short of incisal contact.[128] One author recommends the prosthesis to be out of occlusion by 40 μm.[58] Finally, one author recommends having the occlusion out of occlusal contacts for the first 2 months, in full occlusion for 6 months, and the definitive prosthesis adjusted 8 months post-surgery (Table 1).[62]

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.[50,129]
- It is better to place the occlusal contacts inside the implant diameter.[50,129]
- Interim prostheses should have flat cusps to minimize lateral forces[51] and distribute them over a large area.[19]
- Good symmetrical distribution of the masticatory forces, especially in the initial stages of healing, is important.[1,15,17,98,130]
- The exposure to parafunctional forces can interrupt the course of osseointegration.[31]
- No cantilever extensions should be present to prevent the presence of non-axial forces.[19,131]
- Patients should modify their diets by avoiding hard foods during the initial healing period (about 4 weeks).[34,92,127,132-134]
- 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.[8,20,41,54,127]

Table 2 details the distribution of occlusal forces in full and partial arches.

Number and distribution of implants for overdentures and for fixed interim prostheses

In general, it is advised to have a fixed prosthesis on implants rather than an implant-supported overdenture. Forces acting on implant-supported overdentures increase the magnitude of the bending moment when compared to those acting on an implant-supported fixed prosthesis. This might be due to a lesser control of these forces. The minimal number of implants needed to support a fixed prosthesis should therefore be greater than the number of implants needed for an overdenture.[135] This applies to both the mandible and maxilla. In the mandible, the number of implants needed for an implant-supported overdenture ranges from one to four implants.[37,39,41,110,135-141] Immediately loaded mandibular overdentures are a successful treatment option with long-term success for edentulous patients,[142,143] especially when they are supported by four implants placed in a tripod configuration connected by a U-shaped bar[1,39,41,90,94,97,126,136] The survival rates are similar to those obtained following a delayed approach protocol[1,5,27,136,142,143] (Table 3). Although a number of studies reported good results with three or fewer implants immediately loaded, these clinical cases need to be carefully followed and validated in the long term. Most are based on three, two, and one implant used to retain an overdenture. The rationale behind this type of treatment is usually cost effectiveness. It can be used in elderly populations with low income to improve their quality of life[37,135,137-141] (Table 4).

A greater number of implants are necessary in the maxillary arch due to the quality of maxillary bone.[39,41,94] The palatal resorptive pattern of the maxilla makes a good axial alignment, but the parallel placement of right and left implants is difficult.[85] The position of the implants in the widest anterior–posterior distribution is able to resist the micromovement at the bone/implant interface.[3,20,49] In general, scientific or clinical documentation for immediate loading of maxillary overdentures is lacking.[4,144] Only two studies were found:

(1) The first described 12 patients (mean age: 56.6 years) who received their immediate overdentures with four implants and a bar with a minimum insertion torque of 45 Ncm. Two implants failed in two patients, but were successfully replaced the same day (they were removed with no major complication). No prosthesis failed; however, one patient was unsatisfied with his denture and requested a fixed alternative.[129]
(2) The second study described 22 patients (mean age: 66.7 years) who received their immediate overdenture with four or five implants rigidly connected with a bar, with a minimum insertion torque $\geq$30 Ncm. From the initial 103 implants placed, three failed, and two were successfully replaced.[145]

Table 1 Comparison of results between IFL & INFL in partially and fully edentulous arches

	Number of patients	Gender / age	Number of implants	IFL INFL	Site	Region	Type of prosthesis	Success rate	Bone loss after 1 year
Malo et al[68]	76	N.M.	116	IFL	Healing site: 94—Fresh extraction site: 22	Maxilla & mandible	Partially edentulous	96%	N.M.
Degidi & Piattelli[40]	152	♀:84 ♂:68 /46	646	IFL: 422 INFL: 224	Healing site: 362—Fresh extraction site: 284	Maxilla & mandible	Fully edentulous & partially edentulous	IFL: 98.6% INFL: 99.1%	0.6 ± 0.2 mm 0.6 ± 0.2 mm
Degidi & Piattelli[74]	97	♀:57 ♂:40 /53	388	IFL: 253 INFL: 135	Healing site	Maxilla & mandible	Fully edentulous & partially edentulous	IFL: 99.2% INFL: 99.2%	0.7 ± 0.2 mm 0.7 ± 0.2 mm
Lindeboom et al[24]	48	♀:31 ♂:17 /42	48	IFL: 24 INFL: 24	Healing site	Maxilla	Single implant	IFL: 91.6% INFL: 87.5%	0.23 ± 0.1 mm 0.24 ± 0.1 mm
Drago & Lazzara[15]	27	♀:21 ♂:6 /62	151	IFL	Healing site—Fresh extraction site	Mandible	Fully edentulous	98%	N.M.
Degidi et al[55]	111	♀:66 ♂:45 /40	111	INFL	Healing site—Fresh extraction site	Maxilla & mandible	Single implant	97.2%	<1.5 ± 0.2 mm
Crespi et al[92]	27	♀:15 ♂:12 /57	160	IFL	Healing site: 10—Fresh extraction site: 150	Maxilla & mandible	Fully edentulous & partially edentulous	100%	0.7 ± 0.5 mm
Guncu et al[56]	12	♀: 8 ♂: 4 /41	12	IFL	Healing site	Mandible	Single implant	91.7%	0.45 ± 0.39 mm
Lee et al[67]	Animal study (3 dogs)	N.M.	24	IFL: 12 INFL: 12	Healing site	Mandible	Partially edentulous	N.M.	No difference in marginal bone loss between IFL & INFL
Calandriello and Tomatis[64]	33	♀:17 ♂:16 /52	40	IFL	Healing site	Posterior mandible	Single implant	95%	1.17 ± 0.9 mm
Mijiritsky et al[69]	16	N.M.	24	INFL	Fresh extraction site	Anterior maxilla	Single implant	95.8%	0.9 ± 1.1 mm
Laviv et al[66]	113	N.M.	113	INFL	Healing site—Fresh extraction site	Anterior region	Single tooth	95.5%	N.M.
Zembic et al[6]	11	♀: 3 ♂: 8 / 55	22	IFL	Healing site: 3—Fresh extraction site: 19	Posterior mandible	Partially edentulous	85%	1.63 ± 0.63 mm
Degidi et al[65]	50	♀: 25 ♂: 25 / 45	100	IFL: 25 INFL: 25	Healing site	Posterior mandible	Partially edentulous	IFL: 96% INFL: 96%	0.94 ± 0.3 mm 0.98 ± 0.3 mm
Balshi et al[72]	140	♀: 54 ♂: 86 / 45	164	INFL	Healing site: 100—Fresh extraction site: 64	Maxilla & mandible	Single implant	95.73%	N.M.

N.M. = Not Mentioned

Table 2 Distribution of occlusal forces in full arch and partial arch

	Full arch	Partial arch
Centric occlusion	Bilateral simultaneous anterior and posterior contact to distribute the load over a large area[8,20,41,127]	Symmetrical light contact[8,20,54]
Eccentric occlusion	Bilateral simultaneous anterior and posterior contact with group function guidance for an even distribution of the forces to avoid disrupting the integration process[8,20,41,127]	Posterior restorations: No lateral contact - Canine restoration: Decrease the lateral guidance angle to develop a group function situation. - Anterior restorations: Distribute protrusive contacts evenly to all teeth[8,20,54]

Table 3 Immediate loading of 4 interforaminal implant-supported overdentures in the edentulous mandible

References	Number of patients	Number of implants	Diameter	Length	Region	Success rate
Chiapasco (2004)[39] Morton (2004)[41] Cochran (2004),[126] based on 7 articles (1997 to 2003)	376	1529	≥3.5 mm	≥10 mm	Interforaminal region	96% to 100%
Attard et al[110]	35	140	≥3.75 mm	≥10 mm	Interforaminal region	98.6%
Degidi et al[136]	50	200	≥3.4 mm	≥10 mm	Interforaminal region	100%

Table 4 Immediate loading of 1 to 3 interforaminal implant-supported overdentures in the edentulous mandible

	Number of patients	Number of implants	Diameter	Length	Region	Success rate
Stephan et al[138]	17	51 (3 implants per patient)	≥3.75 mm	≥10 mm	1 in the center and the 2 others were placed 12 to 15 mm distal bilaterally	100%
Marzola et al[137]	17	34 (2 implants per patient)	≥3.5 mm	≥10 mm	Symphysis area: 20 mm apart between canine and lateral incisor	100%
Akca et al [37]	4 cadavers	8 (2 implants per patient)	4.1 mm	10 mm	Symphysis area: 20 mm apart between canine and lateral incisor	100%
Kronstrom et al[140]	19	36 (2 implants per patient)	≥ 3.75 mm	12 to 15 mm	Interforaminal area	81.8%
Stoker and Wismeijer [139]	124	248 (two implants per patient)	≥3.3 mm	≥10 mm	The location was according to the position of the contact point between the lateral incisor and the canine	98.8%
Liddelow and Henry[135]	28	28 (one implant per patient)	> 4 mm	>10 mm	In the mandibular midline	100%
Kronstrom et al[140]	17	28 (one implant per patient)	≥ 3.75 mm	15 mm	In the mandibular midline	81.8%
Liddelow and Henry[141]	35 (one implant per patient)	35 (10 machined #25 oxidized surface implants)	> 4 mm	10 to 18 mm	In the mandibular midline	63% for machined 100% for oxidized surface implants

Table 5 Immediate loading of implant-supported fixed prosthesis in the edentulous arch

	Number of patients		Number of implants		Number of implants / arch		Success rate	
	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla	Mandible
Chiapasco[39] Morton[41] Cochran,[126] based on 7 articles (1997 to 2003)	30	237	294	2086	>6	>4	87% to 100%	80–100%
Gallucci et al[91]	8 patients; 11 edentulous arch		78		6 to 10		97.4%	
Jaffin et al[85]	34		236		6 to 8		93%	
Parel and Tiplett [107] and Simamoto et al[108]	Novum system					3		98%
Malo et al[99]	32		128		4		97.6%	
Degidi and Piattelli[74]	20	14	161	92	6 to 8	6 to 8	98.7%	100%
Vasconcellos et al[3]		15		60		4	100%	
Tortamano et al[2]		9		36		4		100%
Capelli et al[150]	41	24	246	96	4 to 6	4 to 6	97.5%	100%
Kinsel and Liss[19]	39	17	261	83	4 to 10	4 to 10	94.3%	98.8%
Tealdo et al[155]	21		111		4 to 6		100%	
Bergkvist[148]	28		168		6		98.2%	
Francetti et al[152]		62		248		4		100%
Gualini et al[109]		15 (Novum System)		45		3		95%
Biscaro et al[149]	1		10		10		100%	
Penarrocha et al[153]		9		54		6		100%
Pieri and Aldini [154]	9	15	66	78	7 to 8	5 to 6	98.6%	98.6%
Bergkvist et al[33]	28		168		6		98.2%	
Weinstein et al[156]		20		80		4 interforaminal implants (2 axial implants & 2 tilted implants)		100%
Agliardi et al[146]		24		96		4 interforaminal implants (2 axial implants & 2 tilted implants)		100%
Ferreira et al[151]	1	1	4	4	4	4	100%	100%
Agliardi et al[147]	72	101	288	404	4 (2 axial implants & 2 tilted implants)	4 interforaminal implants (2 axial implants & 2 tilted implants)	98.36%	99.73%

The number of implants needed when restoring cases with fixed prostheses in the maxilla is greater than the number of implants needed to restore a fixed prosthesis in the mandible. In general, at least four implants are needed in the anterior mandible to support a fixed prosthesis, and a greater number of implants is necessary in a maxilla with good bone quality and high primary stability[2,19,33,39,41,74,85,91,99,107-109,126,146-156] (Table 5).

Conclusion

Immediate loading appears to be a reliable and safe modality of treatment in the partially or totally edentulous maxilla or mandible in carefully selected cases. The techniques used can be applied to a fixed prosthesis or an overdenture with good clinical and radiographic success rates similar to those reported in the conventional delayed two-stage approach; however, this success relies upon the improvement of the implant texture surface and shape, the surgical protocol, and the prosthetic technique that comes with it. This review looked at the prosthetic components of the immediate loading procedure. They can be placed into six subdivisions:

1. Cross-arch stabilization by splinting (full arch) or by good interproximal contacts (single implant) provides the necessary stability to minimize micromotion and stimulate bone growth (osseointegration).
2. The interim prosthesis fabricated with resin or metal framework is important for long-term success. It is an effective method to reduce deleterious mechanical stresses on immediately loaded implants.
3. It is advised to use a CAD/CAM system to predict the vital structures and the position of implants, with the possibility of slightly modifying the implant position and placement. The main advantage is to reduce the postoperative sequelae. It is a reliable procedure when a temporary prosthesis is used and later replaced by a definitive prosthesis after complete osseointegration.
4. Screw-retained restorations seem to have a superior outcome compared with the cement-retained restorations as it is easier to follow up during the healing period.
5. There is a general disagreement on when and how to provide occlusal contacts, but all authors agree to keep centric contacts only.
6. The number of implants needed when restoring implant cases with fixed prostheses is greater than the number needed for overdentures. In general, at least four implants are needed in the anterior mandible to support a fixed prosthesis, and a greater number of implants are necessary in a maxilla with a good bone quality and high primary stability. The consensus is that micromovements should be controlled by splinting all the implants using a U-shaped bar. To achieve this goal, the distribution of the fixtures is important.

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