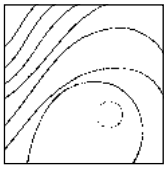
# Immediate Loading of Mandibular Dental Implants in Partially Edentulous Patients: A Prospective Randomized Comparative Study



*Patrice Margossian, DDS, PhD*/Paul Mariani, DDS, PhD***
*Grégory Stephan, DDS, PhD*/Jacques Margerit, DDS, PhD****
*Christian Jorgensen, MD, PhD*****

*While immediate loading in the edentulous mandible is a well-documented procedure, there are limited scientific data on immediate loading in the partially edentulous mandible. Two-year success rates of immediate loading and conventional delayed loading of dental implants in partially dentate mandibles were compared. Patients were randomized into three groups: group A (n = 40), immediate provisionalization with nonocclusal loading; group B (n = 40), immediate provisionalization with occlusal loading; and group C (n = 37), delayed loading with single-stage surgery. Baseline and 2-year measurements included implant stability quotient, insertion torque, and peri-implant bone crest radiography. Two hundred nine implants were immediately loaded in 80 patients. The 2-year success rates were 93.3% for group B and 100% for groups A and C. Immediate provisionalization provided success rates similar to those for delayed loading only when not loaded in occlusion.* (Int J Periodontics Restorative Dent 2012;32:e51–e58.)

*Associate Professor, Department of Prosthodontics, University of Méditerranée II, UFR Odontologie Marseille, France.
**Professor and Head, Department of Prosthodontics, University of Méditerranée II, UFR Odontologie Marseille, France.
***Professor and Head, Department of Prosthodontics, University of Montpellier 1, Montpellier, France.
****Professor and Head, INSERM U844, Department of Rheumatology, University of Montpellier 1, Montpellier, France.

Correspondence to: Dr Patrice Margossian, 232, av. du Prado, 13008 Marseille, France; fax: 0033491321219; email: patrice.margossian@univmed.fr.

A suggested protocol for successful osseointegration of dental implants is to have an extended submerged healing phase.[1] A healing period of 3 to 6 months for submerged and unloaded implants has been described empirically.[2] Over the years, several studies have reported high success rates with nonsubmerged titanium implants and early loading (2 months) protocols.[3,4] The next logical step in the improvement of implant therapy was to reduce the treatment time by loading implants immediately. Immediate loading is defined for some authors as a restoration placed in occlusion with the opposing dentition within 48 hours after implant placement.[5,6] Successful osseointegration of dental implants requires anchoring them directly to the bone. However, in the presence of micromotion above 150 µm, fibrous encapsulation may occur[7,8]; thus, the main criterion for immediate loading of a dental implant is primary stability when placed in the bone.[9] The clinical assessment of stability is often based on insertion torque measurements. Torques of 30 to 40 Ncm

may ensure that sufficient stability has been achieved.[10,11] Careful preparation of the implant site or the implant design can enhance primary stability.[12,13]

Another important factor for proper integration is implant surface topography, particularly in challenging situations. In vitro studies and preclinical trials have shown a positive correlation between increased surface roughness and bone-to-implant contact measured histologically and demonstrated by torque removal values.[14] Furthermore, some authors reported higher success rates for rough implants than machined implants in immediate loading protocols.[15–17]

Since 1999, several studies[18–20] have recommended immediate loading in cases of full-arch maxillary and mandibular prostheses for edentulous patients; however, few[10,21–23] have mentioned immediate loading in partially edentulous arches other than single-site replacements. The aim of this study was to evaluate the 2-year success rates of immediately loaded dental implants in partially edentulous mandibles by comparing conventional delayed loading with occlusal and nonocclusal immediate loading.

## Method and materials

The clinical research ethics committee approved this study.

Any partially edentulous patient requiring dental implants that was at least 18 years old and in good general health was eligible for inclusion in this trial. The patients were thoroughly informed about the procedure and asked to sign a consent form. The inclusion criteria for selection were a need for rehabilitation with an implant-supported prosthesis (two to four units) in a partially dentate mandible that was unilaterally edentulous; an adequate amount of bone height for placement of an implant, with a minimum length of 10 mm, in a prosthetically optimal position; healed bone sites free from infection (at least 4 months after the last extraction); good oral hygiene; and sufficient primary implant stability (minimal insertion torque of 30 Ncm and an implant stability quotient value of at least 60). Exclusion criteria were as follows: all general contraindications for oral surgery, smoking, severe maxillomandibular space discrepancies, and parafunctional habits (bruxism and clenching). All patients agreed to be available for follow-up clinical visits that included postoperative radiographs.

A complete presurgical evaluation was performed for all patients, including a wax-up and fabrication of surgical and radiologic templates. Any splinted provisional restorations were fabricated in the dental laboratory based on the wax-up. Each clinical case was evaluated by examining diagnostic casts for the maxillomandibular relationship, periapical and panoramic radiographs, and computed tomography scans (Somatom Sensation 16, Siemens). A total of 117 partially edentulous patients were consecutively enrolled in the study and were randomly assigned to one of three groups: group A (n = 40), immediate provisionalization with nonocclusal loading; group B (n = 40), immediate provisionalization with occlusal loading; or group C (control; n = 37), delayed loading. Patients were allocated using a sealed envelope procedure so that the groups would be distributed equally.

### *Surgical treatment*

All implants used in the study were placed and restored by a single clinician. Patients were placed under local anesthesia (Primacïne adrenaline, Pierre Rolland) following use of prophylactic antibiotic medications (2 g; Clamoxyl, Smithline Beecham) 1 hour before the surgical procedure. A midcrestal incision was performed, and a full-thickness flap was raised. All surgical procedures were performed with the aid of a custom-made template. Every effort was made to maintain parallelism between the implants (first-generation full Osseotite NT certain, Biomet 3i) and the remaining dentition (Fig 1). To obtain adequate primary stability, the implants had to achieve an initial insertion torque value of at least 30 Ncm, which was facilitated by the tapered shape of the implants.[15] Following implant insertion, definitive abutments (Straight Gingihue, Biomet 3i) were positioned on the implant and a transducer was fixed on the abutment to analyze the resonance frequency (RFA). The implant stability quotient (ISQ) measurement had

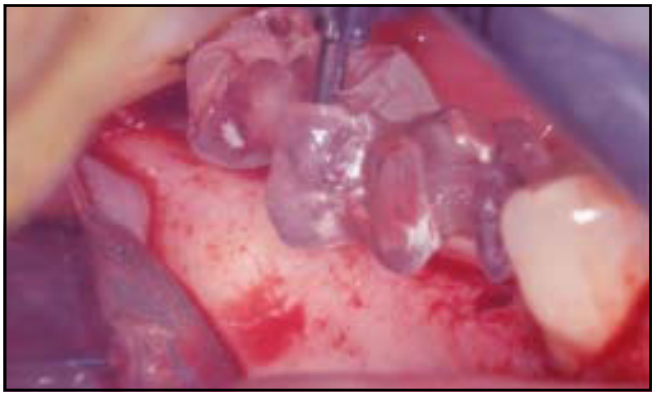


**Fig 1** *Preparation of the implant osteotomy according to the surgical guide.*

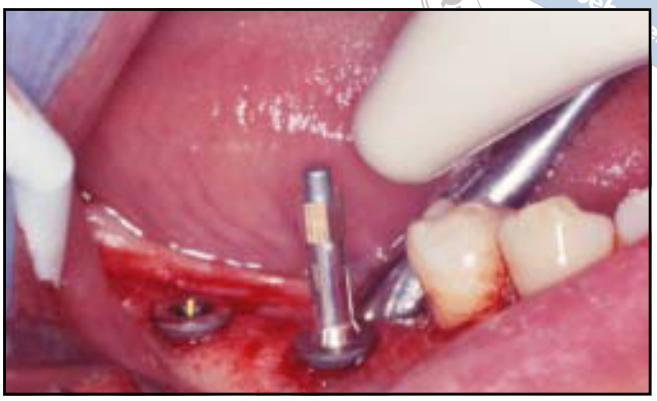


**Fig 2** *Resonance frequency analysis recording (Osstell Mentor).*

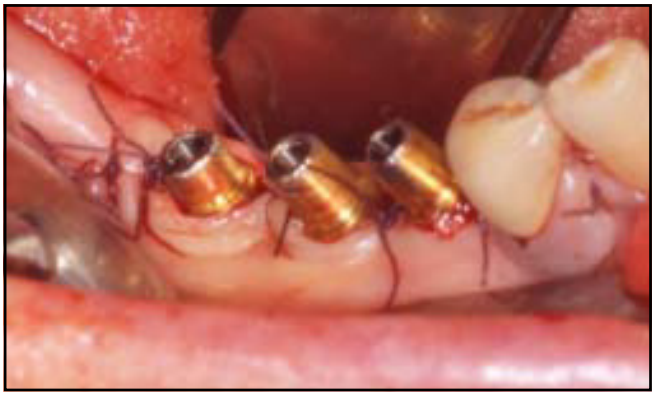


**Fig 3** *Abutments placed at the end of the surgical procedure.*

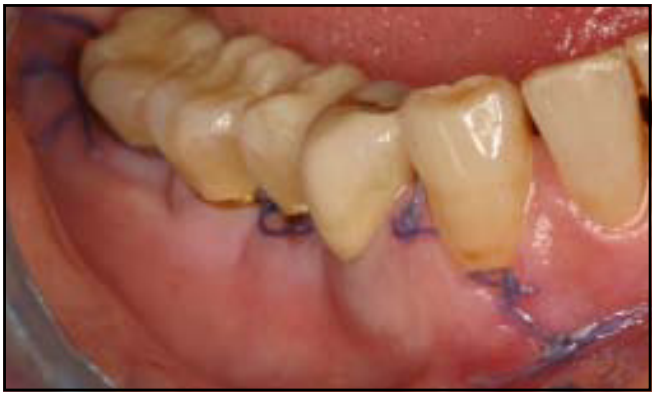
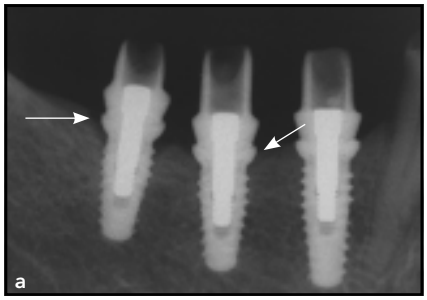


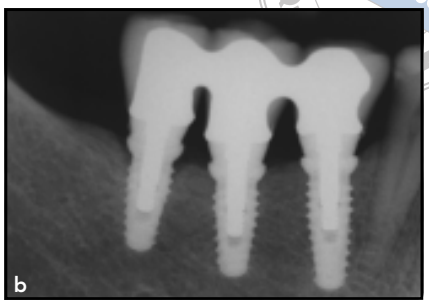
**Fig 4** *Provisional prostheses 2 weeks after placement: day of suture removal.*

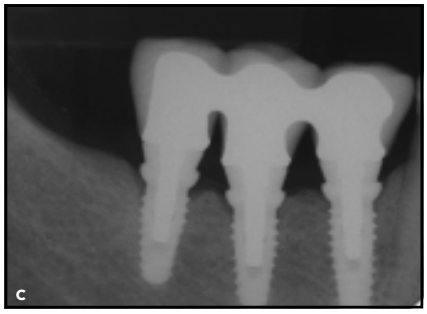
to be above 60 (Osstell, Integration Diagnostics) to confirm primary stability (Fig 2).[24–27] Next, the gingival tissue was closed around the abutments using resorbable sutures (5-0 Vicryl suture, Ethicon). Radiographs were then obtained to verify abutment seating on the implant hexes prior to delivery of the final torque to the abutment screws. The radiographs were also used as baseline measurements for comparisons of the locations of the restorative platforms and the interproximal bone heights on the mesial and distal surfaces adjacent to the implant. Sutures were removed 14 days after surgery (Fig 3).

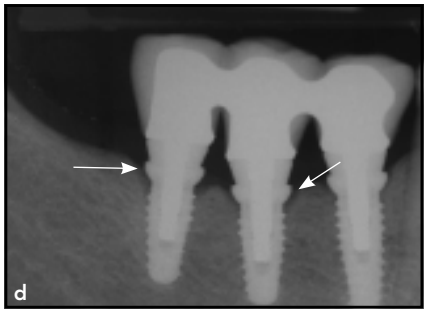
*Restorative procedures*

All group A and B implants were prosthetically provisionalized on the day of implant placement with splinted provisional fixed prostheses. A light-cured liquid dam resin (Opaldam, Ultradent) was placed around the abutments to isolate the surgical sites. The abutment posts were prepared to attain the appropriate height and angulation. A final reduction also took place 4 months later, during the visit to make the definitive prosthesis. All abutment preparations were performed intraorally with irrigation. Cotton pellets were placed into the abutment screw head to prevent acrylic resin intrusion into the access hole. Following lubrication, acrylic resin (Unifast GC America) was placed inside the provisional prosthesis and it was pressed onto the abutment post using hand and occlusal pressure. After the acrylic resin had set, the provisional prosthesis was removed for adjustments and polishing (Fig 4). For group A, the occlusal surface of the provisional restoration was ground down to avoid any occlusal contact with the opposing dentition (approximately 1 mm). For group B, the provisional acrylic resin crown restorations were placed in occlusal




**Figs 5a to 5d** *Radiography* (a) *at surgery,* (b) *at definitive prosthesis delivery,* (c) *after 1 year, and* (d) *after 2 years. Arrows show the marginal bone level.*

contact. A careful occlusal adjustment was performed to minimize lateral forces with light centric occlusal contact and to ensure no excursive contacts. The provisional prosthesis was cemented using polycarboxylate cement (Poly-F Plus, Dentsply DeTrey). For group C, healing abutments were placed on the implants, and delayed loading was performed.

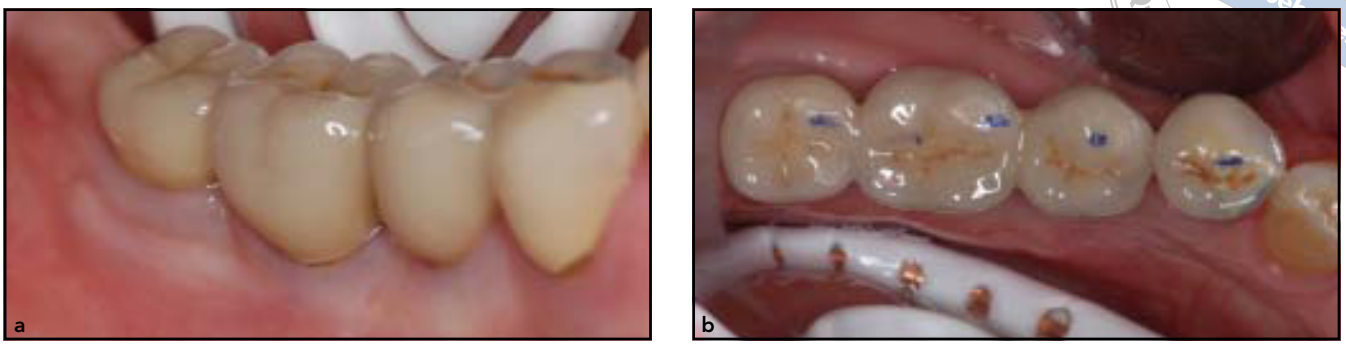
### *Postoperative measures and follow-up*

After surgery, all subjects received ibuprofen (1.2 g per day for 4 days; Advil, Wyeth Consumer Healthcare) and antibacterial mouthwash for 14 days (Eludril, Laboratory INAVA). Ice packs were provided, and a soft diet was recommended for the first 8 weeks following implant placement. Sutures were removed 14 days after surgery. Oral hygiene was limited to brushing around the implants with a soft toothbrush for the first 2 weeks. Thereafter, conventional brushing and flossing were permitted.

Recall examinations were performed at 4, 8, 12, 16, 20, and 24 weeks and yearly thereafter. During each visit, occlusion, prosthesis stability, and oral hygiene were checked. A periapical radiograph was obtained at the time of surgery and every month thereafter using a paralleling technique with a Rinn film holder (Dentsply Rinn) and an individual acrylic resin index affixed to the maxillary dentition to guarantee radiographic reproducibility at all follow-up examinations.[10] The distance between the implant shoulder and the point of bone-to-implant contact was measured. The bone level at surgery was defined as the baseline level. The radiographic bone level was measured at the mesial and distal aspects of each implant on every follow-up radiograph (Figs 5a to 5d). Marginal bone loss was calculated as the difference between follow-up and baseline values. Four months after implant placement, the provisional prosthesis and abutment screws were removed to assess implant stability by RFA. The abutment was then positioned and tightened to 20 Ncm. Final impressions were made directly on the abutments, and definitive porcelain-fused-to-metal splinted restorations were delivered approximately 4 weeks after the impressions were made (Figs 6a and 6b).

### *Success and failure criteria*

Implant success criteria, according to Albrektsson and Zarb,[1,28] were as follows: absence of implant mobility,




**Figs 6a and 6b** *Definitive restoration in place 5 months after the surgical procedure.* (a) *Buccal and* (b) *occlusal views.*

**Table 1** **Prosthesis distribution according to the number of units**

| | Two units | Three units | Four units |
|---|---|---|---|
| Group A (immediate loading; nonocclusive implant) | 21 | 13 | 6 |
| Group B (immediate loading; occlusive implant) | 21 | 14 | 5 |
| Group C (delayed loading) | 19 | 12 | 6 |
| Total | 61 | 39 | 17 |

absence of pain, no radiolucent zone around the implant, and absence of pathologic processes or suppuration. Implants that did not fulfill the success criteria were regarded as failures.

## Results

All implants could be adequately positioned according to prosthetic need, and no implants were excluded from the study because of a lack of primary stability. No patients dropped out. A total of 307 implants were placed, and 117 fixed partial dentures supported by 2 to 4 implants were fabricated (Table 1). Patients healed with minor discomfort; no surgical complications were reported. However, during the provisional phase, some prosthetic complications occurred. The provisional prosthesis fractured in 1 patient (group B) and became loose in another (group A); in both cases, the prosthesis was repaired immediately.

Overall, the implant cumulative survival rate after 2 years of function was 100% in groups A and C. In group B, 7 implants failed, resulting in a cumulative survival rate of 93.26%. One patient lost 1 implant in a three-unit restoration, 4 patients lost 1 implant in two-unit restorations, and 1 patient lost 2 implants in a two-unit restoration. All failed implants were lost between the third and seventh weeks (Table 2). Upon examination, the implants were mobile, caused pain, and showed peri-implant radiolucency; thus, they were removed. The failed implants were successfully replaced with another implant after 4 months of healing. All replacement implants were treated with the delayed loading protocol.

RFA showed an average ISQ of 75.5 ± 4.2 at placement and 72.9 ± 2.3 after 4 months (Table 3). There were no statistically significant differences between groups A, B, and C. For all groups, the RFA revealed an initial decrease in the mean ISQ.

**Table 2** Characteristics of failed implants

| Implant no. | Site* | Length (mm) | Insertion torque (Ncm) | ISQ | No. of units | Time after surgery and provisionalization (wk) |
|---|---|---|---|---|---|---|
| 1† | 45 | 10 | 35 | 84 | 2 | 5 |
| 2† | 46 | 10 | 35 | 82 | 2 | 5 |
| 3 | 35 | 11.5 | 40 | 69 | 3 | 4 |
| 4 | 36 | 10 | 40 | 80 | 2 | 5 |
| 5 | 45 | 11.5 | 35 | 67 | 2 | 4 |
| 6 | 36 | 11.5 | 40 | 77 | 2 | 7 |
| 7 | 47 | 10 | 35 | 77 | 2 | 5 |

*FDI tooth-numbering system.
†Implants lost in same patient.

**Table 3** Mean insertion torque and ISQ values at baseline and 4 months

| | Insertion torque (Ncm) | ISQ at baseline | ISQ at 4 mo |
|---|---|---|---|
| Group A (immediate loading; nonocclusive implant) | 38.5 ± 3.1 | 74.3 ± 4.1 | 72.1 ± 2.6 |
| Group B (immediate loading; occlusive implant) | 37.8 ± 3.2 | 75.8 ± 4.1 | 73.2 ± 2.2 |
| Group C (delayed loading) | 37.7 ± 3.2 | 76.4 ± 4.4 | 73.6 ± 2.0 |

The results from the radiographic evaluation of the marginal bone levels and the change over time are reported in Table 4. The mean bone crest loss was 1.2 mm after 2 years, with no statistically significant differences between groups. No statistical differences were observed for implant length, mesial or distal bone levels, or the insertion torque values measured in the three groups.

## Discussion

This prospective study allowed the establishment of immediate loading protocols. The results showed that a 93.26% success rate was achieved in group B and a 100% success rate in groups A and C. All implants placed met the criteria for immediate loading: an ISQ greater than 60 and an insertion torque greater than 30 Ncm. Seven implants placed with immediate loading and in occlusion failed. The authors found no significant differences in the levels of initial stability between the lost and sustained implants. Implant failure could not be correlated with primary stability beyond a certain level. This underlines the negative impact of occlusion on the immediate loading procedure in partially edentulous patients. Most of the lost implants (85.7%) were two-unit prostheses. In contrast, a study

**Table 4 Mean marginal bone loss (mm)**

| | 6 mo | 12 mo | 18 mo | 24 mo |
|---|---|---|---|---|
| Group A (immediate loading; nonocclusive implant) | −0.78 ± 0.31 | −0.96 ± 0.29 | −1.11 ± 0.30 | −1.27 ± 0.30 |
| Group B (immediate loading; occlusive implant) | −0.75 ± 0.30 | −0.95 ± 0.31 | −1.11 ± 0.30 | −1.28 ± 0.28 |
| Group C (delayed loading) | −0.79 ± 0.26 | −0.98 ± 0.27 | −1.15 ± 0.28 | −1.33 ± 0.25 |

from Cornelini et al[22] showed high success rates (97.5%) with three-unit fixed partial dentures placed with the immediate occlusal loading protocol. This suggests that the number of units in a prosthesis may positively impact implant stability during bone healing. The prosthesis works as an external rigid fixation device that splints the implants together and therefore reduces micromotion. It has been confirmed that controlling micromotion was the key to achieving osseointegration for immediately loaded implants.

A mean marginal bone remodeling of 1.2 mm was observed during the first 2 years of loading. This is consistent with long-term data on implants placed with the delayed loading protocol.[29] The setting of the definitive abutment on the day of surgery and the use of platform switching[30] allowed crestal bone loss to be minimized.[31] The results confirm those from several studies on nonocclusal immediate loading in partially edentulous patients[23,32,33] and on immediately loaded implants that supported single crowns for single-tooth replacements.[34,35]

Immediate provisionalization protocols offer several advantages to both the clinician and patient, including fewer appointments, less healing time, no removable provisional dentures during healing, and, above all, immediate treatment for an oral handicap. This study showed that occlusal loading (even slight occlusion) in an immediate loading protocol significantly reduced the implant survival rate. Partially edentulous patients have primarily esthetic concerns. Therefore, the preferred immediate loading should ensure the total absence of occlusion to guarantee a success rate close to that observed with delayed loading.

## Conclusion

Within the limitations of this study, it was found that immediate nonocclusal loading of dental implants in the partially dentate mandible results in predictable outcomes comparable to those of delayed loading. However, to regard this as a standard protocol, more randomized controlled studies are required on the application of immediate implant loading in partially edentulous patients.

## Acknowledgment

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