Immediate Loading of Two Unsplinted Implants in Edentulous Patients with Mandibular Overdentures: A 10-year Retrospective Review of Patients from a Previously Conducted 1-year Cohort Study

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Purpose: This 10-year retrospective study aimed to report implant bone changes in completely edentulous patients after a mandibular immediate loading protocol using two ball attachments. Materials and Methods: This study was initially designed as a prospective 1-year cohort study, then extended with a 10-year retrospective evaluation of implant bone change. In the first part of the study, 43 edentulous patients wearing satisfactory maxillary and mandibular dentures for at least 3 months were included. Two interforaminal implants (Bränemark system, Nobel Biocare) were placed symmetrically in the anterior mandible using a surgical template and a torque greater than 40 Ncm. Immediately following surgery, 2.25-mm-diameter ball abutments were screwed to the implants, and their matrices (Dalbo Plus, Cendres et Métaux) were incorporated in the denture base. In an initial 1-year study, clinical recalls were scheduled 3, 6, and 12 months after implant placement with a team of two investigators. The follow-up consisted of a clinical examination and a standardized radiographic assessment of the vertical bone change. Implant stability was then monitored. The patient satisfaction was evaluated with a questionnaire before and 3 months after loading. The second part of the study occurred 10 years after the inclusion, as patients were recalled for an implant bone change monitoring. Results: The included patients were 28 to 80 years of age (mean: 61 ± 11.4 years). Three out of 86 implants failed during the healing phase (survival rate of 96.5% [90.1%, 99.2%]). Implant stability was maintained all along the 1-year follow-up (Δ = 73.33, 95% CI [72.39 to 74.26], P = .032). The mean radiographic bone loss was 0.27 ± 0.35 mm at 3 months after surgery, 0.47 ± 0.42 mm after 1 year, and 0.95 ± 0.98 mm after 10 years. General visual analog scale satisfaction was increased by 25 units with the treatment. No patients were lost to follow-up at 1 year, but five were lost at 10 years. Conclusion: This protocol of immediate loading of two unsplinted mandibular implants in overdenture patients using ball attachments is a clinically viable treatment with a high implant success rate and improved satisfaction.

Keywords: ball abutment, immediate loading, implant overdenture, implant success, unsplinted implants

The two-implant mandibular overdenture has been proposed as the first-line treatment for edentulous patients since the McGill consensus.1 This easy, economic, and reliable treatment consisted of loading the implants with the complete denture at approximately 3 months after implant placement.2 Patient satisfaction and oral health–related quality of life are improved over conventional complete dentures, with the benefits of improving confidence and eating function.3,4 The use of bar or ball attachment resulted in similar patient satisfaction rates5 and levels of bone loss.6

Immediate loading has been proposed for a faster increase in patients' quality of life and reduction in the number of surgical and prosthetic visits, by anchoring the complete denture within 24 hours of implant placement.7 The immediate loading of two bar-splinted implants in edentulous patients with mandibular overdentures was shown to be reliable up to 5 years.8-11
While numerous studies have explored the short-term (< 1 year) success rate of two unsplinted implants with ball abutments under immediate overdenture loading, long-term outcomes are less documented. Most short-term studies have revealed encouraging implant survival rates (93% to 100%) and acceptable radiographic bone level changes (RBLC ≤ 1 mm) on patient cohorts whose size ranged from 8 to 42. However, one study involving 19 patients showed an implant survival rate around only 81% after a year. Furthermore, additional short-term studies reported many “major prosthetic complications” such as denture fracture. In a 3-year prospective cohort study of 18 patients, Elsyad et al (2012) found that while the results were overall satisfactory, the vertical RBLC was significantly more important than with conventional loading. In addition to investigating implants restored with ball abutments, a 3-year study of eight patients with implants restored with locator abutments reported a high rate of denture fracture. Thus, long-term studies on immediate loading of two unsplinted implants are missing for validating the success of this protocol.

The objective of this 10-year retrospective study was to report implant bone changes in completely edentulous patients after a mandibular immediate loading protocol using two ball attachments. The initial prospective 1-year multicentric cohort study assessed clinically and radiographically the protocol as well as patients’ satisfaction. Then, the extended 10-year examination assessed retrospectively the RBLCs.

**MATERIALS AND METHODS**

**Patient Selection**

The initial 1-year trial received approval from the French Ethics Committee for the Protection of Persons on April 23, 2002. The protocol was registered with the Agence Nationale pour la Sécurité du Medicament et des Produits de Santé (November 12, 2002) (ANSM, French National Agency for Medicines and Health Products Safety). Patient selection for this multicentric cohort study occurred during a 30-month period in the four dental clinics (Assistance Publique – Hôpitaux de Paris, AP-HP, France) affiliated with the Dental Faculty of Paris Descartes University, and in one private practice. All participants gave a signed informed consent. Screening of participants was performed by four experienced prosthodontists (C.R.B., C.W., A.N.). Forty-three completely edentulous patients were recruited consecutively over 18 months by offering to improve the stability of their existing mandibular complete dentures with implants.

The complete denture was duplicated into a resin radiographic guide containing barium sulfate, as previously described. Briefly, parallel pits of 2-mm diameter were drilled into the guide to mark the lateral incisor, canine, and first premolar positions. To ensure the correct setting of the radiographic guide during the computed tomography (CT) scan exam, the occlusion was recorded with cold curing resin. During scanning, the patient was asked to bite down on the radiographic guide. The analysis of the CT scan allowed for choosing the best implant sites, and confirming/modifying the implant axis for combining prosthetic and anatomical requirements. Then, the radiographic guide was turned into a surgical guide. The surgical guide was used to ensure the implant parallelism, which guaranteed long-term integrity of the ball attachments. Pits were drilled according to the desired position and orientation of the implants with a 3-mm twist drill. Steel tubes with an internal diameter of 2.1 mm (external diameter of 2.8 mm) were then incorporated as drilling guides. Prophylactic antibiotics (2 g of amoxicillin 1 hour before surgery) and mouthrinse with a 0.12% chlorhexidine gluconate (15 minutes before surgery) were administered to all patients. Two crestal incisions with mesio-buccal extension were made to raise small full mucoperiosteal flaps. The surgical guide was then used to facilitate the drilling and ensure symmetrical and parallel implant placement. Two implants (Mk III, TiUnite, Brånemark system, Nobel Biocare) ranging from 10 to 15 mm in length were placed symmetrically in the anterior mandible. In order to obtain an initial stability sufficient for immediate loading, the implant sites were slightly underprepared at the apex. Implants were set with a final torque of

Inclusion criteria for this study included sufficient bone volume in the anterior mandible to receive implants at least 10 mm in length, sufficient interarch space, good hygiene, and daily wear of the complete denture for at least 3 months. The quality of the mandibular complete dentures was quantified in terms of denture stability, border extension, occlusion (bilateral balanced occlusion), and mucosal status. Only complete dentures with a quality score of at least 50 according to Sato et al’s evaluation were included. Exclusion criteria included systemic diseases that could compromise implant surgery (severe kidney, liver, or blood disorders; uncontrolled diabetes; and history of chemotherapy or radiation therapy), Class IV bone quality (Lekholm and Zarb’s classification), and smoking more than 10 cigarettes a day.
at least 40 Ncm. If the insertion torque of 40 Ncm could not be achieved, the procedure was to exclude the patient from the study. However, all implants reached at least the required torque. Resonance frequency analysis (RFA) was performed on the implant level using an L-shaped transducer that confirmed an implant stability quotient (ISQ) superior to 65 units (Osstell, Integration Diagnostics).26

Immediate Loading Procedure
At the end of the surgery, 2.25-mm-diameter ball abutments (Nobel Biocare) were screwed on the implants and torqued to 20 Ncm. The height of the abutments was chosen during the surgery to exceed the mucosa thickness. The mucoperiosteal flaps were adapted around them using interrupted sutures. The fitting surface of the denture directly above the implants was hollowed out. Then, the mandibular denture was transformed into an implant-retained overdenture by the incorporation of Dalbo-Plus caps (Cendres et Métaux). A direct cap fitting procedure with self-curing acrylic resin (Selecta Plus, Dentsply) was performed when possible (Figs 1a to 1e). Specific spacing devices in Teflon were placed on the ball abutments to block the undercuts, to simplify the setting of the Dalbo-Plus matrices, and to keep the matrices parallel to each other in the prosthesis when captured with self-curing resin. However, when excess saliva or blood compromised a direct procedure, a laboratory procedure was preferred. In this case, closed-mouth relining impressions with a polyether impression material (Impregum, 3M ESPE) were made to incorporate the caps into the dentures, and the implant-retained overdentures were delivered in less than 12 hours. The retention was minimal the first week (2 N) and then adjusted with a specific screwdriver (up to 6 to 9 N). All patients were advised to maintain a soft diet and to rinse their mouth with 0.12% chlorhexidine gluconate (3 times a day) for 2 weeks. Then, oral hygiene recommendations were to clean the attachments with a single tufted brush and the dentures with Marseille soap (hard soap made from vegetable oils) every day and with a 15-minute decontamination every week in a 0.12% chlorhexidine gluconate solution.

Outcome and Follow-up
Implant stability was measured immediately after surgery, and at 3, 6, and 12 months with resonance frequency analysis (RFA; Osstell, Integration Diagnostics) at the implant level with the ball abutments removed. The measurements were expressed in ISQ (ranging from 0 to 100).

Intraoral radiographs were performed after surgery and used to measure the RBLC at 3, 12, and 120 months using a standardized technique with a modified bite block27 (Figs 2a and 2b). To periodically obtain identical intraoral radiographs, a special designed film holder was constructed. Briefly, a Dalbo-Plus matrix was stuck to a bite-block X-ray holder (Dentsply, Rinn) and attached to the retentive anchor during imaging.
procedures. Thus, the distance between the implant shoulder and the most coronal bone-to-implant contact was measured at the mesial and distal aspects of each implant. The known distance between two threads of the implant (0.6 mm) was used for calibration of measurement. This procedure allows an accuracy of 0.15 mm for bone loss measurement. Two calibrated examiners (C.R.B., A.N., C.W.) performed the measurements separately using a magnifying lens (×10). The bone level at surgery was defined as baseline. Mesial and distal bone height measurements were made at 3, 12, and 120 months. Peri-implant RBLCs were then calculated for each implant during the following recall.

Although the 10-year recall was not part of the original approved protocol, the success criteria were absence of mobility and less than 1 mm of RBLC at the end of the first year and less than 3 mm at 10 years. When RBLC was higher than that, implant stability was the survival criterion, and implant removal was considered as failure. Implant failure was characterized by implant mobility and radiographic bony craters. The treatment consisted of placing a new implant 6 months after the failed implant removal. The new implant was loaded 3 months later and was not considered for analysis. In the meantime, the remaining implant would likely have to face an extra loading as a single implant. However, this was considered as an acceptable risk factor. Thus, only 83 implants were analyzed in this study after 3 months, but all of the patients completed the 1-year analysis.

Patient satisfaction was assessed with a 10-item questionnaire and a 100-mm visual analog scale (VAS) to determine the benefits of the implant-retained overdenture over the conventional complete denture (Full Denture Satisfaction Index). The questionnaire was submitted the day of the patient inclusion and 3 months after implant placement. General satisfaction; ability to clean the denture, to speak, and to chew; comfort; esthetics; and feelings were evaluated with scores ranging from 1 (very dissatisfied) to 10 (very satisfied).

At the end of the initial study, after 1 year, all patients were advised to consult once a year their usual practitioner or the dentist who followed them for the study. No further investigation was initially scheduled.

**Ten-year Recall for Radiographic Bone Loss Evaluation**
Recalls were scheduled only the first year after implant placement (1-year prospective study), but patients were not summoned back for checkups after 12 months up to 10 years. Spontaneous visits were suggested at a yearly frequency. Patients could benefit from follow-up and maintenance at their convenience with the team or local dentists during the decade. Then, 10 years after implantation, all patients were contacted for a radiographic evaluation of the implant bone loss (with the original bite block). This 90-month extension of the study was not part of the initial protocol.

**Statistical Analysis**
The statistical unit of the study was the individual implant. The initial sample size of the study was computed to reach a ± 10% precision of the estimates. Measures were repeated over time at surgery, 3 months, 12 months, and 120 months. All descriptive statistics were provided with 95% confidence interval. Paired-statistical tests were performed to assess the significance of pairwise comparison over time. A linear model with repeated measures was used if relevant. In order to narrow the evaluation of equivalence over time, a bioequivalence two one-sided test (TOST) with specified symmetric deltas was used. All P values were provided two-sided and uncorrected.

All analyses were conducted using Stata/SE 13.1 (StataCorp).
RESULTS

The immediate loading procedure applied to 43 edentulous patients with a median age of 64 (p25 = 55.5, p75 = 68.5; 28 to 80 years; mean: 61), and equally balanced sex ratio of 19 women and 24 men (P = .54). The mean denture quality score of included patients was 86.44 ± 11.22 (median: 86; p25 = 81, p75 = 96). Three patients lost one implant during the healing period (implant survival of 96.5%), despite ISQ values above 65 on the surgery day. For these patients, the remaining implant was still considered for analysis in this study (Table 1).

All patients were available during the initial 1-year follow-up. Then, at 10 years, five patients were lost to follow-up (four deaths and one moved from the area). These lost patients represented a loss of only eight supplemental implants because two of the lost patients (deaths) were the ones who lost their first implant during the 3-month healing phase.

The distribution of the 86 implants in bone sites is summarized in Table 2. The mean implant length and diameter were 12 ± 1 mm and 3.86 ± 0.12 mm, respectively. The distribution of prosthetic parameters retrieved during the procedure is summarized in Table 3.

Radiographic Outcome

The mean RBLC was 0.27 ± 0.36 mm at 3 months after surgery (0 to 0.12; 0.29 ± 0.39 in mesial and 0.24 ± 0.38 in distal), 0.47 ± 0.42 mm after 1 year (0 to 1.4; 0.53 ± 0.47 in mesial and 0.40 ± 0.45 in distal), and 0.95 ± 0.98 mm after 10 years (0 to 4; 0.98 ± 0.98 in mesial and 0.91 ± 1.06 in distal) (Fig 3). At 10 years, mesial and distal RBLC were not significantly different (P = .2287).

Implant Stability

The overall primary stability was maintained over the first year after the immediate loading. The ISQ values were measured on surgery day, and then at 3 months, 6 months, and 1 year (Fig 4). Bioequivalence testing demonstrated that the stability over 1 year of the implant was within ± 2 ISQ units (P = .006 [paired equivalence student TOST, P < 1.e-4; P = .006]).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Category</th>
<th>Distribution n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone quality (Lekholm and Zarb’s classification²⁵)</td>
<td>A</td>
<td>8 (9%)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>28 (32%)</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>40 (47%)</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>10 (12%)</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Implant sites</td>
<td>Central incisor</td>
<td>4 (5%)</td>
</tr>
<tr>
<td></td>
<td>Lateral incisor</td>
<td>20 (23%)</td>
</tr>
<tr>
<td></td>
<td>Canine</td>
<td>39 (45%)</td>
</tr>
<tr>
<td></td>
<td>First premolar</td>
<td>23 (27%)</td>
</tr>
<tr>
<td>Implant length</td>
<td>10 mm</td>
<td>6 (7%)</td>
</tr>
<tr>
<td></td>
<td>11.5 mm</td>
<td>49 (57%)</td>
</tr>
<tr>
<td></td>
<td>13 mm</td>
<td>29 (34%)</td>
</tr>
<tr>
<td></td>
<td>15 mm</td>
<td>2 (2%)</td>
</tr>
</tbody>
</table>

*Exclusion criteria.
Bone quality was determined by examining the mandible shape on scanner sections (ranging from A to E according to Lekholm and Zarb’s classification²⁵). Bone quality was determined based on both the radiographic assessment, and the sensation of resistance experienced by the surgeon when preparing the implant site (according to Lekholm and Zarb’s classification²⁵). Type I = homogeneous cortical bone; Type II = thick cortical bone with marrow cavity; Type III = thin cortical bone with dense trabecular bone of good strength; Type IV = very thin cortical bone with low-density trabecular bone of poor strength. Most of the patients had identical implants on both sites.

Patient Satisfaction

To evaluate patient satisfaction, VAS scores were compared before implant placement and 3 months after placement. General VAS satisfaction increased by 25.17,33 with the treatment (item 1 in Table 4). All items except for cleaning difficulties showed a statistically significant improvement with the implant placement. Interestingly, the heterogeneity of patients’ satisfaction was reduced in almost all items (Sd ratio test < 1, P < .0001).
DISCUSSION

The purpose of this retrospective multicentric cohort study was to evaluate the implant bone changes of an immediate loading protocol with implant-retained mandibular overdentures using two ball attachments over 10 years. The outcomes showed that immediate loading protocol was a viable treatment that improved oral health–related quality of life. A satisfying implant success, an improvement of patients’ satisfaction, and an acceptable bone loss around implants were reported over the first year. Instead of waiting for the implant healing period with unstable dentures, patients would immediately benefit from a better oral function from this immediate loading protocol. The bone loss results after 10 years confirmed the long-term success of the technique.

The first finding was a high implant survival rate of 96.5% after 1 year. Achieving osseointegration thus validated this immediate loading protocol. This value is also comparable to most previous short-term studies on immediate loading protocol with unsplinted implants.12,13,15–19 None of the retrieved parameters in the study allowed the detection of a common risk factor for the three lost implants (for example, there was no statistical correlation between the failed implants and the implant primary stability; data not shown). Consistent with other reports, the lost implants failed 4 to 6 weeks after surgery, which can be associated with the transition from mechanical retention to biologic integration during the healing phase.15,19 However, in the Ormianer et al (2006) study, the single implant failure was reported at the 12-month follow-up control despite multiple intermediate controls.12 Another study, involving 19 patients, exhibited an implant survival rate around only 81% after a year14. When compared with the protocol described here, a possible explanation for their poor success rate can be an excessive initial retention between cap and ball on the immediate loading week. Indeed, as the prevention of implant movements is important to allow osseointegration and implant survival, the retention was ensured to be minimal the first week (2 N) and then adjusted (up to 6 to 9 N). Moreover, Dalbo Plus cap resilience allowed masticatory stresses that could have affected implant osseointegration to dissipate effectively.

The implant survival rate at 10 years was comparable to implant survival rates of long-term studies (≥ 10 years) on conventional loading.33–36 Implant success was previously defined as a mean RBLC measuring less than 1.5 mm the first year of function, and 0.2 mm annually thereafter.37 According to this definition, 100% of the implants in this study were successful after 1 year and 93% after 10 years (Fig 3). Of the five

![Fig 3](image_url) **Fig 3** RBLC (in mm) at 12 and 120 months for the 86 implants. Implant success baseline was previously defined around 1.5 mm the first year of function, and 3.3 mm at 10 years.37

![Fig 4](image_url) **Fig 4** Resonance frequency analysis (RFA) measurements over time. The mean value was stable during the first year. Bioequivalence testing demonstrated that the stability over 1 year of the implant is within ±2 ISQ units (P = .006 [paired equivalence student TOST, P < 1.e–4; P = .006]).
“unsuccessful” implants at 10 years, a pair belonged to one patient.

These results confirm that implant failure in immediate loading protocols occurs early after loading. The 1-year observation period is sufficient to validate that immediate loading of implants does not hinder bone healing. At the time the study was planned, RFA was commonly used. Through indirect measurement of implant stability, ISQ values were considered predictive indications of osseointegration quality. The ISQ evolution described for the first year of the study reflects the usual mechanical anchorage achieved at implant placement and the transition period during which biologic integration progressively replaces it. After 1 year, RFA is not a pertinent tool anymore since osseointegration and bone remodeling are obtained. Beyond this delay, osseointegration loss may occur, and a standardized radiograph is a low-invasive effective assessment. Also, Schimmel et al report that ISQ values are used mainly as a prognosis factor to indicate immediate loading. Furthermore, repeated removals of all attachments may affect peri-implant tissues.

The second finding was the mean marginal bone level change after 10 years was 0.95 ± 0.98 mm, which was comparable to the RBLC reported in the conventional loading studies. The mean marginal bone level change after 1 year was 0.47 ± 0.42 mm. This value was comparable with conventional loading studies and was consistent with previous reports on immediate loading. Furthermore, the implants exhibiting the highest radiographic bone loss after the first year also showed the highest bone loss at 10 years. Recently, Elsyad et al (2012) compared two groups of 18 patients treated either with immediate or conventional loading during 3 years. Using high-resolution multislice computed tomography, they reported a significantly increased—but acceptable—vertical bone loss at implant distal and labial sites in the immediate loading group. The difference between the proximal values, if existing, is lower than 0.25 (TOST P = .0024).

As described earlier in the Materials and Methods section, the three lost implants were replaced 9 months after removal. Interestingly, the bone levels around the three remaining single implants were not statistically affected by their solitude. Moreover, although radiographic bone changes could have been related to the bone quality (Lekholm and Zarb’s classification), no statistical evidence was found. One of the protocol criteria was to place symmetrically the implants with a 40-Ncm torque. For this reason, the surgeons selected radiographically the densest symmetrical sites, which sometimes occurred to be very anterior. However, RBLCs were more significant in patients exhibiting a thin ridge. In these patients, RBLC increased continuously over time and often exceeded 2.8-mm depth. The use of small-diameter implants might be advised in these thin ridge situations for preserving bone cortical thickness.

### Table 4 Patient Satisfaction for the Mandibular Denture Before and After Implant Placement

<table>
<thead>
<tr>
<th>Questions</th>
<th>VAS score before implant placement</th>
<th>VAS score 3 months after implant placement</th>
<th>P value</th>
<th>Variance ratio test</th>
</tr>
</thead>
<tbody>
<tr>
<td>General satisfaction: Are you generally satisfied with your mandibular denture?</td>
<td>65.56 ± 4.01</td>
<td>92.14 ± 7.63</td>
<td>&lt; .0001</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Cleaning difficulties: Is it difficult to clean your mandibular denture?</td>
<td>89.63 ± 11.64</td>
<td>85.88 ± 20.18</td>
<td>.3231</td>
<td>.7973</td>
</tr>
<tr>
<td>Speaking abilities: Does your mandibular denture affect your speaking abilities?</td>
<td>81.40 ± 20.45</td>
<td>93.88 ± 7.88</td>
<td>&lt; .0001</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Comfort: Does your mandibular denture feel comfortable?</td>
<td>70.56 ± 23.38</td>
<td>91.40 ± 9.42</td>
<td>&lt; .0001</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Esthetics: Are you satisfied with the general appearance of your mandibular denture?</td>
<td>85.44 ± 19.9</td>
<td>92.05 ± 10.31</td>
<td>.0213</td>
<td>.0708</td>
</tr>
<tr>
<td>Stability: Are you satisfied with the stability of your mandibular denture?</td>
<td>49.33 ± 30.99</td>
<td>91.02 ± 11.20</td>
<td>&lt; .0001</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Chewing abilities: Does your mandibular denture generally make it difficult to eat?</td>
<td>52.86 ± 26.08</td>
<td>88.31 ± 11.12</td>
<td>&lt; .0001</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Function: Is food generally suitably chewed before swallowing?</td>
<td>54.56 ± 23.71</td>
<td>83.31 ± 16.17</td>
<td>&lt; .0001</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Oral condition: Are you generally satisfied with your oral condition?</td>
<td>72.23 ± 21.98</td>
<td>90.69 ± 11.37</td>
<td>&lt; .0001</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td>Perception: Do you generally consider your denture as a foreign body?</td>
<td>43.19 ± 33.78</td>
<td>22.33 ± 27.03</td>
<td>.0009</td>
<td>.0006</td>
</tr>
</tbody>
</table>

VAS scores showed a significant improvement of patient satisfaction 3 months after implant placement. However, denture remained difficult to clean.
This 10-year follow-up study confirmed the feasibility of immediate loading protocols on unsplinted implants. The quality of the complete dentures may have played a significant role in these good results. Indeed, denture biomechanical parameters (retention, sustentation, and stability) were assessed prior to their inclusion in the study, and only dentures with a good score were considered to be transformed into implant-retained overdentures.

Implant length is associated with good initial stability and large bone-to-implant contact surface. In this study, the implant length was not a statistically significant parameter for success rate (loss of two 11.5-mm and one 10-mm implants). In the previously referred studies, implant length was detailed but never related to implant success. The reported implant length ranged from 8.5 to 16 mm. Many authors mentioned in their protocol a required minimum length (8.5 mm, 11.5 mm, 15 mm), a unique length (13 mm, 12 mm, 17), and the majority implant length (11.5 mm, 13 mm, 15 mm). Bi- cortical anchorage was also mentioned as a protocol requirement for initial bone stability. The survival rate of short implants still needs to be studied in future research on immediate loading.

A psychometric VAS test was used for assessment of patient satisfaction, as this simple method is easy for the patient to understand. The interpretation of VAS should be used cautiously in patient age range 28 to 80 years, especially when patients are allocated by offering better stability of their dentures. Before implant treatment, the satisfaction level was higher than in previous comparable studies. This difference was probably due to the initial complete denture selection, as only patients with satisfactory dentures were included. As expected, 3 months after implant loading, all items, except hygiene, improved. Indeed, hygiene is notably more complicated in overdentures, as the implant neck and ball abutment need to be plaque-free. Later in the follow-up, the patients were not asked to fill out anymore questionnaires, as previous studies showed a satisfaction stability over the years. After the first 3- or 6-month period, no difference in the satisfaction scores was awaited in comparison with the conventional protocol. Thus, satisfaction was not explored thereafter. Finally, this study design did not allow a comparison of conventional and immediate loading protocols, but showed that oral health-related quality of life could be improved as soon as implant placement.

To the authors’ knowledge, this study on immediate loading was the only one assessing the complete denture quality before patient inclusion and may explain a part of this success. A satisfying stable denture may undergo limited movements and lead to more predictable loads along the implant axis. The other interesting particularity of this study was the absence of patient recall between years 1 and 10. Indeed, some study protocols require so many recalls (with advice and adjustments) that the outcomes do not mimic real life and cannot be generalized in private practice worldwide. Even relines were not scheduled after healing, because the authors’ experience in these minimal invasive procedures showed that the needed amount of relining material is negligible after healing. The inconvenience was that all the information about the prosthetic maintenance relied on the patient’s understanding and memory. For this reason, no results were presented about the prosthetic outcomes over the 10 years.

The mean limitation of this cohort study was not having a control group with randomization of the treatment by immediate or conventional loading. However, this study had a larger sample size and longer follow-up period compared with the other trials published on this subject.

Another limitation is that this protocol relies on the operator expertise, as many prosthetic and surgical parameters may influence the outcomes. Obtaining denture quality, a sufficient implant primary stability, and evaluating the need for an indirect solidarization are, among others, critical parameters. In other studies on immediate loading of two implants with implant-retained overdentures, the denture quality was not assessed. Denture quality was a key factor of the present study protocol to favorably distribute the functional efforts between the prosthetic support surface and the implants, on which less stress was placed. This was the rationale for focusing on denture quality assessment before implant treatment.

Finally, primary stability has been reported to be critical for an immediate loading protocol. The behavior of RFA values over time gives information on the quality of osseointegration of an individual implant. As in most investigations, an initial high insertion torque (≥ 35 Ncm) was established before engaging the implant for the immediate loading protocol. This criterion might limit the immediate loading possibility in some cases.

**CONCLUSIONS**

This retrospective study confirmed that immediate loading of two unsplinted mandibular implants in an overdenture using ball attachments was a clinically viable treatment with an acceptable bone loss over 10 years. The assessment of the complete denture quality before patient inclusion may explain a part of this success.
ACKNOWLEDGMENTS

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