Immediate versus early non-occlusal loading of dental implants placed flapless in partially edentulous patients. One-year results from a randomised controlled clinical trial

Key words  dental implants, early loading, immediate loading, non-occlusal loading, partial edentulism

Aims: To compare immediate versus early (6 weeks) non-occlusal loading of dental implants placed flapless in partially edentulous patients 1 year after loading.

Materials and methods: Sixty patients were randomised: 30 to the immediately loaded group and 30 to the early loaded group. In order to be immediately loaded, implants were inserted with a minimum torque of ≥40Ncm. Implants were fully occlusally loaded after 6 months. Outcome measures were prosthesis and implant failures, and biological and biomechanical complications.

Results: Five implants in five patients randomised to the immediately loaded group did not reach the required primary implant stability. Three of these implants (two prostheses) were not immediately loaded. Two patients who were randomised to the early loaded group were immediately loaded erroneously. Implants in five patients of the early loaded group were conventionally loaded. No patient dropped out and there were no failures. Two complications occurred in the early and one in the immediately loaded group (no statistically significant difference), but were solved.

Conclusions: The use of a flapless technique for placing dental implants in conjunction with non-occlusal immediate or early loading in selected patients can provide excellent clinical results. No differences were observed when comparing implants that were loaded immediately or early. Therefore, when a high primary implant stability is obtained, it might be preferable to load the implants immediately rather than waiting for a few weeks.

Introduction

Patients are more satisfied if they receive a fixed implant-supported prosthesis the same day of implant placement as this means minimal surgical intervention and discomfort, shorter treatment time and lower costs, if the risk of implant failure is not excessively increased1,2. Traditionally, osseointegrated dental implants were submerged and kept load-free for 3 to 4 months in mandibles and 6 to 8 months in maxillae, to minimise the risks of implant failures3. Patients were required to wait for a significant length of time, often wearing suboptimal temporary restorations. It would be beneficial to reduce the healing period without jeopardising implant success. It is, therefore, important to evaluate whether or not good clinical results can be obtained when placing implants with a flapless proce-


dure the same day or within 1 week after implant placement. At implant placement, a mucoperiosteal flap is elevated to better visualise the bone at the insertion sites, ensuring that anatomical landmarks, such as the mental foramina, are clearly identified and protected. A flap facilitates implant placement, maximising bony contact and minimising the risk of bone fenestrations when residual alveolar bone is scarce. However, flap elevation is associated with increased post-operative pain, oedema and discomfort and requires suturing. There are situations where flap elevation may not be necessary because the amount of bone available is adequate for receiving dental implants with a minimal risk of complications. Under these circumstances, implant placement without flap elevation may be indicated. When placing dental implants with a flapless procedure, the operator is basically working blindly and bone fenestrations and/or dehiscence are more likely to occur.

The aim of this randomised controlled clinical trial was to compare implants placed with a flapless procedure and restored immediately (test group), with implants that were loaded early (control group), all restorations being non-occlusally loaded for 6 months in partially edentulous patients. Immediate non-occlusal loading was defined as placement within 72 hours of implant placement of a provisional prosthesis that would not be in occlusal contact for about 6 months (when the impressions for the final restorations will be taken). Early non-occlusal loading was defined as loading of the implants after a 6-week healing period. The null hypothesis was that there would be no difference in prosthesis and implant success rates or complications between the two procedures, against the alternative hypothesis of a difference.

This article is reported according to the CONSORT statement for improving the quality of reports of parallel-group randomised trials and presents data up to 1 year after loading. An article presenting the data of the first 20 patients has been published previously.

Materials and methods

Any partially dentate patient requiring dental implants who was 18 or older and able to sign an informed consent form was eligible for inclusion in this trial. Participants were informed of the nature of the study and signed an informed consent form. For patients with multiple edentulous areas to be restored, the operator was free at the screening visit to select one area to be included in the trial. The implant site should allow the placement of at least one 9.5mm long implant. The bone thickness at the implant site had to be at least 5.5mm. Bone anatomy was determined by means of calipers or palpation. When the clinical inspection was not able to clarify the bone thickness, bone anatomy was assessed on computerised tomography (CT) scans. Data on smoking cigarettes was included and patients were grouped into one of the following three groups:

Fig 1a The maxillary central right incisor needed replacing.
The approximal sides of the tooth are ground to facilitate lateral movements with forceps, so as to minimise the risk of damaging the buccal plate. A fistula can be observed in the keratinised mucosa of the buccal aspect.

Fig 1b Peri-apical radiograph showing root resorption and radiolucency of the tooth apex.

The tooth is extracted.

Fig 1e A palatal free soft tissue graft was used to seal the extraction site.

Anterior view of the site prior to implantation 9 weeks after extraction, the fistula is no longer present and the soft tissues healed nicely.

Fig 1f
Fig 1g Occlusal view of the healed soft tissues at the extraction site.

Fig 1h The implant was placed according to a flapless technique, and was then randomised to the early loading group. A healing abutment was placed.

Fig 1i Frontal view of the implant just after its placement.

Fig 1j The local infection was treated, the abutment was replaced by a longer one and the fistula disappeared. The provisional crown was regularly delivered, but 3 months after implant placement, the fistula reappeared. It was treated and, once the acute phase was resolved, bone augmentation with Bio-Oss and a resorbable barrier was performed to regain the lost buccal bone for aesthetic reasons.

Fig 1k Three weeks after implant placement the buccal peri-implant was swollen and a new fistula was present. The periapical radiograph shows that the healing abutment was not properly seated.
Fig 1l Occlusal picture showing the fistula and the new abutment.

Fig 1m A zirconia abutment was placed 8 months after implant placement. The area healed properly.

Fig 1n Pictures showing healthy peri-implant soft tissues around tooth 11, 1 year (top left) and 2.5 years (top right) after implant placement. There was no recurrence of the fistula. Peri-apical radiographs made at insertion of the zirconia abutment (bottom left) and 2.5 years after implant placement (bottom right). No significant bone change levels were apparent.
Patients were recruited in a single private dental clinic in Rimini, Italy, with extensive experience in immediate loading procedures. All patients were followed at the treatment centre. One experienced surgeon performed all the operations (MM), whereas patients were restored by four (including AM, FB, MM) restorative dentists.

Partially edentulous patients requiring dental implants were randomised to receive implants non-occlusally loaded immediately (test group) or loaded early (control group).

Patients rinsed with chlorhexidine mouthwash 0.2% for 1 minute before the intervention. All patients received prophylactic antibiotic therapy: amoxicillin, 1 or 2 g based on the patient’s weight, 1 hour prior to the intervention. Patients who were allergic to penicillin were given claritromycin 500 mg 1 hour prior to the intervention.

All patients were sedated about 1 hour prior to the intervention with benzodiazepines (5 to 15 mg of dipotassium clorazepate in capsules [Transene, Sanofi-Synthelabo, Paris, France] and 15 to 30 drops of diazepam 2% [Vaplinax, Sirto Pharmaeuticals, Como, Italy]). Some patients inhaled a mixture of 20% nitrous oxide and 80% oxygen for the entire duration of the intervention. Local anaesthesia was obtained using articain with adrenaline 1:100,000 (Ultracain, D-S forte, Aventis Pharma Deutschland, Frankfurt, Germany).

Teeth extractions were performed asatraumatically as possible to preserve the buccal alveolar bone, using perirotomes and small levers (Figs 1a to 1g). Extraction sockets were carefully cleaned of any granulation tissue. Implants were inserted in the desired location following indications provided by surgical templates, with hollow titanium cylinders guiding implant placement in the ideal position for the prosthetic rehabilitation.
A circular incision was carried out in the mucosa using a motor-driven mucosa punch, and the soft tissue was removed. Drills with increasing diameters (VECTOdrl™ Ø 2, Ø 2.8, Ø 3.5, Ø 4.3 mm and SPI® CONTACT profile Ø 3.5 mm; Thommen Medical, Waldeburg, Switzerland) were used to prepare the implant site as suggested by the manufacturer.

Threaded cylindrical titanium implants (SPI® ELEMENT, Thommen Medical) with a sand-blasted acid-etched surface were used (Fig 2). The operator was free to choose the platform diameters (Ø 3.5, Ø 4.5 or Ø 5 mm) and length (≥9.5 mm) according to his preference. In some of the post-extraction sites, SPI® CONTACT cylindrical/conical implants were used (Fig 3).

Bone density at drilling was subjectively evaluated and the bone at the implant site was classified as I (hard) to IV (very soft) according to the Lekholm and Zarb classification. Resistance to implant insertion was objectively recorded with a motor. In soft bone, under-preparation was performed using a shaping drill one size smaller than the final implant diameter or by not preparing the site for its full length. In general, implants were placed at crestal level in healed edentulous ridges, and 1 mm sub-crestally in immediate post-extraction sockets. When a residual gap was present between the implant surface and the bone wall, the gap was filled with Bio-Oss 0.25 to 1 mm granules. No other type of bone-grafting material was used. Maxillary implants were engaged bicortically, whenever possible. A non-submerged technique was used (Figs 1h and 1i).

Before placing the abutments, the envelope containing the randomisation code was opened, informing the surgeon as to whether or not the procedure would involve immediate or early loading. Impression copings or healing abutments (Figs 1h and 1i) were placed accordingly.

Patients were given ice packs and a soft diet was recommended. Smokers were requested to avoid smoking for 48 hours post-operatively. Granular ibuprofen 600 mg was prescribed, but patients were instructed not to take analgesics in absence of pain. Chlorhexidine mouthwash 0.2% was prescribed for 1 minute twice a day for 2 weeks and patients were instructed to avoid brushing and trauma at the implant area for at least 1 week.

An impression with the pick-up impression copings was made for the implants to be immediately loaded using a polyether material (Impregum™ 3M ESPE, Germany) and an open transparent resin impression tray (Set Dental, Italy). The vertical dimension was registered with a wax plate (Dental Wax, Moyco Technologies, USA) or using resin (MultiTray, 3M ESPE) stops and Temp-Bond® (Kerr Corporation, California, USA).

Models were made with class 4 precision plaster and mounted in a standard value articulator. A screw-retained provisional restoration was manufactured using acrylic resin (Ivocron, Ivoclar Vivident, Liechtenstein) and was fixed on the analogue with a temporary cylinder and a titanium screw. The occlusal surface of the provisional restoration was ground to avoid any occlusal contact with the opposite dentition whenever possible in static and dynamic analysis, using an 80 μm thick butterfly. Intraoral radiographs and clinical pictures of the study implants were made. All provisional restorations of the immediately loaded group were placed within 72 hours.

Impressions were taken about 6 weeks after implant placement for patients in the early loaded group. They received non-occlusally loaded provisional restorations identical to those of the immediately loaded group (Fig 4). Intraoral radiographs and clinical pictures of the study implants were made.

Approximately 6 months after implant placement, provisional restorations were removed, individual implants were manually tested to check stability, final impressions were made and the final full occluding metal-porcelain restorations were...
produced and cemented on customised gold, titanium or zirconia abutments (Fig 1m). Intraoral radiographs (Fig 1n) and clinical pictures of the study implants were made.

All patients were seen 1, 2 and 4 weeks after surgery and were recalled every 3 months for oral hygiene maintenance and prosthetic controls up to the first year after implant placement.

Outcome measures evaluated in the present study were:

• Prosthesis failure: the planned prosthesis could not be placed or was lost because of implant failures.

• Implant failure: the presence of any mobility of the individual implant (assessed manually by tightening the abutment screws) and/or any infection dictating implant removal at insertion of the provisional or final prostheses.

• Any biological or prosthetic complications. Examples of possible biological complications include: numbness of the lower lip and chin, peri-implant mucositis (heavily inflamed soft tissue without bone loss), peri-implantitis (bone loss with suppuration or heavily inflamed tissues), and fistulas (Figs 1j to 1k). Examples of possible prosthetic complications included fracture of the implant, abutment screw, framework and occlusal material.

These outcome measures were assessed by an independent assessor (FB), who was not blinded to the interventions. Marginal bone level changes on intraoral radiographs made with the paralleling technique will be assessed by a blinded assessor and reported together with the 3-year follow-up data.

A sample size calculation on the number of patients likely to have at least one implant failure was performed. From a recent study[^10] on partially edentulous patients, the proportion of failures in the immediately loaded group was 0.39 compared with 0.04 in the conventionally loaded group. A two-group continuity-corrected chi-square test with a 0.050 two-sided significance level will have 80% power to detect the difference between a proportion of 0.39 and a proportion of 0.04 (odds ratio of 0.065) when the sample size in each group is of 26 patients. It was planned to include 30 patients in each group to compensate for possible drop-outs.

In this article the outcome up until the first year of loading is reported.

A manually generated restricted randomisation list was used to create two groups with equal numbers of patients. Only one of the investigators, not involved in the selection and treatment of the patients, was aware of the randomisation sequence and had access to the randomisation list, which was stored in a password-protected portable computer. The randomised codes were enclosed in sequentially numbered, identical, opaque, sealed envelopes. Envelopes were opened sequentially only after the implants to be included in the trial were inserted, therefore, treatment allocation was concealed to the investigator in charge of enrolling and treating the patients included in the trial.

All data analyses were to be carried out according to a pre-established analysis plan. The patient was the statistical unit of the analyses. A biostatistician with expertise in dentistry analysed the data, without knowing group allocation. Differences in the proportion of failures and other complications between the groups were compared using Fisher’s exact probability test. All statistical comparisons were conducted at the 0.05 level of significance.

**Results**

All patients eligible for this trial agreed to participate. However, one patient could not be enrolled, because at implant placement a horizontal augmentation procedure was required due to an unexpected lack of bone reformation after the extraction of an endodontically compromised mandibular first molar. The patient refused to have preoperative diagnostic radiographs fearing negative effects of radiation. Sixty patients were consecutively enrolled in the trial and randomised: 30 to the immediately loaded group and 30 to the early loaded group. No patients dropped out, and the data of all patients was used for the statistical analyses (Fig 5).

Deviations from the operative protocol were the following: one SPI ELEMENT platform diameter 4.5mm implant placed in soft bone of a patient in the early loaded group was unstable at insertion and was replaced with a SPI CONTACT platform diameter 5mm with the predecessor surface (as SPI CONTACT platform diameter 5mm with the cur-
rent SPI surface was out of stock in the practice). In two patients of both groups, four SPI CONTACT (Table 2) implants were used instead of the SPI ELEMENT, as agreed at protocol level. One single implant from each group was put in direct occlusion after delivery of the provisional restoration. Nine implants in nine patients did not obtain the planned primary stability (Fig 5). Four implants were in the early loaded group. Three implants (in three patients) out of five implants that did not achieve the planned primary stability of the immediately loaded group were not loaded immediately. One implant with a primary stability <20Ncm was loaded 7 weeks after placement. Another implant with a primary stability of 30Ncm was loaded after 8 months (for this specific implant, which was inserted in an immediate post-extractive site, a pedicle advanced palatal flap was used to better seal the mucosa around the healing abutment in position 24; Fig 6). The last implant (the most distal of three placed in position 16) achieved a maximum primary stability of 30Ncm and was left unloaded, whereas implants in position 14 and 15 were immediately loaded. The implant in position 16 was
loaded after 6 months, when the final restoration was placed. The remaining two implants (inserted with 30 and 35Ncm torque) were immediately loaded. Two implants in two patients of the early loaded group were immediately loaded erroneously. Five patients of the early loaded group had their implants conventionally loaded. Thirteen non-occluding temporary prostheses (15 implants) were
not replaced by occlusally loaded final prostheses after 6 months for various reasons. Of these, five prostheses were loaded immediately and eight loaded early. At the 1-year follow-up six implants (six patients) were still wearing provisional prostheses (four in the early and two in the immediately loaded group).

Patients were recruited and operated on from July 2005 to July 2007. The follow-up focused on the time between implant placement and 1 year after loading. The main baseline patient characteristics are presented in Table 1. Thirty-five implants were placed in the immediately loaded group and 34 in the early loaded group. The lengths and diameters of the inserted implants are presented in Table 2, whereas the bone density, subjectively evaluated, and the maximum insertion torque (primary implant stability) appear in Table 3. There were no apparent significant baseline imbalances between the two groups.

No patient dropped out or was excluded from the trial, and all patients were followed up to 1 year after loading. No prosthesis or implant failed.

Two complications occurred in the early and one in the immediately loaded group in three different patients. In the early loaded group, in one case the abutment screw fractured when delivering the final prosthesis and it took about 40 minutes to fix. In another patient a fistula developed 21 days after implantation (Figs 1k and 1l). When an intraoral
radiograph was taken, it was observed that the healing abutment was not properly seated (Fig 1j). The area was carefully debrided, the abutment was removed, the head of the implant was repeatedly flushed with chlorhexidine, the abutment was replaced with a longer one, and systemic antibiotics were administered to the patient for 10 days. The provisional crown was regularly applied 6 weeks after insertion in accordance with the protocol. After 3 months, the fistula reappeared and was treated with systemic antibiotics (Bassado, doxycycline, 100mg, 2 per day for 10 days) and rinsed with chlorhexidine. Once the acute phase was resolved, 4 months post-insertion, a flap was raised and horizontal guided bone regeneration was performed with the application of Bio-Oss 0.25 to 1mm granules and a resorbable membrane (Bio-Gide, Geistlich Biomaterials). The complication was completely resolved after this intervention (Fig 1n).

In the immediately loaded group 1 month after loading, the screw connecting the provisional crown became loose and was retightened. There were no statistically significant differences for complications between the two procedures (Fisher’s exact test $P=1.0$; difference in proportions = -0.033; 95% confidence intervals -0.182 to 0.108).

Discussion

This study showed that it is possible, after careful patient selection, to achieve excellent clinical results by placing single/multiple implants in partially edentulous cases according to a flapless procedure, thus reducing post-operative patient discomfort[6], and to load them immediately or early, thus reducing treatment time and costs. Not a single implant failed, and only three complications occurred. Two complications were of biomechanical type and were easily solved. The most relevant of these was the fracture of a connecting screw, which took about 40 minutes to be fixed. The only biological complication was a buccal fistula probably originally induced by an improper seating of the healing abutment, possibly favoured by the presence of bony peaks, which did not allow the proper seating of the abutment. At the time, the bone profiler (a specific instrument to allow the removal of bone peaks, particularly during a flapless procedure) was non-existent. The gap between the healing abutment and the implant allowed bacterial proliferation, and two treatment sessions were required to solve this complication. The patient with this problem was selected as an example to show the clinical procedures used in the present investigation (Figs 1a to 1n). This complication did not reoccur or compromise the final aesthetic results.

The main limitation of the present study was the subversion of randomisation, which occurred in five different patients. Three patients randomised to the immediately loaded group had one implant loaded early. This was actually a situation that was predicted at protocol level and the surgeon had some degree of flexibility on how to proceed with the loading of the implant. In fact, the prerequisite for immediate loading was implant placement with a torque exceeding 40Nm. When this was not achieved, the surgeon was allowed to use an implant of larger diameter, to prepare an alternative site if available, or to load the implant early or immediately. The protocol was designed this way to minimise any possible risk for the patients. Such precaution is normally taken in clinical routine, as it has been shown that immediate loading of implants inserted with low torques (<20Ncm) can induce failure rates as high as 90%[10]. Two implants in two patients randomised to the early loaded group were immediately loaded erroneously. Five patients in the early loaded group were actually treated according to a conventional loading protocol, because patients delayed the treatment due to work commitments (1 patient), health problems (1 patient), economic reasons (1 patient), and due to the therapy planning (2 patients). Despite all these deviations from the research protocol, the authors believe that the results were not significantly affected.

A larger number of patients would have been preferable. However, 60 patients treated in a single centre are a considerable number and this number has been matched only by another trial testing the same hypothesis[1]. Although the results of this study are excellent and suggest that the investigated procedures have relevant clinical advantages over conventional procedures for the benefit of the patient, they add no useful information to answer the tested primary hypothesis, as no negative
events (failures) occurred. If there is no significant difference in failures between immediately and early loaded implants, as suggested by a recent meta-analysis\textsuperscript{11}, an immediate loading procedure could be preferable when implants are inserted with a sufficient torque.

It has been suggested that the use of a non-occluding temporary prosthesis during the first 2 months of healing might decrease the risk of early failures of immediately loaded implants\textsuperscript{12}. Other RCTs\textsuperscript{13,14} testing the same hypothesis in a similar population of partially edentulous patients also used non-occlusally loaded restorations, whereas prostheses were occlusally loaded in two other trials\textsuperscript{1,2} that included only fully edentulous patients. The only RCT testing whether or not non-occlusal restorations were able to decrease the risk of implant failure reported inconclusive evidence\textsuperscript{15}. Of the 24 patients included in each group, two patients lost their implants in the occlusally loaded group versus three patients in the non-occlusally loaded group. Therefore, it is unclear whether or not it is actually useful to avoid occlusal contacts of implant-supported immediately loaded provisional restorations. More evidence is needed before any evidence-based clinical recommendations can be given.

There are two recent RCTs comparing immediate and early loading for implants using the flapless-placed procedure\textsuperscript{1,2}. These trials included fully edentulous patients, either in the mandible\textsuperscript{2} or in the maxilla\textsuperscript{1}. No prostheses were lost, but a few failures occurred, with an increased tendency for implants to fail when loaded early. In fact the ratio was one immediately loaded failure to five early loaded failures. A possible explanation for the increased number of failures in the early loaded group could be the pressure of the dentures on the implants placed according to a one-stage procedure. Flaps had to be elevated in about 9 out of 60 patients\textsuperscript{2} and in 4 out of 30 patients\textsuperscript{1}, corresponding to 14% of the patients, whereas in the present study, no flaps were raised. A possible explanation for this difference is that the fully edentulous cases were more complex and received a higher number of implants, which increased the need to raise a flap.

Two RCTs evaluated immediate versus early non-occlusally loaded implants in partially eden-

tulous patients\textsuperscript{13,14}. The major difference with the present trial is that implants were placed after flap elevation. Five immediate and six early loaded implants failed. It can be concluded that immediate loading does not seem to result in a higher risk for failures than early loading, though more studies are necessary to have more precise data on this topic.

Another RCT\textsuperscript{17} showed increased failure rates (25\%) for single implants placed according to the flapless procedure and immediately loaded when compared with flapless-placed conventionally loaded implants (no failures) in the anterior maxilla. These data suggest that the combination of a flapless procedure with immediate loading increases the risks of failure, and that the ability and the experience of the operators in selecting the proper cases and in achieving high values of primary implant stability play a fundamental role in obtaining high success rates. Experienced operators and proper patient selection are the key to a successful outcome, as illustrated in studies using a flapless technique\textsuperscript{18} and immediate loading\textsuperscript{10}. Therefore, great caution should be exercised when extrapolating the results from this trial to other settings. Carefully selected patients with adequate bone width were treated after a thorough diagnostic analysis and with the help of surgical templates. The development of reliable, dedicated computer software to be used together with three-dimensional CT scans may allow more precise planning to predetermine the exact position of the implants\textsuperscript{19,20}. On the other hand, there is still a lack of evidence from RCTs, and this and other studies\textsuperscript{1,2,5,16} suggest that good clinical results can also be obtained without using computer-guided surgery.

**Conclusions**

The use of a flapless technique for placing dental implants, in conjunction with non-occlusal immediate or early loading in selected patients, can provide excellent clinical results. No differences were observed when comparing implants loaded immediately or early. Therefore, when high primary implant stability is obtained it might be preferable to load the implants immediately rather than waiting for a few weeks.
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