Original paper

Instantaneous dental implant loading technique by fixed dentures: A retrospective cohort study

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Abstract

Background. In the context of dental prostheses, splinting multiple implants together may improve their stability. The approach may be especially favorable when performing immediate loading procedures, increasing the implant osseointegration rate, and reducing the risk of implant and prosthetic failure. The instantaneous loading technique (ILT) involves creating a metal framework to splint the implants by intraorally welding them pair-by-pair, using purposefully created abutments.

Objectives. The aim of the study was to investigate the prosthetic success when using ILT to rehabilitate partially edentulous patients through immediately loaded prostheses.

Material and methods. Clinical records of patients treated with ILT were retrospectively assessed, and the prosthetic success rate was analyzed in terms of fractures, chipping, unscrewing, screw fracture rate, and mucositis. Furthermore, the implant success rates were evaluated by measuring marginal bone loss (MBL).

Results. A total of 55 patients (20 males and 35 females with a mean age of 59.8 ±9.4 years), corresponding to 66 prostheses, were included. A total of 160 implants were placed. At the last follow-up (39.6 ±28.4 months), 1 patient (1.8%; 1 prosthesis (1.5%)) showed the fracture of the prosthesis material. Peri-implantitis affected 4 implants (2.5%), and 4 more implants (2.5%) showed radiolucency, affecting 5 patients (9.1%). Two other patients (3.6%) suffered from mucositis. The implant success rate, according to the Albrektsson and Zarb criteria, was 94.4%. No implants were lost. The mean MBL values at the implant level, the prosthesis level and the patient level were 0.28 ±0.56 mm, 0.30 ±0.51 mm and 0.33 ±0.54 mm, respectively.

Conclusions. The instantaneous loading technique appears to be a viable approach to rehabilitating partially edentulous patients through immediate loading.

Keywords: jaw, edentulous, denture, dental prosthesis, implant-supported

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Introduction

Immediate loading refers to delivering the prosthesis and allowing masticatory load within 48 h of implant placement,[1] without waiting for osseointegration, as initially proposed by Brånemark.[2,3] The benefits of immediate loading include immediate functional rehabilitation, and reduced discomfort and morbidity. Under appropriate conditions, the implant and prosthetic success rates of immediate loading are not significantly different from those of the delayed approach.[3–5]

For immediate loading to be successful, fixtures, as in delayed loading, must not undergo micro-movements exceeding 100–150 μm. If this occurs, fibrous tissue may develop at the bone–implant interface, leading to implant failure.[3,6] Therefore, implants must show adequate primary and secondary stability. Several strategies have been proposed to improve implant stability and soft tissue healing around dental implants. For instance, photobiomodulation, a non-invasive, non-thermal therapy capable of stimulating cellular self-repair, has demonstrated encouraging results, especially during the early stages of healing.[7]

Along with implant stability, raising the awareness of the biochemical aspects of peri-implant tissue should be pursued. Indeed, a more severe pro-inflammatory state has recently been associated with peri-implant tissue as compared to periodontal tissue.[8–10] Greater inflammation seems to be due to prosthetic components per se and to their micro-movements, as well as to the presence of excessive cement in cement-retained implant restorations.[11–13]

As a further precaution, prostheses should be designed and connected to implants such that no residual tensions are transferred to the bone–implant interface,[3,14–16] which will also reduce complications, such as abutment fracturing, or screw breaking or loosening (in the case of screwed-on prostheses).[17,18] To this aim, splinting the abutments increases their mechanical stability and allows more accurate impressions.[19–22] Accordingly, some authors have proposed, especially for full-arch rehabilitation, to splint all abutments through a single titanium bar, which is initially modeled to fit the abutments, followed by welding.[20,21] However, modeling the bar is relatively complex, and fitting it to all abutments with no residual tension involves a painstaking trial and error procedure, as adjustments made to one position may create a residual tension elsewhere along the bar.[20]

To overcome these issues, we devised an approach consisting in splinting the adjacent abutments pair-by-pair. Splinting the abutments in pairs eliminates passive tensions, and the complete structure connecting all abutments displays no tension. This is achieved using special abutments (Wings®; T.A.B., Borso del Grappa, Italy) featuring lateral extensions (Fig. 1). The abutments are initially screwed to the implants and their extensions are welded intraorally to solidarize the two adjacent implants. The final metal framework acts as the internal reinforcement structure of the provisional prosthesis fabricated and delivered to the patient on the same day. We named this approach the instantaneous dental implant loading technique, abbreviated to the instantaneous loading technique (ILT), and have been using it for approx. 20 years.

Despite the long-term use of ILT, its clinical outcomes have never been thoroughly studied. Therefore, this study aimed to retrospectively investigate the medium-term frequency of prosthetic complications following the application of ILT to rehabilitate partially edentulous patients.

Material and methods

Clinical investigation

This clinical investigation involved the retrospective assessment of the clinical records of patients who presented with partial edentulism and were rehabilitated using ILT between March 2003 and August 2020 at an Italian private dental clinic in Noventa Vicentina. The Internal Ethics Commission of the clinic assessed and approved the study protocol. Given the retrospective nature of the study, the Commission did not deem it necessary to seek the approval of a third-party ethics committee. The patients' records were selected according to the following inclusion criteria: age between 18 and 85 years; rehabilitation with the use of ILT for partial edentulism; no previous bone graft or bone regeneration intervention; no previous peri-implant bone regeneration technique applied; the details of an immediate intraoral radiograph after implant insertion, taken with a Rinn centering device and a customized silicone bite; a follow-up of at least 6 months after implant placement; at least 1 intraoral radiograph carried out at the last follow-up visit, again with a Rinn centering device and a customized silicone bite; and evidence of informed consent for the use of their clinical data for future clinical investigations. The clinical records of the patients were discarded if any of the following exclusion criteria were met: suffering from osteoporosis or other bone diseases; undergoing bisphosphonate therapy; suffering from any psychiatric disorder or neoplasia; pregnancy; a history of chemotherapy or radiotherapy in the head or neck region at any time in the previous 2 years; immunocompromised; suffering from acute oral infections and/or coagulation disorders; a history of alcohol or drug abuse; smokers; and taking any drug known to interfere with the osseointegration process. The patients could have implants of any brand, but had to have received the provisional or final prosthesis made of the same materials, and manufactured by the same dental technician.

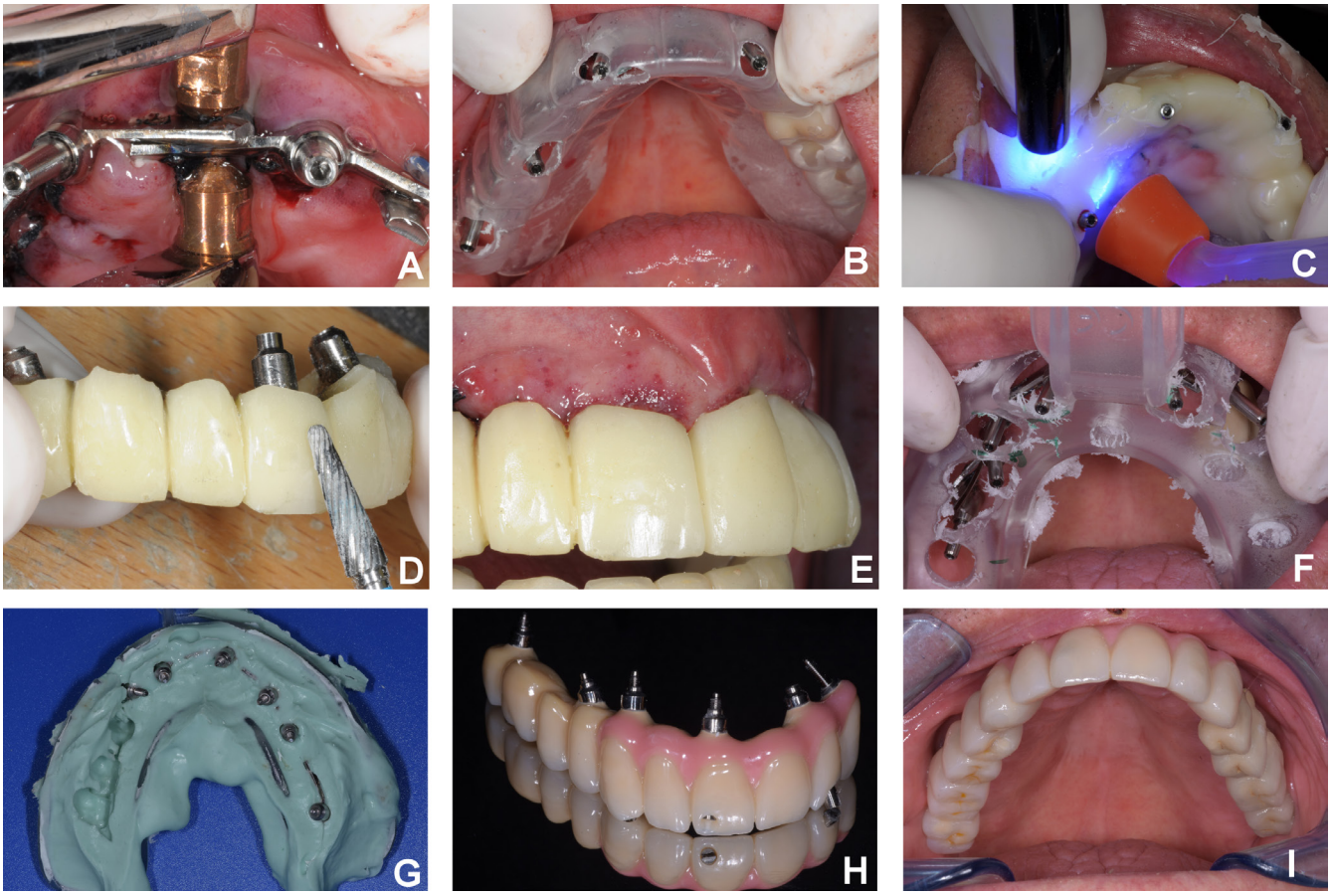

Fig. 1. Main steps of the instantaneous loading technique (ILT)

A – the extensions of the adjacent wing abutments are welded; B – a thermoplastic prosthetic template is positioned in the mouth and drilled correspondingly to the abutments; C – after filling the template with a photopolymerizing resin, the resin is photopolymerized to fabricate the provisional prosthesis; D – the provisional prosthesis is finished by the technician; E – the provisional prosthesis is delivered to the patient; F – to fabricate the final prosthesis, another wing structure is welded and an impression is taken with the use of a tray purposefully drilled correspondingly to the abutments; G – the metal framework is embedded in the impression; H – the impression is used to fabricate the final prosthesis; I – the final prosthesis is delivered to the patient.

All implants needed to have been placed using a personalized surgical guide based on the flapless technique, and the implant seat preparation had to have been carried out according to the manufacturer's protocol.

Surgical and implant placement protocol

After clinical examination and radiographic assessment based on intraoral radiographs and cone-beam computed tomography (CBCT), the diameters, lengths and positions of the implants were pre-planned on the CBCT scans, and a surgical guide was manufactured. Antibiotic prophylaxis (2 g amoxicillin/clavulanic acid (Augmentin); GlaxoSmithKline, Verona, Italy) was prescribed 1 h before surgery, and then every 12 h for 8–10 days. The patients were also advised to carry out mouth rinses with 0.2% chlorhexidine (Corsodyl; GlaxoSmithKline, London, UK) for up to 2 weeks after surgery. Naproxen (500 mg) (Synflex, Milano, Italy) was prescribed 2–4 times a day for 7 days after surgery for pain control.

The surgical area was anesthetized using articaine hydrochloride (40 mg/mL) with epinephrine (1:100,000) (Citocartin, Milan, Italy). With the aid of the guide, the implant placement positions were identified using a dermographic pen, commonly employed to mark the anatomical landmarks/positions of the human body. Access to the alveolar bone was achieved with a mucotome, and the implants were placed according to the manufacturer's instructions with the aid of the guide. The patient was then rehabilitated using ILT (see the following paragraph). Radiographic assessment with the use of intraoral radiographs was performed before surgery, at the provisional (immediately) and final (6 months later) prosthesis delivery, and at least every 12 months thereafter.

Instantaneous loading technique

The instantaneous loading technique involves fabricating the provisional or final prosthesis over a metal structure composed of several wing abutments welded to each

other to connect the adjacent implants (Fig. 1). Wing abutments are available in different lengths (1.7 mm, 2.7 mm and 4.5 mm). The abutments have different angles (flat, 30° or 45°) and all feature two 11.5-millimeter-wide lateral extensions (i.e., the 2 'wings') that can be cut to the desired length before welding. The abutments are connected to the implants with 20-millimeter-long pass-through screws. The extensions of the 2 adjacent wing abutments are overlapped, and then welded. The extensions are flat on the vestibular side and convex on the buccal side, which limits the contact surface between the 2 wings. Delivering a certain welding current increases electrical resistance, and the heat which develops at the contact point creates a strong and resistant weld. To deliver the provisional prosthesis, the technician fabricates a prosthetic template made of a thermoplastic material based on the diagnostic waxing from the alginate impression of the arch of interest. The template is then positioned on the welded wing abutment framework in the oral cavity and drilled correspondingly to the pass-through screws, using a diamond bur. The template is then filled with a photopolymerizing resin, with the screws protruding from the template, and the resin is photopolymerized. The prosthesis is then screwed to the metal structure. A new wing structure is created after 6 months as the armor of the final prosthesis. An alginate impression of the metal structure is obtained, with holes at the positions corresponding to the pass-through screws. The metal structure is then sent to the technician, who utilizes it to fabricate the final prosthesis using a composite resin. The prosthesis is then implanted by tightening the screws at 35 N·cm. The screw holes are filled with the same composite resin as used to manufacture the prosthesis. A representative case is shown in Fig. 2.

Objectives and endpoints

The primary objective of this study was to assess the prosthetic success of definitive rehabilitation delivered through ILT by evaluating prosthesis fractures, chipping, unscrewing, screw fractures, mucositis, and peri-implantitis. The secondary objective was to assess the implant success and survival when supporting the prostheses delivered through ILT by measuring marginal bone loss (MBL) and using the criteria of Buser et al.,[23] modified by Albrektsson and Zarb.[24,25] The criteria were as follows: the absence of persistent pain, dysesthesia or paresthesia in the implant area; the absence of peri-implant infection, with or without suppuration; the absence of perceptible implant mobility; and the absence of more than 1.5 mm of peri-implant bone resorption during the first year of loading or 0.2 mm of resorption per year during the following years. The implants were considered successful if they met all the conditions outlined above.

Measurement of marginal bone loss

For all the included records, the intraoral radiographs were digitally scanned, converted to 600 dpi resolution TIFF images, stored in a personal computer, and analyzed with the ImageJ software (National Institutes of Health, Bethesda, USA) to measure the peri-implant MBL. After loading each image, the software was calibrated using the known implant diameter at the most coronal portion of the implant neck. The distance from the implant–abutment interface to the most apical point of the crestal bone in intimate contact with the implant was then measured to the nearest 0.01 mm on both the mesial and distal sides. The 2 measurements were averaged to get a single peri-implant marginal bone level. Then, at the final follow-up visit, MBL for the particluar implant was calculated as the difference between the peri-implant bone level at that time point and that at baseline (at implant insertion).

The mean MBL was assessed at the implant level, the prosthesis level and the patient level. In the first case, the mean MBL was calculated by averaging all MBL values for all implants. At the prosthesis level, the mean MBL was calculated as the average of the MBL values for all the implants supporting the same prosthesis. At the patient level, the mean MBL for each patient was calculated by averaging the MBL values for all his/her implants.

Bias

Since the patients were treated by only one of the authors (S.D.), which represents a possible source of bias, clinical record selection and data extraction were carried out by the other 3 authors (M.M., A.G. and N.Z.). As a further strategy to address the potential sources of bias, an independent biostatistician performed all statistical analyses.

Statistical analysis

Since the study objective was to investigate the prosthetic success of ILT using descriptive statistics, no sample size calculation was performed. Therefore, the population size of the study corresponds to the number of records meeting the inclusion criteria.

The descriptive statistics of the patient's age and sex, the follow-up duration, and the complication rates were collated using the patient as the statistical unit of analysis. Further descriptive analyses, including the calculation of the complication rates, were carried out using the implants and the prostheses as the statistical analysis units. All statistical analyses employed the Origin 2021 software (Microcal Software Inc., Northhampton, USA). Statistical tests were regarded as significant at $p < 0.05$. The results were expressed as mean and standard deviation ($M \pm SD$) or as median and interquartile range (Me (IQR)) depending on whether their distribution was normal or non-normal, respectively, according to the Shapiro–Wilk test.

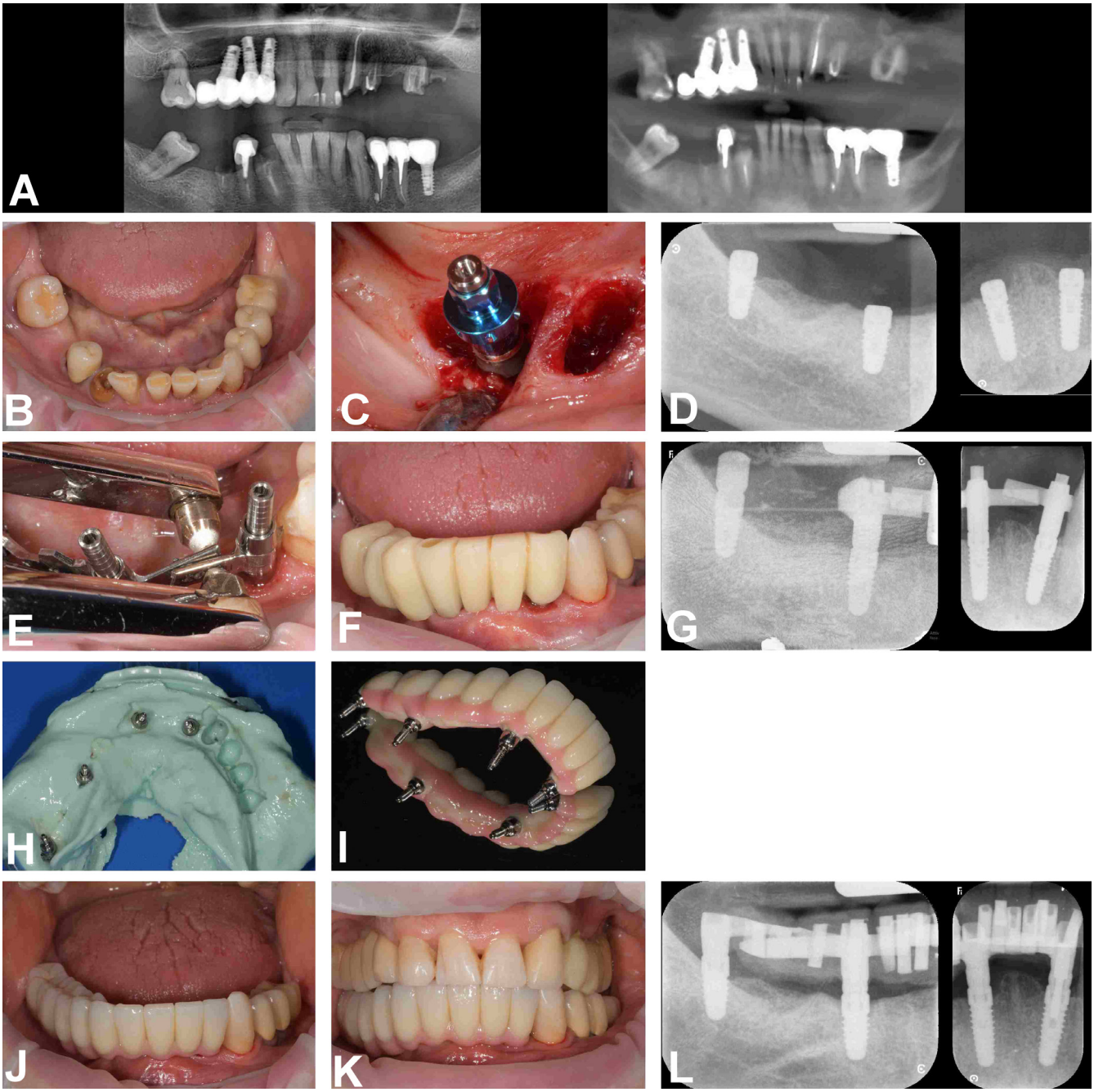

Fig. 2. Illustrative case, showing the application of the instantaneous loading technique (ILT) to fabricate a four-implant, nine-crown prosthesis

The patient at presentation was partially edentulous in the 4th quadrant (A,B); teeth 3.2, 3.1, 4.1, 4.2, 4.3, 4.4, 4.7, as well as the 4.5 residual root, were lost and extracted. Four implants were placed according to a flapless approach (C,D). After positioning the wing abutments, their extensions were welded (E) and an impression was taken, embedding the framework, and the provisional prosthesis was delivered to the patient (F,G). To fabricate the final prosthesis, a new wing framework was created 6 months later and an impression was taken (H), embedding the framework, which was used to fabricate the final prosthesis (I) to be delivered to the patient (J,K,L). The image panels show the intraoral radiographs taken at implant insertion (D), the provisional prosthesis delivery (G) and after 18 months of prosthetic rehabilitation (L).

Results

In all, 55 patients with clinical records that met the study criteria were included. These comprised 20 males and 35 females with a mean age at surgery of 59.8 ±9.4 years, ranging from 41 to 82 years. The patients were supplied with 160 implants and 66 prostheses. Forty-eight patients received 1 prosthesis, 4 received 2 prostheses, 2 received 3 prostheses, and 1 received 4 prostheses. The replaced elements, the number of implanted prostheses and the implant manufacturer are listed for each patient in Table 1. The distribution of prostheses in the arches is reported in Table 2. The prostheses replaced 2–9 lost elements (Table 3). Seventy-two (45.0%) and 88 (55.0%) implants were inserted in the maxilla and the mandible, respectively. While the implants differed in size

Table 1. For each patient, the replaced elements, the number of implanted prostheses and the implant manufacturer are reported

Patient	Replaced elements*	Number of implanted prostheses	Implant manufacturer
1	29, 30, 31	1	Biomax, Vicenza, Italy
2	30, 31	1	BTK, Dueville, Italy
3	30, 31	1	iRES®, Mendrisio, Switzerland
4	4, 2	1	BTK, Dueville, Italy
5	20, 31	1	BTK, Dueville, Italy
6	2, 4, 5	1	BTK, Dueville, Italy
7	28, 30	1	BTK, Dueville, Italy
8	2, 3, 10, 13, 15, 30, 31	3	BTK, Dueville, Italy
9	29, 31	1	Biomax, Vicenza, Italy
10	11, 13, 15	1	Biomax, Vicenza, Italy
11	12, 13, 14, 15	1	BTK, Dueville, Italy
12	28, 29, 31	1	iRES®, Mendrisio, Switzerland
13	17, 20	1	Biomax, Vicenza, Italy
14	2, 5	1	BTK, Dueville, Italy
15	3, 4	1	BTK, Dueville, Italy
16	18, 20	1	BTK, Dueville, Italy
17	29, 31	1	BTK, Dueville, Italy
18	30, 31	1	Biomax, Vicenza, Italy
19	12, 14, 15	1	BTK, Dueville, Italy
20	18, 20	1	BTK, Dueville, Italy
21	18, 19	1	BTK, Dueville, Italy
22	7, 10	1	JDentalCare, Modena, Italy
23	18, 19	1	Biotech Dental Italia, Salerno, Italy
24	29, 31	1	iRES®, Mendrisio, Switzerland
25	23, 26	1	JDentalCare, Modena, Italy
26	30, 31	1	iRES®, Mendrisio, Switzerland
27	18, 20	1	BTK, Dueville, Italy
28	2, 3, 4	1	BTK, Dueville, Italy
29	18, 19	1	BTK, Dueville, Italy
30	18, 19	1	BTK, Dueville, Italy
31	30, 31	1	BTK, Dueville, Italy
32	19, 21	1	BTK, Dueville, Italy
33	13, 14, 15	1	BTK, Dueville, Italy
34	12, 14, 15	1	BTK, Dueville, Italy
35	18, 19	1	BTK, Dueville, Italy
36	23, 26	1	BTK, Dueville, Italy
37	10, 12, 13, 15	1	Biomax, Vicenza, Italy
38	18, 19	1	iRES®, Mendrisio, Switzerland
39	18, 19, 21, 27, 29, 31	2	Biomax, Vicenza, Italy
40	30, 31	1	Biotech Dental Italia, Salerno, Italy
41	2, 4	1	Biomax, Vicenza, Italy
42	30, 31	1	BTK, Dueville, Italy
43	2, 3, 5, 7, 9, 11	1	BTK, Dueville, Italy
44	30, 31	1	BTK, Dueville, Italy
45	18, 20 ,30, 31	2	BTK, Dueville, Italy
46	2, 3, 5, 7, 8, 12, 13, 15	3	BTK, Dueville, Italy
47	13, 15	1	BTK, Dueville, Italy
48	18, 19	1	Biomax, Vicenza, Italy
49	1, 5, 6, 11, 12, 15, 18, 19, 28, 30, 31	4	BTK, Dueville, Italy
50	7, 6, 12, 13, 15	2	BTK, Dueville, Italy
51	18, 19, 20, 30, 31	2	BTK, Dueville, Italy
52	18, 19	1	BTK, Dueville, Italy
53	14, 15	1	BTK, Dueville, Italy
54	23, 25, 29, 31	1	BTK, Dueville, Italy
55	14, 15	1	BTK, Dueville, Italy

* American numbering system.

Table 2. Distribution of prostheses according to their position in the patients' mouth

Prosthesis position	Number of prostheses
Upper right	14
Upper central	1
Upper left	11
Lower right	21
Lower central	2
Lower left	17
Total	66

Table 3. Distribution of prostheses according to the number of elements they replaced

Number of elements replaced by the prosthesis	Number of prostheses
2	26
3	18
4	14
5	3
6	4
9	1
Total	66

(the diameters and lengths were 3.25, 3.50, 3.70, 3.75, 4.00 mm, and 8.5, 10.0, 10.5, 11.5, 12.0, 13.0, 15.0 mm, respectively), they were all tapered in shape and had a double-etched, sandblasted surface. The average follow-up time from implant insertion and loading (loading was immediate) was 39.6 ±28.4 months (range: 7–213 months; *Me* (*IQR*): 35 (26–50) months). A total of 178 intraoral radiographs were analyzed.

After implant placement, all patients healed uneventfully, with no reports of subjective complaints. Technical complications concerned 1 prosthesis (1.5%) and 1 patient (1.8%), in whom the composite material of a single prosthesis fractured. The prosthesis was replaced with a provisional one stored at the clinic and sent to the technician for repair. No prosthetic frames were fractured and no prostheses became unscrewed. Furthermore, neither the screws nor the implants were fractured. Peri-implantitis affected 2 patients (3.6%) and 4 implants (2.5%), with 2 implants per patient. Four implants (2.5%) in 3 patients (5.5%) (2 patients had 1 implant each, and the third patient had 2 implants) showed peri-implant radiolucency. Two patients (3.6%) suffered from mucositis.

Overall, 151 (94.4%) implants were successful, according to the Buser et al.[23] and modified Albrektsson and Zarb criteria.[24,25] At the last follow-up control, there were 9 implants (5.6%) that survived and no implant was lost.

At the implant level, the average marginal bone resorption at the last follow-up was 0.28 ±0.56 mm (range: 0.00–3.15 mm). Meanwhile, it was 0.30 ±0.51 mm (range: 0.00–2.74 mm) at the prosthesis level and 0.33 ±0.54 mm (range: 0.00–2.74 mm) at the patient level.

Discussion

Our results show that over a medium-term follow-up, ILT allows the successful rehabilitation of partially edentulous patients by delivering a provisional prosthesis that can be immediately loaded. The observed technical and biological complication rates are consistent with similar approaches involving splinting implants through a single bar.

In a study on 40 patients rehabilitated by immediately loaded provisional prostheses built over a continuous titanium bar welded intraorally, Degidi et al. in 2006 first reported a prosthesis success rate of 100% over 6 months after placement.[20] These results were similar to ours. Our results can also be compared to those reported by Albiero et al., who observed no mechanical or biological complications at a 1-year follow-up in 10 consecutive patients rehabilitated using 60 immediately loaded implants supporting fixed full-arch prostheses constructed over intraorally welded bars and placed through a computer-guided flapless procedure.[26] In 2015, Marchesi et al. achieved similar results over 26.5 months, after rehabilitating 17 consecutive patients with 2 parallel and 2 tilted implants in the maxilla, splinting their angulated abutments with an intraorally welded titanium bar.[27] Similar results were also reported by Degidi et al., who prospectively evaluated 40 patients with an edentulous mandible, using a fixed restoration supported by an intraorally welded titanium bar placed on the same day as the implants; they reported no evidence of framework fractures at a 24-month follow-up.[21] Meanwhile, Degidi et al. prospectively treated 20 patients with 4 interforaminal implants that were immediately loaded with a fixed restoration supported by an intraorally welded titanium framework, and observed no fractures or radiographically detectable alterations of the welded frameworks 24 months after surgery.[28] The same group also prospectively assessed 30 patients who received 3 axial and 4 tilted implants in the edentulous maxilla.[29] Immediately after implant placement, the definitive abutments were connected to the implants and a titanium bar was welded to them with an intraoral welding unit. This framework supported the definitive restoration. At 36 months, the authors observed no fractures or radiographically detectable alterations of the welded frameworks.[29] Degidi et al. prospectively treated 60 patients with fully edentulous arches with 324 immediately loaded implants and delivered fixed restorations supported by intraorally welded titanium bars.[30] At a 36-month follow-up, they recorded no fractures or radiographically detectable alterations of the welded frameworks.[30]

The MBL observed in our study cannot be directly compared with the values reported previously, given the different nature of the surgical and prosthetic protocols involved. Overall, the implant success rates and the mean MBL observed in the present study appear consistent with those generally noted in other immediate loading rehabilitation procedures.[31,32] Therefore, the current research supports the working hypothesis that the core of ILT, namely splinting the adjacent implants in pairs, promotes excellent passivation, and limits complications in the implants and the prostheses they support. The authors, based on their experience, found ILT easier and faster than any approach they had tried involving the welding of a single titanium bar to splint more implants together. The technique is also made easier by the different angles of extensions with which wing abutments are provided, which was particularly helpful and straightforward when creating a complete metal framework. These observations should be the subject of comparative studies assessing if the learning curve and the surgery time differ between the 2 techniques (wing abutments/a single bar) under homogenous conditions. To the best of our knowledge, and as outlined by other authors using similar approaches, the only contraindication for this technique that could increase the rate of prosthesis fractures seems to be bruxism.[33,34] Finally, delivering a prosthesis based on ILT involves less costs for the patient than other rehabilitation methods and may be an option for those who cannot afford more expensive treatment.

Limitations

A limitation of the present study was its retrospective design. Therefore, prospective studies should assess the performance and safety of the ILT approach. Such studies may reduce the possibility of confounding variables affecting the results and may enable the evaluation of specific covariates, other than the technique itself, that modulate the technical and biological complications and MBL when patients are rehabilitated via this approach. Moreover, future studies should use the same implants rather than various devices like in the present study. Comparative studies should assess whether ILT provides any advantage over other techniques involving the splinting of the adjacent implants by intraoral welding and the use of a framework to support an immediately loaded restoration. Patients should be followed up for a longer time to validate the present results.

Conclusions

Within the limitations of the present study, ILT seems a viable approach to rehabilitating partially edentulous patients through immediate loading. Whether ILT is easier, faster, and as safe and effective as other technical approaches involving the intraoral welding of a bar connecting all implants should be the subject of appropriately designed prospective, comparative clinical studies.

Ethics approval and consent to participate

The study protocol was assessed and approved by the Internal Ethics Commission of a private dental clinic in Noventa Vicentina, Italy. The patients had given their informed consent for the use of their clinical data for future clinical investigations (one of the inclusion criteria).

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

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