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# Computer-assisted implant surgery and immediate loading in edentulous ridges with dental fresh extraction sockets. Two years results of a prospective case series study

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**Abstract. – INTRODUCTION:** The two-stage surgical approach for implant placement first documented in 1977 by Brånemark, represents today the most used protocol for placing implants.

**AIM:** Aim of this prospective case series study was to compare the clinical and radiological performance of 12 edentulous jaws treated with of a modified prosthetic and surgical protocol for 3D software planning, guided surgery, immediate loading of implants inserted in edentulous jaws and extraction sockets and restored with Cad-Cam Zirconia and titanium full arch frameworks.

**MATERIALS AND METHODS:** This work was designed as a prospective case series study. Twelve patients have been consecutively rehabilitated with an immediately loaded implant supported fixed full prosthesis. A total of 72 implants, Nobel Replace Tapered Groovy; Nobel Biocare AB, Goteborg, Sweden) 26 of which were inserted in fresh extraction sockets, were inserted. Outcome measures were implants survival, radiographic marginal bone-levels and bone remodeling, soft tissue parameters and complications.

**RESULTS:** All patients reached 24 months follow-up, and no patients dropped out from the study. The cumulative survival rate was 100%; after 24 months mean marginal bone remodelling value was: 1.35±0.25, mean PPD value was 2.75±0.40 mm and mean BOP value was 3.8%±1.8%. Only minor prosthetic complications were recorded.

**CONCLUSIONS:** Within the limitations of this study our data seem to validate this surgical and prosthetic protocol with valid results when applied in selected cases.

*Key Words:*
Computer-assisted implantology, Dental implants, Immediate loading, Prosthodontic driven implantology.

## Introduction

The two-stage surgical approach for implant placement was first documented by Brånemark[1] in 1977 and today represents the most used protocol for placing implants. Comparable results to the classical two stages approach, have been reported with the one-stage surgical procedure and transmucosal healing of implants.

Other studies have reported successful dental implants following computer-guided surgery also using the All-on-Four and All-on-Six concepts (NobelGuide, Nobel Biocare)[4-6].

In 2002, the concept of software planning and surgically guided techniques combined with immediate loading was clinically introduced in Leuven, Belgium[7]. These early treatments were limited to the edentulous maxilla and required a full-thickness mucoperiosteal flap. Later, the procedure was refined to include flapless implant placement through virtual planning by producing a stereolithographic surgical template incorporating precision titanium drilling sleeves[8].

The growing interest in minimally invasive surgery, together with the possibility of fitting prostheses with immediate function, have led to the development of software and digital workflows allowing the planning and manufacturing of a surgical guide and provisional prosthesis (fabricated prior to surgery), that can be inserted immediately after the implant surgery step.

Moreover computer-aided implant surgery minimizes positioning error compared to manual or conventional-guided placement[7,9].

The growing need for patients to be rehabilitated with a fixed, implant-supported prosthesis immedi-

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ately after surgery and to avoid wearing temporary removable prostheses, have lead clinician and researchers to analyse implant insertion in fresh extraction sockets with immediate loading even in the chronically infected alveolar bone[10].

Based upon these assumptions, aim of this prospective case series study was to compare the clinical and radiological performance of 12 edentulous jaws treated with a modified prosthetic and surgical protocol for 3D software planning, guided surgery, immediate loading of implants inserted in edentulous jaws and extraction sockets and restored with Cad-Cam Zirconia and titanium full arch frameworks.

## Materials and Methods

### *Study Design*

This was a prospective case series study in which clinical and radiological data analysis was carried out on consecutively treated patients to be prosthetically restored with fixed full arches prosthesis. The investigation was conducted according to the principles embodied in the Helsinki Declaration of 1975 for biomedical research involving human subjects, as revised in 2004 and was approved. At the preliminary visit all patients were duly informed on the nature of the study.

### *Selection Criteria*

Patients of any race and gender were included in the study if they were at least 18 years old and in good general health, physically and psychologically able to undergo conventional implant surgery and restorative procedures (ASA-1, ASA-2).

Inclusion criteria were: patients with hopeless teeth in need to be restored with full arches prosthesis.

Exclusion criteria were: presence of systemic diseases (i.e. haematologic disease, uncontrolled diabetes, serious coagulopathies and diseases of the immune system); irradiation to the head or neck region within 12 months before surgery; presence severe bruxism or clenching habits; pregnancy; poor oral hygiene; poor motivation to return for scheduled follow-up visits. The included patients were treated by surgeons and prosthodontists with considerable clinical expertise in immediate loading procedures.

According to the above criteria a total of 12 patients underwent to the same procedure: computer guided flapless implant insertion and implants immediate loading with a screw-retained provisional prosthesis. One patient who was rehabilitated on the upper and lower jaw, was treated with this protocol only on the mandible, while the others were only treated on the upper jaw. A total of 72 implants, Nobel Replace Tapered Groovy; Nobel Biocare AB, Goteborg, Sweden) 26 of which were inserted in fresh extraction sockets, were inserted.

### *Clinical Procedures*

For all cases, the following prosthetic and surgical protocol was used. The patients were subjected to a clinical evaluation, and a medical history was taken. Informed consent was collected. Preliminary screenings, including intraoral and panoramic radiographs, were performed. Eligible patients received oral hygiene instructions, and impressions and baseline photographs of their dentition were taken. Aesthetic and functional evaluations were done and a facial bow was used to register upper maxilla position. In the laboratory, cast models were mounted in a semi adjustable articulator and it was confirmed that all patients needed implant supported cross-arch prosthesis restoration.

After the diagnostic phase, it was determined that, for all patients, the teeth would be removed and the implants would be inserted with a computer-assisted protocol that performed tooth extraction and immediate loading simultaneously.

From each impression, a wax setup was developed and a dental-supported provisional prosthesis was customized according to the aesthetic and functional evaluations. Only three or four long-term hopeless teeth were left in the oral cavity of each patient to support only for few months the provisional prosthesis while the other teeth were immediately extracted . In all cases, we waited for a minimum of 2 to a maximum of 6 months for alveolar bone healing and a radiological template was made according to the aesthetic and functional wax-setup. A silicone interocclusal record was also made as a radiographic index.

In accordance with the NobelGuide data acquisition protocol (Nobel Biocare, Gothenburg, Sweden), two CT scans were performed: one of the patient wearing the radiographic guide as well as the radiographic index, and the other of the template alone. CT scan data were transferred to the NobelGuide Procera® software program for 3D diagnostic analysis and virtual implant planning. Anatomical conditions had to allow the placement of at least six implants in the ideal po-

sition for prosthetic rehabilitation. When an implant was planned with the software, it was very easy to see the tooth to extract, as well as the vestibular and palatal cortical bones. After bone volume analysis, implants were planned on a palatal or lingual site and the implant platform position was programmed 2 mm under the coronal part of the vestibular alveolar crest. The software planning data were sent to the manufacturer (Nobel Biocare, Gothenburg Sweden), where a surgical template with hollow metallic sleeves was produced to guide the implants according to the positions identified with the planning software. Based on the surgical guide and the model obtained from Nobel Biocare, metal-acrylic resin screw-retained provisional prostheses were prefabricated.

The surgical procedure was performed under local anaesthesia with articaine chlorhydrate plus 1:100,000 adrenaline (Pierrel S.p.A, Milan, Italy). All patients were given diazepam (Valium, 10 mg, Roche, USA) as a sedative agent before surgery. Antibiotics (amoxicillin 875 mg and clavulanic acid 125 mg GlaxoSmithKline S.p.A., Verona, Italy) were given 1 h before surgery and twice a day for 6 days thereafter. An anti-inflammatory drug (ketoprofen 80 mg Dompe' S.p.A, Milan, Italy) was administered twice a day for 4 days postoperatively. An antacid agent (omeprazole 20 mg, Pensa Pharma S.p.A, Milan, Italy) was given on the day of surgery and once daily for 6 days postoperatively. Each patient rinsed with chlorhexidine gluconate (0.2%) for 1 min before the intervention (Curasept, Curaden Healthcare srl, Saronno, Varese, Italy). Surgical templates were placed intraorally in the right position and in relation to the opposing arch and then fixed with three or more anchor pins. Considerable care was taken when placing the surgical template due to the presence of the teeth. After correct placement and stabilisation of the surgical template, flapless implant surgery was performed in accordance with the drilling protocol for the type of implant used (NobelReplace Tapered Groovy, Nobel Biocare, Gothenburg, Sweden). Implants were inserted with a pre-set insertion torque of 35 to 45 Ncm. The implant length ranged from 8 to 13 mm and the implant diameter was 4.3 or 5 mm. In all fixtures installed in fresh extraction sockets, the space between the vestibular cortex and the implant surface was filled with bovine bone grafts (BiOSS Geistlich, Wolhusen, Swiss), and collagen or connective tissue was used to cover the graft and thicken the soft tissues.

All implants were immediately loaded with the prefabricated screw-retained provisional prosthesis. When needed, minor adjustments were made to correct occlusion. In all post-extraction sites, the profile of the prosthesis was recontoured with resin to provide better support for the soft tissues. Ice packs were provided and a soft diet was recommended for 1 month. All patients were included in an implant maintenance program. Smokers were asked to refrain from smoking for at least 48 h postoperatively. Chlorhexidine gluconate mouthwash (0.2%) was prescribed for 1 min twice a day for 2 weeks. The patients were instructed on oral hygiene, and they returned every 3 months for a maintenance appointment. To be deemed successful, implants were required to meet all of the following criteria: clinical stability, patient-reported functionality without any discomfort, and the absence of infection. After 6 months, the prostheses were removed and the implants were individually tested for stability. The definitive prosthetic restorations, either Procera Implant Bridge Titanium as the framework with composite resin as aesthetic material or Procera Implant Bridge Zirconia (Nobel Biocare, Gothenburg Sweden) with ceramic, were then used.

## The Following Outcome Measures were Used

### *Implant Survival*

The removal of implants was dictated by instability, progressive marginal bone loss, infection or implant fracture. The stability of individual implants was measured by the prosthodontist at the time of definitive bridge delivery (6-8 months after implant placement) by applying 35 Ncm of removal torque and after 12 and 24 months.

### *Complications*

All types of complications, either mechanical or biological were recorded.

### *Marginal Bone Remodelling*

Peri-implant marginal bone levels were evaluated on intraoral digital radiographs taken with the parallel technique at the time of implant placement, at 12, 24 months and after loading. If radiographs were inconclusive, they were repeated. A blinded radiologist, unaffiliated with the study centre, interpreted all radiographs. The distances from the mesial and distal interproximal bone to the reference point (the horizontal inter-

face between the implant and abutment) were measured with a image software measurement tool (NIH Scion Image Corporation 4.0.2, Frederik, Maryland, USA) calibrated against the space between two threads to the nearest 0.1 mm, and the mean of these two measurements was calculated for each implant. The measurements were recorded with reference to the implant axis.

The marginal bone remodelling was calculated as the difference between the reading at the examination and the baseline value. Mesial and distal bone height measurements were averaged for each implant. Mean values and standard deviation were recorded.

### *Peri-implant Mucosal Response*

Probing pocket depth (PPD) and bleeding on probing (BOP) were measured by a blinded operator with a periodontal probe (UNC 15) at 12 and 24 months after loading. Three vestibular and 3 lingual values were collected for every implant by the same dentist. Mean values and standard deviation were recorded.

## Results

Twelve consecutive patients, 8 females and 4 males, with a mean age of 57 (range, 40-68). No patient dropped out of the study and the follow-up was for all cases of at least 24 months after implant insertion. No deviations from the protocol occurred. Data were collected in sheets (Excel, Microsoft, Redmond, WA USA) at baseline, and 12, 24 months after implant loading. A total of 72 implants were placed (26 of them in fresh extraction sockets), with an insertion torque between 35-45 Ncm and were immediate loaded.

### *Implant Survival*

No implants failed accounting for a CSR of 100% after 24 months.

### *Prosthesis Success*

No prosthesis failures were recorded: all final prosthetic reconstructions were stable and in good function after 24 months.

### *Complications*

No major biological complications were recorded. Three patients had peri-implant mucosal inflammation with BOP around post-extraction implants after 3 months. Improved oral hygiene reduced the peri-implant inflammation.

No major mechanical complications occurred. One provisional acrylic bridges fractured 6 months after immediate loading and were repaired. Two resin titanium bridges experienced fracture of the acrylic resin after 10 and 12 months and were repaired by the dental technician.

### *Peri-implant Marginal Bone Remodelling.*

The average l marginal bone remodelling from baseline to last radiological control (24 months) . was: 1.35 ± 0.25 (Table I).

### *Peri-implant Mucosal Response.*

After 24 months mean PPD value was 2.75±0.40 mm, Mean BOP value was 3.8% ± 1.8% (Tables II, III).

## Discussion and Conclusions

During the last few years, studies have increasingly investigated the clinical and radiological outcome of guided implant placement, a good number of these studies seem to confirm the [illegible]th predictability of 3D planning software[11,1[illegible]] and have indicated that immediate loading of oral implants yield acceptable to excellent results in full-arch prosthetic restorations.

Our team has recently retrospectively investigated Nobel guide protocol in full edentulous maxillae with a follow-up of 18 months with a CSR of 97.8%[6] and published a pilot study on a modified protocol for implant installation in free-flaps[13,14]. High survival rate and marginal bone loss comparable with other procedures were reported and higher patient satisfaction in this challenging situation too.

A growing number of retrospective studies have also reported a high success rate for patients restored using the All-on-four and All-on-six treatment protocols combined with computer-guided flapless implant surgery[5,6,15]. The advantages of computer-assisted protocols include the minimally invasive approach (flapless surgery or

**Table I.** Peri-implant mean marginal bone remodelling.

| Mean marginal bone remodelling | |
|---|---|
| 12 months | 24 months |
| 1.17 ± 0.30 | 1.35 ± 0.25 |

Values represent mean ± SD.

**Table II.** Mean PPD values in mm.

| Mean PPD | | |
|---|---|---|
| 6 months | 12 months | 24 months |
| 3.1 ± 0.57 | 2.78 ± 0.65 | 2.75 ± 0.40 |

Values represent mean ± SD.

only a small access incision to preserve keratinized gingiva), which improves implant insertion by allowing it to be mapped and planning virtually before the actual surgery. It also allows clinicians to order a surgical template that helps guide the implants during the surgery, and makes it possible to fabricate a screw-retained provisional prosthesis before implant insertion.

The literature concerning implants inserted into fresh extraction sockets is mixed. Some studies affirm that implants cannot preserve the alveolar bone and that immediate implant insertion in dental sockets is an unpredictable treatment with many aesthetic problems due to unavoidable vestibular cortex resorption[16,17]. Other authors have reported a high implant success rate when fixtures are inserted immediately after teeth extraction[10,18]. Polizzi et al[19] developed a new, immediate post-extraction computer-assisted protocol using Procera software and a double radiological template; it seems to be useful but requires further clinical assessment[20].

We believe that clinicians should comply with patients' requests, and for this reason, we agree with some authors about the need to use minimally invasive techniques and to avoid when possible aesthetic or functional problems associated with the use of removable prosthesis after teeth extractions.

The literature concerning immediate implant insertion into dental sockets is conflicting due to the various implant insertion protocols. For example, Araujo et al[16] analysed implant insertion with an open flap technique using large implants and without grafting the space between the fixture and vestibular alveolar bone. This approach is likely to be accompanied by extensive vertical and width bone resorption caused by implant trauma and the unavoidable vestibular resorption caused by full-thickness flaps.

**Table III.** Mean BoP values in %.

| Mean BOP values | | |
|---|---|---|
| 6 months | 12 months | 24 months |
| 6.3.± 2% | 5.8 ± 3.5% | 3.8% ± 1.8% |

Values represent mean ± SD.

Therefore, complete teeth removal and immediate implant insertion into fresh sockets could have a high implant success rate, but could also cause many aesthetic and prosthetic problems, especially on the upper jaw, due to the vestibular bone resorption and the inherent difficulty in performing a correct wax-up when many damaged teeth are still present in a patient's mouth.

For this reason, we developed a new prosthetic and surgical protocol that is easy to apply, does not require a long learning curve, involves only a few implants that are inserted into dental sockets, and only uses a single radiological template.

Obviously some limitations exist. For one, severely damaged teeth may not be able to support a provisional prosthesis for a few months. In such cases, it may be preferable to use a removable prosthesis and to wait for complete bone remodelling before implant installation.

In conclusion, we believe that immediate implant insertion into fresh dental sockets represents a valid opportunity for clinicians, especially when a full-arch implant-supported restoration is needed, but some parameters have to be considered if the goal is not only implant insertion, but also prosthetic and aesthetic results. Within the limitations of this study (number of patients and implants inserted), our data seem to validate this surgical and prosthetic protocol with valid functional and aesthetic results.

### Conflict of Interest

The Authors declare that they have no conflict of interests.

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