Five-Year Follow-Up of Immediate Fixed Restorations of Maxillary Implants Inserted in Both Fresh Extraction and Healed Sites Using the NobelGuide™ System

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ABSTRACT

Background: Transition from a hopeless dentition to an implant prosthesis, without wearing a removable denture, requires adaptation with guided surgery in postextraction cases.

Purpose: The study aims to evaluate mid-term follow-up of patients with compromised dentition treated with immediate fixed restorations on maxillary implants inserted in fresh extraction and healed sites by using NobelGuide™ (Nobel Biocare AB, Gothenburg, Sweden) in combination with a specially designed radiographic stent.

Materials and Methods: Twenty-seven patients (females 20, males 7) aged 34 to 71 years (mean 55.8) were treated with flapless surgery. Immediate full-arch ($n = 19$) or partial ($n = 10$) restorations were delivered. Patients were followed both clinically (mean 61.3 months, 48–77) and radiologically for up to 5 years (mean 46.5 months, 12–61). Cumulative survival rate (CSR) was assessed. Marginal bone remodeling was evaluated at implant insertion, after 2 and 4/5 years. Soft tissue parameters as well as biological and mechanical complications were also recorded.

Results: One-hundred sixty implants were assessed. Four implants in two patients failed and were removed (overall CSR 97.33%), and two were replaced. All final prostheses were stable and in good function throughout the study. Bone loss from insertion to 2 years, for implants placed in both extraction and healed sites, was 0.85 mm (SD 1.28, $n = 130$); from insertion to last radiological control (4–5 years), 1.39 mm (SD 1.88, $n = 127$); and between 2 years and last control, 0.64 mm (SD 1.66, $n = 111$). No bone loss difference was found between extraction and healed sites at any time ($p > .05$). At the last visit, most implants showed normal mucosa. No other complications occurred.

Conclusions: This 5-year retrospective study demonstrated a good outcome with regard to implant survival, marginal bone changes, and soft tissue conditions.

KEY WORDS: edentulism, guided implant surgery, immediate loading, postextractive implant, radiographic stent

INTRODUCTION

Demographic statistics from World Health Organization and the US Bureau of Statistics[1] indicate that in Europe, North America, and Japan, the percentage of population >65 years old is strongly increasing and will be almost doubled in 2025 when compared with 2005. Furthermore, people reaching the age of 65 will have an average life expectancy of 17 additional years. In accordance with this demographic development, epidemiologic survey data[2] indicate that in the United States, the adult population in need of one or two complete dentures will increase from 33.6 million adults in 1991 to 37.9 million adults in 2020.

It is well known how edentulism affects a patient's life with impairment of psychosocial functioning, nutritional disturbances, and overall impairment of the patient's quality of life.[3]

Moreover, removable full or partial dentures can accelerate bone resorption by a factor of 2 to 3 while

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fixed implant-supported prostheses reduce further bone resorption to normal physiologic levels.[4]

Dental implant-supported prosthetics are well documented to improve patient quality of life. Studies have shown improvements to the patient's social life, chewing capacity, self-esteem, and significantly better comfort, function, speech, esthetics, self-image, and dental health, with dental implants compared with traditional dentures.[5–13] When it comes to long-term predictability, several papers[14–19] have documented the long-term reliability of dental implants in the treatment of edentulism in both maxilla and mandible; in all these studies, implants were used with either a one or two-stage surgical approach but always with a delayed loading protocol. Since the early 1990s when Schnitman and colleagues[19] first documented the reliability of the immediate loading of implants in the fully edentulous mandible, this concept has been further documented and reported to also be feasible and predictable in cases of maxillary partial and total edentulism.[20–23] Predictable results are believed to depend on good initial implant stability, controlled loading conditions, and an osseo-conductive implant surface.[24]

With regard to dental implant therapy in edentulous patients, different considerations need to be taken into account and can influence the decision-making process: (1) denture wearers or patients with hopeless teeth; (2) how much hard and soft tissue has to be replaced (mild/moderate/severe resorption); (3) maxilla or mandible; (4) type, number, and distribution of implants; (5) surgical approach and loading protocol; (6) esthetic considerations (smile line, transition line, etc); (7) fixed/removable solution; (8) type of prosthetic construction; (9) financial issues; and (10) patient demands.

Until recently, a transition period with an interim denture was mandatory before implant treatment in patients with hopeless teeth. This period, besides having psychological implications, contributed to further loss of bone volume. In order to avoid this loss of bone, some authors have investigated and published clinical evidence advocating the extraction of hopeless teeth followed by immediate placement of a full arch implant-supported rehabilitation[25,26]

In recent years, three-dimensional software programs for diagnosis and implant treatment planning have become more and more common in clinical practice. One of these systems is the NobelGuide® (Nobel Biocare AB, Gothenburg, Sweden). This system utilizes data from computed tomography (CT) scans of the patient and a radiographic guide and then, with the availability of sophisticated software, it is possible to virtually perform the implant surgery in an easy and effortless manner prior to doing so in an actual surgical field. Computer-aided design and computer-aided manufacturing (CAD-CAM) technologies are then employed for the successive production of a surgical template, which will facilitate the surgery, often flapless, and make possible the fabrication of a provisional prosthesis to be delivered right after implant placement. This procedure is well established for patients who are edentulous in the area to be treated. If a patient needs implants where there are some remaining teeth, some difficulties can occur in the diagnosis and the correct planning. In fact, it is a necessary condition in the standard protocol that the patient should present with completely healed ridges after teeth extractions prior to the CT scan analysis. If the radiographic analysis is performed shortly after the extractions of the residual teeth, the bone remodeling that will take place during the early phases of the healing will affect the adaptation of the surgical guide in the mouth of the patient. Furthermore, when the surgery will be performed, there will be a clinical difference in the volume and contour of the bone from that seen on the computer during the virtual surgery, and it could be impossible to insert the implants in the correct locations. This situation would require the patients to wear a transitional removable denture until the bone remodeling has taken place, a period of time from 6 months to more than 1 year, if we want to obtain a predictable successful procedure.

Many authors[27–32] have demonstrated that implant insertion in postextraction sockets is a viable option provided that high primary stability of the implant is achieved.

The increasing demand for patients to have a smooth transition from a hopeless dentition to a fixed implant-supported prostheses, without wearing an interim removable denture, raises new challenges to adapt these CAD-CAM techniques to immediate insertion in postextraction cases.

A step-by-step technique for the fabrication of a two-piece radiographic guide lets the patient to retain hopeless teeth during the diagnostic phases until the day of the surgery and allows for a prosthetically driven virtual planning of the implants to be inserted, independently from the position of the teeth to be

extracted. This method has been described by Cantoni and Polizzi in a previous article.[33]

The aim of the present study was to retrospectively assess the mid-term outcomes of patients with compromised dentition treated with immediate fixed restorations of maxillary implants inserted in fresh extraction and healed sites and by using the NobelGuide™ (Nobel Biocare AB) system in combination, in the planning phase with a specially designed radiographic stent.

This study follows the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines 36 (http://www.strobe-statement.org/).

MATERIALS AND METHODS

This retrospective study evaluates data collected from 27 consecutive patients of both sexes (females 20, males 7), aged 34 to 71 years (mean age 55.8), presenting compromised dentition in the maxilla and treated with immediate full arch ($n = 19$) or partial ($n = 10$ in 8 patients) restorations and flapless implant surgery in fresh extraction and healed sites, by using a specially designed radiographic stent in conjunction with the NobelGuide™ system (Nobel Biocare AB). Overall, 160 implants were placed (61 NobelSpeedy Groovy, 83 NobelSpeedy Replace Groovy, 9 Replace Select Tapered, 7 NobelReplace Tapered Groovy, Nobel Biocare AB), all placed in the maxilla. The patients were clinically followed for up to 5 years (mean 61.3 months, range 48–77) and radiologically for up to 5 years (mean 46, 5 months, range 12–61).

Ninety-two (92) and sixty-eight (68) implants were placed in healed and extraction sites, respectively. All patients were treated in one specialized implant rehabilitation center. One clinician (G.P.) performed all surgical procedures, and various prosthodontists performed the prosthetic procedures. One dental laboratory technician manufactured all restorations. The investigation was conducted according to the principles embodied in the Helsinki Declaration. The patients were enrolled and treated consecutively provided that they fulfilled the inclusion criteria and gave their informed consent for the treatment. The following inclusion criteria were used: patients with hopeless residual dentition (confirmed by clinical and radiological examination) requiring a partial or full arch implant-supported rehabilitations in maxilla, healthy condition, both full mouth bleeding on probing (BoP) and a full mouth plaque index lower than or equal to 25%, absence of inter-arch discrepancies, insertion torque ≥35 Ncm. In addition to universally accepted exclusion criteria for implant surgery,[34] the following exclusion criteria were used: severe bruxism and/or severe parafunctional habits. Smoker patients (≤20 cigarettes/day) were not excluded.

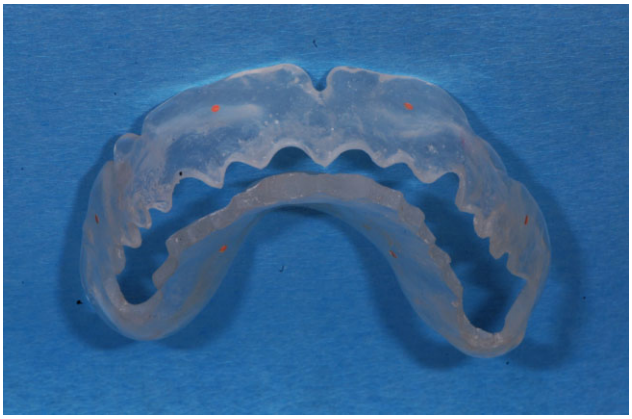

Figure 1 Base portion of the radiographic guide.

Fabrication of the Radiographic Guide and Diagnostic Protocol

The radiographic guide used for the diagnostic phase consists of two different parts that can be connected together: the "base" portion and the "teeth set-up" portion. The base portion is fabricated with an open window around the teeth to be extracted. This is to facilitate the adaptation of this portion of the radiographic guide in the mouth while the teeth are still present. This portion will carry six to eight radiopaque markers positioned according to the NobelGuide protocol (Figure 1). The second part of the guide is obtained from a wax-up of the teeth in their ideal position, disregarding the teeth to be extracted (Figure 2). This second portion must fit precisely onto

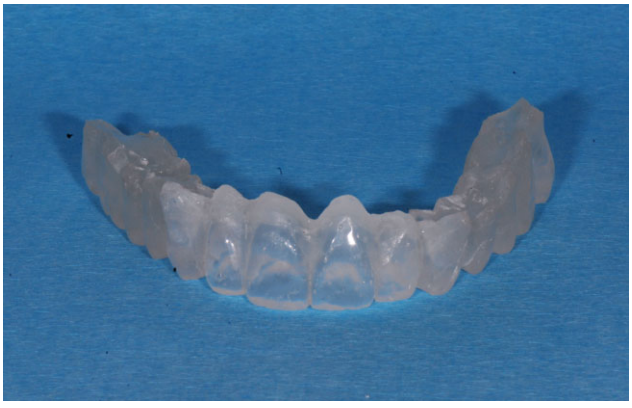

Figure 2 Teeth setup portion of the radiographic guide.

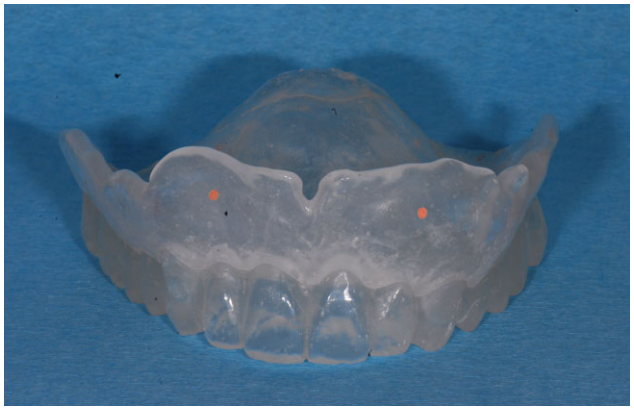

Figure 3 The two portion of the radiographic guide assembled together.

the base portion of the guide (Figure 3). The patient will undergo an initial CT scan prior to the extractions of the hopeless teeth, wearing only the base portion of the radiographic guide with the occlusal index (Figure 4, A and B). The dicom set files obtained from this first CT scan will contain data regarding the anatomy of the patient's jaw and data regarding the position of the markers in the base portion of the radiographic guide. After this scan, the patient can be dismissed and the base portion and the teeth setup portion are then connected together and scanned in a second CT following the standard NobelGuide protocol. The dicom set files obtained from this second CT scan will contain data regarding the ideal plan for positioning of the teeth from the teeth setup portion, plus the data regarding the position of the markers, which is the same as in the first scan. Once these two sets of data are converted with the NobelGuide Procera® software, the clinician will be able to preview the anatomy of the patient's jaw and the ideally planned position of the teeth, independently from the position of the teeth to be extracted. Implants in extraction sites are virtually planned with teeth/roots still in their alveoli. Once the planning is completed, the clinician receives the surgical template. The surgical template cannot be tried in the mouth until the hopeless teeth are extracted at the time of the implant surgery. All the procedures that follow are those of the standard NobelGuide protocol.

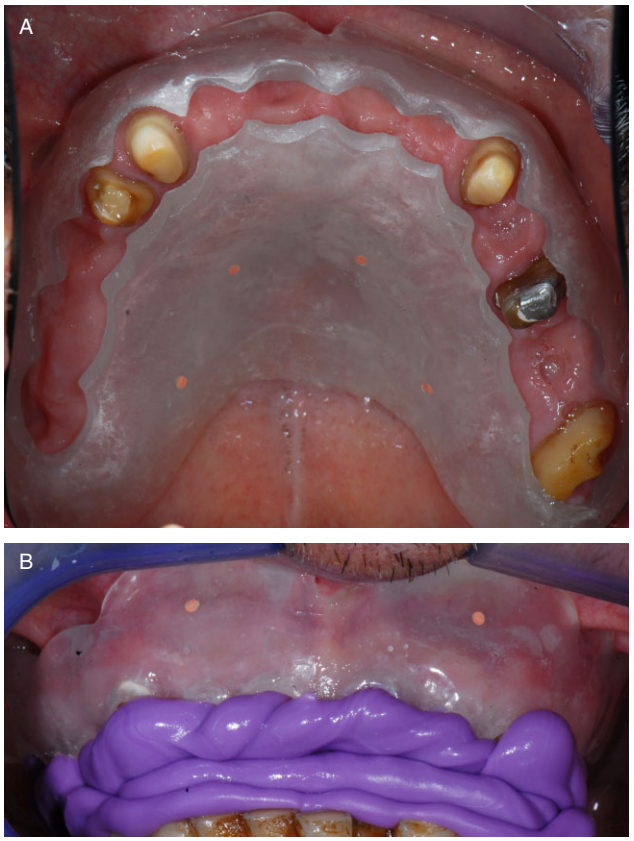

Figure 4 *A*, Patient wearing the base portion of the radiographic guide with hopeless teeth still present. *B*, Patient wearing the base portion of the radiographic guide with occlusal index during the CBCT scan.

Surgical Protocol

All patients underwent the same surgical protocol. Antimicrobial prophylaxis was achieved with amoxicillin 1 gr (Zimox, Pfizer, New York, NY, USA) twice daily for 6 days starting 2 hours before surgery. Oral premedication with flurazepam monohydrochloride 15 mg (Flunox, Teofarma srl, Valle Salimbene, MI, Italy), octatropine methyl bromide 40 mg + diazepam 5 mg (Valpinax, Crinos, Milano, Italy) was given prior to surgery. Local anesthesia with articaine 4% with 1:100.000 adrenaline (Articaina, Pierrel, Milno, Italy) was injected to infiltrate the buccal and palatal regions of the surgical area. Conscious sedation with midazolam i.v. 0.05 to 0.15 mg/kg (Ipnovel, Roche, Basel, Swiss) was performed; ranitidine i.v. 100 mg (Ranidil, Menarini, Firenze, Italy) and ondansetrone i.v. 4 mg (Zofran, GlaxoSmithKline, Brentford, Middlesex, UK) were also administered for gastro protection and prevention of nausea and vomiting. All patients were monitored for vital signs (heart rate, blood pressure, oxymetry). A single postoperative administration of desametazone i.v. 8 mg (Decadron, Visufarma, Roma, Italy) + ketorolac i.v. 30 mg (Toradol, Recordati, Milano, Italy) was also given.

Particular care was paid during tooth/root extractions in order to preserve integrity of the alveolus walls,

especially the buccal bone plate; all remnants were carefully removed from the socket.

In the healed sites, the implant platform was positioned at the bone level while in extraction sites the platform was placed at the buccal bone crest level. In order to be suitable for immediate implant placement and loading, the extraction sites had to present with all of the walls intact. In these cases, the bone regenerative procedures were limited at the alveoli of the frontal area in order to reduce ridge resorption and to fill the gap between the buccal bone plate (bundle bone) and the implant surface. Anorganic bovine bone substitute (Geisthlich Bio-OSS®, Wolhusen, Switzerland) was used as grafting material.[35]

In extraction sites presenting severe residual bone defects, like buccal bone dehiscence and soft tissue recession, and considered as a future useful healed site, soft and hard tissue regenerative procedures were performed, trying to obtain a socket seal with a connective tissue graft or with the use of collagen membrane (Geisthlich Bio-Gide®, Wolhusen, Switzerland).

The implant insertion procedure was performed following the standard NobelGuide protocol with slight modification of the technique in the extraction sites and tuber-pterygoid region. In the software-based planning phase of these cases, it is often impossible to guide an implant to the proper final depth due to the sleeve interfering with the edentulous ridge. This scenario will prevent the proper adaptation of the surgical guide (CAD-CAM object obtained from the radiographic guide) (Figure 5A). As a consequence of the requirement to keep the sleeves completely inside the radiographic stent during the 3D-planning phase (Figure 5B), some implants needed to be placed deeper than planned, after the surgical guide was removed. In these sites, in order to get this optimal position, an extended depth over-drilled site preparation was made based upon the measurements of the vertical discrepancy between the planned and final

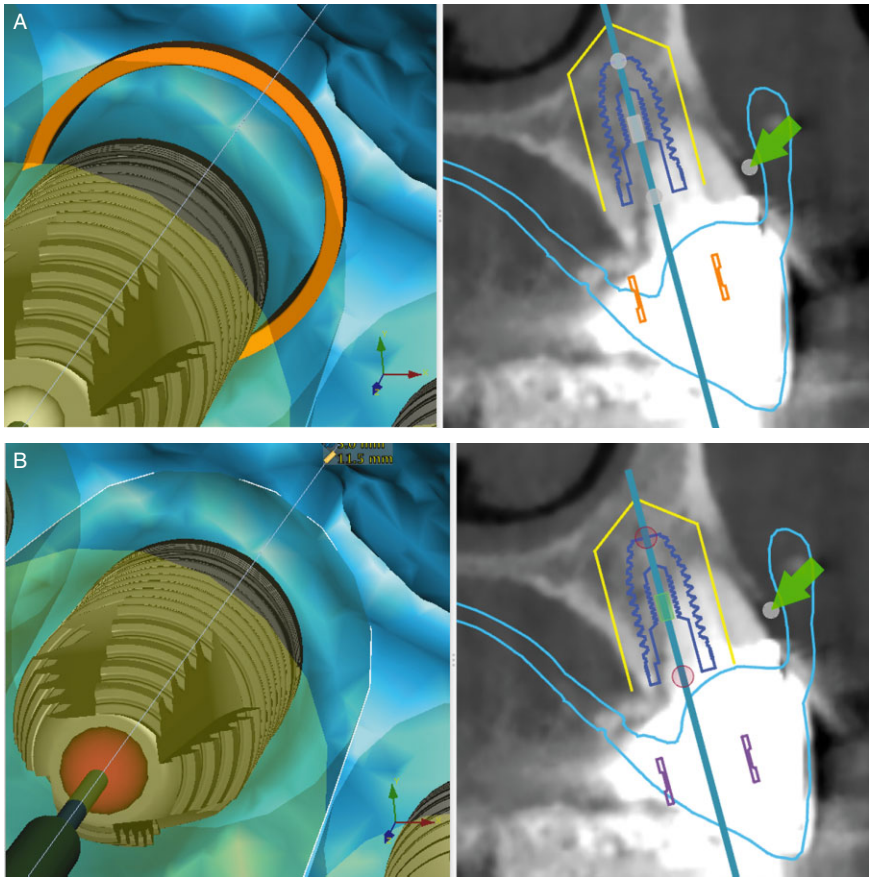

Figure 5 *A*, Extraction site. Despite the special reassembled radiographic guide, the sleeves used for the drill guides could interfere with the correct position of the correspondent surgical guide after the tooth extraction. *B*, The only option is to plan the implant with the sleeve completely included in the stent, completing the final deeper insertion after the removal of the surgical stent.

proper implant position. In order to compensate for this vertical discrepancy, an intraoral passivation of the provisional fixed bridge was then needed. This was necessary because, in this study, we delivered the bridge the same day.

Prosthetic Protocol

The provisional restoration was fabricated prior to the surgery on mounted casts obtained from the surgical template (as in the standard NobelGuide protocol) and from an alginate impression of the opposing arch. It had a reinforced framework that went around the temporary abutments without being connected to them. The framework left enough space around the abutments in order to compensate for small variations in the position of the implants that could occur during surgery. Additionally, the temporary abutments were adjusted in length on the casts so as not to interfere with the opposing dentition. After surgery was performed, the abutments were connected directly to the implants or to the multi-unit-abutment. The provisional restoration was inserted in the mouth, and checked for passive fit around the abutments (Figure 6). If any tension was detected, more space was provided by adjusting the provisional restoration. Once the prosthesis was completely seated, a preliminary occlusal adjustment was performed. Using a disposable syringe filled with cold-cure acrylic resin, the abutments were then connected to the temporary restoration by injecting the resin in the space between the abutments and the framework, having the patient close into occlusion (Figure 7). When the resin was fully set, the provisional restoration was removed from the mouth by unscrewing the abutments' screws. The restoration was then refined and polished by the laboratory technician and delivered to the patient approximately 2 to 3 hours later (Figure 8). A final check of the occlusion and of the interproximal spaces was then performed. The screw access holes were closed with a cotton pellet and temporary filling material. Periapical radiographs were then obtained of all implants. All patients received appropriate postoperative instructions and prescriptions. Oral antiseptic and soft brushing were recommended for the first 2 weeks. The patients were re-called for follow-up and oral hygiene checks after 2 weeks, and 3, 6, and 12 months. On average, the provisional fixed restorations were removed after 6 months and replaced with screw-retained final prostheses (Procera Titanium or Zirconia framework with acrylic or ceramic esthetic material) (Nobel Biocare AB).

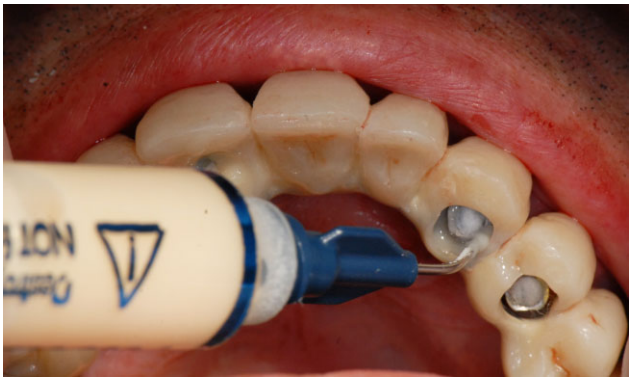

Figure 7 Injection of cold-cure acrylic resin between the abutments and the framework.

Outcomes

Implant survival rate was assessed 15 days after prosthesis delivery and then yearly up to 5 years after surgery. The success and survival criteria used in this report are a

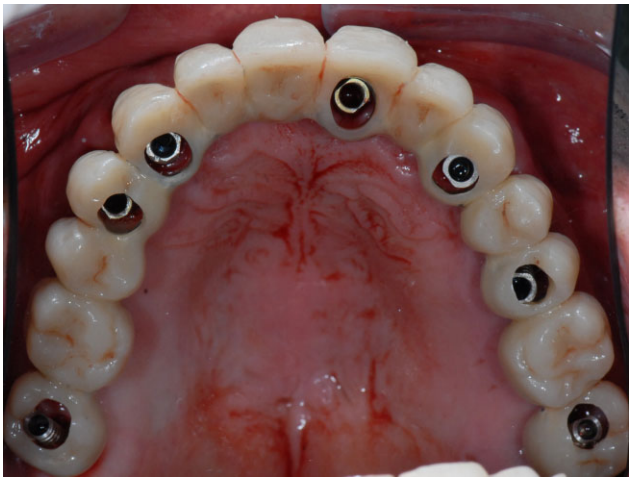

Figure 6 Provisional restoration inserted and checked for passive fit.

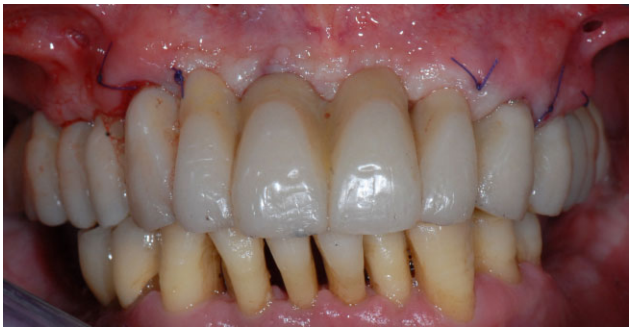

Figure 8 Provisional restoration delivered to the patient shortly after surgery.

modification of the success criteria suggested by van Steenberghe.[36] According to these criteria, a "successful implant" is an implant that: (1) does not cause allergic, toxic, or gross infectious reactions either locally or systematically; (2) offers anchorage to a functional prosthesis; (3) does not show any signs of fracture or bending; (4) does not show any mobility when individually tested by tapping or rocking with a hand instrument; and (5) does not show any signs of radiolucency on an intraoral radiograph using a paralleling technique strictly perpendicular to the implant-bone interface. A "surviving implant" is when the implant remains in the jaw and is stable, and when the subject's treatment is functionally successful even though all the individual success criteria are not fulfilled. A "successful prosthesis" is a prosthetic reconstruction that is stable and in good function. A "failed implant" is an implant that has been removed, fractured beyond repair, or cannot be classified as a successful or surviving implant.

Changes in marginal peri-implant bone level, defined as modification of the distance between the implant/abutment junction and the highest coronal point of the supporting bone, were evaluated on the basis of the periapical radiographs taken perpendicular to the long axis of the implants with the parallel technique. The measurement was rounded off to the nearest 0.1 mm. Conventional film holders or manual forceps were used to place the films. The radiographs were repeated when quality was poor. An independent radiologist made the bone-height measurements. An image analysis program (National Institutes of Health Scion Image Corporation 4.0.2, Frederick, MD, USA) was used to measure the distance between the implant platform and the most coronal level of the bone deemed to be in contact with the fixture surface. The first bone-to-implant contact at surgery was defined as the baseline. Measurements were taken mesially and distally and then averaged for each implant, at the time of implant placement and then at the final follow-up visit. The marginal bone remodeling was calculated as the difference between the reading at the final examination and the baseline value. Three groups were created: overall implants and, to avoid bias in marginal bone remodeling due to different implant sites, healed and postextraction implants.

Periodontal parameters (plaque and gingival index scores) around the implants, were assessed. Plaque score was recorded using a plastic periodontal probe (Plast-o-Probe, Dentsply Maillefer, Ballaigues, Switzerland), defined as the presence of plaque (yes/no) on the abutment/restoration complex. Gingival index was defined as follows: 0 = normal gingiva; 1 = mild inflammation, slight change in color, slighter edema, no BoP; 2 = moderate inflammation, redness, edema, and glazing, BoP; 3 = severe inflammation, marked redness and edema, ulceration, tendency to spontaneous bleeding.

Statistics

The statistical analysis was performed using SPSS for Windows release 18.0 (SPSS Inc., Chicago, IL, USA). Descriptive analysis was performed using mean, standard deviation, and frequency distribution. The implant was used as the statistical unit of the analysis.

Life tables of implant cumulative survival rates (CSRs) were calculated. Wilcoxon signed rank test for paired data was utilized to compare overall (implants in both healed and postextraction sites) bone levels between insertion and follow-ups, and to compare bone remodeling between extraction and healed sites at all three time points. The test was two tailed and the level of significance was set to 5%.

RESULTS

One hundred sixty implants in 27 patients have been assessed. The patients were clinically followed for 5 years (mean 61.3 months, range 48–77) and radiologically up to 5 years (mean 46.5 months, range 12–61).

Four implants in two full-arch patients failed, resulting in an overall implant CSR of 97.33% (Table 1). All fixed prostheses maintained stable and in good function during the follow-up, accounting for a prosthesis CSR of 100% (Figures 9 and 10). The fixed screw retained bridges consisted of Procera Implant Bridge in zirconium ($n = 11$, 38%), Procera Implant Bridge in titanium ($n = 7$, 24%), Porcelain Fused to Metal ($n = 6$, 21%), and provisional fixed-bridges with acrylic teeth and metal-reinforced framework ($n = 6$, 21%).

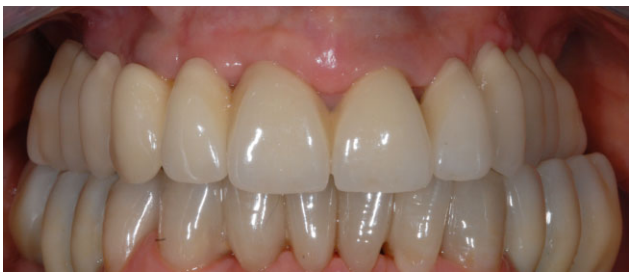

Figure 9 Case no. 2, 5 years follow up, upper arch.

TABLE 1 Life Table Analysis of Surviving Implants: All Implants

Time	Implants	Failed	Not followed*	CSR (%)
Insertion to 6 months	160	0	0	100
6 months to 1 year	160	2	0	98.75
1–2 years	158	0	17	98.75
2–3 years	141	2	0	97.33
3–5 years	139	0	0	97.33
>5 years	139			

*The latest recorded patient follow-up occurred in this time period.
CSR, cumulative survival rate.

Two of the failed implants were placed in healed sites, position 23–24; the other two in postextraction sites, position 13–14. Failures of the healed site implants occurred after 2 years; no implant replacement was made as the prosthesis was well supported by the remaining implants. The reason for failure of these two implants was progressive bone loss, and high-risk factors (smoking habit, 20 cigarettes per day) present in this patient. Extraction site implants were removed after 6 months despite the absence of inflammatory symptoms. These implants failed to osseointegrate as noticed when the provisional restoration was removed to take the impression for final prosthesis fabrication. They were successfully replaced and included in the final prosthesis.

Periodontal parameters: 24 implants in three patients showed a slight amount of plaque around implant-abutment interfaces, accounting for a cumulative plaque score of 15% at implant level and 11% at patient level. Gingival index was reported as 90% of normal gingiva; 7% of mild inflammation; and 1.75% of moderate inflammation and BoP. Spontaneous bleeding and exudation was present in one postextraction site (0.62%). This site was successfully treated with topical application of minocycline hydrochloride (Minotek, OraPharma, Horsham, PA, USA).

Radiographic Analysis

Marginal bone levels and distribution frequencies for all sites (both extraction and healed) at different time points are shown in Table 2. The mean marginal bone level was –0.83 mm (SD 1.27, $n = 153$) at implant insertion, –1.70 mm (SD 1.40, $n = 134$) at 2 years follow-up, and –2.21 mm (SD 1.89 mm, $n = 132$) at the last

TABLE 2 Bone Levels and Distribution Frequencies: All Sites

	Implant Insertion		2 Years Follow-Up		3–5 Years Follow-Up	
Mean (mm)	–0.83		–1.70		–2.21	
SD (mm)	1.27		1.40		1.89	
n	153		134		132	
	n	%	*n*	%	*n*	%
>3.0	1	0.6	–	–	1	0.6
2.1–3.0	1	0.6	–	–	–	–
1.1–2.0	6	3.8	1	0.6	–	–
0.1–1.0	11	6.9	5	3.1	5	3.1
0	27	16.9	11	6.9	4	2.5
–1.0—0.1	49	30.6	27	16.9	25	15.6
–2.0—1.1	35	21.9	42	26.3	34	21.3
–3.0—2.1	13	8.1	29	18.1	36	22.5
–4.0—3.1	8	5.0	12	7.5	9	5.6
≤4.0	2	1.3	7	4.4	18	11.3

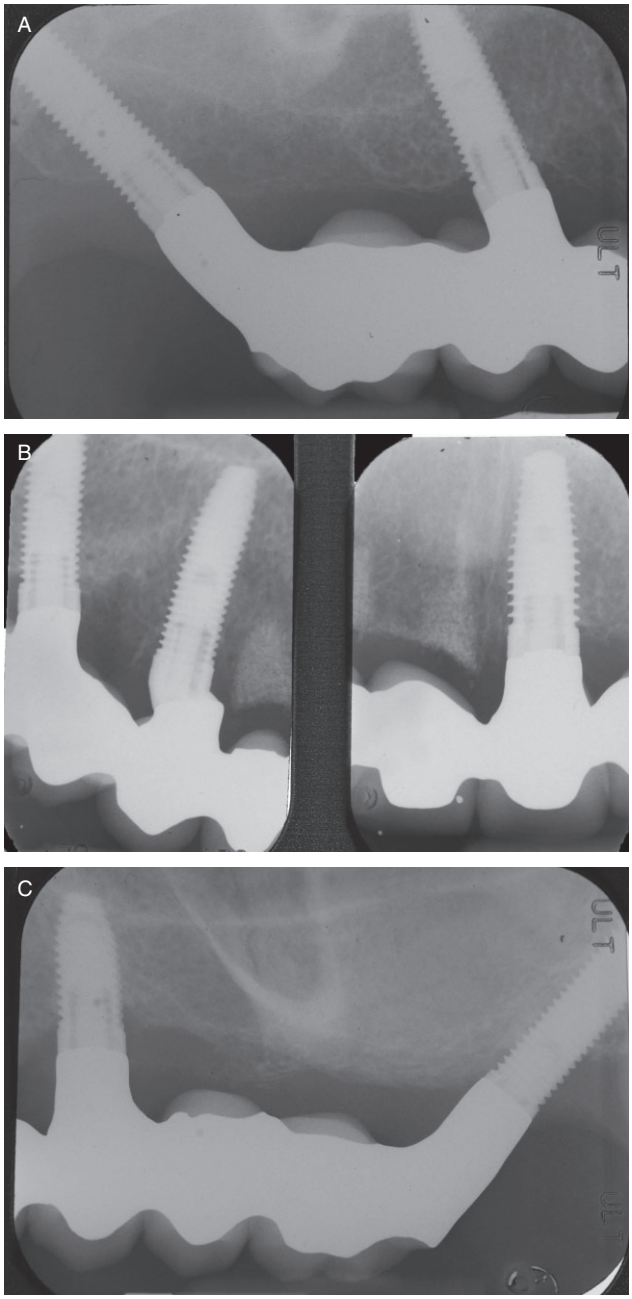

Figure 10 *A*,*B*,*C*, Case no. 2 – Periapical radiographs at 5 years.

radiological control. Marginal bone levels assessed separately for extraction and healed sites at different time points are shown in Table 3. Marginal bone loss and distribution frequencies for all sites at different time points is reported in Table 4: bone loss from implant insertion to 2 years was 0.85 mm (SD 1.28, $n = 130$); bone loss from implant insertion to the last radiological control (mean 46.5 months) was 1.39 mm (SD 1.88, $n = 127$); and bone loss between 2 years and last control was 0.64 mm (SD 1.66, $n = 111$). These data indicate an overall good stability of the peri-implant bone (Figure 10). The frequency of distribution of implants showing greater than 3 mm bone loss after 5 years was 3.1. Marginal bone loss assessed separately for extraction and healed sites at different time points are shown in Table 5. Bone loss for implants in extraction sites was slightly less than in healed sites. Nevertheless, no statistically significant differences in bone loss values were found between extraction and healed sites at any time ($p > .05$).

Complications

No other biological complications occurred and no mechanical complications were reported.

DISCUSSION

The results emerging from this study, aimed to retrospectively assess the radiological and clinical mid-term outcomes of patients with hopeless teeth treated according to the described technique, support the success of this approach which allows for prosthetically guided implant planning and avoidance of a transitional denture period.

This investigation was designed as a retrospective study whose main limitation is intrinsic in its retrospective nature. A further limitation is that only one center treated and followed up all the patients. Nevertheless, the high implant cumulative survival rates (97.33%), and the clinical and radiological data obtained in this study were certainly favorable. Only 4 out of 160 implants failed and the marginal bone loss was limited, reflecting an overall stability of the peri-implant marginal bone, despite the fact that many patients were moderate to heavy smokers. Bone loss for implants in

TABLE 3 Bone Levels Extraction and Healed Sites

Site	*n*	Mean (mm)	SD (mm)
Extraction			
Implant insertion	65	−0.66	1.35
2 years follow-up	48	−1.48	1.33
3–5 years follow-up	57	−1.75	1.71
Healed			
Implant insertion	88	−0.96	1.20
2 years follow-up	86	−1.82	1.42
3–5 years follow-up	75	−2.56	1.95

TABLE 4 Bone Remodeling: All Sites

	Implant Insertion to 2 Years		Implant Insertion to 3–5 Years		2 Years to 3–5 Years	
Mean (mm)	−0.85		−1.39		−0.64	
SD (mm)	1.28		1.88		1.66	
n	130		127		111	
	n	%	*n*	%	*n*	%
>3.0	–	–	2	1.3	1	0.6
2.1–3.0	1	0.6	–	–	1	0.6
1.1–2.0	2	1.3	3	1.9	5	3.1
0.1–1.0	22	13.8	12	7.5	30	18.8
0	15	9.4	1	0.6	4	2.5
−1.0—0.1	37	23.1	38	23.8	39	24.4
−2.0—1.1	36	22.5	36	22.5	19	11.9
−3.0—2.1	8	5.0	22	13.8	4	2.5
−4.0—3.1	6	3.8	5	3.1	2	1.3
<−4.0	3	1.9	8	5.0	6	3.8

extraction sites was slightly less than for those in healed sites, but no statistically significant differences in bone loss values were found between extraction and healed sites at any time ($p > .05$). Soft tissue parameters were normal in the large majority of patients.

These findings seem to be in line with the same good outcomes experienced by other authors[37–45] using healed bone ridges with three-dimensional software planning, flapless guided surgery, and immediate provisional delivery. It is becoming more and more established that the benefits from these technologies are substantial for both the clinicians and patients. In fact, due to its documented relatively high level of accuracy,[46,47] the use of three-dimensional planning and guided surgery system adopted in this study allows for maintaining the residual bone volume while reducing the risk of damage to the anatomical structures. It also allows for a sensible reduction of surgery time and makes it possible to deliver an immediate implant-supported temporary bridge with less postoperative discomfort, pain, and swelling for the patient. These procedures and their advantages are well established when patients are edentulous in the area to be treated, but in case of a patient needing implants when still retaining hopeless teeth, some problems can occur in the diagnosis, correct planning, and treatment. A prerequisite prior to the CT scan data acquisition is that the patient should present with completely healed ridges, a condition not present immediately after teeth extractions. If the CT scan is performed shortly after the extractions of the residual teeth, the bone remodeling taking place during the early phases of healing will affect the adaptation of the surgical guide in the mouth of the patient, resulting in a clinical situation in which bone volume and contour differ from that seen on the computer during the virtual surgery, and it could be impossible to correctly insert the implants. All this imposes the patient to wear a transitional removable denture for 6–12 months until bone remodeling has taken place, in order to obtain a predictable successful procedure.

Our technique for the fabrication of a multipiece (reassembled) radiographic guide delivers the patients further tangible benefits: it lets the patient maintain

TABLE 5 Bone Remodeling Extraction and Healed Sites

Site	*n*	Mean (mm)	SD (mm)
Extraction			
Implant insertion to 2 years	48	−0.65	1.37
Implant insertion to 3–5 years	55	−1.00	1.96
2 years to 3–5 years	41	−0.41	1.51
Healed			
Implant insertion to 2 years	82	−0.96	1.23
Implant insertion to 3–5 years	72	−1.69	1.78
2 years to 3–5 years	70	−0.78	1.74

hopeless teeth during the diagnostic phase until the day of the surgery and allows for a prosthetically driven virtual planning of the implant insertions, independently from the position of the teeth to be extracted, while avoiding the necessity for an interim removable denture. In our opinion, this is the major benefit for the patient and main advantage for treatment feasibility. The absence of the transition phase with a removable denture means that the buccal bone plate at the extraction sites can be kept intact allowing for implant placement that would otherwise be impossible after resorption takes place. Needless to say, the psychological implications and benefits for the patient are substantial when the prosthesis can be delivered by avoiding the transitional denture period.

As there are currently no other clinical papers reporting findings by other authors when adopting this technique, it is not possible to compare our data with those from similar studies. Nevertheless, the technique is easy to learn and it should produce the same favorable results as ours when applied by experienced dental implant teams (surgeon, prosthodontist, and dental technician) who have had previous good experience with three-dimensional planning and guided treatment.

CONCLUSIONS

Within the limitations of a retrospective study, this 5-year follow-up of 27 immediate fixed restorations of maxillary implants inserted in fresh extraction and healed sites by using the NobelGuide™ system in combination with a specially designed radiographic stent, demonstrated good treatment outcomes with regard to implant survival, marginal bone changes, and soft tissue conditions. The posttreatment level of patient satisfaction was extremely high and particular satisfaction has been expressed in having avoided the transition period with the removable denture before the surgery.

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