Immediately restored full arch-fixed prosthesis on implants placed in both healed and fresh extraction sockets after computer-planned flapless guided surgery. A 3-year follow-up study

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Abstract
Background: The treatment of patients by the use of immediate implant placement in postextractive site is a challenging procedure.
Purpose: A 3-year clinical and radiological study of post-extractive implants placed using flapless guided surgery and immediately functioning.
Materials and Methods: Thirty-two patients (23 females and 9 males), aged between 44 and 73 years (a mean age of 59.5) were treated with immediate full arch restorations and flapless implant surgery in fresh extraction and healed sites. A double-guide technique stent in conjunction with the NobelGuide system (Nobel Biocare AB, Goteborg, Sweden) was used.
Results: A total of 285 implants over 32 patients were assessed. The patients were clinically and radiologically followed for 3 years. One hundred and ninety-five implants were placed in the maxilla and 90 in the mandible. Eight patients received implants in both arches. One hundred and ninety-seven implants were placed in extraction sites (137 maxilla, 60 mandible) and 88 in healed sites (58 maxilla and 30 mandible). The overall cumulative implant survival rate (CISR) was 97.54%. Two implants failed in maxillary healed sites (CISR 96.55%), three in maxillary extraction sites (CISR 97.81%), and two in mandibular extraction sites (CISR 96.66%). No implant failed in healed mandibular sites (CSR 100%). All fixed prostheses maintained stability and good functionality during the follow-up, accounting for a cumulative prosthesis survival rate (CPSR) of 100%. The overall marginal bone level (MBL) was 20.52 mm (SD 20.18) after 6 months, 20.88 mm (SD 20.20) after
12 months, 21.05 mm (SD 20.21) after 24 months, and 21.32 mm (SD 20.41) after 36 months.
Conclusions: Computer-guided surgery using double-template technique (DTT) shows a predictable outcome in the medium term, decreasing treatment timing and patient discomfort.

KEYWORDS: computer-guided surgery, immediate function, immediate loading, flapless surgery, post-extractive implants

INTRODUCTION

Edentulism affects a patient's life with impairment of psychosocial functioning, nutritional disturbances, and overall loss of quality of life. The conventional approach to implant therapy includes typically a two-step procedure whereby a standardized healing time of between 3 and 6 months is respected to create good conditions for healing. During this time, no implant loading is performed.1,2 Good primary implant stability obtained after insertion is the main prerequisite for implant success.3,4 Many authors have found that a single-stage implant procedure with immediate loading can also provide good results.5–8

The main reasons for the development of new clinical protocols in implant dentistry include reduce treatment time and patient discomfort and achieve high levels of predictability and a good aesthetic outcome. Until recently, patients with failed dentition would need to go through a transition period with a temporary denture. As we all know, this transition period has got negative psychological implications on many patients.9 On top of this, it further contributes to an increased bone volume loss. Furthermore, full or partial dentures can accelerate bone resorption by a factor of

between 2 and 3 while fixed implant supported prostheses reduce further bone resorption to normal physiological levels.9

In order to avoid loss of bone and achieve a full arch implant supported rehabilitation, some authors have studied and published clinical evidence of the effectiveness of immediate implant placement right after tooth extraction.

Generally, extraction socket might be a risk factor for immediate implant placement because of the reduced amount of bone and insufficient primary implant stability. However, some studies have focused on the combined use of immediate post-extraction implant placement and immediate or early loading to reduce the treatment time. These studies have reported different survival rates. De Bruyn and Collaert10 reported a survival rate of 61% for early loaded implants placed in post-extraction sockets compared with 99.3% for healed sites. Balshi and Wolfinger11 and Chaushu and colleagues12reported survival rates of 80% and 82.4%, respectively, for immediately loaded implants in fresh extraction sites. Glauser and colleagues13 found that 88% of implant placed in extraction sockets were successful compared with 78% of the implants installed in healed sites. In contrast, other authors described more encouraging results showing that, with an appropriate biomechanical, surgical, and medical protocol, it is possible to achieve high-implant stability reaching a survival rates ranging from 97.3% to 100%.14–21 Guida and colleagues22 reported histological evidence that immediate loading does not appear to impair osseointegration of an immediate post-extraction implant compared with an unloaded postextraction. The two obtained the same percentage of bone-to-implant contact after 6 months of healing. However, in the case of loaded implants, a more dense, mature, well-organized peri-implant bone including many areas of remodeling and some osteons were found; on the contrary, the bone tissue surrounding the unloaded implant was constituted of only thin bone trabeculae.22

In recent years, the developments of computer-aided design/ computer-assisted manufacture (CAD/CAM) technologies have also brought great improvements in the field of oral implant dentistry.

These new methods allow clinicians to analyze the patient’s anatomical structure on a computer in relation to a diagnostic prosthesis. With sophisticated software, it is possible to virtually perform implant surgery in an easy and effortless manner before going into the real surgical field. With these technologies, it is also possible to prepare the prosthesis in advance, and complete rehabilitation of the patient can take place shortly after completion of the surgical procedure.23,24

After teeth extraction, the patient should present completely healed ridges before doing any CT scan analysis. If this is performed shortly after extraction of the residual teeth, then the bone remodelling process taking place during the early healing phases will affect the adaptation of the surgical guide in the patient0s oral cavity. Furthermore, when the surgery is performed, the volume and the contour of the bone will be different from those seen on the computer during the virtual surgery with the result that placing implants could become difficult. The increasing demand of patients to have a smooth transition from a hopeless dentition to a fixed implant-supported prosthesis without wearing an interim removable denture raises new challenges to adapt these CAD/CAM techniques to immediate implant loading cases. Few studies on immediate implants in post-extraction sites supporting immediate full-arch rehabilitation combined with flapless computer driven surgery are currently available.23,24

Some authors23 have reported the use of guided surgery in post-extraction maxillary cases taking advantage of digital planning for proper implant placement. However, this

procedure is limited by the fact that the surgical template can fit only after the teeth are extracted.
Using this protocol with a single surgical template would make the template stabilization difficult when multiple extractions and immediate implants placement are planned. The position of implants could be deviated and the application of a prefabricated prosthesis at the end of the surgery would be very complicated. The authors report their experience with a technique that uses two drilling templates to ensure proper positioning of the implants in healed and in post-extraction sites in accordance with digital planning. This allows the delivery of the prefabricated prosthesis immediately after the end of surgery.
The aim of this study is to evaluate the clinical outcome of immediately loaded implants placed in full-arch rehabilitation immediately after extraction of hopeless teeth, by using computer flapless guided surgery with a double-guide technique.

MATERIALS AND METHODS

This study evaluates data collected in two private practices (Faenza and Prato, Italy) from 32 consecutive patients of both genders (23 females and 9 males), aged between 44 and 73 years (a mean age of 59.5). The patients presented compromised dentition in the maxilla and were treated with immediate full arch restoration and flapless implant surgery in fresh extraction and healed sites by using a doubleguide technique stent in conjunction with the NobelGuide system (Nobel Biocare AB, Goteborg, Sweden).
Clinical and radiological data analyses were carried out over a 3-year period. The investigation was conducted according to the principles embodied in the Helsinki Declaration of 1964, amended in 2008, for biomedical research involving human subject. No ethical committee approval was requested. All patients were informed about the study and gave a written consent. The patients were enrolled and treated consecutively provided that they fulfilled the inclusion criteria and gave their informed consent for the treatment.
The inclusion criteria were the following: the need for maxillary or mandibular full implant supported rehabilitation; the presence of residual teeth with clinical or radiographic evidence of advanced endodontic and/or periodontal lesions or root fracture judged to be no longer recoverable The presence in the arch of at least one healed site useful for implant insertion.
The exclusion criteria were the presence of acute endodontic and/ or periodontal pathology in the teeth to be extracted and heavy smoking habits (more than 10 cigarettes/day).

Technique

After a clinical examination, including anamnesis and preliminary radiographic evaluation (intraoral and/or panoramic radiographs) and photos (Figures 1 and 2), each patient was prepared for high-resolution spiral CT study casts mounted in an articulator; all anatomic landmarks were obtained from well-extended impressions patients' arches.
A specially created prosthesis acrylic replica with teeth was prepared and at least six to eight small (1.5 mm) gutta-percha markers were randomly inserted in the prosthesis surface, acting as radiopaque markers according to double scanning technique.
A silicone radiographic index was prepared and double-CT scan procedure performed: one of the patients wore the prosthesis and the radiography index and the other only the prosthesis. The master cast was duplicated and the teeth removed from the cast to the gingival level. Particular care was taken to leave the gingival margin intact

around them. Diagnostic probing to the osseous crest of the hopeless tooth at the interproximal, buccal, and palatal aspects was performed and accurately transferred to the cast. A wax-up of the teeth in the corrected final position was then completed providing valuable information to the clinicians when planning the depth level of the implant shoulder. If the teeth that need extraction were misaligned or flared in the arch, the wax up of the ideal final prosthetic position served as guide for modification of the double piece radiographic guide before CT scan as reported by Cantoni and Polizzi.23 The ideal profile of the prosthetic restoration was visualized in the software during virtual planning suggesting the correct implant angulation.

Vestibular borders had to be extended until the fornix bypassing the undercuts determined by the flared teeth. These hyper-extended borders allowed us to support a sufficient number of pins and a sufficient amount of resin to underpin the metal cylinder in correspondence to the post-extraction sites.

The patient underwent a CT scan before the extractions of the hopeless teeth wearing the radiographic guide as per standard protocol. The DICOM files obtained from the CT scan contained data regarding the anatomy of the patient's jaw and the ideal teeth positions with the correct prosthetic plan.

The two different sets of axial CT slices were processed with Procera planning software (ProceraCadDesign, Nobel Biocare AB, Goteborg, Sweden) and fused on the basis of radio-opaque markers. In such way, the surgeon was able to perform virtual planning of ideal implant insertion for each patient with a clear vision of the prosthetic result to be achieved.

Software planning and ordering of two drilling templates

The clinicians were able to place implants in ideal positions from a prosthetic and surgical point of view in the software. Implants were virtually placed in the healed sites in a standard way; in the planned extraction sites, implants were planned in a palatal position in order to obtain the maximal primary stability for the fixture at the time of surgery and 2.5– 3 mm below the coronal aspect of the buccal plate. Extraction sites were accurately chosen. The sites had preserved buccal plate and a good volume of residual bone (at least 3 mm) apical to the teeth, which had to be extracted. The selected patient had at least one implant inserted in a healed site.

In maxillary sites, implants were planned to engage the sinus or nasal floor cortical plate. When choosing implants, diameter was a consideration: <2 mm implants were selected to reduce the gap between the implant surface and the buccal plate to the minimum in order to avoid the use of grafting materials. All implants were planned in the right distribution across the arch and in a sufficient number to allow an immediate loading protocol. In addition, implants were planned parallel to each other both on the front and sagittal plan to facilitate the adaptation of the prosthesis.

A minimum of 3–4 anchor pins were planned on the buccal aspect and one or two anchor pins on the palatal/lingual aspect to gain good stability of the templates and prevent bending movements in the mouth during surgical procedures.

Two planning data were performed for each patient: one with implants placed in both healed and post-extraction sites and another with implants inserted only in the healed sites. These data were sent to Nobel Biocare Company (Goteborg, Sweden) and two drilling templates per patient were fabricated. The first guide as well as the buccal and palatal/lingual anchor pins were planned (Figure 3). This plan was approved in the software and the drilling template, which corresponds with the post-extractive template, was visualized, checked, and ordered. To produce the second guide, only

the implants in the healed sites and the anchor pins previously placed were left, the new planning was approved and ordered (Figure 4).
The shape of the mucosal part of the two guides was the same and the anchor pins had the same number and position as well as the same sleeves corresponding to the implants inserted in healed sites (Figure 5). The template with the sleeves only for the healed sites was used first as a pre-extractive template. It was very stable in the patient's mouth because it was supported by residual teeth. Implants were placed in the healed sites using a standard protocol. These were used as reference implants for the re-positioning of the second template after teeth removal. The second post-extractive template, having the corresponding position of the anchor pins, was accurately repositioned and stabilized in the right tridimensional position in the mouth secured to the reference implants by Template Abutments (Nobel Biocare AB, Goteborg, Sweden).

Pre-surgical laboratory procedures
Once the two surgical templates arrived, the first pre-extractive template was checked on the first model to detect any interference between the guide and the model (Figure 6). The guide has only the sleeves corresponding to the "reference implant" inserted in the healed sites. It was checked in the patient's mouth prior to the surgery.
The second surgical post-extractive template was verified on the stone model simulating the extraction of the remaining teeth. Any interferences between the guide and the stone model with the extracted teeth were accurately detected. The sleeves and the surrounding resin often interfere with soft or hard tissues. Wherever possible, this interference was removed taking off some resin and avoiding to touch the metallic cylinders to avoid any damages. Any interferences of soft or bone tissue were removed from the cast and accurately communicated to the clinician who will remove the same tissue during the surgery before seating the second surgical template.
Before removing any parts from the stone cast, it was duplicated before to avoid information losses on the shape of the soft tissue. After these procedures of interference removal, the second guide fit perfectly with the stone model. Guided cylinders and implant analogues were secured to the guide, and after perforating the stone model with intact tissues, analogues were placed into the master cast by the guide. Full provisional prostheses made of titanium–acrylic resin were pre-fabricated on the base of the post-extractive surgical template once adapted to the master cast.

Surgical procedure
Periodontal compromised patients were treated with scaling, root planning, and periodontal surgery at least 3 months before implant placement. Patients were all administered with local anesthesia (4% articaine hydrochloride with adrenalin 1:100 000), intravenous sedation (a fractioned administration of 0.5–1 mg Midazolam and 0.5 mg atropine) and antibiotic therapy (1 g Ceftriaxone intravenously). All patients rinsed with chlorhexidine–gluconate 0.2% for 1 minute prior to surgery.
The first drilling template (pre-extractive template) was seated in the mouth and fixed to the jaw-bone by anchor pins. The stability of the template was previously tested. Circular incisions were made through the template in the mucosa using a motor driven punch or a Canterbore drill (Nobel Biocare AB, G€oteborg, Sweden) provided by the manufacturer. The soft tissue was carefully removed. In cases in which fixed gingiva was poorly represented, no punch or Canterbore drill was used while mini-flaps were elevated. Drills with increasing diameter were used to prepare the implant osteotomies with the aid of removable sleeves of different diameter, as per the instruction from the

manufacturer. Based on the virtual planning, one or more fixtures were inserted through the first surgical template (Figure 7A). Once these first implants were inserted, the first surgical template was removed and all the planned extractions were performed in an atraumatic way in order to preserve integrity of the alveolus walls. An accurate alveolar bone curettage was performed to remove granulation tissue and soft tissue remnants. A periodontal probe was used to evaluate the integrity of the buccal plate of the post-extraction sockets.

At this point, the second surgical template (post-extractive template) was inserted and fixed with the anchor pins in the same position of the first guide (Figure 7B) and with expansible template-abutments screwed onto the fixture previously inserted in the healed sites. This technique allowed the surgeon to replace and stabilize the second drilling template in the same position of the previous one following planning accurately. Implant sites were then prepared in fresh extraction socket using sleeves and drills of varying diameters as previously described. To ensure primary stability, the drilling protocol included under-preparation with drills of 2.8 or 3 mm according to bone density found in the sites.

Screw-tapping was performed in presence of very dense bone (D1) and countersinking was done in some cases to eliminate crestal bone interferences to avoid compromising good seating of the prefabricated prosthesis. All implants were inserted using a torque controller (Osseocare, Nobel Biocare AB, G€oteborg, Sweden) and with a maximum of 35 Ncm. Excessive insertion torque can compromise the procedure producing undesirable implant deviations leading to loss of accuracy. All implants had a guided insertion trough the guide (Figure 7C) and all the pre-fabricated prosthesis were screwed onto the implants at the end of the surgery (Figure 7D–F). A panoramic radiograph was done at the end of the surgery to identify any misfits of the prosthesis (Figure 7G); clinical photos were taken to document occlusion (Figure 7H).

Post-operative care

Ice packs were provided and a soft diet was recommended for 1 month. Smokers were invited to avoid smoking for at least 1 week after operation. Oral hygiene and post-operative home care instructions were provided and the patient was dismissed under antibiotic and anti-inflammatory therapy for 1 week (granular ibuprofen 600 mg twice a day and amoxicillin associated to clavulanic acid 1 g twice a day). Chlorhexidine di-gluconate 0.12% mouthwash was prescribed for the chemical plaque control twice a day for 2 weeks.

Clinical and radiological follow-up protocol

Periapical radiographs (Figure 8) were done at implant insertion (baseline) and then at 6, 12, 24, and 36-month interval to evaluate marginal bone loss around implants. A long cone periapical x-ray was performed by using polyvinylsiloxane positioning jig to guarantee same film positioning.

An independent radiologist analyzed radiographs. After 3 months, a clinical examination was performed to check implant mobility, absence of pain, paresthesia, peri-implant bleeding, and infection with suppuration.

Changes in marginal peri-implant bone level were defined as modification of the distance between the implant–abutment junction and the highest bone implant contact. The measurement was rounded off to the nearest 0.1 mm.

A Peak Scale Loupe (Peak Optics, GWJ Co., Hacienda Heights, California) with a magnifying factor of 79 and a scale graduated in 0.1 mm were used. Measurements

were taken mesially and distally and then averaged for each implant. Each radiograph was calibrated by using the known length of the implant as a reference.

Statistics

The statistical analysis was performed by an independent statistician using StataCorp. 2015 (Stata Statistical Software: Release 14, Stata- Corp LP, College Station, Texas). Descriptive analysis was performed calculating mean, standard deviation, and frequency distributions for the outcome variables. The single implant was used as the statistical unit of the analysis. Tables of implant cumulative survival rates (CSRs) were calculated. An analysis of variance (ANOVA) was conducted among implants to compare the effect on marginal bone loss over time (comparing bone remodeling between extraction and healed sites at all five time points: baseline, 6, 12, 24, and 36 months) in both healed versus extraction sites, using Bartlett's test for equal variances. The level of significance was set at 5%.

RESULTS

The reason for tooth extractions reported in Table 1 A total of 285 implants in 32 patients were assessed. The patients were clinically and radiologically followed for 3 years. One hundred and ninety-five implants were placed in the maxilla and 90 in the mandible. Eight patients received implant insertion in both arches. One hundred and ninety-seven implants were placed in extraction sites (137 maxilla, 60 mandible) and 88 in healed sites (58 maxilla, 30 mandible) as shown in Table 1.

Ninety-five were MKIII Tiunite implants (59 healed sites and
36 post-extraction sites), 87 were NobelActive (21 healed sites and 66 post-extraction sites), 83 were Speedy Groovy (45 healed sites and 38 post-extraction sites), 20 Nobel Replace (7 healed sites and 13 post-extraction sites).

Five implants in four full-arch patients failed. The overall implant CSR was 97.54% (Table 2). Two implants failed in maxillary healed sites (CSR 96.55%), three in maxillary (CSR 97.81%), and two in mandibular extraction site (CSR 96.66%), while no implant failed in mandibular healed sites (CSR 100%). All fixed prostheses maintained stable and good function during the follow-up, accounting for a prosthesis CSR of 100%. Sixteen patients were treated only in the maxilla, seven patients only in the mandible, and nine patients received a full-mouth rehabilitation in both arches, with a total of 25 maxillary prosthesis and 16 mandibular prosthesis (a total of 41). The fixed screw-retained bridges consisted of Procera Implant Bridge in zirconium–porcelain (41.46%), 6 in the mandible and 11 in the maxilla; Procera Implant Bridge in titanium (41.46%), 7 mandible and 10 maxilla. The remaining arches treated were provisionally fixed-bridges with acrylic teeth and metal-reinforced framework for a total of 2 in the mandible and 4 in the maxilla (n56, 14.63%). Failures of the maxillary healed site implants occurred after 2 years in one patient (patient no. 16) and after 3 years in another patient. The reason for failure was progressive bone loss. No implant replacement was made as the prosthesis was well supported by the remaining implants. The three failures in maxillary extraction sites and the two failures in mandibular extraction site were detected after 6 months. These implants failed to osseointegrate as noticed when provisional restoration was removed to take the impression for final prosthesis fabrication. They were successfully replaced and included in the final prosthesis.

Marginal bone level

In the healed sites, the mean marginal bone level was 20.35 mm at the baseline, 20.49 mm after six months, 20.87 mm at 12 months, 21.04 mm at 24 months, and 21.31 mm at 36 months. In the extraction sites, the mean marginal bone level was 20.94 mm at the baseline, 20.53 mm at six months, 20.89 mm at 12 months, 21.06 mm at 24 months, and 21.33 mm at 36 months (Figure 9).

The overall marginal bone resorption was 20.52 mm (SD 20.18) after 6 months, 20.88 mm (SD 20.20) after 12 months, 21.05 mm (SD 20.21) after 24 months, and 21.32 mm (SD 20.41) after 36 months (Table 3).

The ANOVA revealed a statistically significant difference between healed and extraction sites at the baseline (P5.0001) but no statistically significant difference between the two groups at 6 (P5.052), 12 (P5.376), 24 (P5 .542), and 36 months (P5.721).

The reason for the difference measured of the post-extractive implants at the baseline, can be explained by the placement of this implants in empty sockets. Therefore, the distance between the abutment (connection junction) and the first bone-implant contact is more apically, in order to achieve primary implant stability, compared with the implants placed in healed sites, which are placed at the bone crest level.

At 6 months, 97.5% of implants inserted in the post-extraction sites and all implants inserted in healed sites showed a marginal bone level between 20.1 and 21 mm. At 12 months, 70.1% of post-extractive implants and 64.8% healed sites showed a marginal bone level between 20.1 and 21 mm, while 29.9% of post-extractive implants and 64.8% healed sites showed a marginal bone level between 21.1 and 22.0 mm. At 36 months, the overall marginal bone level was between 20.1 and 21.0 mm in 26.3% and between 21.1 and 22.0 mm in 67.7%, only 6% of all implants showed a marginal bone level between 22.1 and 23.0 mm. No implant showed a marginal bone level>23 mm (Table 4).

DISCUSSION

The results of this study indicate that rehabilitation of edentulous jaws through surgical planning, fabrication of customized surgical templates and pre-fabricated prosthesis using computed tomography 3- dimensional implant planning software, CAD-CAM technology, and flap-less surgery applied to immediate loading is a reliable and predictable treatment even in post-extractive cases. The 97.54% overall cumulative survival rate achieved for a follow-up of 36 months compares favorably with other flap or flap-less “hand-made” immediate function protocols in fresh extraction sockets reported in the literature.15–21

Although the conventional protocol still represents the gold standard, some recent reviews show excellent implant prognosis for immediate restoration of implants placed in fresh extraction sites.25,26

Very few data are available in the literature regarding computer assisted implant placement in fresh extraction sites. However, a limitation of our study is represented by the analysis applied, considering the implants as not independent.

In 2009, Cantoni and Polizzi23 reported a novel two-piece radiographic guide to avoid patients waiting after teeth extraction for a variable healing time of at least 6 months and having to wear a removable denture that will cause the patient discomfort and social unease.

The technique reported by Cantoni and Polizzi was limited by the use of a single surgical template whose shape was based only on information from the second CT scan of the two-piece radiographic guide.

Therefore, the surgical template cannot be tried in the mouth until the hopeless teeth are extracted. This can only be done at the same time as the implant surgery.
Using this protocol with a single surgical template would make stabilization of the template very difficult when multiple extraction and immediate implants placement are planned. Deviation of the implants from the planned position would represent the main issue with impossibility to apply the prefabricated prosthesis at the end of the surgery.
Polizzi and Cantoni27 proposed a slight modification of the technique in the extraction sites. Since the sleeves used for the drill guides could interfere with the correct position of the correspondent surgical guide after tooth extraction, they planned the sleeves completely inside the radiographic template to avoid any interference between the guide and the soft/hard tissue. In order to get an optimal position, an extended depth over-drilled site preparation was made in the post-extractive sites based on the measurements of the vertical discrepancy between the planned and final implant position. The final deeper insertion after the removal of the surgical stent was achieved manually.
Therefore, the authors had to compensate for this vertical discrepancy by injection of cold-cure acrylic resin between abutments and the framework of the provisional prosthesis.
The technique presented here has aimed the elimination the interference between the template and the plaster model. The combination of the double surgical templates allows a full-guided implant placement with the insertion of a pre-made prosthesis with rigid framework without need for any compensation.
Despite these problems, the authors reported a high cumulative survival rate (97.33%) with 21.39 mm (SD 21.88) marginal bone loss for implants placed in both extraction and healed sites upon follow-up at 5 years.27
Using an implant planning software is advantageous: it is possible to place implants virtually prior to surgery finding a correct position not only in healed but also in extraction sockets anticipating the dynamic bone level changes occurring due to natural healing process after tooth extraction.
In our case, it was possible to choose long implants because in post-extractive sites only the apical part of the implant is anchored to the residual bone. In this way, the implant primary stability may be reached, even in critical situation and might be improved by under-preparation of the implant sites and/or by the splinting effect of the prefabricated prosthesis.
The splinted implants provide mutual support, which may resist prostheses mobility, thus, stabilizing the individual implants.
The technique described in this paper requires us to make an analysis. First, it is important to discuss the optimal number of implants. In terms of primary stability, we could use the term “minimal number of implants” and “maximal number of implants” for postoperative maintenance.
Second, primary stability balanced with accuracy in implant placement is an important topic. The higher the primary implant stability, the higher the risk of losing accuracy due to deviation of the implant direction and misfit in the pre-fabricated supra construction.
These risks can be avoided by using a screw tap prior to the placement of the implant.
At the Consensus conference on immediate loading held in Barcelona in 2002,7 it was stated that the minimal implant length would be 10 mm regardless of implant diameter or design. Considering that the implant is placed in an extraction socket, only the very apical part will be in bone. To compensate, longer implants should be used and the number of implants should be increased.

Another reason to increase the number of implants in the anterior maxilla is to maintain the soft tissue contour which will be preserved by the implant placed directly after the dental extraction. Implants placed in extraction sockets result in an optimal 3-dimensional position and maintain an optimal soft tissue profile. The implants should be planned for a parallel placement in order to ensure easy fitting of the restoration as well as a good oral hygiene for the patient.

A crucial factor is the correct selection of the macro-implant fixture design. Despite the fenetal trend of using tapered implants, in this study, parallel-walled implants were used as they are easier to place in guided insertion especially when the quality and the amount of residual bone prove good. In cases where the density and/or the residual bone volume is low, such as in extraction sites, implants with more aggressive macro-design exploiting the self-tapping capacity of fixtures as Speedy Groovy and the Nobel Active are preferred.

This technique included flapless surgery, since it has been demonstrated that immediate implant placement in fresh extraction sockets without incisions or flaps elevation ensures ideal peri-implant tissues healing, minimizing crestal bone loss preserving the pre-surgical gingival and bone aspects.17,28,29

When the buccal plate is preserved, the buccal gingiva contour may be maintained and immediate flapless implant placement protocol may be followed, in spite of the presence of periodontal or endodontic lesions.

Software 3-dimensional planning plays a key role in assessing the integrity and thickness of buccal cortical as well as even the virtual positioning system allows us to manage the correct orientation of the fixtures evaluating the proper relationship between implant diameter and distance between implant and cortical buccal plate.18,30,31

The relatively low mean marginal bone loss observed in this study in the extraction sites may be attributed to flapless computer-guided implant placement that keeps the circumferential gingival fibers intact and ensures less disruption of the blood vessels supplying the buccal plate hard tissue.

Therefore, the soft tissue healing resulted clinically in a good esthetic outcome with a scalloped soft tissue profile and with papillae filling the available interproximal spaces. In addition, the radiographical analysis indicated that with a flapless approach, the bone remodelling occurred in the first 6 months while, as previously reported, it does not stabilize until 1 year.18 These findings are in agreement with Schropp and colleagues.32and Botticelli and colleagues 33 who demonstrated the most of bone remodeling occurs 3–6 months after tooth extraction.

An important issue that may emerge in the use of the reported technique is the interference of bone structures, especially where there is a large discrepancy between the direction of the extracted teeth and the planned final direction of the implants. This marginal bone needs tobe removed before the abutment elements or supra construction will be placed.

CONCLUSIONS

The double-template (DT) technique reported here allowed to shorten treating time with decreased patient discomfort, provide precise virtual planning, ensuring predictability in placing implants both in post-extractive and healed sites while having a minimally invasive surgery.

This study shows that transferring the virtual planning to the surgical field provides accuracy allowing to fit the pre-fabricated prosthesis onto the implants at the very end of surgery.

However, due to the complexity of the procedure, it should be used by experienced operators. Accurate diagnosis, appropriate treatment software planning, and meticulous handling of the laboratory phases are essential in achieving predictable results. In addition, guided implant placement involves additional costs over conventional placement (the software, CT scans, the surgical templates, laboratory, and planning time). Finally, further longitudinal comparative studies should be conducted to validate this technique and its success rate.

CONFLICT OF INTEREST

This study was not supported by any company and all the authors have not conflict of interest.

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