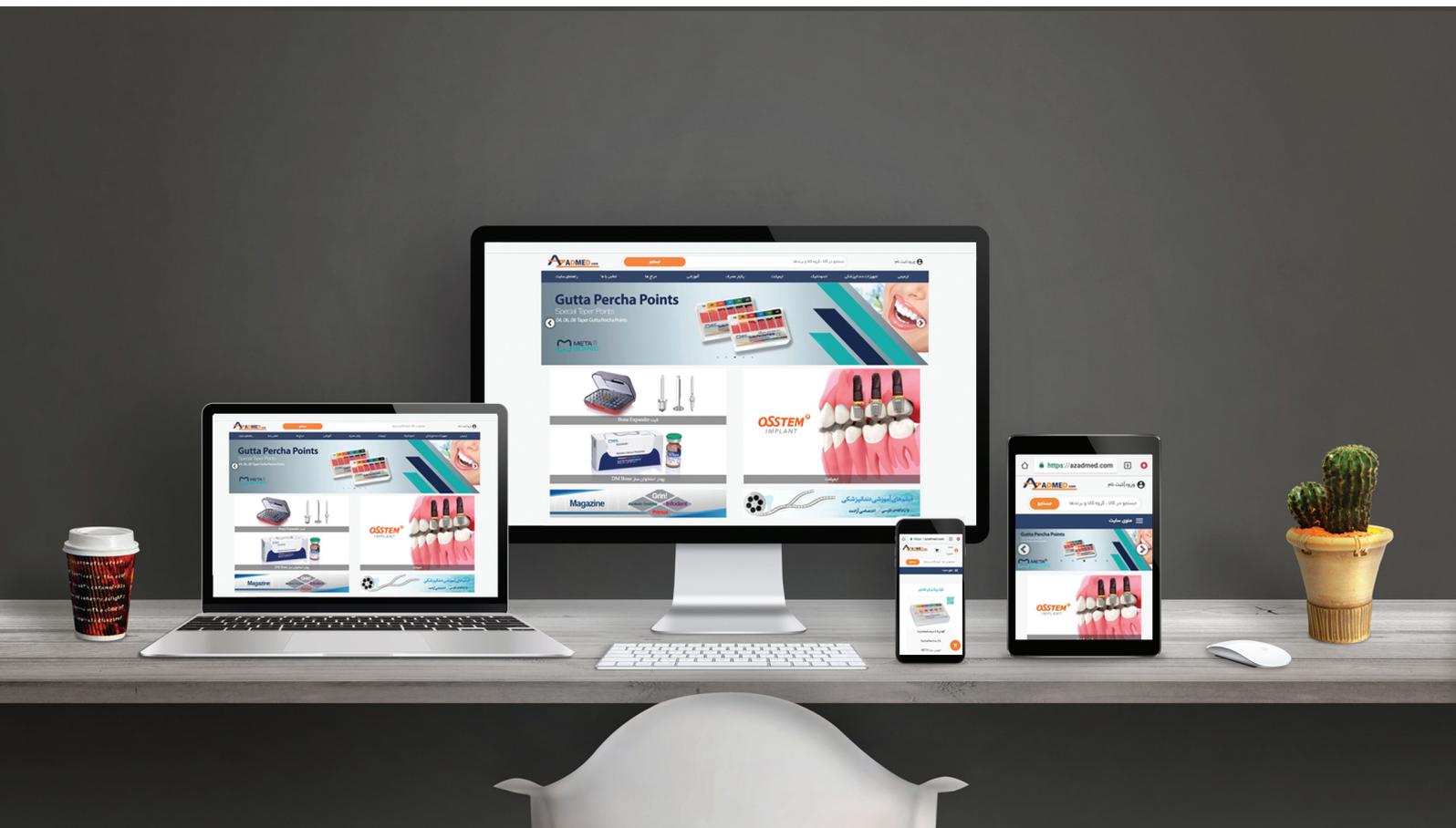




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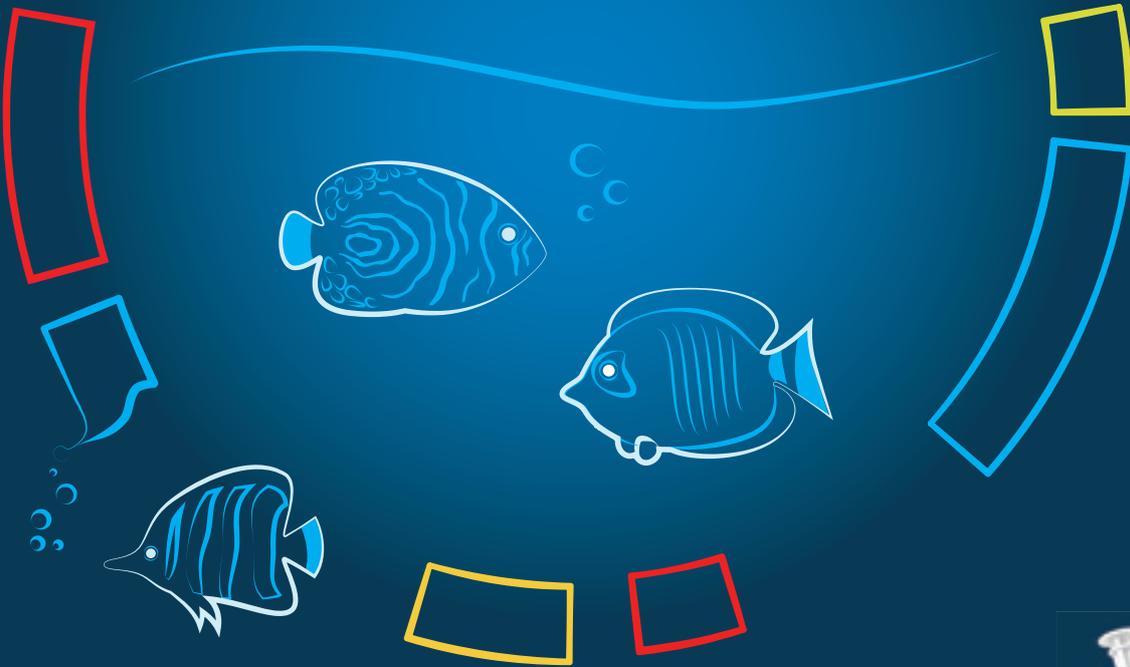
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New perspectives in periapical surgery

Periapical surgery has long been performed in patients with periapical disorders. The massive introduction of dental implants in dental practice has not displaced periapical surgery, which remains the first treatment option in the case of teeth amenable to recovery and is preferable to implant placement.

A new scenario has emerged in periapical surgery with the introduction of novel retrograde filler materials, finer and more precise surgical instruments, and endoscopic and microscopic surgical field illumination and magnification. In effect, it is now possible to eliminate the periapical lesion while preserving the causal tooth, with high long-term success rates.

Despite this, however, there is a notorious lack of clinical documentation on periapical surgery presented at courses and congresses and published in scientific journals compared with the cornerstone in dental practice today: implantology.

It is worth knowing that, in many cases, teeth that are to be removed and replaced with implants could in fact be preserved. In this regard, the technical advances in periapical surgery are able to improve the quality of life of our patients and help them keep their teeth.

Dr. Miguel Peñarrocha Diago
Co-Editor

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Dr. Miguel Peñarrocha Diago

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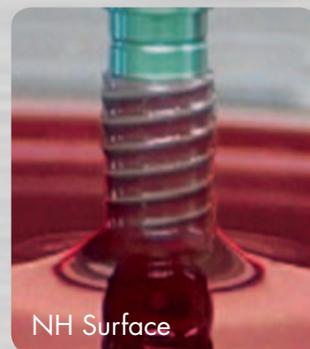
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Accuracy of computer-assisted template-based implant placement using a conventional impression and scan model or digital impression: A preliminary report from a randomized controlled trial

Abstract

Objective

The objective of this study was to compare implant survival rate, template-related complications and virtual planning accuracy of computer-assisted template-based implant placement using a conventional impression and scan model or digital impression to rehabilitate partially edentulous patients using flapless or miniflap procedures and immediate loading.

Materials and methods

Any partially edentulous patients requiring at least one implant, to be planned on the basis of cone beam computed tomography (CBCT) scans using dedicated software, were enrolled in the trial. Patients were randomized according to a parallel-group design into two arms: intraoral digital impression (fully digital group) versus conventional impression and scan model (control group). Implants were to be placed flapless and loaded immediately, if inserted with a torque over 35 N cm, with reinforced provisional prostheses. Three deviation parameters (horizontal, vertical and angular) were defined and calculated between the planned and placed implant positions and analyzed statistically. Results were compared using a mixed-design repeated-measures analysis of variance model ($\alpha = 0.05$).

Results

Twelve patients were randomized to the fully digital group (6 patients with 17 implants) and control group (6 patients with 20 implants). The mean error in angle was $2.56 \pm 1.52^\circ$ (range: $0.3\text{--}5.0^\circ$) in the fully digital group and $2.18 \pm 1.41^\circ$ (range: $0.3\text{--}5.8^\circ$) in the control group ($P = 0.519$). In the horizontal plane (mesiodistal), the mean error was 0.57 ± 0.32 mm (range: $0.1\text{--}1.1$ mm) in the fully digital group and 0.43 ± 0.26 mm (range: $0.1\text{--}0.9$ mm) in the control group ($P = 0.249$). In the vertical plane (apico-coronal), the mean error was 0.67 ± 0.51 mm (range: $0.0\text{--}1.6$ mm) in the fully digital group and 0.43 ± 0.32 mm (range: $0.0\text{--}1.2$ mm) in the control group ($P = 0.180$).

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Conclusion

Within the limitations of the present randomized controlled trial, it was found that intraoral digital impressions may be a viable alternative to conventional impressions and scan models for the rehabilitation of partially edentulous patients using computer-guided template-assisted implant placement.

Keywords

Intraoral scanner, digital impression, guided surgery, accuracy, dental implants.

Introduction

Proper implant position has a significant impact on the esthetic and functional outcomes of implant-supported restorations.^{1,2} Therefore, the implant must be placed accurately according to the treatment plan. Computer-assisted template-based implant placement (guided surgery) has become increasingly popular owing to improved planning and the higher transfer accuracy of the virtual plan to the surgical site compared with freehand insertion or freehand final drilling.³ Hence, it has undoubtedly been a major achievement to provide optimal 3-D implant positioning with respect to both anatomical and prosthetic parameters, as well as higher patient satisfaction.⁴

A recently published meta-analysis of *in vitro* and *in vivo* studies found a total mean error of 1.12 mm at the entry point and 1.39 mm at the apex.⁵ The accuracy of computer-assisted template-based implant placement depends on several factors, from data set acquisition to the surgical procedure. Originally, guided surgery protocols advocated a dual-scan protocol.⁶ In recent years, new technologies combining data from computed tomography (CT) or cone beam computed tomography (CBCT) images with information on the soft tissue and crown morphology have been developed. Dedicated software allows for accurate virtual implant planning, always based on the prosthetic volume of the teeth to be rehabilitated and making immediate loading easier.^{4,7-9} Surgical guides may be produced by computer-aided design/computer-aided manufacture technology, such as stereolithography, manually in a dental laboratory or by high-resolution 3-D printer. Finally, irrespective of the method of manufacture, the optimal fit of the surgical template and its

stabilization are essential to accurately transfer the virtual implant position to the patient's mouth.

Digital impressions replace the need for conventional materials that can be inconvenient and messy for patients. Today, there is no doubt about the potential of recent intraoral optical impression systems available on the market as regards diagnosis and the treatment plan. Particularly noteworthy is the complete integration with other digital technologies to provide for accurate and faster patient-centered health solutions.^{10,11} Nevertheless, to the best of our knowledge, at the time of writing this article, there were no other published randomized clinical trials evaluating a fully digital approach to computer-assisted template-based implant placement.

The aim of the present study was to compare implant survival rate, template-related complications and virtual planning accuracy of computer-assisted template-based implant placement using a conventional impression and scan model or digital impression. The null hypothesis was that there would be no difference between these interventions. This trial is reported in accordance with the CONSORT Statement for improving the quality of reporting of parallel-group randomized trials.¹²

Materials and methods

This study was designed as a randomized controlled trial of parallel-group design conducted at a private center in Rome, between May 2016 and March 2017. Surgical and prosthetic procedures were performed by one expert clinician (MT). To the best of our knowledge, at the time of writing this article, there were no other similar

Fig. 1



Fig. 1
Intraoral digital impression
in the fully digital group.

Fig. 2



Fig. 2
Conventional impression,
wax-up and scan model in
the control group.

studies, not allowing for a true sample size calculation. Hence, it was decided to publish preliminary results with 12 patients.

Partially edentulous patient aged 18 years or older, able to sign an informed consent form and in need of an implant-supported fixed restoration was considered eligible for this study. Any potential implant locations based on individual patient requirements were considered eligible in the present trial. No set location or group of locations was excluded.

Patients were not admitted to the study if any of the following exclusion criteria were present: general medical contraindication to oral surgery (American Society of Anesthesiologists [ASA] Physical Status Class III or IV), irradiation of the head and neck area less than 1 year before implantation, psychiatric problems, alcohol or drug abuse, pregnant or nursing, untreated periodontitis, severe bruxism or clenching, uncontrolled diabetes, poor oral hygiene and motivation, and inability to complete the follow-up. The investigation was conducted according to the principles embodied in the Declaration of Helsinki of 1975 for biomedical research involving human subjects, as revised in 2008. All of the patients were informed about the nature of the treatment and their written consent was obtained. Data collection was designed to preserve patient anonymity.

All of the patients received preoperative photographs, periapical radiographs or panoramic radiographs for initial screening and evaluation. The prosthetic-driven planning workflow started with taking a CBCT scan (CRANEX 3Dx, SOREDEX, Tuusula, Finland) of the enrolled patient, using a wax bite to separate

the dental arches. The next step was to create a digital model, accomplished in two ways: the clinician used an intraoral scanner to create a digital impression (**Fig. 1**), or the clinician took a conventional impression and then scanned the impression using an extraoral scanner (**Fig. 2**). Patients were randomly assigned to undergo intraoral digital impressions (fully digital group) or conventional impressions (control group). In the fully digital group, a digital impression was taken using a CS 3600 intraoral scanner (Carestream Dental, Atlanta, Ga., U.S.). The digital data (STL interface format) were imported into 3-D design software (exocad DentalCAD, exocad, Darmstadt, Germany) to realize a virtual wax-up according to the functional and esthetic requirements. In the control group, a polyether impression (Impregum, 3M ESPE, Seefeld, Germany) was taken with a customized tray (Diatray Top, Dental Kontor, Stockelsdorf, Germany). The impressions were poured with Type IV Gypsum (T6, Techim Group, Arese, Italy) and then the models were mounted in a fully adjustable articulator (PROTARevo 7, KaVo Dental, Biberach, Germany). Afterward, a dental wax-up was produced according to the functional and esthetic requirements. Finally, the master cast and wax-up were digitalized using a laboratory scanner (Sinergia-Scan, Version 2016 Plus, Nobil-Metal, Villafranca d'Asti, Italy).

In both groups, the STL and DICOM data were imported into a 3-D software planning program (3Diagnosis, Version 4.2, 3DIEMME, Cantù, Italy). Then, the reprocessed surface extrapolated from the DICOM data (using a Hounsfield scale filter) and the surface generated by the master cast scanning process or by the intraoral scanning process were merged

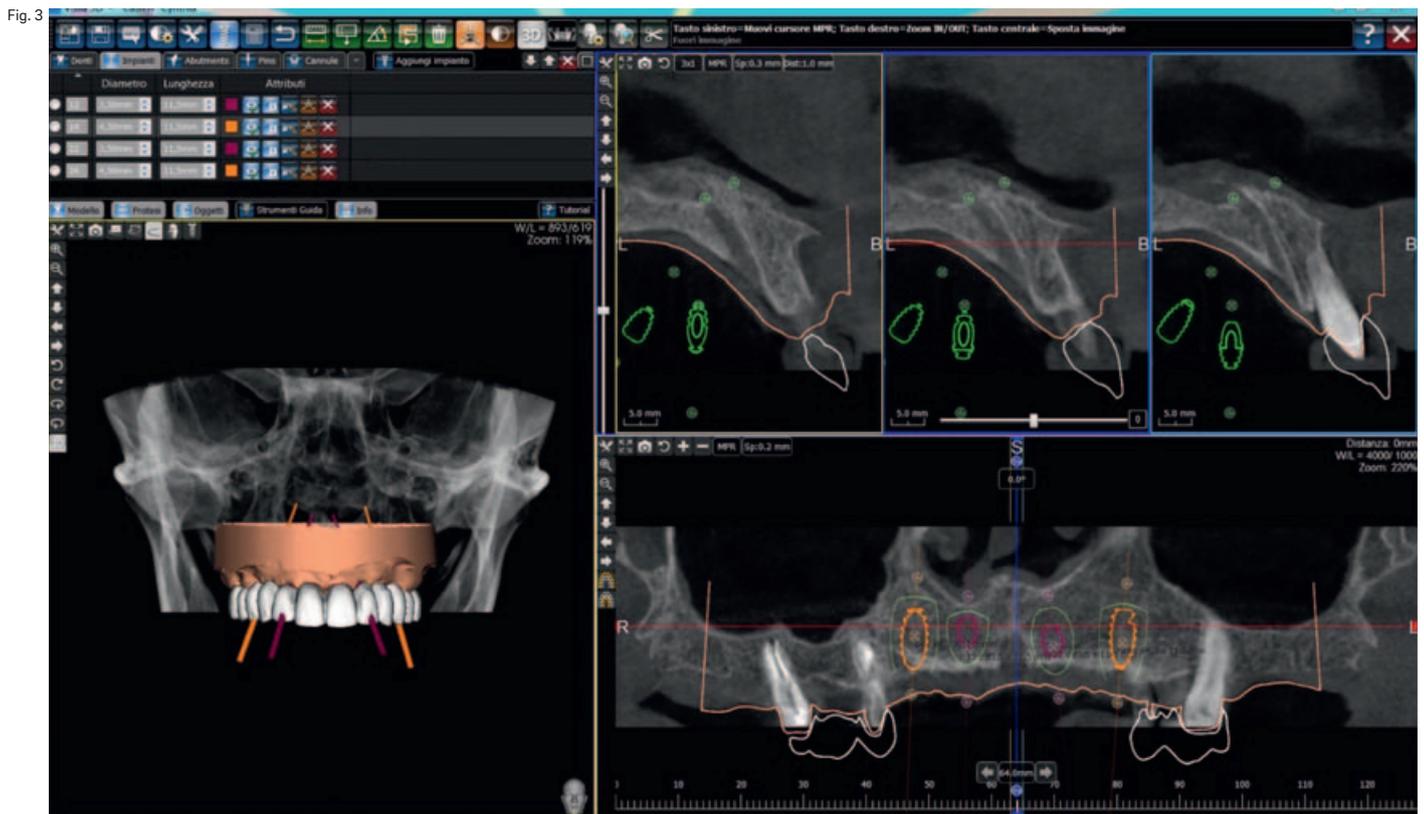


Fig. 3

using the software's best-fitting repositioning tools. At this point, the size and location of prosthetic-driven implants/abutments were planned, taking into account the bone quality/quantity, soft-tissue thickness, anatomical landmarks, and the type, volume and shape of the final restoration (**Fig. 3**). After careful functional and esthetic evaluation and final verification, the prosthetic-driven plan was approved, and a stereolithographic surgical template was fabricated with a newer rapid prototyping technology (New Ancorvis, Bologna, Italy).

One hour before implant placement, all of the patients underwent professional oral hygiene, used a prophylactic antiseptic containing 0.2% chlorhexidine (CURASEPT, Curaden Healthcare, Saronno, Italy) for 1 min and received prophylactic antibiotic therapy (2 g of amoxicillin or 600 mg of clindamycin if allergic to penicillin). In the control group, the accurate fit of the surgical templates was tried on the master model and tested in the patient's mouth, while in the fully guided group, the fit of the surgical template was tried directly in the patient's mouth to fit (Fit Checker, GC, Tokyo, Japan). All of the patients were treated under local anesthesia using articaine with 1:100,000 epinephrine, administered 20 min before surgery. The surgical

template was stabilized in relation to the opposing arch using a silicone surgical index, derived from the mounted casts (control group) or from the virtual plane (fully guided group), and two to four preplanned anchor pins.

Hopeless teeth were extracted after implant placement in order to improve the stability of the surgical template and to align the pre- and post-surgical scans. In the case of immediate post-extractive implants, residual teeth were extracted as atraumatically as possible immediately before surgery. Residual gaps were filled using a synthetic hydroxyapatite enriched with magnesium (SINTlife, Finceramica, Faenza, Italy) or with beta-tricalcium phosphate (Q-Oss+, Osstem, Seoul, South Korea). Sinus lift procedures were performed using minimally invasive transcresal sinus floor elevation (Crestal Approach Sinus KIT, CAS-KIT, Osstem).¹² The bone graft material was based on autogenous bone collected at the implant site, combined with a synthetic hydroxyapatite enriched with magnesium (SINTlife) or with beta-tricalcium phosphate (Q-Oss+).

Planned implants (Osstem TSIII, Osstem) were placed flapless or with a minimally invasive flap using dedicate drills (OsstemGuide Kit [Taper], Osstem), according to a fully guided

Fig. 3

Merging of CBCT, DICOM and STL files. Frontal and cross-sectional views of virtual implant planning used to create the surgical templates.

Fig. 4



Fig. 4
Dental panoramic tomogram taken 1 year after loading.

Fig. 5



Fig. 5
Frontal photograph taken 1 year after loading.

protocol. Implant sites were prepared based on the bone density evaluated by the surgeon at the first drilling. In the case of poor bone density, the implant site was underprepared.¹² All of the implants were inserted with a minimum insertion torque of 35 Ncm and were immediately loaded at implant or abutment level. Any flaps were then sutured with Vicryl 4-0 sutures (Ethicon J&J International, Sint-Stevens-Woluwe, Belgium). The prefabricated temporary acrylic restorations were trimmed and polished chairside. Single restorations received a nonoccluding occlusal scheme. Multiple-unit implant-supported temporary restorations were splinted together and reinforced using a metal framework.

Immediately after implant placement, patients of both groups received a digital impression (CS 3600), taken at implant level using dedicate abutments (Type AQ scan body, New Ancorvis), to check the position of the placed implants. Afterwards, all of the patients received oral and written recommendations about medication, oral hygiene maintenance and diet. Any sutures were removed 10–14 days later, after local cleaning using an antiseptic agent (0.2% chlorhexidine, CURASEPT, Curaden). Patients were followed monthly for up to one year after implant placement (**Figs. 4 & 5**).

Outcome measurements

– Early implant failure: An implant was considered to be a failure if it was lost owing to mobility, implant fracture and/or any infection requiring implant removal. The stability of each implant was measured manually with a torque of 25 N cm at delivery of the final restoration and later with the prosthesis removed, if needed (infection, extensive periapical bone loss, mucosal inflammation).

– Template-related complications: limited access in posterior areas; buccal bony dehiscence (due to a mismatch of the surgical template), evaluated by sounding the implant site with a periodontal probe (PCPUNC156, Hu-Friedy Italy, Milan, Italy) before implant placement; insertion of a different implant than planned and fracture of the surgical template. All of the complications were recorded during follow-up by the same clinician (MT), who performed all of the surgical procedures.

– Accuracy: Three deviation parameters (horizontal, vertical and angular) were defined and calculated between the planned and placed implant positions (**Fig. 6**). The postoperative STL file, derived from the intraoral scan (**Fig. 7**), was geometrically aligned with the files exported from the planning, by automated image registration using maximization of mutual information (DentalSCAN, Version 6, Open Technologies, Brescia, Italy; **Figs. 8 & 9**). The horizontal (lateral), vertical (depth) and angular deviations between virtual and placed implants was calculated along the long axis of each implant. An expert engineer (FC) performed all of the measurements.

Randomization

One computer-generated restricted randomization list was created. Only one of the investigators, not involved in the selection and treatment of the patients, was aware of the randomization sequence and had access to the randomization lists stored in a password-protected portable computer. The random codes were enclosed in sequentially numbered, identical, opaque sealed envelopes. Envelopes were opened sequentially after eligible patients signed the informed consent forms; therefore, treatment allocation was concealed from the investigators in charge of enrolling and treating the patients.

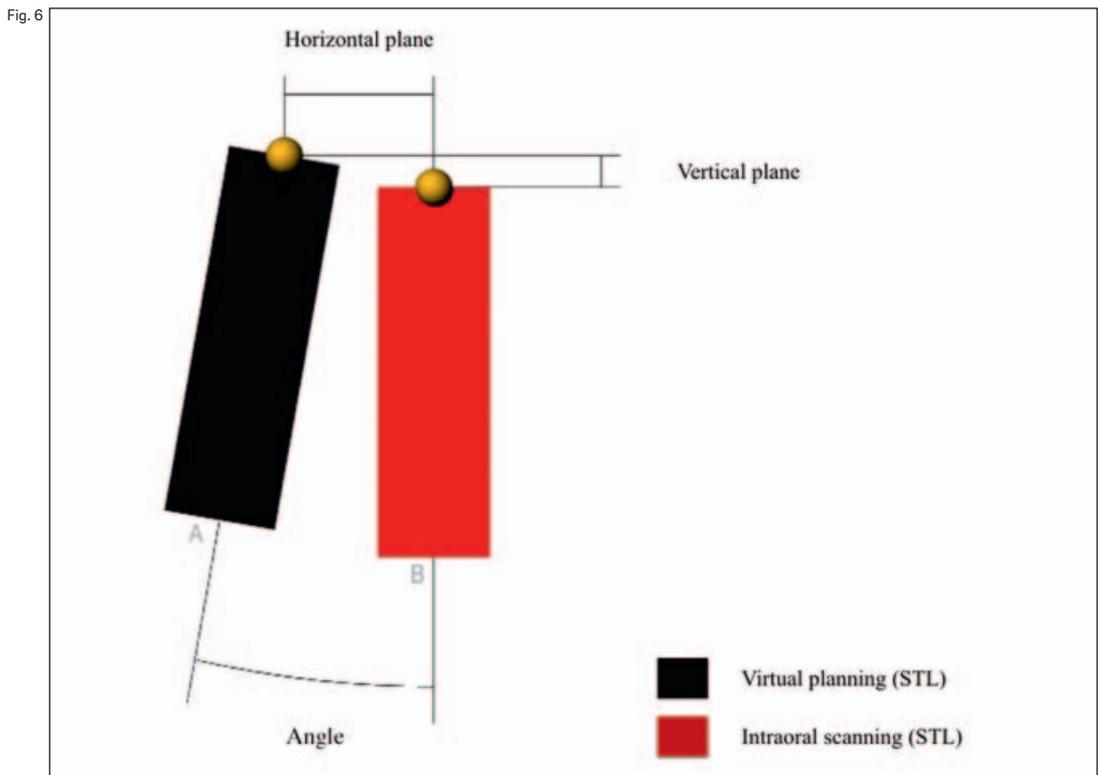


Fig. 6
Schematic diagram of the measurement of deviations between planned and placed implants.

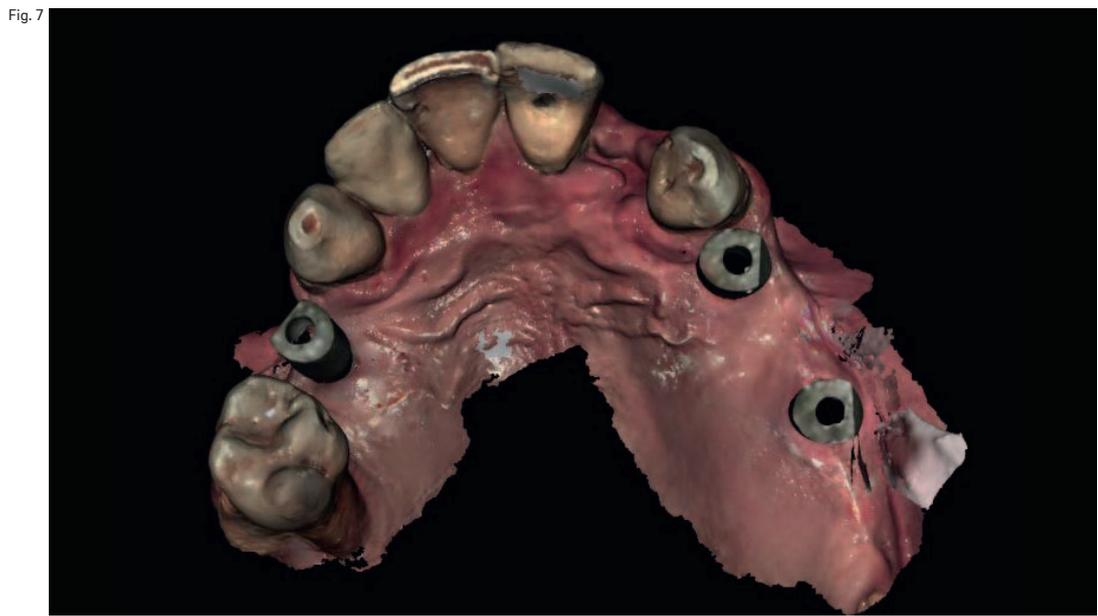


Fig. 7
Postoperative intraoral digital impression.

Statistical analysis

Patient data were collected in a Numbers spreadsheet (Version 3.6.1 for Mac OS X 10.11.4). A biostatistician with expertise in dentistry analyzed the data using SPSS software (IBM SPSS Statistics for Macintosh, Version 22.0, IBM, Armonk, N.Y., U.S.) for statistical analysis. Descriptive analysis was performed for numeric parameters using mean ± standard deviation

and median with a 95% confidence interval. Template-related complications between the two groups were compared using the Fisher exact probability test. The mean differences in the overall deviation in the clinical outcomes compared with the virtual plan were compared between groups using a mixed-design repeated-measures analysis of variance model. All statistical comparisons were conducted with a *P* value set at 0.05.

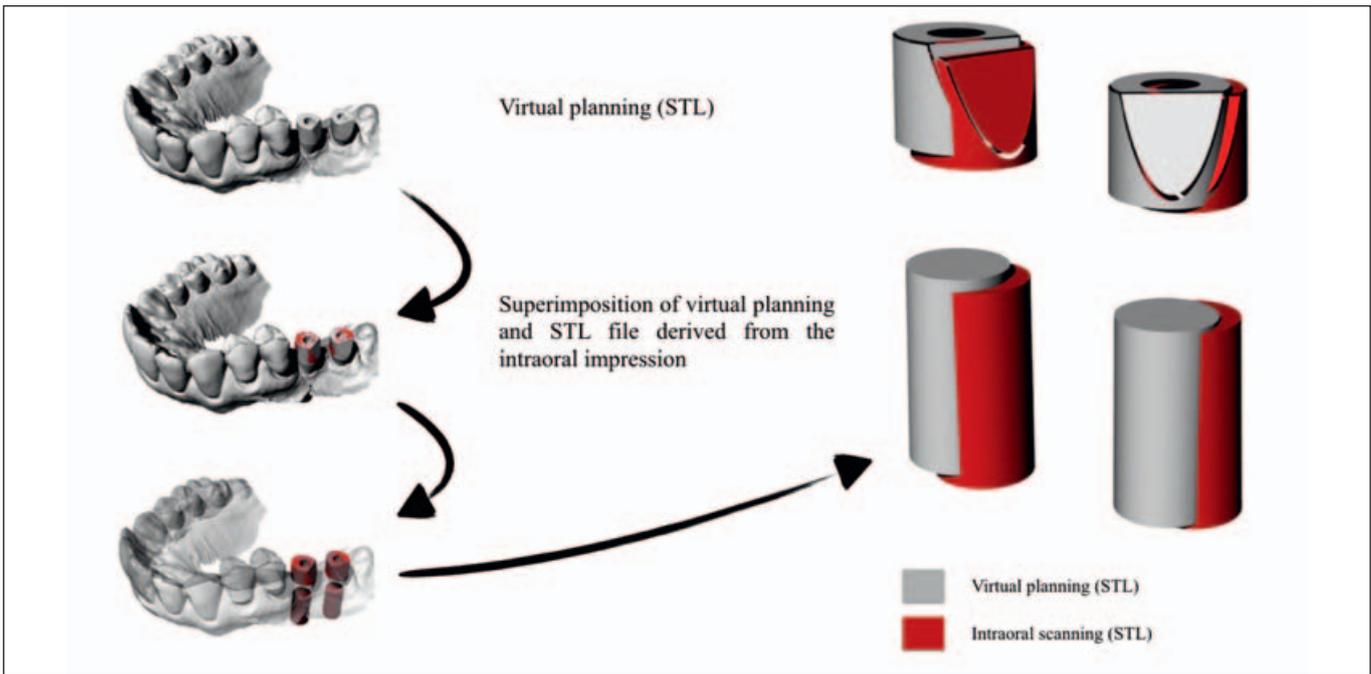


Fig. 8

Fig. 8
Schematic diagram of the superimposition of virtual planning (gray) and the STL file derived from the intraoral impression (red).

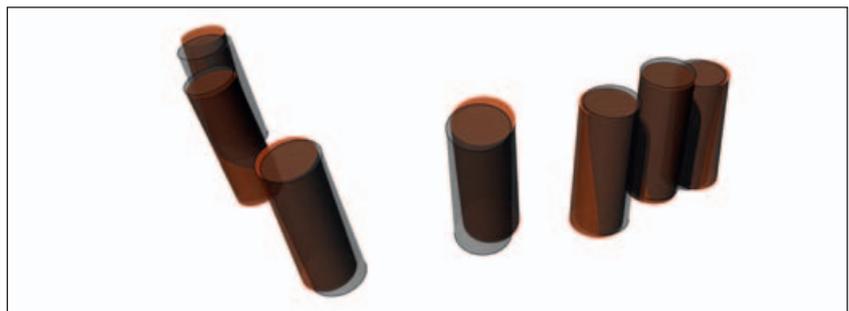


Fig. 9

Fig. 9
Three-dimensional superimposition of planned and placed implants.

Fig. 10
Maximum angular deviation calculated according to the implant diameter and length.

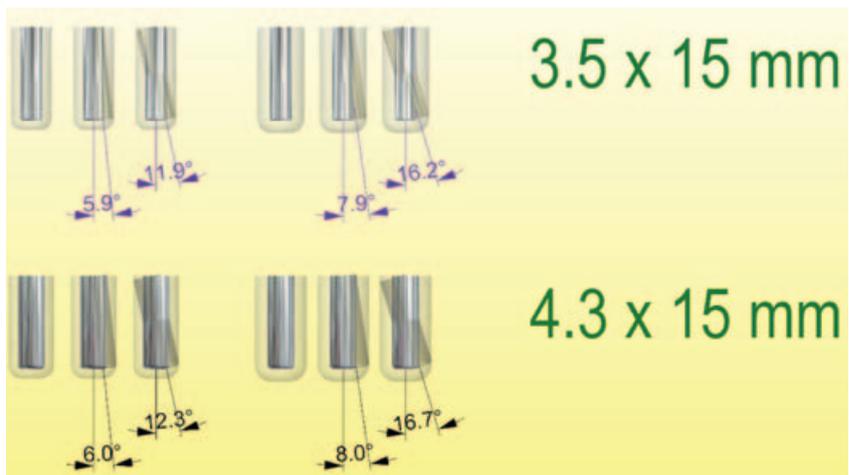


Fig. 10

Results

Preliminary data from the 12 patients were included in the present study. Patients were randomized to the fully digital group (6 patients with 17 implants) and control group (6 patients with 20 implants). All of the implants were

inserted according to the manufacturer's instructions, with an insertion torque ranging between 35 and 45 N cm. Overall, the analysis of the final accuracy found a total mean error of $2.34 \pm 1.44^\circ$ (range: $0.3\text{--}5.8^\circ$) in angle, 0.49 ± 0.29 mm (range: $0.1\text{--}1.1$ mm) in the horizontal plane (mesiodistal) and 0.53 ± 0.42 mm

(range: 0.0–1.6 mm) in the vertical plane (apico-coronal). All the measurements were within the safety margins of the software. In all the three measures, there were no statistically significant differences between fully digital and conventional impressions. The mean error in angle was $2.56 \pm 1.52^\circ$ (range: 0.3–5.0°) in the fully digital group and $2.18 \pm 1.41^\circ$ (range: 0.3–5.8°) in the control group ($P = 0.519$). In the horizontal plane (mesiodistal), the mean error was 0.57 ± 0.32 mm (range: 0.1–1.1 mm) in the fully digital group and 0.43 ± 0.26 mm (range: 0.1–0.9 mm) in the control group ($P = 0.249$). In the vertical plane (apico-coronal), the mean error was 0.67 ± 0.51 mm (range: 0.0–1.6 mm) in the fully digital group and 0.43 ± 0.32 mm (range: 0.0–1.2 mm) in the control group ($P = 0.180$).

Discussion

This randomized controlled trial was conducted with the aim of understanding which procedure is preferable, a conventional impression and a scan model or a digital impression, to rehabilitate partially edentulous patients using computer-assisted template-based implant placement. Implants were placed flapless or with a minimally invasive flap and when possible loaded immediately. Both techniques achieved successful results, and no statistically significant differences were observed regarding early implant failure, template-related complications or virtual planning accuracy.

To the best of our knowledge, at the time of writing this article, there were no other published randomized clinical trials comparing conventional impressions and scan models to digital impressions to plan and rehabilitate partially edentulous patients using computer-assisted template-based implant placement. This made it difficult to evaluate the results of the present study against comparable studies.

The scientific evidence available concluded that, regarding implant survival rate, guided surgery has no obvious differences compared with the conventional protocols.⁴ However, according to D'haese et al., the most frequent surgical and mechanical complications are recognized to be specifically associated with computer-guided template-assisted surgery, including misfit of the surgical guide, fracture of the complete acrylic denture and misfit of the suprastructure.¹⁴ In the present study, no implant failed early and no templated-related complications were observed in either group.

Several independent uncontrolled prospective studies reported substantial deviations in 3-D directions between virtual planning and final implant position, as well as postsurgical complications.^{15–17} However, excellent clinical results have also been reported using this technique.^{13, 14, 18–19} Vasak et al. found a mean deviation of 0.43 mm (buccolingual), 0.46 mm (mesiodistal) and 0.53 mm (depth) at the level of the implant shoulder and of 0.70 mm (buccolingual), 0.63 mm (mesiodistal) and 0.52 mm (depth) at the apex level, respectively.²⁰ A maximum deviation of 2.02 mm was found in the apico-coronal direction; nevertheless, significantly lower deviations in the mesiodistal direction were observed for implants in the anterior region and mandibular implants than for implants in the posterior region and maxillary implants. In a historical systematic review and meta-analysis by Jung et al., a mean error in angulation of 4.0°, with a maximum of 20.4°, was found.²¹ In the present study, a total mean error of $2.34 \pm 1.44^\circ$ (range: 0.3–5.8°) in angle, 0.49 ± 0.29 mm (range: 0.1–1.1 mm) in the horizontal plane (mesiodistal) and 0.53 ± 0.42 mm (range: 0.0–1.6 mm) in the vertical plane (apico-coronal) was found. In all of the cases, the maximum values (5.8° in angle, 1.1 mm in the horizontal plane and 1.6 mm in the vertical plane) did not exceed the safe offset of the software (1.5 mm in the horizontal plane and 2.0 mm in the vertical plane). Although no statistically significant differences were observed between conventional impressions and scan models and digital impressions, a trend of higher discrepancy between virtual and placed implants was observed in the fully digital group (mean error of $2.56 \pm 1.52^\circ$ in angle, 0.57 ± 0.32 mm in the horizontal plane and 0.67 ± 0.51 mm in the vertical plane). Major deviations were found for edentulous areas of three or more teeth (1.1 mm in the horizontal plane in the mandible and 1.6 mm in the vertical plane in the maxilla).

No data were reported in the scientific literature about the acceptable angle deviation. In the present study, based on a worse projection using implants of 3.5 and 4.0 mm in width and 15.0 mm in length and with standard offset, the maximum acceptable value ranged from 5.9 to 12.3° (**Fig. 10**). In the present study, a higher angular deviation was found in partially edentulous patients treated in the control group (5.8°). In contrast, minimum values of 0.1 mm in the horizontal plane and 0.0 mm in the vertical plane were observed in both groups, while a minimum angular deviation of 0.3° was observed in the fully guided group.

The main purpose of computer-guided template-assisted surgery is to pre-visualize the approved prosthetic design of the tooth or teeth to be replaced and to relate it to the patient's available soft and hard tissue. According to a recent study by Vermeulen, in cases of one or more missing teeth in the anterior maxilla, guided surgery yields significantly higher predictability and accuracy than freehand surgery in transferring the virtual implant position to a model situation.³ Therefore, implant position can be optimized according to the esthetic and functional needs and an interim prosthesis can be manufactured prior to the surgical procedure, allowing immediate function.

Conclusion

Within the limitations of the present randomized controlled trial, it was found that intraoral digital impressions may be a viable alternative to conventional impressions and scan models for the rehabilitation of partially edentulous patients using computer-guided template-assisted implant placement. In both groups, the maximum 3-D deviations did not exceed the safe offset of the software.

Competing interests

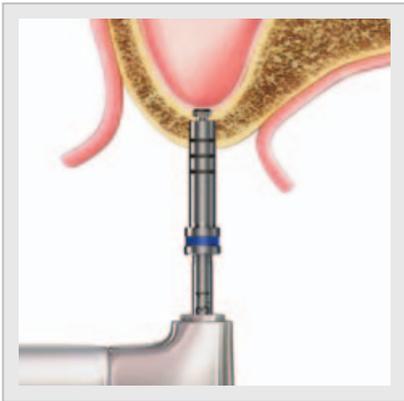
The authors declare that they have no competing interests.

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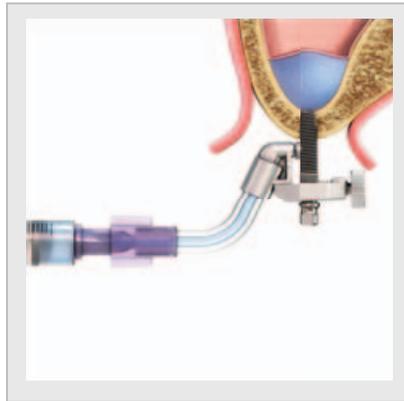
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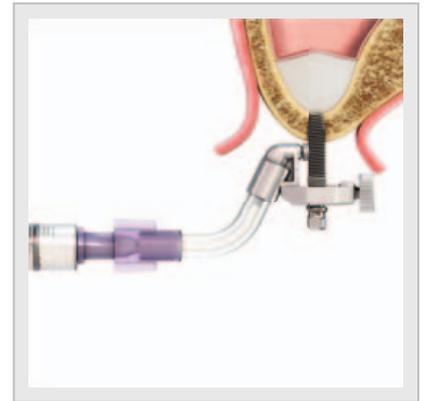
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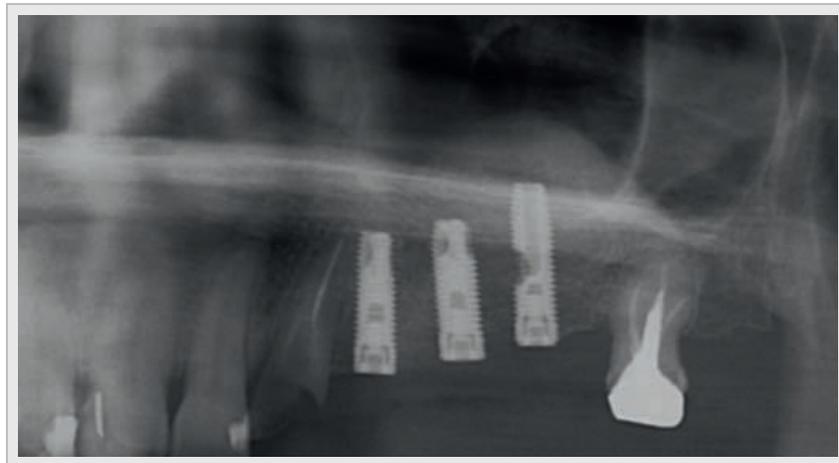
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Zero apicectomy in endodontic microsurgery

Abstract

Background

Surgical endodontic treatment is an option for teeth with periapical periodontitis and may be indicated for teeth previously submitted to unsuccessful endodontic treatment and teeth with a strong possibility of failure by the nonsurgical approach. This procedure includes root sectioning and preparation of a cavity in the root canal followed by retrograde obturation.

Furthermore, the presence of apical true cysts requires surgical treatment as well, as these cysts are less likely to heal by nonsurgical root canal therapy because they are self-sustaining and no longer dependent on the presence or absence of root canal infection. Accordingly, surgical intervention of apical true cysts is necessary.

The limitations of periapical radiography have led to significant interest in cone beam computed tomography (CBCT) in endodontic applications. The number of CBCT scans taken every year is increasing as awareness increases, resolution increases and costs decrease.

Case presentation

In this article, we describe a new approach in surgical endodontics that focuses on preserving the integrity of the apical part of the root. This approach entails conducting root canal treatment and surgical cyst removal in one session. We illustrate this approach with a series of cases showing the preoperative condition and postoperative healing, with a recall period of 6 months, 1 year, 2 years, and yearly up to 5 years.

Conclusion

Zero apicectomy in endodontic surgery is a novel technique that combines high-resolution CBCT visualization of the apical situation, root canal treatment with the use of efficient irrigation with EndoVac, and root surface conditioning in order to allow the preservation of the apical part of the root *ad integrum*. Zero apicectomy clears the infection from inside the bone and treats the root canal in the same session, giving the body a greater opportunity to heal in a healthy, clean environment. Current literature has not described this technique; however, clinical cases have proven its success.

Keywords

Apicectomy, EndoVac, CBCT, surgical endodontic treatment.

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Introduction

Surgical endodontic treatment is an option for teeth with apical periodontitis and may be indicated for teeth previously submitted to unsuccessful endodontic treatment and teeth with a strong possibility of failure by the nonsurgical approach.^{6,14,29} This procedure usually consists of several steps, including retrograde obturation, which is performed after root sectioning and preparation of a cavity in the root canal.⁶

Furthermore, the presence of apical true cysts requires surgical treatment as well, as these cysts are less likely to heal by conventional root canal therapy because they are self-sustaining and no longer dependent on the presence or absence of root canal infection.^{8,26,24} Accordingly, surgical intervention of apical true cysts is necessary.^{15,20,23,25} This technique can be performed when conducting a root canal treatment or a retreatment of the root canal system, combined with a surgical approach for the removal of the cyst. If access to the root canal system is not possible, a conventional apicectomy can be performed.

The limitations of periapical radiography have led to significant interest in cone beam computed tomography (CBCT) in endodontic applications. It seems that number of CBCT scans taken every year is increasing as awareness increases, resolution increases and costs decrease.²⁸ With the use of CBCT, cystic lesions are easily identified.

In this article, we will describe a new approach in surgical endodontics that focuses on preserving the integrity of the apical part of the root. We will illustrate this approach with a series of cases showing the preoperative condition and postoperative healing.

Materials and methods

Once there is a positive diagnosis of an apical cyst with CBCT, the patient is informed of the situation and the different steps of the treatment. The procedure is performed under local anesthesia with the use of articaine with 1:100,000 epinephrine infiltrated under the periosteum. We then proceed by isolating the tooth or teeth with a rubber dam and then shaping and cleaning the root canal system. The irrigation is conducted with the EndoVac negative-pressure device (SybronEndo, Orange, Ca., U.S.).²¹ Once the working length has been determined elec-

tronically, the irrigation cannula can be placed at the working length.²¹ After the irrigation is completed, a temporary filling is placed in the access cavity and the rubber dam removed. The obturation of the canal is deferred, as the canal cannot be properly dried at this stage.

The following step is performing the surgical part, first by raising a flap and identifying the cyst. The cystic area is carefully spooned out while preserving the cementum and ligaments that are attached to the root surface. The exposed part of the root is rinsed with normal saline followed by the application of citric acid at a neutral pH with a microbrush on the root surface. After the latter step, the area is rinsed abundantly again with sterile water or normal saline. As the flap is temporarily put back in place, the tooth or teeth are isolated again with a rubber dam, the temporary filling is removed and a full sequence of irrigation with the use of EndoVac is conducted again. The master cone is adjusted, and full obturation of the root canal system is performed using warm vertical obturation. A temporary filling material is then placed in the access cavity and the isolating dam removed. The final step consists of raising the flap again and checking whether any large extrusion of the obturation material occurred that would need to be removed. The sutures are placed, and postoperative medication is prescribed.

Discussion

Apical periodontitis (AP) is an inflammatory or immune response in the apical periodontium that often results from intracanal microorganisms. The resulting apical bone resorption is a defense mechanism that prevents the spread of infection and appears radiolucent on radiographs.^{23,16} Because AP is usually asymptomatic, it is frequently only detected during routine radiographic examination.⁴ In this sense, radiography is essential for the successful and timely diagnosis of AP and historically has been limited to periapical and panoramic radiographs.¹ Furthermore, radiographic imaging is essential in all stages of endodontics, from diagnosis through long-term assessment of healing outcomes. In conjunction with symptoms, outcome is assessed by comparison of preoperative and immediate postoperative radiographs, with subsequent radiographs taken at recall appointments.^{12,18}

The diagnostic value of pretreatment radiographs depends on how well they reflect the histology of AP. Studies that have investigated the correlation between histological appearance and radiographic manifestations have found that the absence of radiographic signs does not preclude apical inflammation, and the radiographic appearance is always smaller than the histological extent of the lesion.^{20–23} Radiographic signs pathognomonic of AP include radiolucent changes in periradicular trabecular pattern and altered shape and width of the periodontal ligament (PDL) space.^{3, 7, 11, 13} However, periapical radiographs and panoramic imaging have inherent limitations, such as superimposition and distortion of important structures that commonly mask lesions.^{17, 19} In addition, lesions in cancellous bone cannot be consistently detected with these radiographic techniques.⁵ Therefore, in some cases, extensive bone resorption may be present even when there is no radiographic evidence of it.⁵ The appearance of the periapical tissue on a radiograph is influenced by the superimposition of anatomical structures and the variable nature of the overlying bone density and texture.^{12, 18} The limitations of periapical radiography have led to significant interest in CBCT.

Currently, the use of CBCT imaging has made it possible to visualize the related anatomical structures in 3-D with higher resolution. This has improved the overall diagnostic efficacy and made early diagnosis possible for some specific clinical situations.^{22, 27} In endodontic practice, CBCT imaging with limited fields of view has been suggested for diagnosis in patients with contradictory or nonspecific clinical signs and symptoms.²⁷

Postsurgical excisional wound healing after periradicular surgery entails dentoalveolar healing (i.e., reestablishment of an apical attachment apparatus) and alveolar healing (i.e., osseous repair of trabecular and cortical bone).² Cementum deposition on the root end is considered the critical step in dentoalveolar wound healing.² Consequently, creating an environment conducive to cementogenesis should enhance the healing process after surgical endodontic treatment.

In periodontal surgery, dentin demineralization leads to enhanced connective tissue attachment through splicing of exposed dentinal collagen with new collagen fibers produced during wound healing and early deposition of cementum on the dentinal surfaces.⁹

Demineralizing the root surface with citric acid has been shown to increase cementogenesis

and promote periradicular wound healing by exposing the collagen matrix, which stimulates fibroblast attachment and growth.⁹ The lower pH of citric acid may induce initially a more intense inflammatory response compared with saline. This may inhibit the healing process as measured by new bone formation. As healing progresses, the potential benefits of the anti-collagenase activity may allow for more rapid collagen formation and ultimately allow more rapid new bone formation.¹⁰

The irrigation is conducted with EndoVac, as the EndoVac System safely delivers irrigants to the apical terminus of root canals.²¹ The device consists of a delivery/evacuation tip attached to a syringe of irrigant and the high-volume suction of the dental chair. Using a combination of a macro- or microcannula attached to the suction device, the irrigant introduced into the pulp chamber is pulled by negative pressure down the canal into the tip of the cannula and removed through the suction hose, thus avoiding any extrusion of the irrigant outside the root canal area, since the PDL barrier is lost then and the use of conventional irrigating methods could result in pushing the chemicals into the exposed surgical site.²¹

Case descriptions

Case 1

The patient was referred to the clinic with a swelling in the palatal area of the maxillary lateral incisor (**Figs. 1a & b**). Axial slices of CBCT scans showed substantial bone loss at the apical level of the maxillary lateral incisor (**Fig. 1c**) and at the level of the two maxillary central incisors (**Fig. 1d**).

After administration of the anesthesia, a syringe was inserted into the palatal mucosa and a large amount of pus was aspirated. After following the procedural steps previously described and the removal of the cystic reaction, a long section of the root canals was exposed, especially that of the lateral and central incisors.

Immediate postoperative radiographs were taken (**Figs. 1e & f**), and then 1-year follow-up radiographs (**Figs. 1g & h**). The 1-year follow-up images showed the formation of new bone around the teeth and of a new PDL. The 5-year follow-up radiograph (**Fig. 1i**) indicated an intact PDL, a smaller fibrous area and no signs of external or internal resorption.

Figs. 1a & b

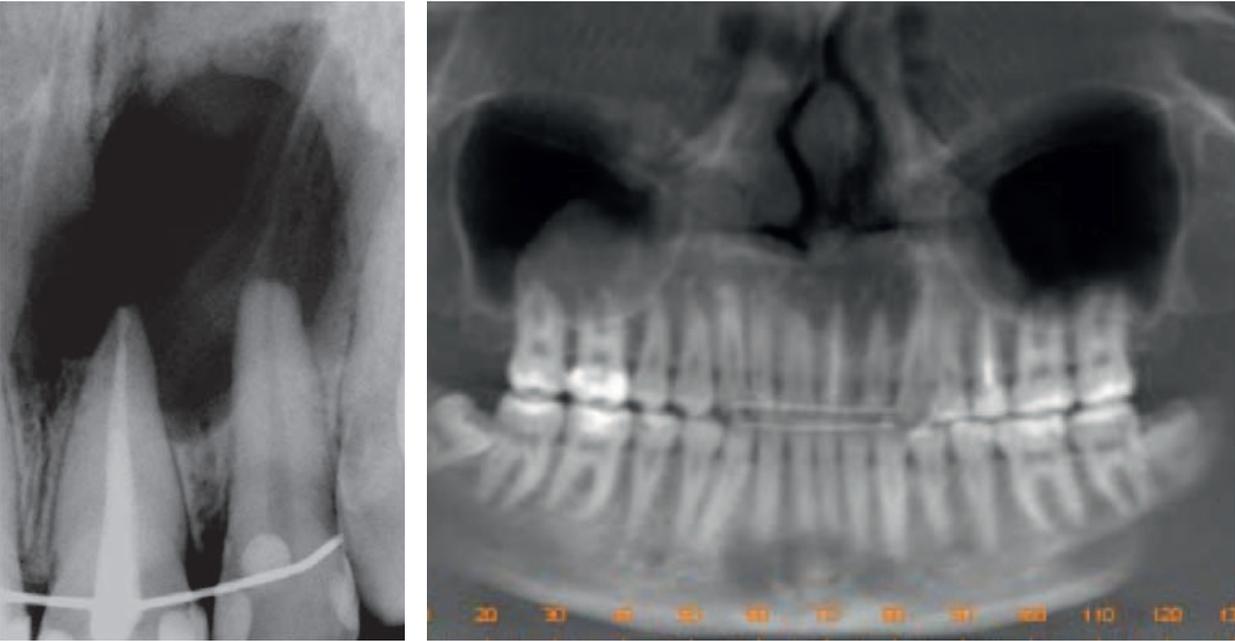
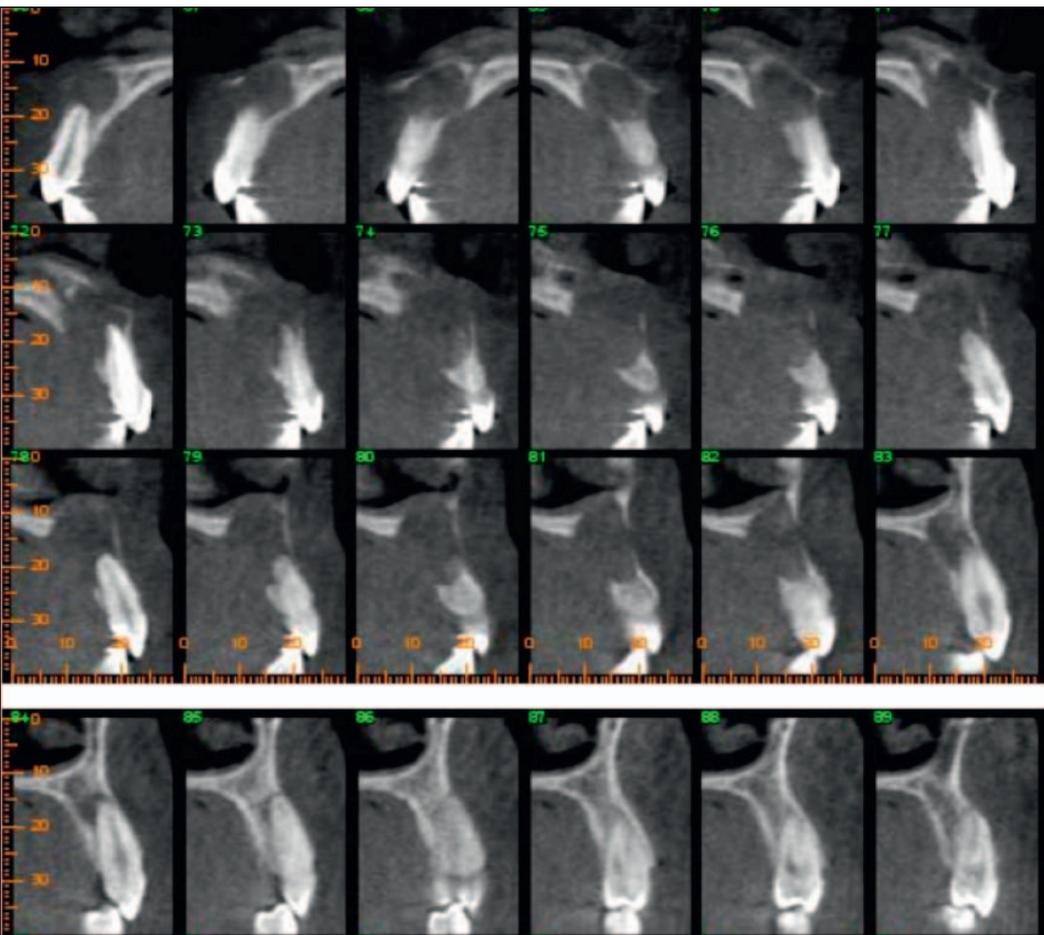


Fig. 1c



Figs. 1a & b

Preoperative periapical and panoramic radiographs.

Fig. 1c

CBCT axial slices.

Fig. 1d

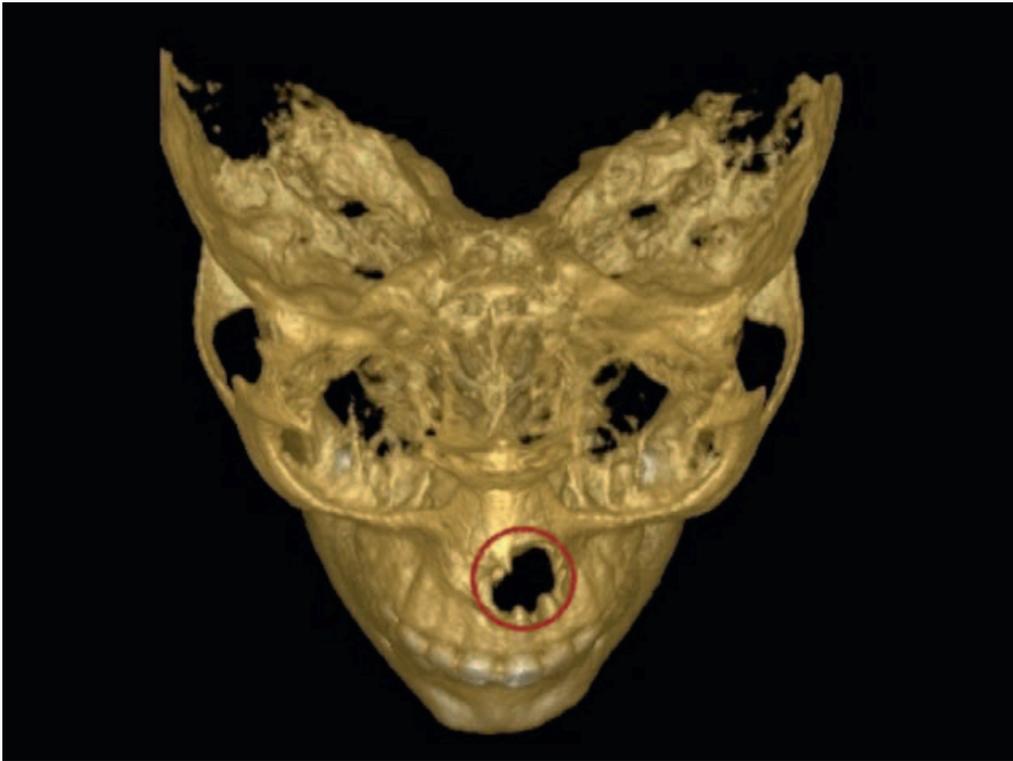


Fig. 1e



Figs. 1f-i

Fig. 1d
CBCT 3-D reconstruction demonstrating the extent of the lesion(s).

Figs. 1e & f
Immediate postoperative radiographs of the lateral incisor (left) and central incisor (right).

Figs. 1g & h
One-year follow-up radiographs.

Fig. 1i
Five-year follow-up radiograph.

Case 2

The patient was referred to have a mandibular molar checked. He was trying by all means to retain the molar, even though he had been advised to have it extracted and replaced with an implant. The preoperative radiograph (**Fig. 2a**) showed a substantial periapical lesion, although the previous dentist had placed calcium hydroxide paste in the canals. Furthermore, the patient was complaining of tingling in his lower lip. The i-CAT (KaVo Dental, Biberach, Germany) showed

that the cystic reaction extended far, almost reaching the mandibular canal (**Fig. 2b**).

The same approach as described previously was performed in an attempt to treat and save the molar. Once the flap had been elevated, it appeared that the cystic reaction was also manifesting under the periosteum above the cortical bone and there was another cystic reaction close to the mandibular nerve (**Fig. 2c**). Postoperative radiographs were taken (**Fig. 2d**) and complete healing was seen with full reconstruction of the bone (**Fig. 2e**).



Fig. 2a
Preoperative periapical radiograph.

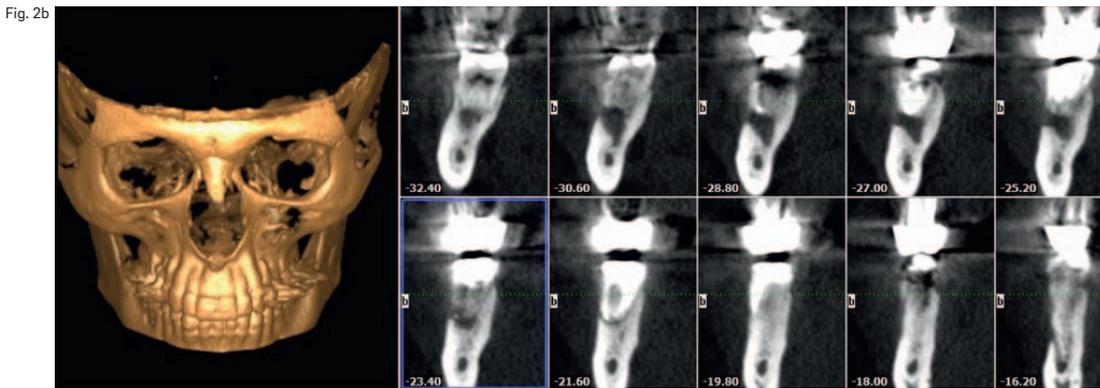


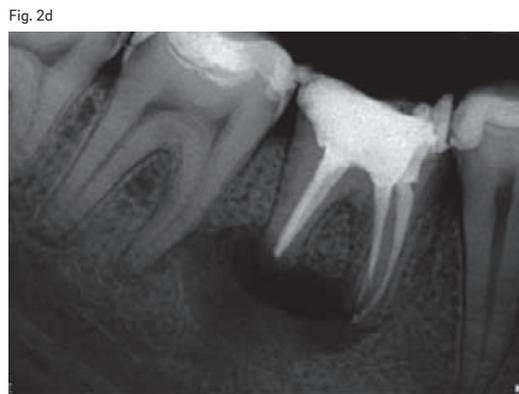
Fig. 2b
CBCT images of the patient.

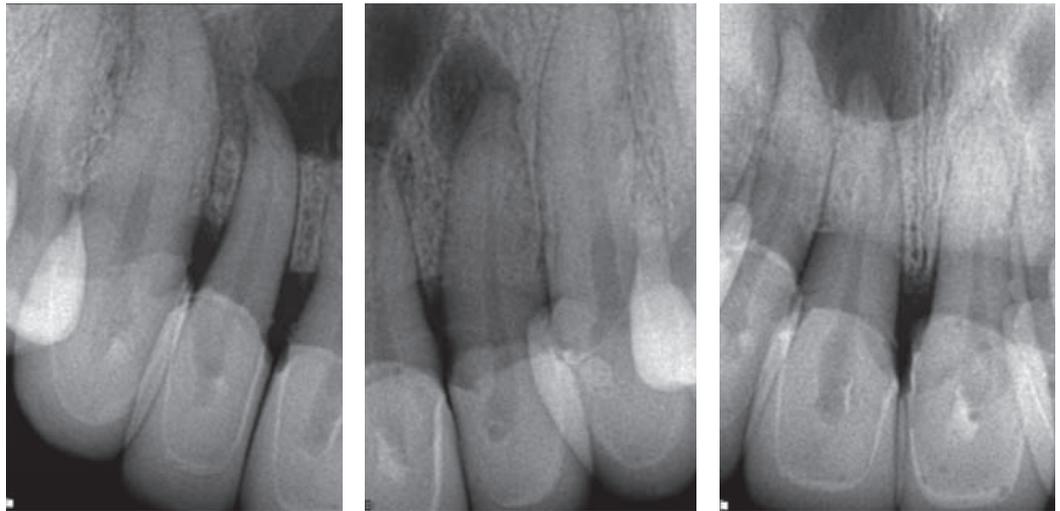
Fig. 2c
The cystic reaction in the vicinity of the mandibular canal.

Fig. 2d
Immediate postoperative radiograph (left).

Fig. 2e
One-year follow-up radiograph.

Fig. 2f
Two-year follow-up radiograph.





Figs. 3a-c

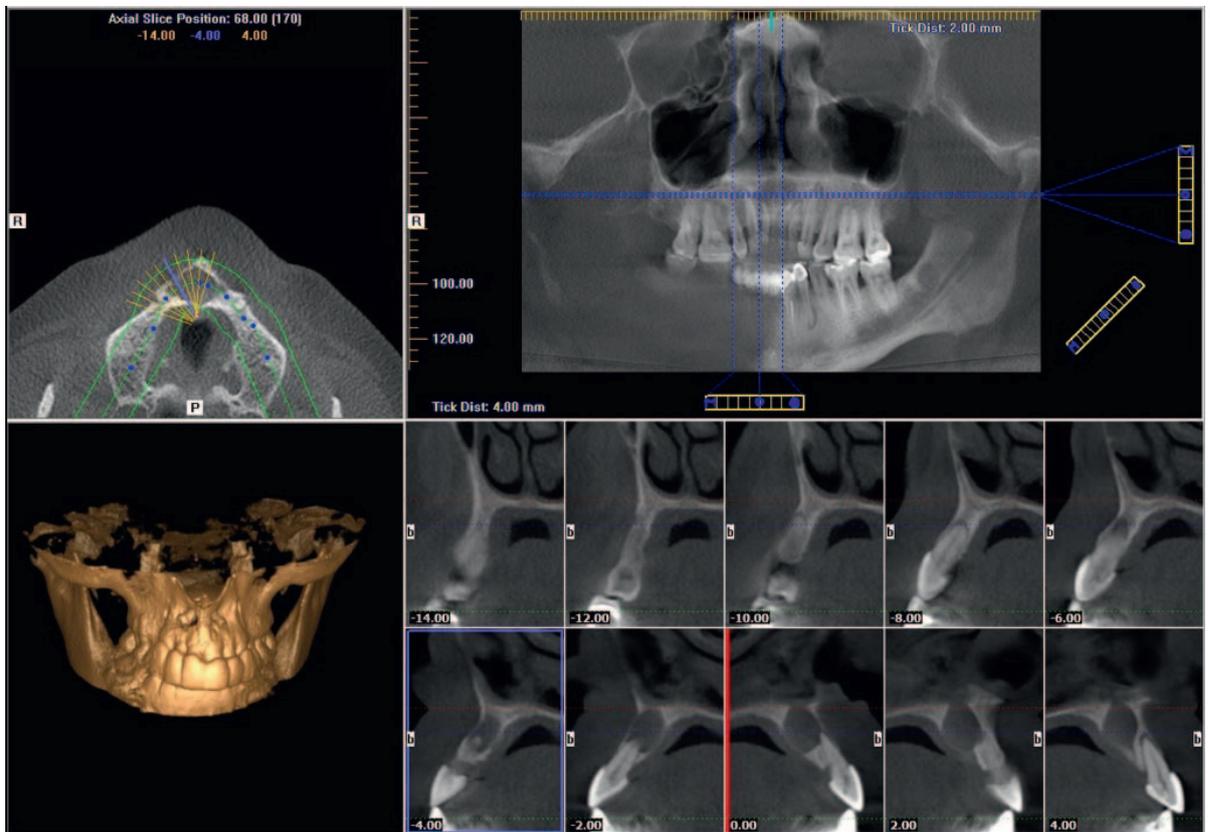


Fig. 3d

Figs. 3a-c

Preoperative radiographs: maxillary anterior teeth.

Figs. 3d & e

CBCT images.

Case 3

The patient was referred to the clinic to have the maxillary anterior teeth checked. The patient had had crowns placed several years before and apparently the pulps of those teeth had become necrotic and resulted in periapical infections. On the preoperative radiographs (Figs. 3a-c) and on the i-Cat (Figs. 3d & e), the periapical cysts could be easily identified and massive bone loss was evident.

The same approach as described previously was used to treat all of the anterior teeth to remove the multiple cysts while preserving the bone as far as possible and only using the bone defect that was created by the infection to scoop out the cystic reaction (Figs. 3f & g). Postoperative radiographs were taken (Fig. 3h), as well as radiographs at the 18-month follow-up (Fig. 3i). Further follow-up was not done, as the patient was unavailable.

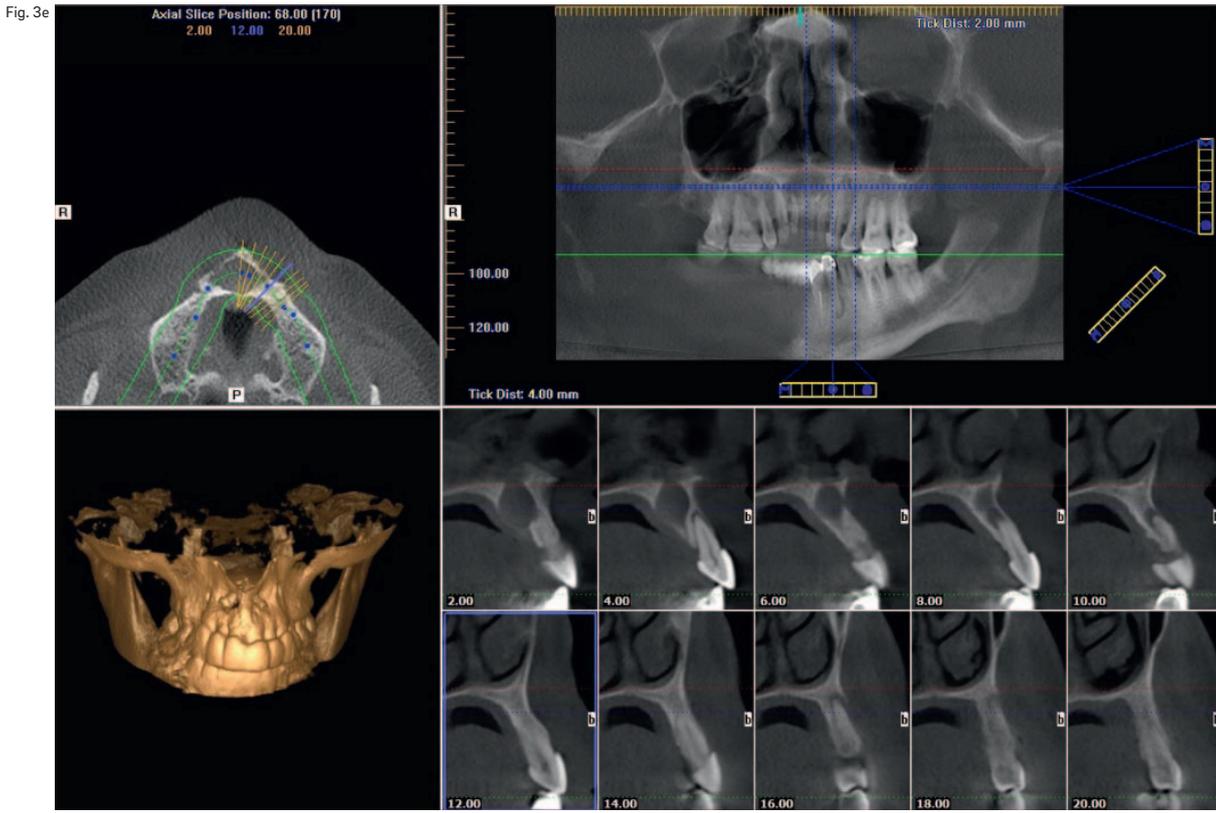
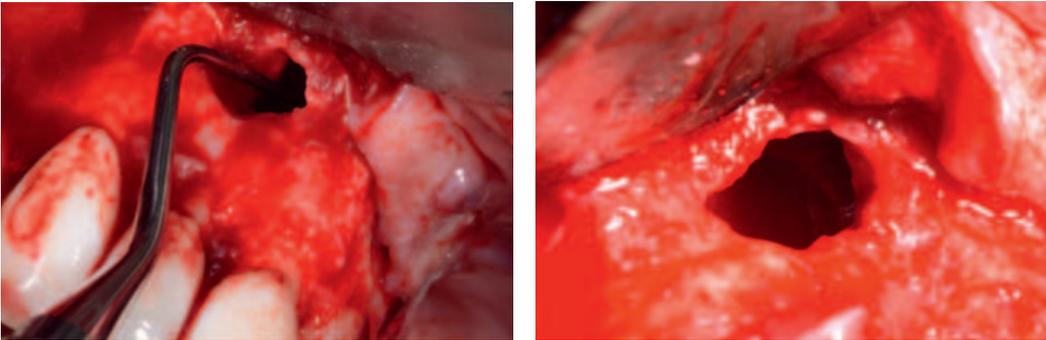


Fig. 3e

Figs. 3f & g



Figs. 3f & g

Intraoperative photographs showing the defects resulting from the cystic reactions.

Fig. 3h

Immediate postoperative radiographs.

Fig. 3i

Eighteen-month follow-up radiographs.

Figs. 3h & i



Conclusion

Zero apicectomy in endodontic surgery is a novel technique that combines high-resolution CBCT visualization of the apical situation with the use of efficient irrigation with EndoVac, root canal treatment and root surface conditioning in order to allow the preservation of the apical part of the root *ad integrum*. Preserving the total length of the root has many benefits, including, most importantly, the stability and longevity of the tooth, as cutting the root exposes dentinal tubules. Since we perform retrograde obturation of the main canal, we cannot guarantee that the exposed dentin is bacteria-free. Comparing this with other

techniques, in which we drain the cyst for a certain period without having the ability to know in advance if surgery will be needed later, zero apicectomy clears the infection from inside the bone and treats the root canal in the same session, giving the body a greater opportunity to heal in a healthy, clean environment. Current literature has not described this technique; however, clinical cases have proven its success.

Competing interests

The authors declare that they have no competing interests.

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How can the tapered implant design influence bundle bone preservation: An experimental study in American Foxhound dogs

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Abstract

Objective

The objective of the present study was to evaluate bone–implant contact (BIC) in a new implant design after immediate and delayed placement at different levels in relation to crestal bone in American Foxhound dogs.

Materials and methods

The second, third and fourth mandibular premolars and first molars of 6 American Foxhound dogs were extracted bilaterally. At random, 4 immediate implants were placed in the hemimandibles of each dog in the crestal (control group) and subcrestal position (test group). Three dogs were allowed a healing period of 8 weeks; the other 3 had a healing period of 12 weeks. After the healing periods, histomorphometric analysis of the specimens was performed to measure BIC values and bone remodeling in crestal and subcrestal implants.

Results

All of the implants healed without incident and were available for histological analysis. Lower bone resorption was observed in the group of implants placed subcrestally in healed bone and immediately post-extraction.

Conclusion

Our findings suggest that less resorption can be expected when implants are inserted 2 mm subcrestally overall for both immediate and deferred implants compared with placement at the crestal level. In addition, higher BIC values were found at 12 weeks of follow-up in the group of implants placed subcrestally in healed bone compared with those placed subcrestally immediately.

Keywords

Top DM, tapered implants, healed bone.

Introduction

After loss of a tooth, there is progressive involution of the alveolar bone in both the horizontal and vertical dimensions.^{4, 5, 17, 18} In addition, the most rapid reduction of alveolar bone after dental extraction occurs during the first months.^{4, 5}

For more than a decade, different clinical studies have demonstrated that immediate implant placement in fresh extraction sites may be an effective therapy not only because it reduces the number of surgical procedures,^{37, 41} but also because it favors the preservation of the ridges' morphological contours and simplifies clinical techniques.^{11, 28, 35, 50, 51} Bone remodeling begins directly after the preparation of the implant bed, as well as the healing process of the bone. Osteoblast adhesion to the implant surface and the osseointegration process begins approximately 3 weeks after surgery.⁵⁴ During this healing process, bone remodeling occurs.^{33, 49} This often results in crestal bone loss.^{31, 32} However, findings from experiments in humans and dogs have demonstrated that marked reduction in the height of the alveolar ridge occurred consistently after tooth extraction⁴ and that implant placement in fresh extraction sockets had no effect on the process of bone modeling.^{5, 9, 17, 18}

Several authors have studied the clinical and radiographic changes that occur around dental implants inserted at different levels in relation to the crestal bone. Clinically, implants are often placed subcrestally in esthetic areas to avoid exposure to metals and to create sufficient space to develop a suitable emergence profile.²¹ Subcrestal placement of implants may have an additional benefit, as it improves bone–implant contact (BIC) in the neck region of the implant.^{30, 59}

Positioning the implant–abutment junction more apically contributes to the maintenance of mucosal texture and tonality and favors the re-establishment of marginal tissue architecture.²⁷ Thus, different microgap designs result in different shapes and sizes of the periimplant (dis-shaped) bone defect in submerged implants in either equicrestal or subcrestal positions.⁵⁸ A previous animal study evaluated bone remodeling and BIC after immediate placement at different levels in relation to the crestal bone of beagle dogs. Cylindrical and tapered implants were inserted crestally and 2 mm subcrestally. These studies suggested that apical positioning of the top of the implant does not jeopardize bone crest and periimplant tissue remodeling.

However, less resorption was observed when implants were placed 2 mm subcrestally. Moreover, higher BIC values were found in implants placed subcrestally.^{38, 39}

Bone–implant contact is among the most important factors contributing to implant stability. Thus, many authors have specified the factors that influence BIC levels, implant position and bone density.^{23, 24, 26, 46, 56, 57} Experimental and clinical studies have demonstrated that implants designed with a shorter, smooth coronal collar caused no additional bone loss and might help reduce the risk of an exposed metal implant margin in areas of esthetic concern.^{3, 29}

The anatomy and surface treatment of the neck of the implant, together with the type of connection between the implant and the prosthetic components, have been considered as with regard to reducing crestal bone loss.²⁷ Based on the data revised, it is hypothesized that the vertical positioning of the implant platform in relation to the crestal bone may influence the location of the first BIC. As a consequence, the biological width may be established in a more coronal position. Therefore, the objective of this study was to compare the BIC of implants with smooth necks and no microthreads, which represent a rough surface, placed at crestal and subcrestal levels in healed bone and immediately post-extraction in dogs.

Materials and methods

Six American Foxhound dogs of approximately 1 year of age were used in this study. The Ethics Committee for Animal Research at the University of Murcia, Murcia, Spain, approved the study protocol, which followed guidelines established by the European Union Council Directive of February 2013 (R.D.53/2013). Clinical examination determined that all of the animals were in good general health; moreover, all of the animals presented with intact maxillae, without any general occlusal trauma or oral viral or fungal lesions.

The choice of this kind of dog was due to these being the animals that we have in our animal facilities approved for research. The animals were quarantined for the application of rabies vaccines and vitamins. The dogs were kept in kennel cages before and after surgery, received appropriate veterinary care, and were allowed free access to water and standard laboratory nutritional support throughout the trial period. After surgery, the animals received

antibiotics (enrofloxacin, 5 mg/kg, bid) and analgesics (meloxicam, 0.2 mg/kg, tid) via the systemic route.

Surgical procedure

The animals were pre-anesthetized with acepromazine (0.12%, 0.25 mg/kg), buprenorphine (0.01 mg/kg) and medetomidine (35 µg/kg). The mixture was injected intramuscularly into the femoral quadriceps. The animals were then taken to the operating theater, where, at the earliest opportunity, an intravenous catheter was inserted (diameter of 22 or 20 G) into the cephalic vein, and propofol was infused at a slow, constant infusion rate of 0.4 mg/kg/min. Conventional dental infiltration anesthesia (articaine, 40 mg; 1% epinephrine) was administered at the surgical sites. These procedures were carried out under the supervision of a veterinary surgeon. Mandibular premolar and molar extractions (P₂, P₃, P₄ and M₁) were performed bilaterally. The teeth were sectioned in the buccolingual direction at the bifurcation using a tungsten carbide bur so that the roots could be extracted individually without damaging the remaining bony walls with a contra-angle handpiece (W&H, Bürmoos, Austria). The surgical device used for odontosection was the Implantmed (W&H).

Crestal incisions were performed bilaterally in the premolar–molar region of the mandible. Full-thickness mucoperiosteal flaps were elevated, and recipient sites in the molar regions on both sides of the mandible were prepared for the present experiment, while the other regions were used for different experimental purposes, the results of which are reported elsewhere. The healed bone was prepared to place cylindrical, self-tapping implants with BIONER's Top DM expansive core (BIONER Sistemas Implantológicos, Sant Just Desvern, Spain; 8.0 mm in length, 3.5 mm in diameter). A total of 48 implants were installed, 8 in each dog in healed and post-extraction bone (**Figs. 1a–d**). The implants had a BIOTECH surface characterized by high roughness without etching along the implant body.

The crestal or subcrestal positioning of the implants and the type of placement (healed bone or immediately post-extraction) were determined randomly by the randomization plan generator at www.randomization.com. The subcrestal position was 2 mm below the buccal and lingual bone crests. After insertion of the

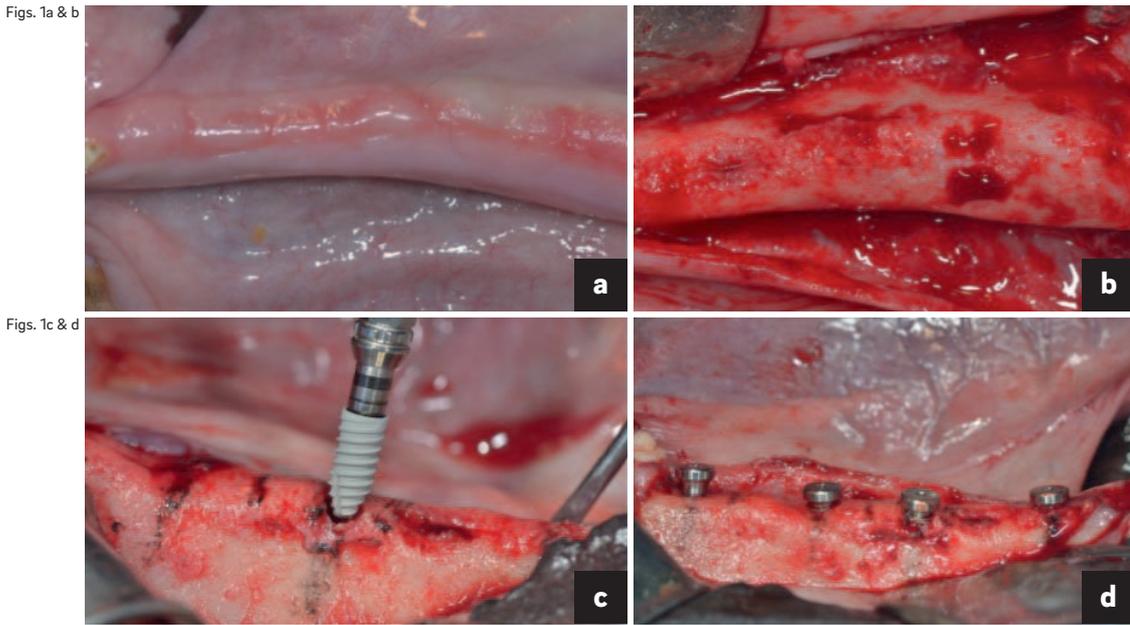
implants, the healing abutments were connected to evaluate the periimplant soft tissue. The flaps were sutured with 4-0 silk (Lorca Marín, Lorca, Spain).

After the surgical procedures, the animals received antibiotic treatment (amoxicillin, 500 mg, bid) and analgesics (ibuprofen, 600 mg, tid) systemically. In addition, the dogs were fed a soft diet for 7 days and plaque control was maintained through the application of Sea4 (Blue Sea Laboratories, Alicante, Spain). The wounds were inspected daily for postoperative clinical complications. Two weeks after surgery, the sutures were removed.

Histological and histomorphometric analysis

Three animals were sacrificed at 8 weeks and the other 3 animals were sacrificed at 12 weeks through an overdose of Pentothal Natrium (Laboratorios Abbot, Madrid, Spain) and perfused through the carotid arteries with a fixative containing 5% glutaraldehyde and 5% formaldehyde. The specimens were washed in saline and fixed in 10% buffered formalin. The specimens were processed to obtain thin sections of soil with the Precise 1 automated system (Assing, Rome, Italy). The specimens were dehydrated in ascending series with alcohol and embedded in a glycol methacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization, the specimens were sectioned along their longitudinal axes with a high-precision diamond disk, at about 150–30 µm. A total of 2 slides were obtained for each implant. The slides were stained with toluidine blue and observed under a normal transmitted light microscope and a polarized light microscope (Leitz, Wetzlar, Germany).

The histological preparation evaluated the distance from the top of the implant collar to the first contact with buccal and lingual bone (A-Bc and A-Lc), as well as the heights of the buccal and lingual bone ridges with respect to the neck of the implant (**Fig. 2**). Resorption of the buccal bone wall compared with resorption of the lingual bone wall was expressed as a linear measure. The buccal and lingual bone plates were measured from the implant shoulder to the first BIC and to the top of the bony crest. The percentage of BIC of native bone was also measured along the perimeter of the implant between the coronal end of osseointegration at the buccal and lingual aspects. The apical portion of each



Figs. 1a–d

(a) Healed bone.
 (b) Separate flap where bone repair was observed after 8 weeks of healing.
 (c) Top DM implant.
 (d) Implants with healing screws placed at crestal and subcrestal levels.

Fig. 2

The histological preparation evaluated the distance from the top of the implant collar to the first contact with buccal and lingual bone (A-Bc and A-Lc), as well as the heights of the buccal and lingual bone ridges with respect to the neck of the implant.

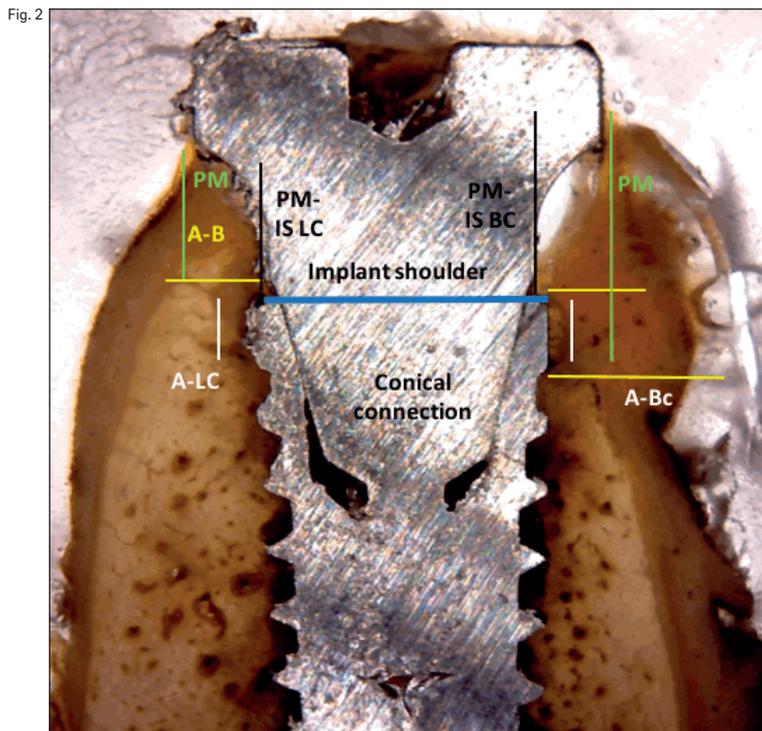


Fig. 2

implant was excluded from the measurement because some implants were inserted into the dental nerve. The total amount of bone in contact with the implant was calculated as the sum of native bone and newly formed bone (BIC%). Histomorphometry of BIC percentages was performed using a light microscope (Laborlux S, Leitz) connected to a high-resolution video camera (3CCD, JVC KY-F55B, Yokohama, Japan) and connected to a monitor and PC (Intel

Pentium III 1200 MMX, Intel, Santa Clara, Calif., U.S.). This optical system was associated with a scanning pad (Matrix Vision, Oppenweiler, Germany) and a software package for histometry with image capture capabilities (Image-Pro Plus 4.5, Media Cybernetics, Immagini & Computer, Milan, Italy). The total amount of bone in contact with the implants was calculated as the sum of native bone and newly formed bone.

Statistical analysis

Mean values and standard deviations were calculated using a BIC descriptive test and bone resorption measurements. The Wilcoxon test was applied to the comparison of mean averages and to quantify relationships between differences. Brunner and Langer nonparametric tests were applied to the mean values for crestal and subcrestal implants and for periimplant mucosa measurement. All histomorphometric parameters were analyzed using descriptive methods (IBM SPSS Statistics for Windows version 19.0, IBM Corp., Armonk, N.Y., U.S.). For all of the tests performed, the significance level chosen was 5% ($p < 0.05$).

Results

When buccal, lingual, mesial and distal dimensions of the entrance to the fresh extraction sockets were measured before implant placement, mean alveolar ridge measurements of the extraction sockets were 5.3 ± 0.6 mm (${}_2P_2$), 5.7 ± 0.2 mm (${}_3P_3$), 5.9 ± 0.2 mm (${}_4P_4$) and 8.9 ± 0.5 mm (${}_7M_1$).

Histological evaluation

Healing was uneventful for all of the animals and no implants were lost. Operative surgical sites healed without incident. All of the implants were available for histological analysis. The gaps between all of the implants and the bony walls disappeared as a result of bone filling and resorption of the alveolar crest in both groups (control and test). Direct contact between the living bone with slight vestibular resorption was observed, with stable soft tissue at 8 weeks for the crestal position and with a thicker gingiva in implants placed at the subcrestal level. Bone remodeling in the region of the marginal defect was accompanied by marked decreases in the dimensions of the buccal and lingual bone walls at 12 weeks at crestal and subcrestal levels (**Figs. 3 & 4**). For all of the implants, the keratinized oral epithelium was continuous with the junctional epithelium along the implants and the healing screws. Underlying connective tissue was observed with a dense network of collagen fibers around the implants placed in subcrestal healed bone, improving the quality of the periimplant gingiva (**Fig. 5**) compared with crestally placed implants.

After evaluation of all of the measurements, the distance from the top of the implant neck to the first BIC at the buccal aspect (A-Bc) showed statistically significant differences at 12 weeks in the test group compared with the control group (**Figs. 6 & 7**). In addition, the distance from the top of the implant collar to the lingual bone crest (A-Lc) showed significant differences between the crestal group and the subcrestal group after the healing period of 8 weeks. The A-Lc measure (distance between the implant collar top and the first BIC in the lingual aspect) was statistically significant after the healing period of 12 weeks in the subcrestal group.

Total BIC values were higher for implants of the test group at 8 weeks with subcrestal placement and even higher in this group of implants after 12 weeks of healing compared with the crestal placement group (**Table 1**). The values of the BIC lingual aspect are described in **Table 2**. These were higher for the subcrestal group, and values increased from 8 to 12 weeks. The direct contact surface between the implant and the bone was larger for the test implants, with no statistically significant differences. Subcrestal placement always showed higher BIC values at 8 and 12 weeks (**Figs. 5 & 8**).

Table 3 shows that the analysis of the periimplant mucosa and buccal implant shoulder (PM-IS BC) presented higher values for the implants placed crestally at 8 and 12 weeks compared with subcrestal placement, with statistically significantly different values at 12 weeks.

Discussion

The removal of single teeth followed by immediate placement of an implant results in marked alterations to buccal ridge dimensions (30–43%) and the horizontal (63–80%) and vertical (65–69%) gaps between the implant and bone walls.⁴⁶ The present investigation showed marked alterations after a healing period of 8 weeks that affected both the buccal and lingual bone walls. A-Bc and A-Lc values were lower for implants placed in healed bone at the subcrestal level than for those placed at the crestal level. In addition, resorption was more pronounced, which is in agreement with studies previously published by our group.²³ The present study revealed a greater depth of crestal bone resorption in the buccal bone than in the lingual crest. This bone dehiscence after implant placement corroborates the previously reported findings.^{4, 5, 23, 25, 52}

Figs. 3 & 4

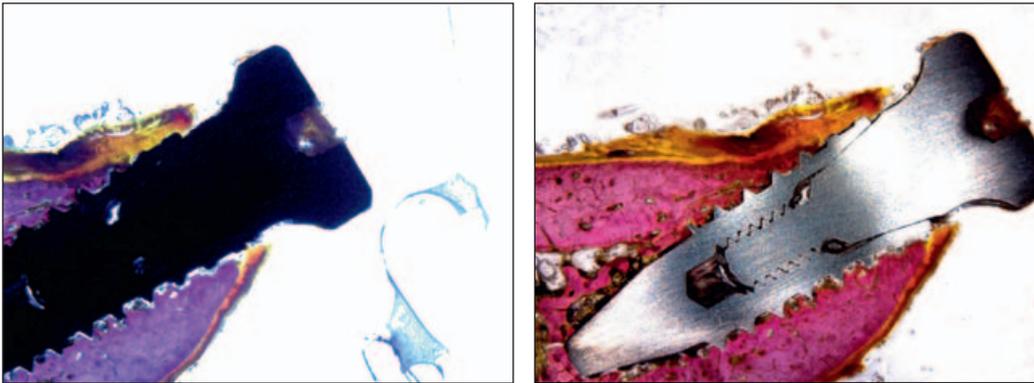


Fig. 3

Biopsy at 8 weeks of an implant placed at the crestal level. Slight resorption of the vestibular wall was observed, with stable and thick soft tissue.

Fig. 4

Biopsy at 8 weeks of an implant placed at the subcrestal level. Slight resorption of the vestibular wall with neoformed bone was observed around the implant neck, with stable and thick soft tissue.

Figs. 5 & 6

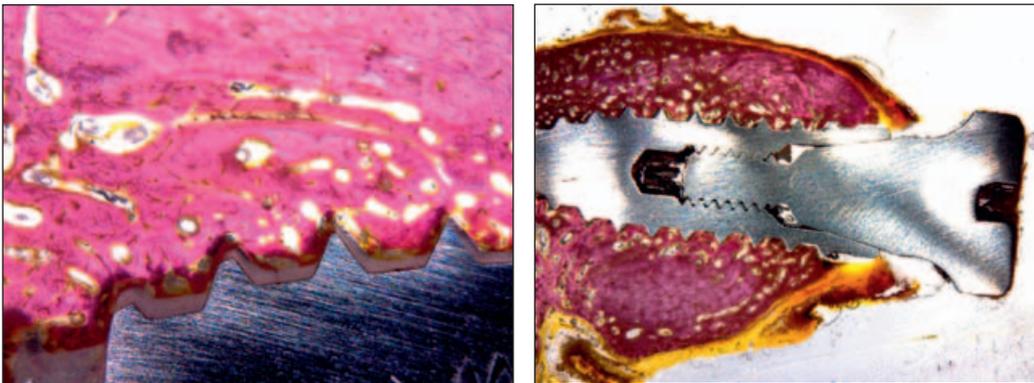


Fig. 5

Bone-implant contact at 12 weeks in unloaded bone. The bone was in intimate contact with the BIOETCH surface.

Fig. 6

Biopsy at 12 weeks of an implant placed at the crestal level. Remodeling of the buccal and lingual walls with neoformed bone around the implant neck was observed.

Figs. 7 & 8

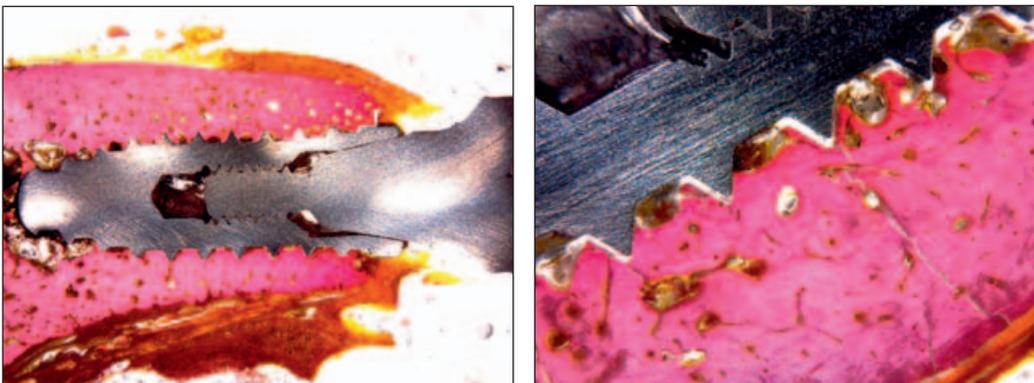


Fig. 7

Biopsy at 12 weeks of an implant placed at the subcrestal level. Remodeling of the vestibular and lingual walls with a large amount of neoformed bone protecting the implant neck was observed.

Fig. 8

Bone-implant contact at 8 weeks in healed bone. The bone was in intimate contact with the BIOETCH surface.

Table 1

Implant placement (healing period)	V-L (mean ± SD)	A-B (mean ± SD)	A-Bc (mean ± SD)	A-L (mean ± SD)	A-Lc (mean ± SD)
Crestal (8 weeks)	0.58 ± 0.30	1.83 ± 0.40	1.33 ± 0.50	0.45 ± 0.70	1.24 ± 0.70
Subcrestal (8 weeks)	0.64 ± 0.50	1.44 ± 0.90	1.22 ± 0.70	0.67 ± 0.70	1.52 ± 0.50
Crestal (12 weeks)	0.83 ± 0.30	1.26 ± 0.70	1.69 ± 0.30	0.88 ± 0.80	1.22 ± 0.70
Subcrestal (12 weeks)	0.84 ± 0.10	1.31 ± 0.50	1.57 ± 0.10	0.33 ± 0.80	0.98 ± 0.90
<i>p</i> value	0.7219	0.0345	0.1281	0.0235	0.0122
Level of significance	<i>p</i> > 0.05	<i>p</i> < 0.05*	<i>p</i> < 0.05*	<i>p</i> < 0.05*	<i>p</i> < 0.05*

V-L = difference between the buccal bone crest and the lingual bone crest; SD = standard deviation; A-B = distance from the top of the implant neck to the buccal bone crest; A-Bc = distance from the top of the implant collar to the first BIC at the buccal aspect;

A-L = distance between the top of the implant collar and the lingual bone crest; A-Lc = distance from the top of the implant collar to the first BIC at the lingual aspect;

* indicates statistical significance.

Table 1

Mean values (mm) ± standard deviation mm for the Brunner and Langer test (nonparametric analysis of repeated measures). Description of the data in healed bone.

	Crestal			Subcrestal		
	Mean ± SD	p value	Significance	Mean ± SD	p value	Significance
8 weeks	35.22 ± 0.87	0.4333	$p > 0.05$	47.22 ± 0.87	0.324	$p < 0.05^*$
12 weeks	41.52 ± 0.11	0.0231	$p > 0.05^*$	54.87 ± 0.23	0.012	$p < 0.05^*$

Table 2

Implant placement (healing period)	PM-IS BC		PM-IS LC		IS BC		IS-LC		BC-LC	
	Mean ± SD	Median	Mean ± SD	Median	Mean ± SD	Median	Mean ± SD	Median	Mean ± SD	Median
Crestal (8 weeks)	3.20 ± 0.12*	3.2	2.92 ± 0.46*	2.9	2.17 ± 0.90	2.1	1.78 ± 0.80	1.7	1.61 ± 0.80	1.6
Subcrestal (8 weeks)	2.10 ± 0.16*	2.0	2.88 ± 0.90*	2.8	1.80 ± 0.40	1.7	1.60 ± 0.10	1.6	1.40 ± 0.90	1.4
Crestal (12 weeks)	2.70 ± 0.82*	2.7	3.12 ± 0.18*	3.0	1.99 ± 0.60	1.9	1.72 ± 0.30	1.7	1.61 ± 0.60	1.6

Table 3

PM-IS BC = distance from the periimplant mucosa to the buccal bone crest;
 PM-IS LC = distance from the periimplant mucosa to the lingual bone crest;
 IS-BC = distance from the top of the implant shoulder to the first BIC at the buccal aspect;

IS-LC = distance from the top of the implant shoulder to the lingual bone crest;
 BL-LC = difference between buccal bone crest and lingual bone crest;
 SD = standard deviation; * indicates statistical significance.

Table 2
 Mean values of BIC % ± standard deviation at the different time periods. Description of the data in healed bone.

Table 3
 Brunner and Langer test (non-parametric repeated measures analysis of variance) applied to mean values ± standard deviation and median values (mm) related to implants placed subcrestally. The level of significance was set at $p < 0.05$.

Moreover, the delicate marginal portion of the buccal bone wall frequently contains proportionally larger amounts of bundle bone than the lingual wall does.¹¹ Bundle bone is a tooth-related tissue that, after tooth loss, will model and eventually disappear.^{4,5}

In the present study, BIC values decreased in the subcrestal group from the healing period of 8 weeks to the 12-week healing period in implants placed in healed bone. This finding corroborates that of Araújo et al.^{6,7} The authors concluded that the BIC established during the early healing phase after implant insertion was partially lost when the buccal bone wall was resorbed. The gaps between the implant and the walls of the alveoli for immediate post-extraction implants were filled with bone tissue after the 8-week healing period. In the present study, a more coronal BIC was obtained in the test group (subcrestal). The total BIC revealed higher values in the subcrestal group. The higher BIC values of the test group after 8 and 12 weeks of healing suggest that bone regeneration may be more favorable for implants placed subcrestally, which is in agreement with results reported by other authors.⁵⁵ Therefore, subcrestal insertion of dental implants may facilitate anterior BIC at the implant neck. It was also observed that a comparatively larger portion of the implant surface was in direct contact with the bone within the defect area after a period of 12-week wound healing for the control and test implants compared with the 8-week healing

period. This is in accordance with previous articles published by other authors.⁵⁵ They concluded that higher BIC values were found after 3 months of healing, compared with results after 1 month of healing.

The present study demonstrated that, regardless of the vertical positioning, subcrestal placement (test group) and crestal placement (control group) showed similar outcomes and bone resorption patterns, with minor differences between them.

The buccal and lingual BIC values were always higher for the subcrestal implants. Therefore, for these measurements, more favorable results should be obtained with subcrestal placement of implants. Clinically, implants are often inserted at crestal bone level.^{13,14} However, implants can be inserted subcrestally in esthetic areas to minimize the risk of exposure to metals and to allow sufficient space in the vertical dimension to develop an adequate emergence profile.^{24,38,39} The modeling in the marginal defect region was accompanied by marked attenuation of the dimensions of both the delicate buccal and the wider lingual bone walls. At the buccal aspect, this resulted in some marginal loss of osseointegration.^{6,7} In this regard, Caneva et al. suggested that implants should be placed 1 mm subcrestally to reduce or eliminate exposure of the rough portion of the implant above the alveolar ridge.²⁴ In addition, subcrestal placement of an implant may facilitate BIC earlier at the implant neck.

Conclusion

Our findings suggest that less resorption can be expected when implants are inserted 2 mm subcrestally for both immediate and deferred implants compared with placement at the crestal level. In addition, higher BIC values were found at 12 weeks of follow-up in the group of implants placed subcrestally in healed bone compared with those placed subcrestally immediately. The

design of an implant with a smooth neck without microthreads and with a surface highly receptive to osteoblasts improves osseointegration in the initial stages, which *a posteriori* increases.

Competing interests

The authors declare that they have no competing interests.

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Improved fully digital workflow to rehabilitate an edentulous patient with an implant overdenture in 4 appointments: A case report

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Abstract

Background

The digital revolution is changing the world, and dentistry is no exception. Through the development of new equipment and workflows, the diagnosis and treatment of patients are becoming simpler and more efficient. However, a fully digital approach to treating edentulous patients may be a challenge and time-consuming, because edentulous sites are often flat and smooth, with few features.

Case presentation

This clinical case presentation demonstrates step by step a fully digital workflow to rehabilitate a 67-year-old edentulous patient with a removable complete dental prosthesis. Treatment included cone beam computed tomography scan taken according to a modified double-scan protocol, existing removable complete dental prosthesis digitalization, computer-guided template-assisted implant placement, an optical impression taken with a modified template, a CAD/CAM titanium bar and a cobalt–chromium, friction fit superstructure framework.

Conclusion

A fully digital workflow was effective in restoring function and esthetics in an edentulous male patient treated with an overdenture fully supported by four implants and a CAD/CAM titanium bar with a low-profile attachment system.

Keywords

Intraoral scanner, digital impression, guided surgery, accuracy, dental implants, overdenture.

Introduction

Prosthetic-driven implant placement is a key factor for successful implant therapy.¹⁻⁴ Hence, computer-assisted template-based implant placement has become increasingly popular owing to improved planning and the higher transfer accuracy of the virtual plan to the surgical site compared with freehand insertion or freehand final drilling.⁵ Nevertheless, the accuracy of computer-assisted template-based implant placement depends on several factors, from data set acquisition to the surgical procedure. Originally, guided surgery protocols advocated a dual-scan protocol.⁶ Today, the continuous technological progress in both computer-based development and the dental manufacturing process offers additional instruments for treatment planning, surgical placement and prosthetic rehabilitation in an interdisciplinary team approach.

An accurate fit of the implant master cast affects the passive fit of an implant-supported fixed complete dental prosthesis.⁷ Thus, an accurate implant impression is a prerequisite for fabricating an accurate master cast and therefore an accurately fitting prosthesis.⁸ There are various implant impression techniques that have been utilized to fabricate a definitive cast for the production of an accurately fitting implant-supported fixed complete dental prosthesis.^{8,9} In a recent randomized controlled trial, it was concluded that the clinical outcome of plaster impressions for completely edentulous patients was found to be the same as for splinted polyvinyl siloxane impressions.⁸ Today, there is no doubt about the potential of recent intraoral optical impression systems available on the market regarding diagnosis and treatment planning, as well as for the fabrication of fixed dental prostheses. Their accuracy compares well with traditional impression taking.¹⁰ Moreover, intraoral scanners have been successfully used in the fabrication of partial^{11,12} and removable complete dental prostheses.¹³ However, scanning edentulous areas with intraoral scanners may be difficult and time-consuming because edentulous sites are smooth and devoid of features. Thus, the fabrication of complete-arch restorations remains a challenge when data are directly acquired with an intraoral scanner.

The aim of the present study is to present a fully digital pathway in a model-free approach to rehabilitate a maxillary edentulous patient with an implant overdenture. A newly developed

technique to take an accurate intraoral optical impression of edentulous patient is described.

Case report

A partially edentulous 67-year-old man with a removable complete dental prosthesis in the upper jaw and a removable complete partial prosthesis in the lower jaw was referred to a private center in Rome, Italy, for a possible maxillary implant-supported rehabilitation. The patient had been edentulous in the upper jaw for years. Nevertheless, he had never been comfortable with his maxillary removable complete dental prosthesis, and he stated that he was interested in an implant-supported fixed dental prosthesis.

First clinical appointment

The patient's medical history was collected and preoperative photographs, radiographs, periodontal screening and model casts were obtained for initial evaluation. During the clinical examination, the existing removable complete dental prosthesis and functional and esthetic aspects were evaluated, with particular attention to the fit of the prosthesis, vertical dimension of occlusion, facial support and lip position. Extraoral examination of the patient without the existing removable complete dental prosthesis showed a wide nasolabial angle and insufficient lip support (**Figs. 1 & 2**). All treatment options were then discussed and evaluated together with the patient. An implant-supported fixed dental prosthesis was excluded because of the need for facial support. Hence, a maxillary implant-supported overdenture was considered the only possible therapeutic option.

The prosthetic-driven planning workflow started with a modified double-scan protocol, with 4–6 drops of flowable composite added to the existing removable complete dental prosthesis, instead of spherical gutta-percha markers (**Fig. 3**).⁶ In this technique, the first scan was a cone beam computed tomography (CBCT) scan (CRANEX 3Dx, SOREDEX, Tuusula, Finland) of the patient wearing the existing removable complete dental prosthesis. A wax bite was used to separate the dental arches (**Fig. 3**). The second scan was only of the existing removable complete dental prosthesis, performed using an optical intraoral scanner (Carestream Dental, Atlanta, Ga., U.S.) to allow the merging of the

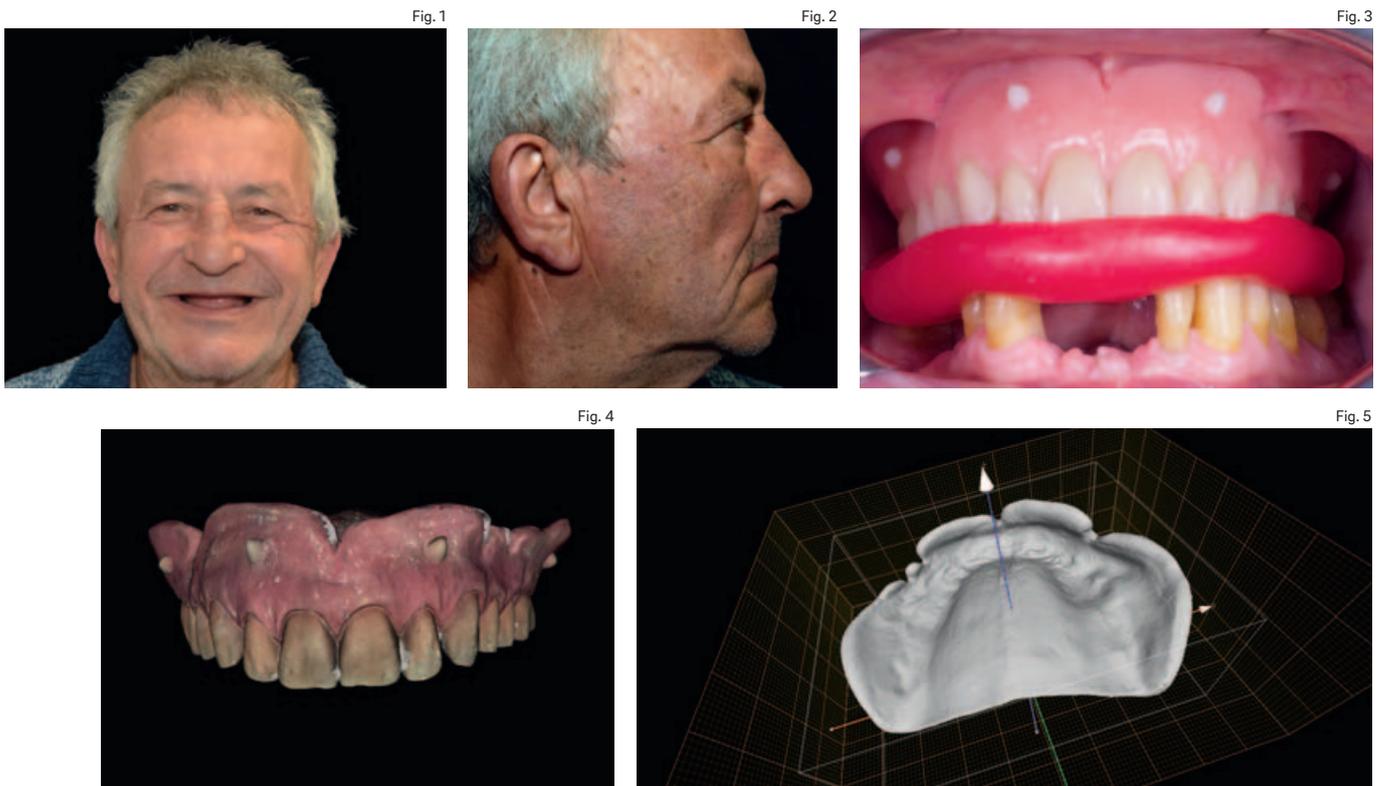


Fig. 1
Frontal extraoral view.

Fig. 2
Lateral extraoral view.

Fig. 3
Existing removable complete dental prosthesis with 6 drops of flowable composite and a wax bite.

Fig. 4
Optical scanning of the existing removable complete dental prosthesis.

Fig. 5
Three-dimensional STL file of the existing removable complete dental prosthesis.

DICOM data with the STL file (**Figs. 4 & 5**). Using reverse engineering, a virtual model was achieved (**Fig. 6**).

The STL and DICOM data were imported into a 3-D software planning program (3Diagnosis, Version 4.2, 3DIEMME, Cantù, Italy). The reprocessed surface extrapolated from the DICOM data and the surface of the existing removable complete dental prosthesis generated by the scanning process were merged with the best-fitting repositioning tools of the software (3Diagnosis). At this point, four prosthetic-driven implants with a diameter of 3.5 or 4.5 mm and a length of 13.0 mm (Osstem TSIII, Osstem, Seoul, South Korea) were planned, taking into account the bone quality and quantity, soft-tissue thickness, anatomical landmarks, and the type, volume and shape of the final restoration (New Ancorvis, Bargellino, Italy; **Fig. 7**). After careful functional and esthetic evaluation and final verification, the prosthetic-driven plan was approved, and a stereolithographic surgical template was fabricated with a newer rapid prototyping technology (New Ancorvis; **Fig. 8**).

Second clinical appointment

One hour before implant placement, the patient underwent professional oral hygiene, used a prophylactic antiseptic containing 0.2% chlor-

hexidine (CURASEPT, Curaden Healthcare, Saronno, Italy) for one min and received prophylactic antibiotic therapy (2 g of amoxicillin or 600 mg of clindamycin if allergic to penicillin). The accurate fit of the surgical templates was tried directly in the patient's mouth (Fit Checker, GC, Tokyo, Japan). The patient was treated under local anesthesia using articaine with 1:100,000 epinephrine, administered 20 min before surgery. The surgical template was stabilized using a silicone surgical index, derived from the virtual plane, and five preplanned anchor pins (New Ancorvis). Planned implants (Osstem TSIII) were placed flapless using dedicate drills (OsstemGuide KIT, Osstem; **Fig. 9**). All of the implants were inserted with a minimum insertion torque of 35 N cm according to previously published protocols.¹⁴ Preplanned multiunit abutments were immediately screwed on to the implants (New Ancorvis) and never removed. Immediately after implant placement, the patient received a digital impression (CS 3600 intraoral scanner, Carestream Dental), taken at abutment level, using dedicate scan abutments (Type AQ, New Ancorvis; **Figs. 10a & b**). In order to improve the accuracy of the digital impression in a fully edentulous patient, a second digital impression was taken using a dedicate opaque template, made by virtual planning, that was stabilized in the patient's

Fig. 6

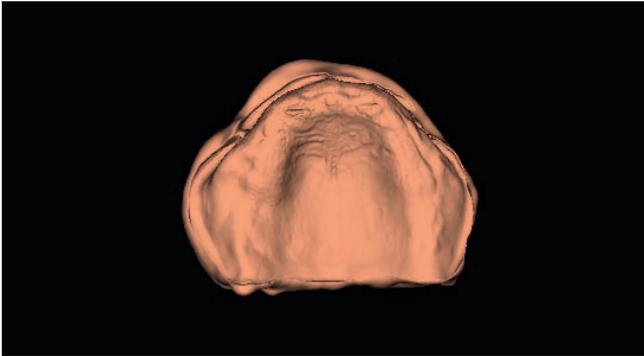


Fig. 7

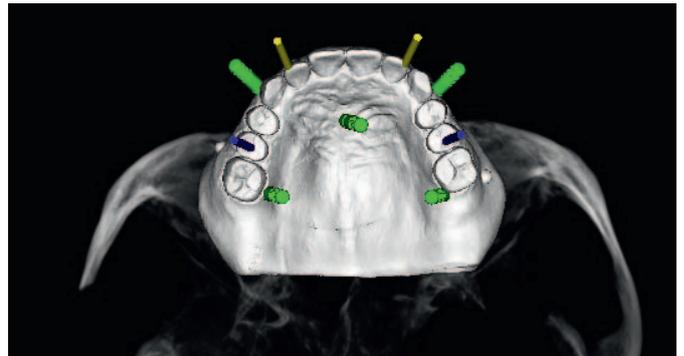


Fig. 8



Fig. 9



mouth using the same anchor pin positions of the surgical guide. This template was customized to maintain the tooth design, but allow the screwing of the scan abutments (Type AQ; **Fig. 11**) so that the new STL file could be superimposed with the previous planning (**Fig. 12**). Finally, the multiunit abutments were covered with dedicate caps, and the existing removable complete denture was relined at chairside with a autopolymerizing resin (Hydro-Cast, Sultan Healthcare, York, Pa., U.S.), thereby ensuring no pressure on the healing abutments. After implant placement, the patient received oral and written recommendations about medication, oral hygiene maintenance and diet.

A CAD/CAM titanium bar was anatomically designed by an experienced dental technician and CAD designer (MA) according to the implant position and the shape and volume of the existing removable complete dental prosthesis (exocad DentalCAD, Engine Build 6136, exocad, Darmstadt, Germany; **Fig. 13**).¹⁵ Three threadable low-profile attachments (OT Equator, Rhein'83, Bologna, Italy) and two spheres (Rhein'83) were planned along the implant bar (**Fig. 14**). A cobalt-chromium alloy framework was then directly designed on to the CAD/CAM titanium bar project (**Fig. 15**) according to the existing tooth setup (exocad Partial Framework CAD, Version 0.x, exocad). The designs of the

virtual bar and the superstructure framework were transmitted to the production center (New Ancorvis), where a one-piece titanium bar was milled from a homogenous solid block of medical titanium alloy (Ti6Al4V), while the cobalt-chromium, friction fit superstructure framework was laser melted (**Fig. 16**).

Third clinical appointment

The fit of the implant bar and the superstructure framework was clinically and radiographically tested in the patient's mouth according to established criteria (**Figs. 17 & 18**).^{16,17} An interocclusal record was taken in centric relation, and master models, fabricated using rapid prototyping techniques, with specially designed implant replicas, were mounted in a fully adjustable articulator (PROTAREvo 7, KaVo Dental, Biberach, Germany; **Fig. 19**). Digital analysis of movement was performed using the ARCUSdigma device (KaVo Dental) to ascertain and document all the settings required for programming the articulator (e.g., condylar inclination, Bennett angle, immediate side shift and shift angle). Finally, the overdenture was finished using a silicone index derived from the existing removable complete dental prosthesis as tooth reference, and the borders sealed to minimize food impaction, and saliva or air leakage.

Fig. 6

Virtual model derived from the scan of the existing removable complete dental prosthesis.

Fig. 7

Prosthetic-driven virtual implant planning.

Fig. 8

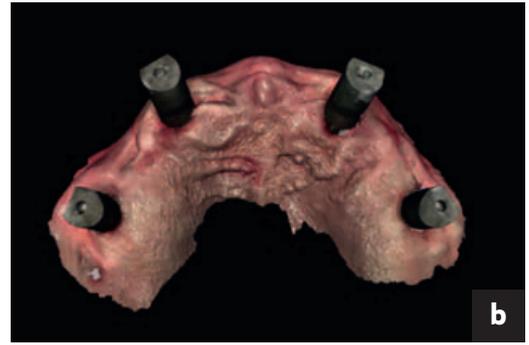
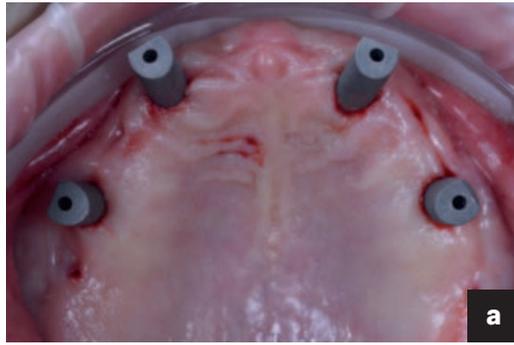
Surgical template.

Fig. 9

Implants placed flapless using the surgical template.

Figs. 10a & b

Scan abutment screwed to the multiunit abutments (a) and optical intraoral impression (b).



Figs. 10a & b

Fig. 11

Second optical intraoral impression with a specially designed template.

Fig. 12

STL file derived from the second optical intraoral impression.

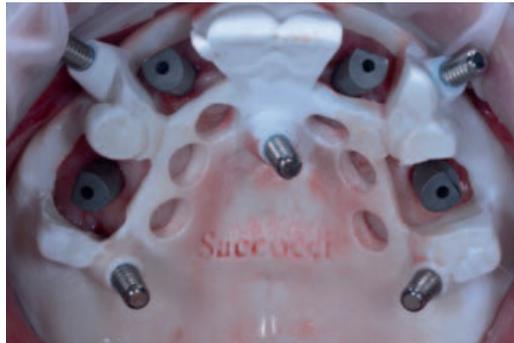


Fig. 11

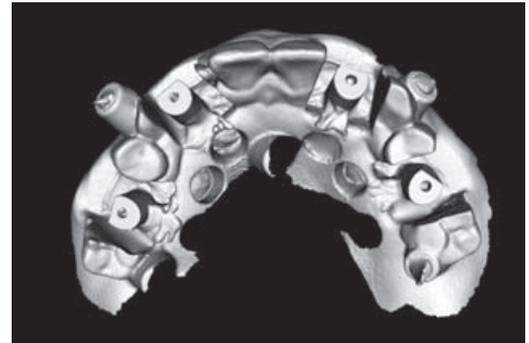


Fig. 12

Fig. 13

CAD of the titanium bar.

Fig. 14

CAD/CAM titanium bar with low-profile attachments and spheres.

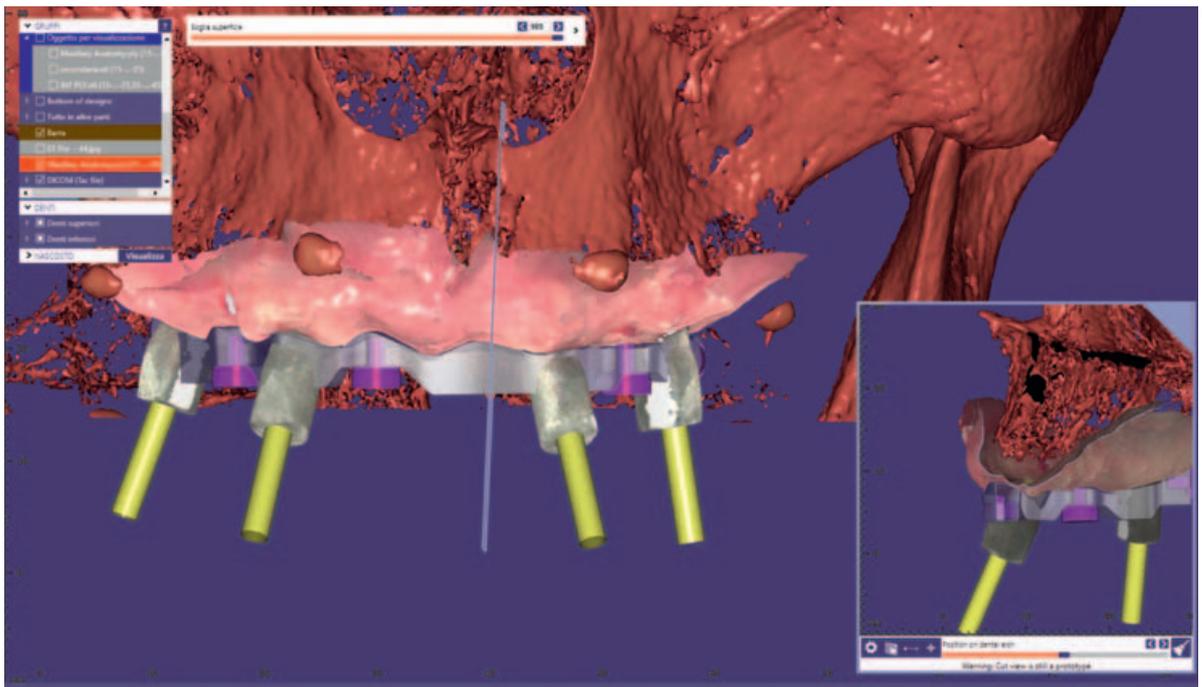


Fig. 13

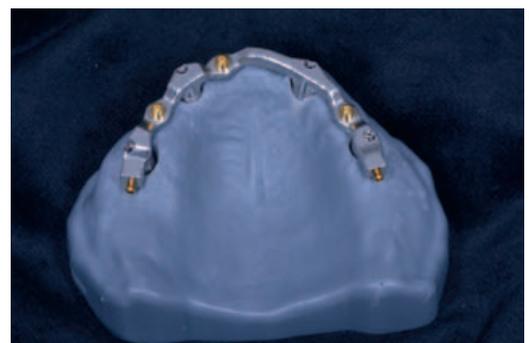


Fig. 14

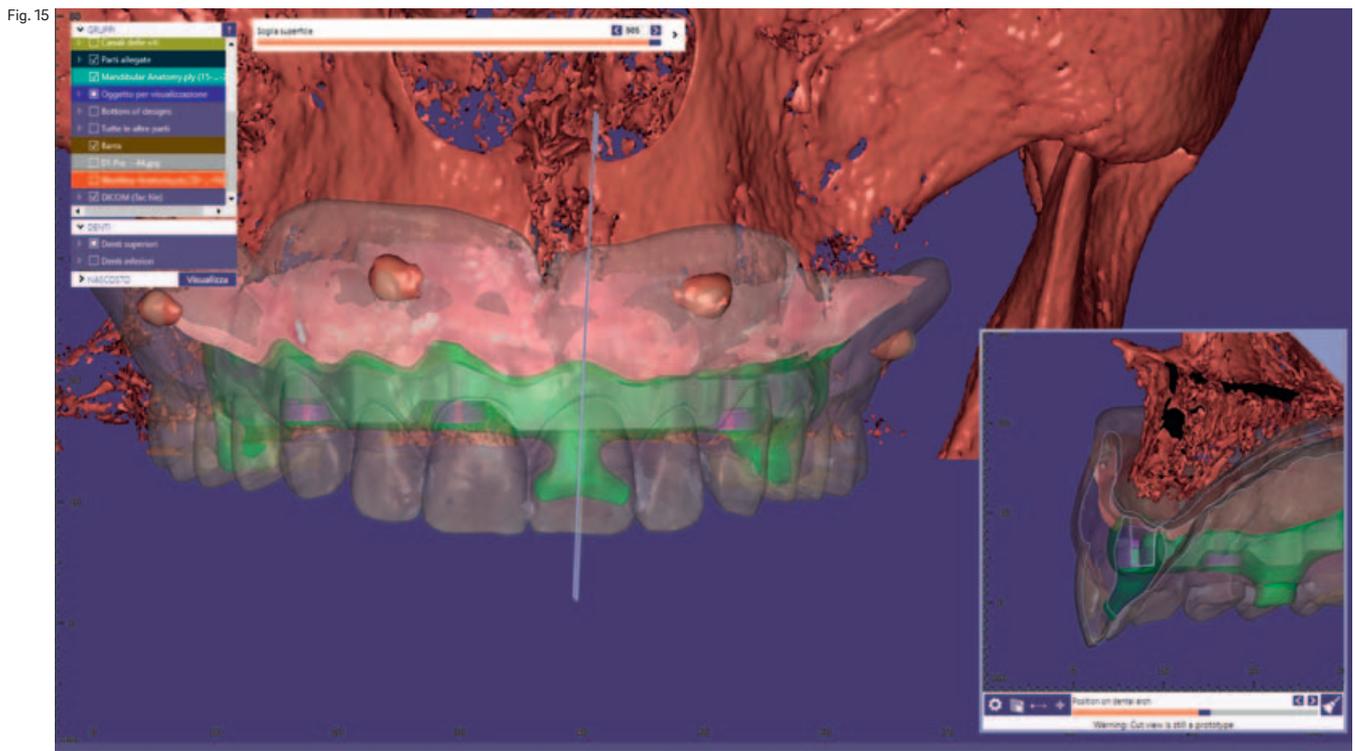


Fig. 15



Fig. 16

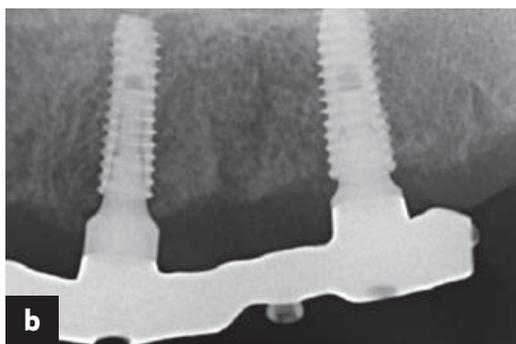
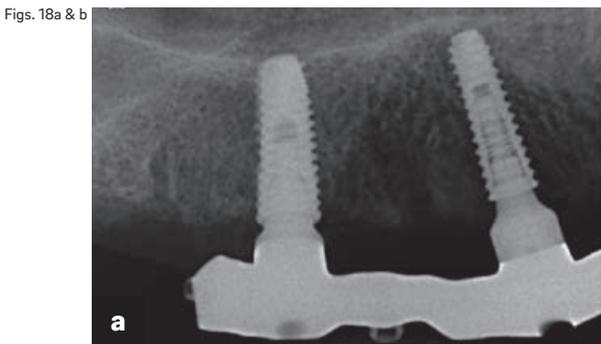


Fig. 17

Fig. 15
CAD of the superstructure framework.

Fig. 16
Superstructure framework.

Fig. 17
Intraoral try-in of the CAD/CAM titanium bar.



Figs. 18a & b

Figs. 18a & b
Periapical radiographs showing the perfect fit between the CAD/CAM titanium bar and the implants (multiunit abutments).

Fig. 19
Implant overdenture mounted in the fully adjustable articulator.



Fig. 19

Fig. 20
Implant overdenture in the patient's mouth.



Fig. 20

Fig. 21
Dental panoramic tomogram after prosthesis delivery.

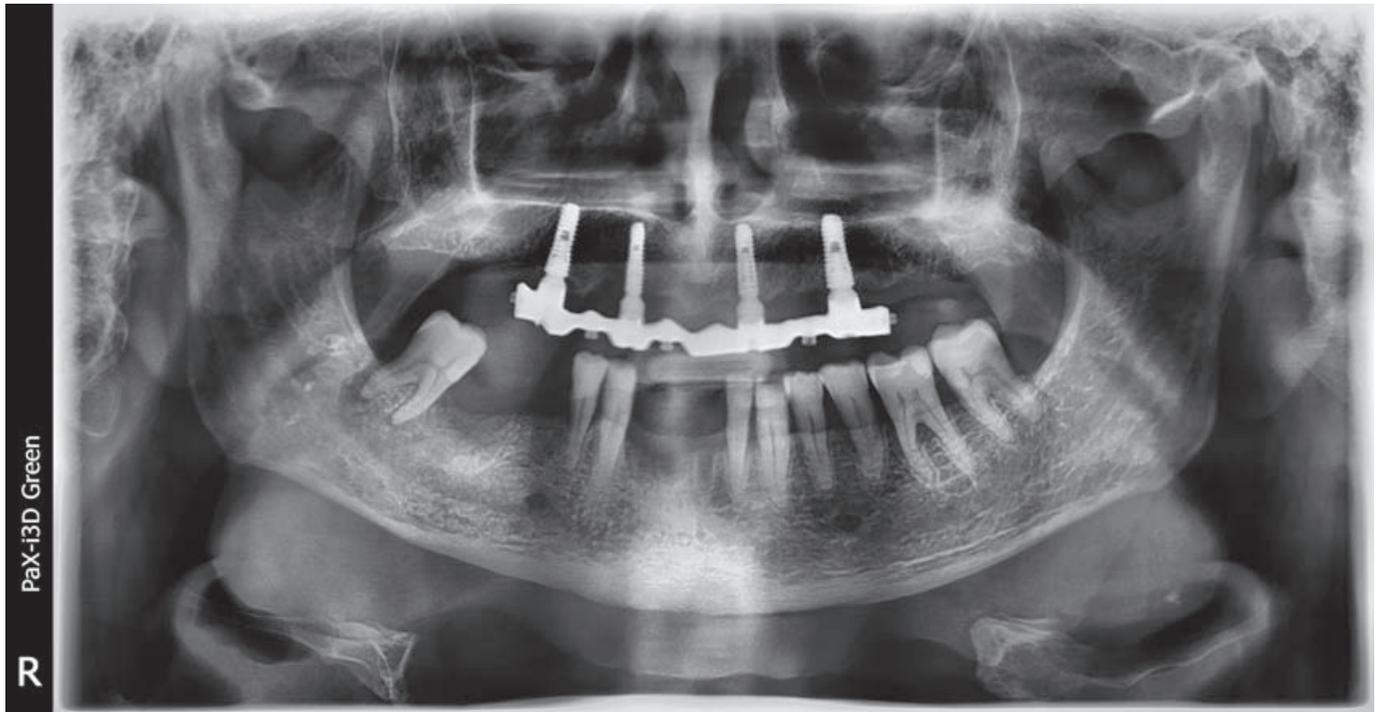


Fig. 21

Fourth clinical appointment

The titanium bar was screwed at the abutment level according to the manufacturer's instructions and the implant overdenture was delivered 6 weeks after the first visit (**Figs. 20 & 21**). The patient was enrolled in a standard implant recall program. Oral hygiene maintenance was checked and radiographs were taken early after final prosthesis delivery. Occlusion was checked at every appointment.

Discussion

This clinical report describes a new technique for fabricating a maxillary implant-supported, removable complete dental prosthesis using an intraoral digital scanner to register implant positions and soft-tissue morphology. The main limitation of the present study is that a single case report is not suitable for representative population samples; thus, findings from a case report cannot be generalized. A second limita-

tion could be an over interpretation of the results. Hence, these results should be interpreted with caution, since the literature presents a lack of scientific evidence. Nevertheless, a case report represents a means of detecting new techniques, due to the time from observation to publication, much shorter than for other kinds of studies.

Existing technologies such as CBCT, in conjunction with virtual 3-D reconstruction of implant placement and fabrication of surgical templates with stereolithography, are used in both treatment planning and implant placement. However, errors of 1.5 mm and 1.0 mm have been reported in horizontal and vertical dimensions for the CBCT technique.^{18,19} Furthermore, CBCT images are subject to severe contamination from scatter signals that induce large image artifacts, which limit the applications of CBCT.²⁰ In order to overcome the drawbacks related to CBCT technologies, the existing removable complete dental prosthesis was digitalized using a more accurate intraoral scanner.²¹

The use of intraoral scanners in dental clinics for taking digital impressions of teeth and implants is rapidly growing, improving workflow with other digital technologies. Optical impressions are more comfortable for the patient and less time consuming. At the same time, they are accurate and easier for the clinician.²²⁻²⁸ A recent systematic literature review and meta-analysis by Chochlidakis et al. concluded that intraoral scanners can be safely used for taking impressions of single and multiple abutments in dentate patients.²³ However, there is still a lack of evidence on the possibility of using intraoral scanners to take impressions for long-span restorations or in the case of fully edentulous patients.⁹ In a recent *in vitro* study by Imburgia et al., the CS 3600 had the best performance in terms of trueness and precision in both partially and fully edentulous models with 6 implants.²¹ Mangano et al., in another *in vitro* study, found no differences in trueness and precision between partially and fully edentulous models.²² However, this result may be due to the fact that the

3-D surface models of the partially edentulous patient were not cut and trimmed and the related calculations were consequently performed on the whole arch.

In the present study, in addition to the digital data acquisition of soft-tissue morphology and implant positions, a second optical impression was taken with a specially designed opaque template in conjunction with the same scan abutments (New Ancorvis) to acquire accurate digital data at the implant level in a completely edentulous patient, as if the patient was partially edentate. This technique may allow the avoidance of one appointment needed to try a segmental verification device to confirm implant analogue positions.²⁹

The presented technique uses CAD/CAM technology with a subtractive manufacturing process to fabricate a milled bar (infrastructure framework) and an additive process to fabricate a friction fit superstructure framework. This digital restorative pathway may decrease patient discomfort and reduce the labor associated with fabricating implant-supported, removable complete dental prostheses. According to previously published prospective studies, the overdenture fully supported by four implants and a CAD/CAM titanium bar with a low-profile attachment system can be considered an effective and predictable option for patients in both maxilla and mandible.^{15,30} Minimum marginal bone remodeling and technical complications can be expected, together with good periodontal parameters and patient satisfaction, over time.^{15,30}

Conclusion

The present case report may encourage the use of intraoral scanners to take accurate intraoral optical impressions, even in the case of edentulous patients and according to the presented protocol. Nevertheless, further randomized controlled trials with larger sample sizes are needed to confirm the outcomes that emerged from the present work.

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Thirteen-year follow-up of a cross-arch implant-supported fixed restoration in a patient with generalized aggressive periodontitis and parafunctional habits

Abstract

Background

As implant treatment becomes part of mainstream dental therapy, dental offices should implement protocols for individualized, systematic and continuous supportive care of the periimplant tissue. This article describes the 13-year management of a patient with generalized aggressive periodontitis and bruxism treated using Brånemark TiUnite implants with machined collars.

Materials and methods

In the upper jaw, a cross-arch implant-supported fixed restoration was delivered. In the lower jaw, an implant-supported fixed partial prosthesis was provided, retaining some natural dentition, which increased the risk of a periodontal reservoir. Treatment included multiple extractions and submerged implants. Implant survival rate, patient satisfaction, marginal bone maintenance and soft-tissue condition at the modified titanium surfaces of the dental implants were evaluated up to 13 years of function.

Results

Two adjacent implants were lost 3 years after loading owing to periimplantitis and these were not replaced. One implant had bone loss after recementation and retained cement that subsequently responded to intervention with bone recovery. Furthermore, the maxillary prosthesis was remade once after 3 years of function, owing to porcelain breakage in the esthetic zone.

Conclusion

This clinical case may provide information about benefits of a long-term patient history follow-up, with emphasis on periodontal and occlusal risks. A comprehensive diagnosis, multifactorial approach, good clinician-patient relationship and vigilant maintenance of oral hygiene were needed in order to ensure an optimal treatment and a successful long-term result.

Keywords

Dental implants, long-term follow-up, periodontally compromised patients, periodontitis, supportive periodontal therapy.

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Introduction

Endosseous dental implants have been widely used to aid the support of restorations replacing missing teeth. This has been widely reported in the literature dating back to the early 1960s.^{1,2} Implants have added predictable treatment options for patients, clinicians and dental technicians.^{3,4} Nevertheless, technical and biological complications may occur either at an early stage, owing to failed integration during healing, or later, regarded as loss of integration and stability after healing and during functional loading.⁵ Smoking, low bone density, irradiation, infection, relative overload, previous periodontitis and parafunctional habits, such as bruxism, are some of the described risk factors that may lead to implant failure.^{5,6} In the case of parafunctional habits, in a systematic review, it was noted that treated patients with periodontitis may experience more implant loss and biological complications compared with nonperiodontitis patients with implants.⁴ During the first year of function, a certain amount of physiological marginal bone loss is often observed around a dental implant, and this probably reflects remodeling/adaptation after surgery⁷ and during loading;⁸ thereafter, minimal further bone loss has been annually observed.^{6,9} As a consequence, the prerequisites for implant success are marginal bone loss of up to 1.0 mm within the first year of implant loading and successive annual mean marginal bone loss of 0.2 mm during the follow-up period.^{9,10} Continuous bone loss with clinical signs of infection, such as bleeding and suppuration, is referred to as periimplantitis, irrespective of the sequence of events.¹¹ Depending on the definition used, the prevalence of progressive bone loss/periimplantitis in long-term studies has been reported to range from 7.7 to 39.7%.¹² Periodontally healthy patients and patients with chronic adult periodontitis show no difference in periimplant variables and implant survival rate, but patients with generalized aggressive periodontitis have greater periimplant pathology, more marginal bone loss and a lower implant survival rate.¹³ Furthermore, it is of interest to note that the impact of a history of periodontitis on early implant loss was found to be negligible in patients that have been treated with supportive periodontal therapy.¹⁴ However, in the long term, periimplantitis was detected more than twice as frequently in periodontally compromised than in periodontally healthy subjects.^{13,15}

Furthermore, based on clinical experience, it has been noted that bruxers are a high-risk category regarding successful implant outcomes and this has been reported in the literature.¹⁵ Studies have reported more frequent technical complications, including implant loss, in bruxers.¹⁶

This case report describes the 13-year management of a patient with generalized aggressive periodontitis and bruxism treated using Brånemark TiUnite implants (Nobel Biocare, Yorba Linda, Calif., U.S.) with machined collars. In the upper jaw, a cross-arch implant-supported fixed restoration was delivered. In the lower jaw, an implant-supported fixed partial prosthesis was provided, retaining some natural dentition, which increased the risk of a periodontal reservoir.

Case report

A 57-year-old woman with a history of generalized aggressive periodontitis presented to our clinic for a periodontal consult and treatment in 2003. Despite an overall full-mouth root planing, multiple surgeries and antibiotics, the patient continued to exhibit progressive bone loss. Two years after the initial consult, a comprehensive clinical, radiographic and study cast evaluation found that the remaining dentition showed recurrent abscesses with progressive bone loss due to chronic periodontal disease (**Fig. 1**). Furthermore, the case was complicated by pathological tooth mobility, furcation involvement at the maxillary molars, occlusal instability and parafunctional habits, including bruxism.

Various treatment options were discussed with the patient, including maxillary and mandibular conventional removable complete dentures, as well as implant-supported overdenture or implant-supported fixed restorations. The patient's chief desire was to replace her existing teeth with implant-supported fixed restorations without conventional removable complete dentures or removable prostheses. After detailed consultation, the extraction of all of the remaining maxillary dentition and its replacement with dental implants were suggested. The patient understood and agreed to the treatment plan and was informed about the higher risk of implant failure owing to her periodontal disease and bruxism, especially if some natural teeth were retained. The standard outcome in these cases is up to 98.05% at the 10-year follow-up,¹⁷ but owing to the pre-existing periodontal disease and bruxism, the success rate was expected to be

Fig. 1
Pretreatment photograph:
frontal view.

Fig. 2
Implants placed in the upper
jaw after the second-stage
surgery.

Fig. 3
Implants placed in the lower
jaw after the second-stage
surgery.

decreased to 90% at the 10-year follow-up.^{12, 13} The outcome would be dependent on the patient's daily routine, home care and professional recall visits. The patient decided to proceed with rehabilitation of the upper arch with a fixed complete denture, being aware of the associated cost, advantages and disadvantages. Comprehensive clinical, radiographic and study cast evaluation found that the previously placed implant in the maxilla (TiUnite machined collar Brånemark System MkIII, Nobel Biocare), inserted in the left central area to restore a tooth lost to an endodontic fracture complication in 1999, could be maintained for planned rehabilitation.

Three months after removal of the teeth and residual ridge healing, 7 Biocare replace implants (Nobel Biocare) were placed in additional sites across the maxillary arch. Simultaneously, extractions were performed of the mobile teeth in the right mandibular posterior site. Four months after extraction, 3 Biocare replace implants were placed to replace the extracted teeth. Bone grafting was not required for all procedures. All of the placed implants achieved stability at placement and were fully osseointegrated, evidenced by radiography and clinical torque testing to 35 N cm, performed 3 months after insertion, during healing abutment connections (**Figs. 2 & 3**). Finally, the case was referred to a prosthodontist for full-arch upper fixed-removable and partial-arch fixed tooth form prostheses. All efforts were made to retain some access for a proxy brush under the prosthesis to reduce the periimplantitis risk. The maxillary and mandibular prostheses were seated with custom titanium abutments using a temporary cement (Improv Temporary Implant Cement, Salvin Dental Specialities, Charlotte, N.C., U.S.). The patient had regular visits for periodontal control and maintenance in a well-organized scheme with appointments over the years.

The maxillary prosthesis was remade once after 3 years of function, owing to porcelain breakage in the esthetic zone. However, after the remake, the patient improved compliance regarding use of the bruxism appliance and the prosthesis remained intact and functional for over 11 years.

Nevertheless, there was progressive bone loss at a Class 3 furcation site of the mandibular first molar (**Fig. 4**) that responded to root resection therapy in 2003 and remained stable thereafter (**Fig. 5**). The overall reduced periodontal disease activity may in part be due to



Fig. 1



Fig. 2



Fig. 3

the extraction of most of the involved teeth and in part to long-term therapy with a daily dose of 100 mg of minocycline for acne, begun by the patient in 2004, then switched in 2008 to 100 mg of doxycycline, cut into quarters and taken daily. Despite her progressive periodontal history, the bone loss at the implants showed the typical pattern of about 0.5 mm of bone loss beyond the machined collar and at most sites there was no sign of periimplantitis related to marginal bone loss. However, there were two sites in the left maxillary molar area where periimplant bone loss had developed. The implants placed at this position were both lost after 3 years of loading, primarily related to implant proximity between them, limiting proper oral hygiene access (**Figs. 6 & 7**). These implants were not replaced and the prosthesis was retained with a distal cantilever pontic at the first molar area off the most distal implant site at the second premolar area in the full-arch prosthesis. Acute suppuration and about 2 mm

Fig. 4



Fig. 5

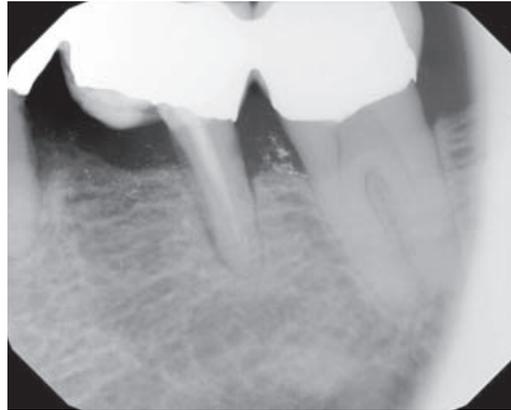


Fig. 4

Teeth affected by periodontitis in the left lower jaw.

Fig. 5

Root resection therapy performed on the left mandibular first molar.

Fig. 6



Fig. 7



Fig. 6

The 2 implants in the left upper jaw affected by periimplantitis.

Fig. 7

Removal of the implants.

Fig. 8

Periimplant bone loss at the left mandibular second molar.

Fig. 9

The left mandibular second molar site shown fully recovered.

Fig. 8



Fig. 9



of periimplant bone loss were also observed at the 6-year follow-up at the right mandibular second molar implant (**Fig. 8**), related to retained cement that was noted about 6 months after a recementation of the splinted crowns. A flap was raised at the right mandibular molar area, then the exposed TiUnite surface was decontaminated with citric acid and hard-tissue defect walls and soft-tissue excess were reduced as part of flap closure. At the 7-year follow-up examination, subgingival irrigation with minocycline hydrochloride microspheres (Arestin, OraPharma, Valeant Pharmaceuticals International, Laval, Quebec, Canada) was performed. At the year 8 visit, the right mandibular

second molar site had fully recovered bone reformation (**Fig. 9**). Although the patient had active periodontal disease activity, good clinical (**Figs. 10 & 11**) and radiographic (**Fig. 12**) outcomes were illustrated at the 8-year follow-up visit, owing to the impact of supportive periodontal therapy.

At the year 13 visit, the second molar still remained stable in response to intervention, with a full recovery of historic bone loss that was once about 2 mm beyond the machined collar. Good clinical (**Figs. 13 & 14**) and radiographic (**Figs. 15a & b**) outcomes were recorded at the 13-year follow-up visit, owing to good oral hygiene maintenance and regular recall.

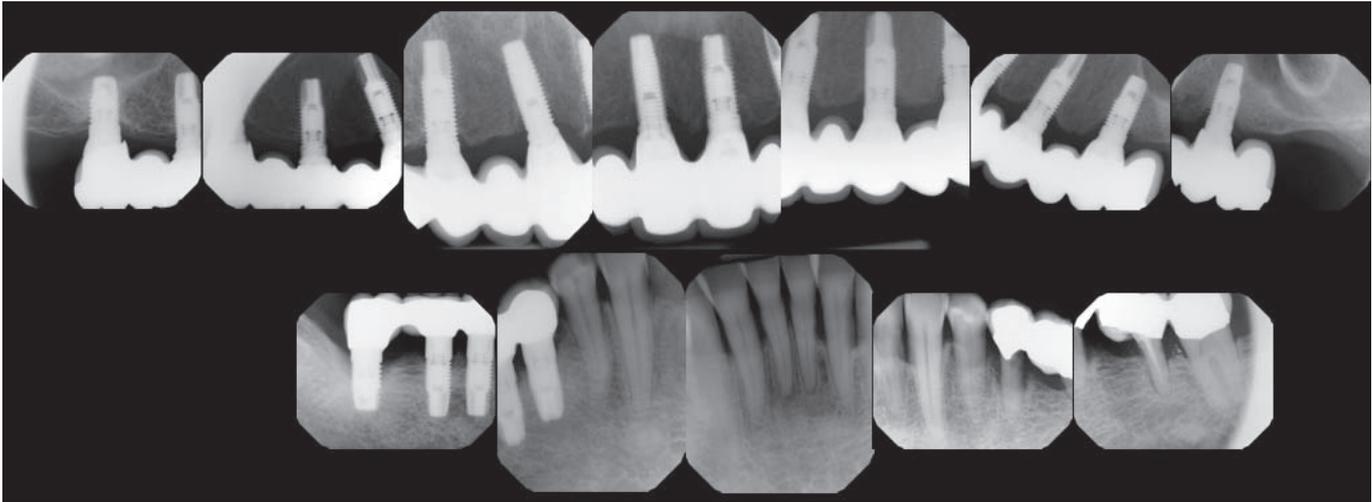


Fig. 10

Fig. 10
New prosthesis and follow-up after 8 years: right side view.

Fig. 11
New prosthesis and follow-up after 8 years: frontal view.

Fig. 12
New prosthesis and follow-up after 8 years: radiographs.

Fig. 13
Follow-up after 13 years: frontal view.

Fig. 14
Follow-up after 13 years: right side view.



Fig. 11



Fig. 12



Fig. 13



Fig. 14

Discussion

Little is known about the long-term outcome of implants with oxidized surfaces, especially in periodontitis-susceptible patients. The management of this case presented a challenge to the treating clinician, as the patient presented with generalized aggressive periodontitis complicated by bruxism. Supportive periodontal control and maintenance following a predesigned subject-tooth, implant site risk assessment

method is of key importance for long-term success after periodontal surgery.^{18, 19} The two implant losses at the 3-year time point were in accordance with the literature finding that patients with a history of generalized aggressive periodontitis are more clearly prone to late failure rates, even when minimally rough implants are used when periodontal therapy is followed.²⁰ Complicating factors such as implant proximity and retained cement may have been the initiating factors.

Fig. 15a



Fig. 15a

Radiographic follow-up of the maxillary molars up to 13 years.

Fig. 15b

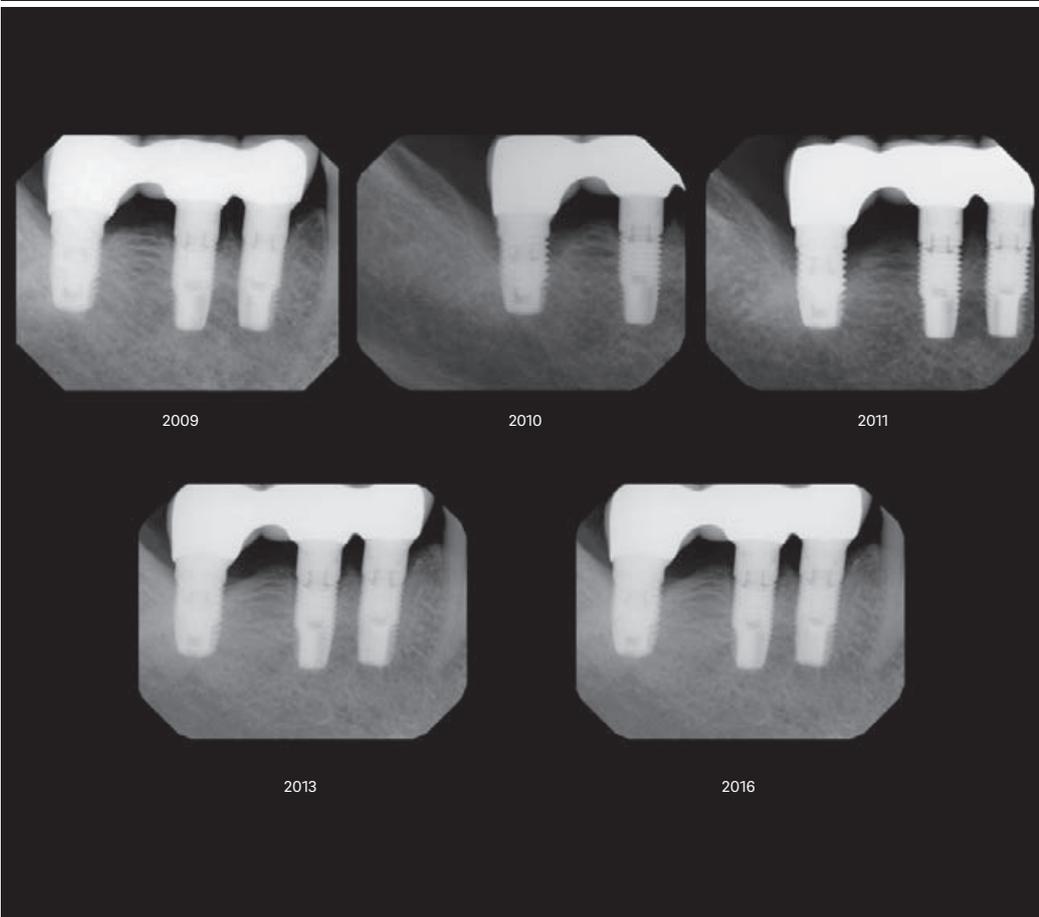


Fig. 15b

Radiographic follow-up of the right mandibular second molar from the start of the periimplantitis up to the 13th year of follow-up.

Varying degrees of marginal bone loss are normally seen around dental implants, regardless of all the efforts to eliminate it.²¹ Maintenance and improvement of periimplant bone, as well as the establishment and maintenance of a soft-tissue barrier around the implant abutment, are prerequisites for long-term esthetic and functional success of an implant-supported restoration.⁵ However, during clinical function, some implants may show extensive and sometimes continuous bone loss, whose primary cause is not well understood. Previous authors have proposed several factors that may increase marginal bone loss around dental implants, including surgical trauma, biological width establishment, lack of passive fit of the superstructure, implant–abutment microgap and occlusal overload.^{21,22} Continuous bone loss with clinical signs of infection, such as bleeding and suppuration, is referred to as periimplantitis, irrespective of the sequence of events.¹² Depending on the definition, the prevalence of continuous bone loss in long-term studies has been reported to range from 7.7 to 39.7%;¹² however, some authors have regarded this as unrealistically high.¹⁰ These figures are mainly based on implants with a machined and relatively smooth surface. Today, most implants have some type of surface treatment to promote a stronger bone tissue response, such as blasting, etching, anodic oxidation and combinations of techniques.^{23, 24} The moderately rough, highly crystalline, and phosphate-enriched titanium oxide surface of the TiUnite implants features an increased titanium dioxide layer, a moderately rough microstructure that enlarges the osseointegrable surface area, and it has been reported to enhance the adhesion of human osteoblastlike MG-63 cells to titanium without significantly affecting the pattern of gene expression.²³ Concerns have been raised that bone loss and subsequent exposure of a rough implant surface may facilitate establishment of a periimplant infection.²⁴ Though the numbers of longer-term follow-up are small, positive clinical and radiographic performance of implants with a porous anodized surface has been reported.^{18, 24} This contradicts a short-term animal study that stated that the porous anodized surface of TiUnite is more susceptible to progressive periimplant loss once established.²⁵

In the presented case, the patient's chief desire was to have her hopeless teeth replaced with implant-supported fixed restorations, keeping the remaining teeth. The patient

understood and agreed to the treatment plan and was informed about the higher risk of implant failure owing to her periodontal disease. The outcomes of this case depended on patient compliance with the periodontal program. Follow-up and intervention, when indicated, are important in a case with a history of periodontal disease. In particular, the good outcome at site 47 demonstrates the benefit of flap intervention to remove retained cement and, potentially, the added benefit of subgingival antimicrobial delivery to address periimplantitis and recover lost radiographic bone despite prior infection and bone loss. This would suggest that a contaminated microrough surface does not always lead to progressive bone loss if there is suitable intervention. Also in this case, the usage of the bruxism appliance was critical to reduce potential biological and technical complications. According to a recent systematic review, bruxism is unlikely to be a risk factor for biological complications around dental implants, but it is more likely to be a risk factor for technical complications.¹⁶ The caution that is urged when using implants to support dental prostheses in bruxers is due to the common fear that bruxism can cause overloading and may affect osseointegration and/or compromise the integrity of technical components and veneering materials. Keeping this in mind, care must be exercised in periodic control of occlusal design and presence of nonaxial loads on implant-supported restorations, and adequate levels of oral hygiene must be maintained in the long term in order to avoid increasing the risk of periimplant disease.

Conclusion

Implant treatment in patients exhibiting ongoing active periodontal disease and bruxism is not contraindicated provided that adequate infection control and an individualized maintenance program are assured. The results of this case illustrated good clinical and radiographic outcomes with long-term prosthetic stability. Confounding factors, such as the minimally rough surface of the implant, did not seem to cause bone loss.

Competing interests

The authors declare that they have no competing interests.

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Flap design: New perspectives in periapical surgery

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Abstract

Flap design in periapical surgery should be adequate for the planned surgical procedure, offering good access to the zone surrounding the affected apexes without altering the soft-tissue circulation. A full-thickness flap including mucosa, submucosal connective tissue and periosteum should be raised. A description is provided of the most frequently used types of flaps in periapical surgery:

1. Luebke–Ochsenbein flap, involving submarginal incision, with semilunar or Partsch flap variants;
2. Neumann flap with intrasulcular incision in its triangular and trapezoidal versions;
3. papilla base incision flap;
4. papilla-preserving flap; and
5. palatal flap.

Designing the flap is a key aspect of periapical surgery: It should ensure adequate exposure of the surgical field and allow the surgeon to work quickly and comfortably. Furthermore, there should be no tension capable of complicating the work of the dental professional or of causing patient discomfort, and soft-tissue damage due to retractor compression is to be avoided. A good flap design with delicate manipulation of the soft tissue is necessary for successful periapical surgery.

Keywords

Periapical surgery, endodontic surgery, surgical technique, flap design.

Introduction

Two factors are important for securing optimum functional and esthetic outcomes in periapical surgery: flap design and the suturing technique used. Flap design in periapical surgery should be adequate for the planned surgical procedure, offering good access to the zone surrounding the affected apex without altering the circulation in either the mobilized or nonmobilized soft tissue.¹

A number of factors must be taken into account in preparing the flap: the location and extent of the apical lesion, the periodontal condition of the affected tooth and of the adjacent teeth, the condition of the surrounding anatomical structures, and the presence and quality of prosthetic restorations in contact with the gingival margin.¹ The flap should encompass at least one tooth on either side of the affected tooth. Acute flap angles are to be avoided. A narrow corner is difficult to trim and suture and can suffer ischemia and become detached, favoring the formation of scars.

A full-thickness flap including mucosa, submucosal connective tissue and periosteum should be raised. The interdental papilla should not be divided (sectioned) and should be either totally included within or separate from the flap. The incisions are to be sufficiently extensive to ensure that the retractor rests on bone and does not compress part of the flap.

Types of flaps

Classically, the most commonly used type of flap in periapical surgery has been the trapezoidal or triangular Neumann flap, with an intrasulcular incision and two vertical releasing incisions. However, owing to the improvements in surgical techniques and suture materials, oral surgery has become more conservative and delicate, and the Luebke–Ochsenbein flap with submarginal incisions is now more widely used.

1. Submarginal incision flap (Luebke–Ochsenbein flap)

A horizontal incision is made in the attached gingival tissue about 3–4 mm above the gingival margin, with two vertical releasing incisions on either side of the flap located one or two teeth distal to where the lesion is located (**Figs. 1–3**). This type of flap is easy to detach, but can leave a postsurgical scar if the repositioning sutures are not performed adequately.²

The Luebke–Ochsenbein flap is less aggressive with the gingival tissue than an intrasulcular incision flap, and it is easy to make the incision slightly triangular or angled in order to secure precise repositioning (**Figs. 4–6**). It is particularly useful in patients with fixed prosthesis restorations, since correct application of the technique results in less recession of the gingival margin^{3,4} and interdental papillae.⁵

Fig. 1

Clinical view before the trapezoidal submarginal flap for periapical surgery of tooth #11.

Fig. 2

Detachment of the trapezoidal submarginal flap.

Fig. 3

Intraoperative view after osteotomy and resection of the apex of tooth #11.

Fig. 1



Fig. 2



Fig. 3





Fig. 4



Fig. 5



Fig. 6



Fig. 7



Fig. 8



Fig. 9

Fig. 4
Initial view before preparation of the triangular submarginal flap for periapical surgery of tooth #12.

Fig. 5
Detachment of the triangular submarginal flap.

Fig. 6
Clinical view showing the osteotomy for accessing the apex of tooth #12.

Fig. 7
Clinical view of tooth #23 before surgery.

Fig. 8
Detachment of the semilunar (Partsch) flap.

Fig. 9
Intraoperative view after osteotomy to access the apex of tooth #23.

The semilunar (Partsch) flap is a variant involving submarginal incision in the alveolar mucosa to form a crescent- or semilunar-shaped flap. It is little used in periapical surgery because it affords limited surgical access to the root apex. Furthermore, owing to the presence of muscle fibers, flap tension is high, making suturing difficult and increasing the risk of suture dehiscence.⁶ The semilunar flap is almost exclusively used in application to the maxillary canines (**Figs. 7–9**).⁷ Care is required to avoid performing the incision above the bone defect.

2. Neumann flap with intrasulcular incision

This flap offers perfect access for periapical surgery, with sufficient access to the affected bone and lesion-related roots.⁶ The intrasulcular incision in turn may be triangular or trapezoidal. The most common intrasulcular flap involves a triangular incision with a single vertical releasing incision located distal and one or two teeth distal to the lesion. This flap is characterized by increased tension, the traction forces increasing

Fig. 10



Fig. 11



Fig. 10

Clinical view before periapical surgery of tooth #21.

Fig. 11

Detachment of a triangular flap with sulcular incision.

Fig. 12

Intraoperative view after osteotomy.

Fig. 13

Clinical view before periapical surgery of teeth #12 and 22.

Fig. 12



Fig. 13



Fig. 14

Sulcular incision along the gingival margin of the teeth and two vertical releasing incisions distal to the canines.

Fig. 15

Detachment of the trapezoidal sulcular flap.

Fig. 14



Fig. 15



especially at the fixed extremity (**Figs. 10–12**). This technique allows easy flap repositioning after periapical surgery.

A modification of this flap involves a trapezoidal incision where a horizontal incision is made over the interdental papillae and along the neck of the teeth. Furthermore, two vertical releasing incisions are made on either side of the flap (leaving one or two teeth outside the lesion as a safety margin; **Figs. 13–15**). The important inconvenience of this technique is that post-operative gingival recession can occur—with a

strong esthetic impact in the case of surgery of the anterior maxillary segment.^{3,5,8}

3. Flap with incision at the base of the papillae

This flap was originally described by Velvart⁹ and is characterized by a horizontal incision following the dental sulcus along the neck of the teeth and extending to the base of the papillae. The latter is left adhered for posterior suturing of the flap. A vertical releasing incision is more-



Fig. 16



Fig. 17



Fig. 18



Fig. 19



Fig. 20

Fig. 16
Clinical view before periapical surgery of tooth #11.

Fig. 17
Flap at the base of the interdental papillae to ensure their preservation.

Fig. 18
Clinical view before surgery of tooth #34.

Fig. 19
Design and detachment of a papilla-preserving flap.

Fig. 20
Intraoperative view after ostectomy.

over made (**Figs. 16 & 17**). This is a surgically complicated flap requiring adequate surgeon experience. The literature shows this technique to produce less recession at interdental papillary level than a sulcular incision.⁸

4. Papilla-preserving incision flap

In this case, a horizontal incision is made following the dental sulcus to the dental papilla, avoiding incision of the latter and tracing the vertical releasing incision at this point.⁴ This flap is useful in teeth with a generous mesiodistal width, affording an adequate surgical field (**Figs. 18–20**).

5. Palatal flap

A festoon flap is performed at the gingival margins on the palatal side. This flap is used in periapical surgery of the palatal roots of the maxillary molars. If the flap needs to be expanded to gain greater visibility, the incision can be extended mesial to the canine. Palatal releasing incisions are not necessary, though if any such incision is made, it should be performed between the canine and premolar—which represents the vascularization limit between the nasopalatine artery and the anterior palatine artery—or distal to the second molar, behind the emergence point of the anterior palatine artery (**Figs. 21–23**).¹⁰

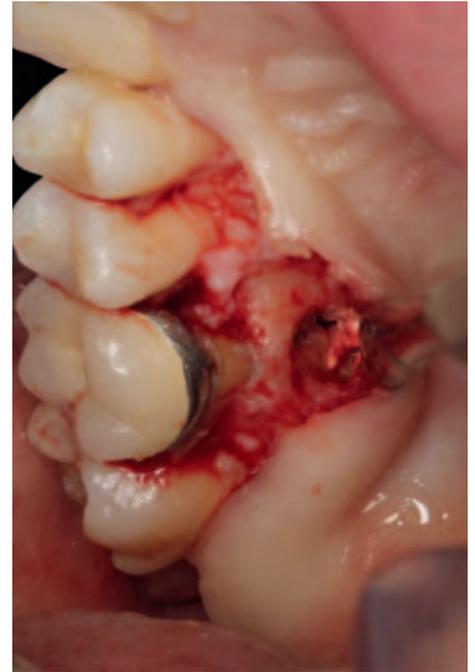
Fig. 21



Fig. 22



Fig. 23



Conclusion

Designing the flap is a key aspect of periapical surgery: It should ensure adequate exposure of the surgical field and allow the surgeon to work quickly and comfortably. Furthermore, there should be no tension capable of complicating the work of the dental professional or of causing patient discomfort, and soft-tissue damage due to retractor com-

pression is to be avoided. A good flap design with delicate manipulation of the soft tissue is necessary for successful periapical surgery.

Competing interests

The authors declare that they have no competing interests.

Fig. 21

Clinical view before the festoon palatal flap.

Fig. 22

Design and detachment of a palatal flap.

Fig. 23

Osteotomy for accessing the palatal root.

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Paradise Island, Bahamas — February 2018

The next MIS Global Conference is to take place from February 8 to 11 at the beautiful Atlantis Resort in the Bahamas. After the tremendous success of the last conference in Barcelona, Spain, with its fascinating scientific program, high-level lectures and amazing entertainment, this global conference promises to deliver yet another intense and unforgettable experience.

Inspiring speakers with a world of experience

The scientific committee, headed by Prof. Lior Shapira, has undertaken the challenge of making this year's conference even better than before. Shapira and his colleagues are "making every effort to address contemporary treatment possibilities, and provide insight into the present and future of dental implants as part of clinical dentistry." They have also promised that "the podium will be occupied by high-quality clinicians, researchers, and educators who will share ... their extraordinary experience and clinical excellence."

With the official launch of the V3 Implant System in the U.S. currently underway, MIS is devoted to bringing the dental world the latest innovations and is committed to helping clinicians improve patient care. At the conference, various workshops will provide opportunities for meaningful learning in an intimate environment, with accomplished experts in specific areas of interest. The two-day main program will feature world-prominent speakers presenting their expertise, which could be implemented in everyday dental practice and optimize dentists' skills for the benefit of their patients. Some of the key topics include evolution and horizons in implant therapy, biological principles and predictable esthetics, the long-term forecast for implant therapy and going digital.

TEDxMIS

In the spirit of "ideas worth spreading" and a commitment to innovation, MIS is proud to announce its partnership with TEDx. TEDxMIS is an independently organized TED event that will take place on February 10 and feature world-leading thinkers and achievers in the field of implant dentistry. The goal of TEDxMIS is to give conference guests the opportunity to experience a unique series of fast-paced, eye-opening talks that will inspire them and provoke meaningful engagement with their peers.

Call for clinical cases

As part of its commitment to promoting young clinicians, MIS is continuing the tradition of holding a clinical case competition during the global conference. For the 2018 event, the focus will be on modern technologies and techniques in clinical practice. The 15 best clinical cases will be presented as posters at the conference venue, with prizes awarded to the three winning cases.

Breathtaking views and spectacular entertainment

Similar to past events, the 2018 conference is expected to be an extraordinary experience of knowledge sharing, with the opportunity to network with colleagues from the international dental community. This year, however, conference guests will also enjoy one of the most beautiful and exotic locations in the Atlantic Ocean, the Atlantis Resort on Paradise Island. When they are not engaged in the workshops and lectures, guests will be able to take in the marine habitat, participate in sports activities, and explore the culture and colors of the Bahamas. Full of impressive and fun events, the MIS Global Conference entertainment program will leave guests with fond memories and looking forward to the next gathering.



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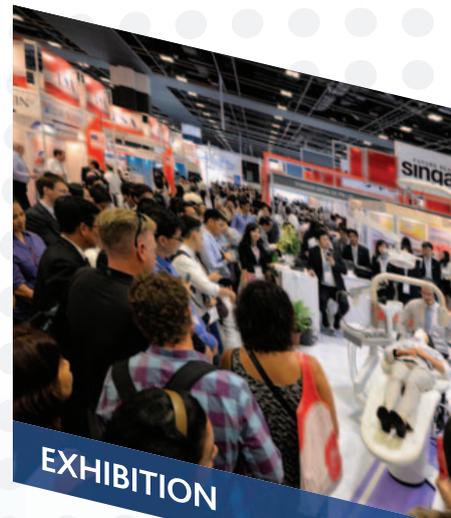
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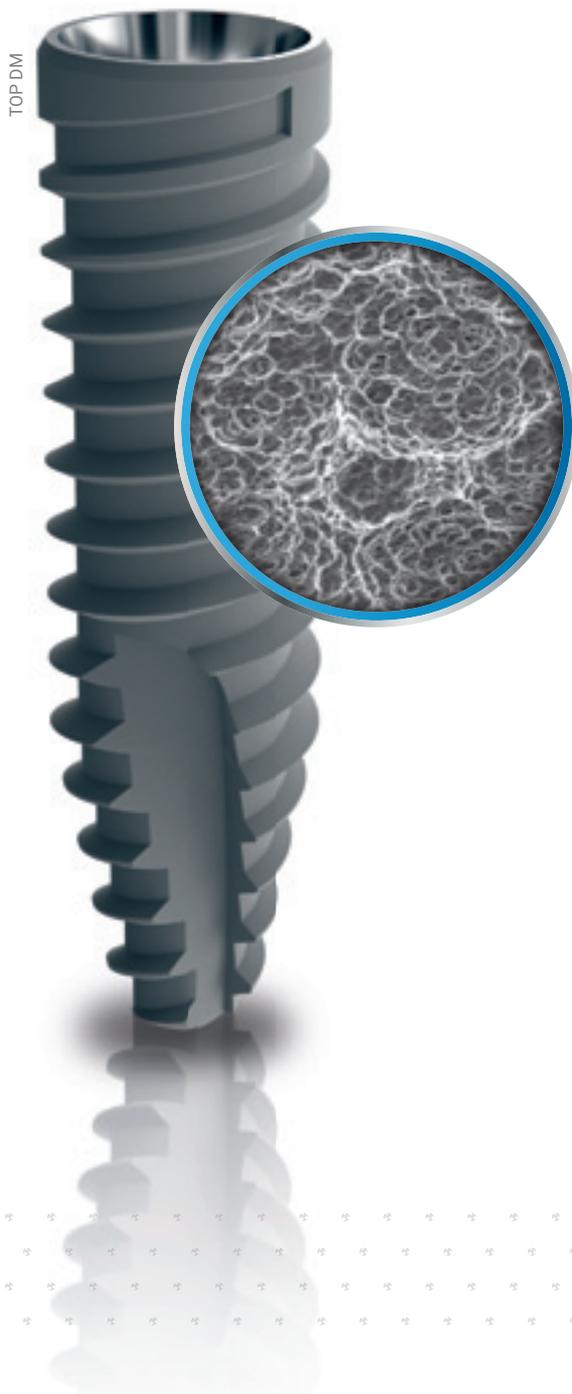
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Prama, the transgingival implant conceived according to the principles of the B.O.P.T. technique, reveals its versatility also simplifying full arch rehabilitations. The freedom of choice between a **cylindrical or conical endosseous morphology** makes surgically positioning it simple and secure. The wide range of prosthetic solutions covers **all clinical needs**, from a single crown in esthetic sectors to overdentures. **Prama is the implant to reach prosthetic excellence, always.**




sweden & martina
I M P L A N T O L O G Y

EAO)))
EUROPEAN ASSOCIATION FOR OSSEointegration
CONGRESS

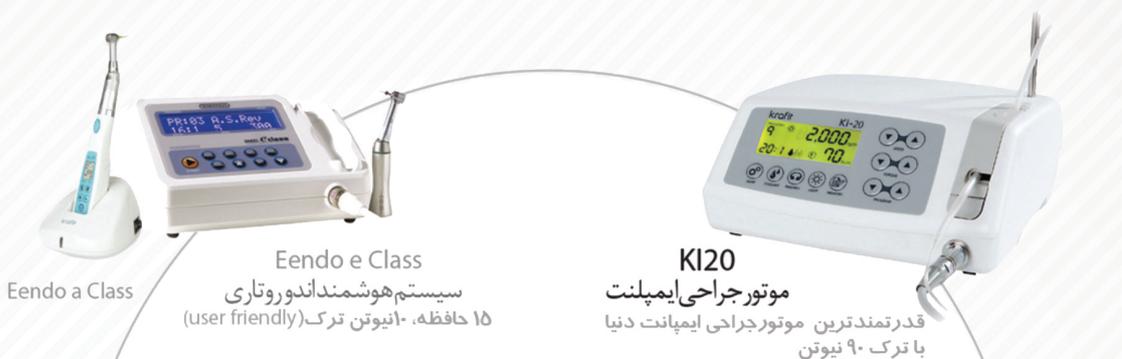
JOINT MEETING

SEPES
Sociedad Española de Prótesis Estomatológica y Estética

MADRID
FROM OCTOBER 5TH
TO OCTOBER 7TH, 2017

5 OCTOBER 2017 | 10:30-12:30, ROOM 105 | Dr. Ignazio Loi
B.O.P.T.: innovative techniques on natural teeth and implants





سیستم تزریق گرم گوتا پرکا و فیلینگ ورتیکال با تراکم عمودی
ساده و آسان با نتیجه متفاوت

