Implant treatment planning in fresh extraction sockets: Use of a novel radiographic guide and CAD/CAM technology

Tommaso Cantoni, DDS, MScD[1]/Giovanni Polizzi, DDS, MD[1]

Diagnosis and implant treatment planning in cases where hopeless teeth need to be extracted and immediately replaced with implants are more difficult and challenging than a standard multistage approach. Software and CAD/CAM technologies are becoming increasingly common to help clinicians in their practices. They use data from CT scans of the patient and of a radiographic guide for virtual implant treatment planning on a computer and the successive production of a surgical template, which will facilitate surgery and enable fabrication of a prosthesis to be delivered immediately. These procedures, however, are well-established only for patients who are already edentulous in the area to be treated; they are difficult to apply to a patient whose desire is to keep the hopeless dentition until the day of implant surgery to avoid having to wear a removable partial or complete denture. This article describes the advantages and the technique for fabrication of a novel 2-piece radiographic guide that, in conjunction with CAD/CAM technology, will help clinicians in the diagnosis and implant treatment planning of patients who want to retain their teeth until surgery. *(Quintessence Int 2009;40:773–781)*

Key words: CT scan, flapless surgery, fresh extraction sockets, guided surgery, immediate function, immediate implant insertion, radiographic guide

The standard procedure in implant treatment[1] when hopeless teeth are retained is to extract them, let the residual ridge heal for a variable period of time,[2] do the radiographic analysis, and finally perform the implant surgery. Improvements in the macro design of implant geometry and the micro texture of implant surfaces have allowed clinicians to shorten treatment time. Many authors have demonstrated that implant insertion in postextraction sockets is a viable and successful option, provided that high primary stability is achieved.[3–8] In these cases, however, diagnosis of the available bone and assessment of the correct position of the implant can be difficult because of the presence of hopeless teeth that need extraction.

In recent years, the developments of computer-aided design/computer-assisted manufacture (CAD/CAM) technologies have also brought great improvements in the field of oral implant dentistry. These new techniques allow clinicians to analyze the anatomy of the patient on a computer in relation to a diagnostic prosthesis.[9–11]

With sophisticated software, it is possible to virtually perform the implant surgery in an easy and effortless manner before going into the real surgical field. The real surgery is then simplified and can be performed without raising a flap using a surgical template with precise sleeves and drill guides based on the virtually planned surgery. With these technologies, it is also possible to prepare the prostheses in advance, and complete rehabilitation of the patient can take place shortly after completion of the surgical procedure.[12–14] One of these systems, called NobelGuide (Nobel Biocare), can be used for single-tooth replacement, partially edentulous cases, and complete-arch rehabilitations and is based on the possibility to make a computed tomography (CT) scan of both the patient and the prosthesis.

[1]Private practice, Verona, Italy.

Correspondence: Dr Tommaso Cantoni, Via Gobetti 9, 37138 Verona, Italy. Fax: 39045572236. Email: tcantoni@tin.it

Fig 1 Master cast of the arch to be analyzed: maxillary left canine and second premolar will be extracted.

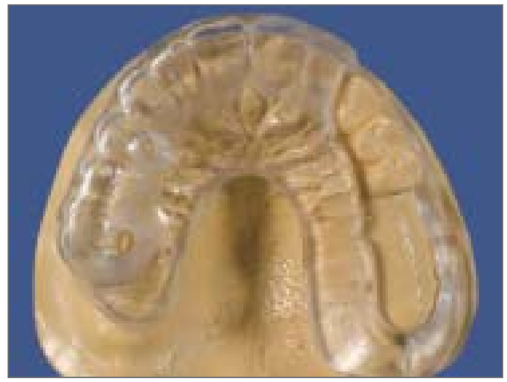


Fig 2 Base portion of the radiographic guide repositioned on the master cast.

Fig 3 Repositioning notches on the border of the window of the base portion.

A necessary condition, so far, was that the patient should present completely healed ridges, after teeth extractions, before the CT scan analysis. If the radiographic analysis is performed shortly after extraction of the residual teeth, the bone remodeling that will take place during the early phases of healing[15,16] will affect the adaptation of the surgical guide in the patient's mouth. Furthermore, when the surgery is performed, the volume and contour of the bone will be different from those seen on the computer during the virtual surgery, and it could be impossible to correctly insert the implants.

The increasing demand of patients to have a smooth transition from a hopeless dentition to a fixed implant-supported prosthesis without wearing an interim removable denture raises new challenges to adapt these CAD/CAM techniques to cases treatment planned for immediate insertion in fresh extraction sockets.

The purpose of this article is to present a novel radiographic guide to be used in conjunction with CAD/CAM techniques that allows the patient to retain hopeless teeth during the diagnostic phase until the day of implant surgery and allows for a prosthetically driven virtual planning of the implants in the extraction sites.

TECHNIQUE

The radiographic guide is fabricated as follows and consists of 2 parts, the base portion and the teeth setup portion, which can be connected.

Step 1—Preliminary phase

Study casts with all anatomic landmarks are obtained from well-extended impressions of the arches of the patient (Fig 1) and mounted on an articulator.

Step 2—Fabrication of the base portion

The master cast of the arch to be examined is used to fabricate the base portion of the radiographic guide. This portion will be built like a base of a complete denture with flanges and palatal support with an open window around the teeth to be extracted (Fig 2).

In partial cases, the base portion will cover only the occlusal surfaces of the teeth that are retained, without the buccal flange,

Fig 4 Waxup of the teeth in the desired and corrected final position.

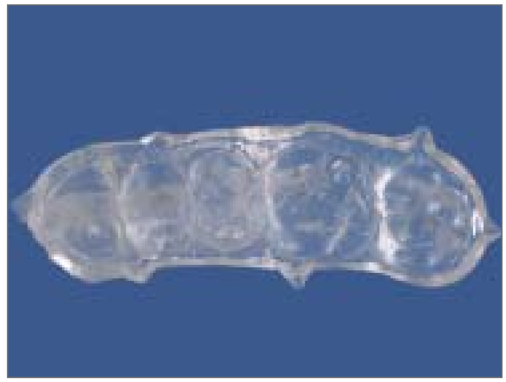


Fig 5 Teeth setup portion of the radiographic guide.

Fig 6 The 2 parts of the radiographic guide assembled.

like a nightguard. This is to facilitate adaptation in the mouth of this portion of the radiographic guide.

The base portion should be made of self-curing acrylic resin at least 2.5 mm thick to be stiff enough and to be correctly reproduced into the surgical template.

This portion will have some repositioning notches around the border of the window (Fig 3) and will carry at least 6 radiopaque markers placed according to the NobelGuide protocol.

Step 3—Fabrication of the teeth setup portion

The teeth to be extracted are removed from the cast to the gingival level. A waxup of the teeth in the corrected final position is then completed (Fig 4).

The base portion is repositioned on the cast, and the waxup of the teeth is extended to fill the gap with the border of the window of the base portion. This completed waxup is also processed in self-curing acrylic resin.

Once this second portion is finished, no radiopaque markers must be included in it. This will represent the teeth setup portion of the radiographic guide (Fig 5).

Step 4—Assembly of the radiographic guide

The teeth setup portion will then be repositioned on the base portion, locking into the repositioning notches of the border of the window with a stable and precise fit (Fig 6). Once these 2 parts come together, the radiographic guide is completed and assembled.

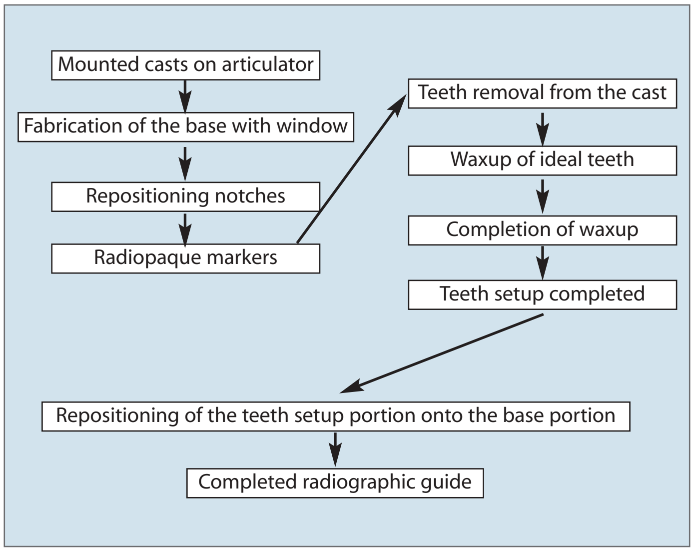


Fig 7 Flow chart illustrating the sequence of fabrication.

Fig 8 Patient wearing the base portion of the radiographic guide during the CT scan (full arch case, occlusal view).

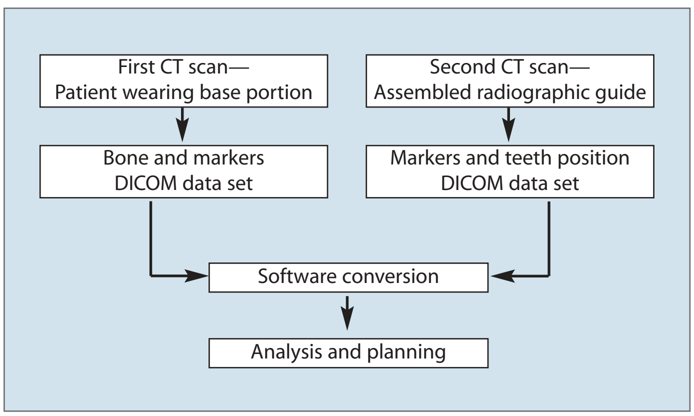


Fig 9 Flow chart illustrating the CT scans sequence.

A summary of the fabrication procedure sequence is presented in Fig 7.

Step 5—CT scans

The patient will then undergo a CT scan, before the extractions of the hopeless teeth, wearing only the base portion of the radiographic guide (Fig 8).

The DICOM (Digital Imaging and Communications in Medicine) files obtained from this first CT scan will contain data regarding the anatomy of the patient's jaw and data regarding the position of the markers in the base portion of the radiographic guide.

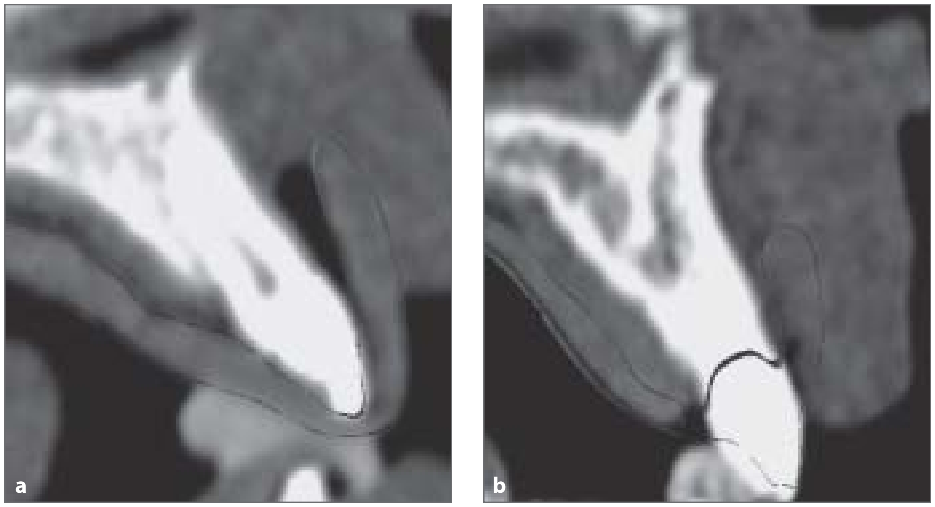
The base portion and the teeth setup portion are then assembled together and scanned in a second CT scan following the standard NobelGuide protocol.

The DICOM files obtained from this second CT scan will contain data regarding the ideally planned teeth positions in the teeth setup portion, and data regarding the position of the markers in the base portion, which are the same as in the first scan.

Step 6—Software conversion, analysis, and planning

Once these 2 sets of data are converted with the NobelGuide Procera software, the clinician can preview the anatomy of the patient's jaw and the ideally planned position of the teeth, independently from the position of the teeth to be extracted. Implants in extraction sites are virtually planned with teeth/roots still in their alveoli (Fig 9).

After planning completion, the clinician orders the surgical template. Because the shape of this surgical template is based only upon the information from the second CT scan, it will fit to the oral situation only after teeth extraction. Therefore, the surgical template cannot be tried in the mouth until the hopeless teeth are extracted. This will be done at only the time of implant surgery. All the remaining procedures will be the same as those of the standard NobelGuide protocol.



Figs 10a and 10b In a 1-piece radiographic guide *(a)*, the flange is not in contact with the mucosa, while in the 2-piece guide *(b)*, the flange is well adhered to it.

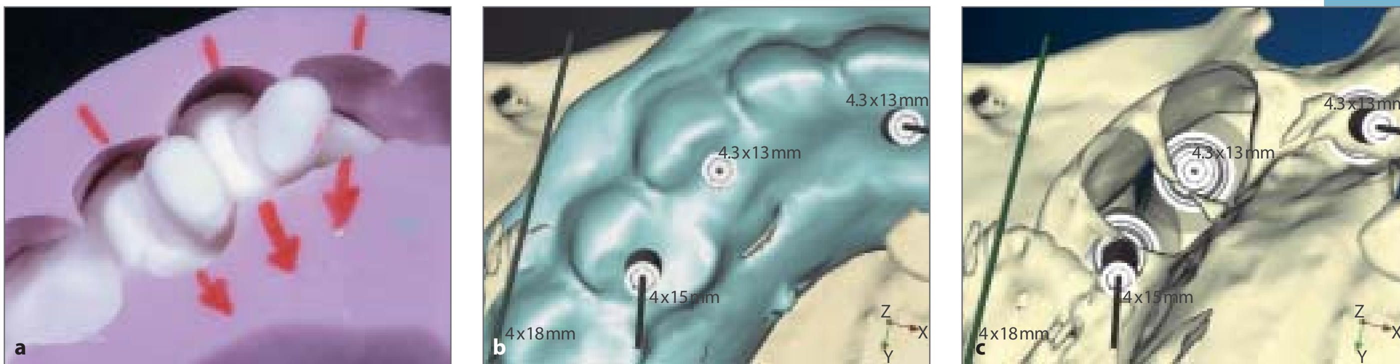
DISCUSSION

When treatment for a patient who needs immediate insertion of implants in fresh extraction sites is planned using the NobelGuide concept, this specially designed radiographic guide offers many advantages over a standard 1-piece radiographic guide.

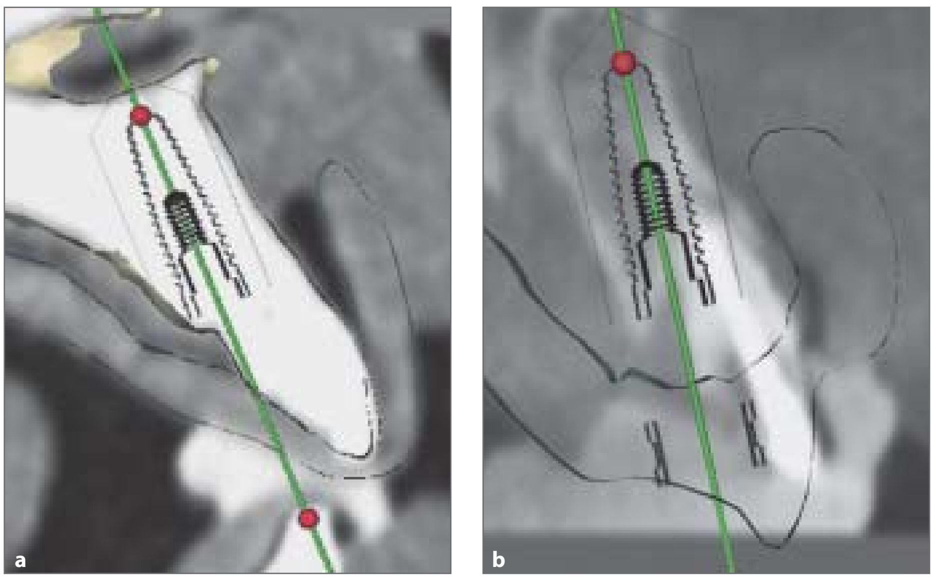
If the hopeless teeth that need to be extracted are not prepared as abutments but maintain their original shape (even by means of artificial crowns), a 1-piece radiographic guide will have to bypass the undercuts determined by those teeth. Sometimes, due to the buccal prominence of the roots, there will be undercuts also across the alveolar region, especially in the frontal area of the arch. This will result in a radiographic guide that will not adhere to the mucosa because its flange has to be wider and larger to bypass those undercuts during its path of insertion (Fig 10a). The base portion of the 2-piece radiographic guide instead, having an open window that goes around the hopeless teeth, seats directly in contact with the mucosa without touching the teeth and being influenced by them (Fig 10b). When prominent alveolar bone is present, the border of the window will be placed at the height of contour of the prominence, thus not being influenced by this undercut either (Fig 11). The flanges of the base portion will then be well adapted to the gingival contour, allowing for a more precise planning. Consequently, the surgical template, because it is well adapted to the mucosa, will be more stable during the initial phases of surgery.

Fig 11 The border of the open window in the base portion is positioned at the alveolar prominence to bypass the undercut.

Another important advantage is obtained when the teeth that need extraction are misaligned in the arch. This could happen, for example, when they are flared out because of periodontal disease, or when some teeth migrated in a wrong position because of congenitally missing or early extraction of other teeth. A 1-piece radiographic guide could not give information on the final desired position



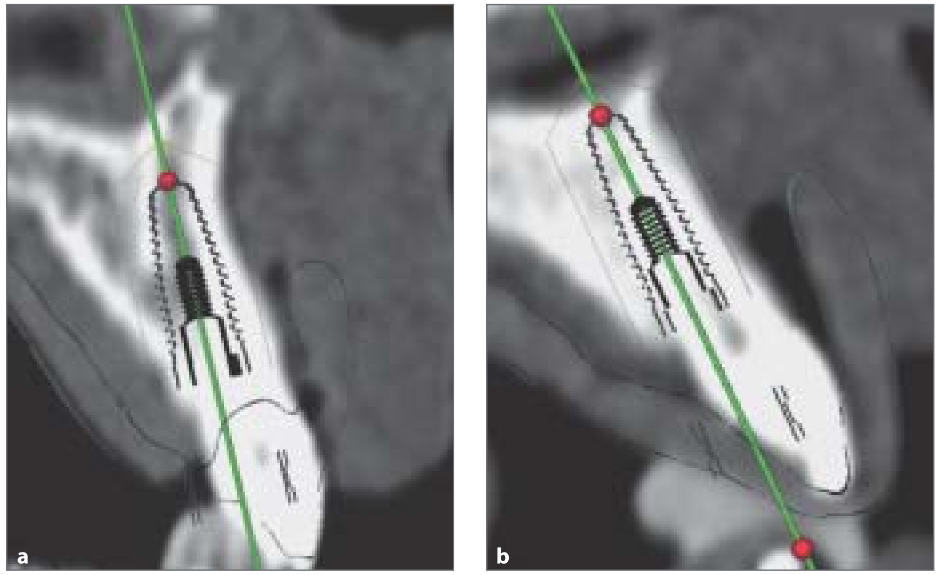
Figs 12a to 12c Sequence of planning with misaligned teeth in the arch. *(a)* Silicone index of the correct waxup of final teeth position showing their relation with misaligned existing teeth to be extracted. *(b)* Occlusal view showing correct position of implants in relation to the radiographic guide. *(c)* Planned implants in correct position regardless of existing misaligned teeth.



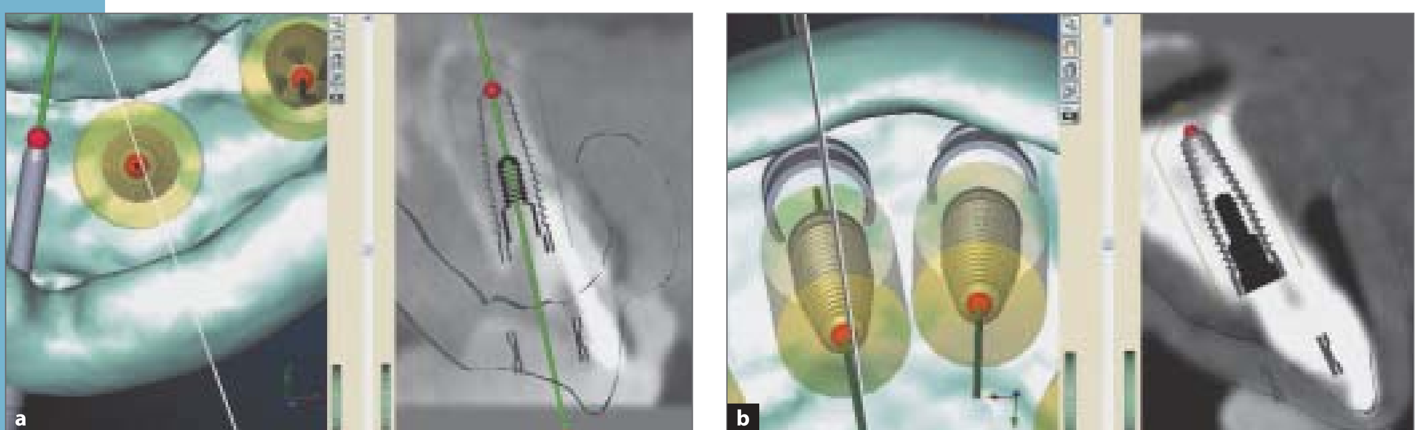
Figs 13a and 13b Flared tooth to be extracted: With a 1-piece radiographic guide *(a)*, there is no indication for planning the implant in relation to the final correct tooth position; with a 2-piece guide *(b)*, it is possible to correctly plan the implant in relation to the final desired tooth position.

of the teeth because it would have to adapt to the position of the existing teeth, which are in the wrong position at the time of the CT scan. With the 2-piece radiographic guide, the patient undergoes the first CT scan wearing only the base portion of the radiographic guide, which carries the radiologic markers and is unaffected by the position of the existing teeth (Figs 12a to 12c). Once the teeth portion of the guide is repositioned on the base portion and the assembled radiographic guide is scanned, it will give the information of the desired position of the teeth. This will allow a correct prosthetically driven implant planning at the computer (Figs 13a and 13b). The alternative would be to wait after teeth extraction for a variable healing time of at least 6 months, having the patient wear a removable denture that needs frequent relining, and then peform the radiographic analysis. This will cause the patient discomfort and social unease.

When teeth are removed from the cast before the waxup, particular care has to be taken to leave the gingival margin intact around them. This is important when an implant is planned for insertion into the extraction socket. The negative profile of the gingival margin is reproduced in the mucosal surface of the teeth setup portion, and it



Figs 14a and 14b Planned implant into extraction socket: With a 2-piece radiographic guide *(a)*, it is possible to visualize the gingival contour in relation to the bone; with a 1-piece guide *(b)*, the information of the gingiva is lost.



Figs 15a and 15b In the 2-piece radiographic guide *(a)*, the guided sleeves are completely supported; not enough support can result with a 1-piece guide *(b)*.

will be well visualized in the software during the virtual planning (Fig 14a). This provides additional valuable information to the clinician when planning the depth level of the implant shoulder. This information cannot be reproduced in a 1-piece radiographic guide because it does not adhere well to the gingival margins because of the undercuts of the teeth, specifically when existing teeth are unprepared (Fig 14b).

Another advantage with the 2-piece radiographic guide is that the teeth portion, being completely solid, offers a perfect support for the guided sleeves in the surgical template. They will be completely embedded and therefore well supported within the existing structure of the surgical template (Fig 15a). If a 1-piece radiographic guide is used, because it has to go around teeth still in the mouth, most likely there will not be enough material to hold the guided sleeves (Fig 15b), which creates restrictions in the manufacturing process of the surgical template.

Because the 2 pieces of the radiographic guide can be easily connected, the 2 CT scans (1 of the patient and 1 of the assembled radiographic guide) can be taken one right after the other, with no need of any modification and no additional loss of time.

Fig 16 Initial situation of the patient: provisional restoration on natural teeth.

Fig 17 Completed waxup of the desired teeth position with the base portion of the radiographic guide.

Fig 18 Completed 2-piece radiographic guide.

Fig 19 Provisional cylinders connected to the implants positioned in fresh extraction sockets.

Fig 20 Provisional fixed restoration delivered right after connection to the cylinders.

A case that was planned with this technique for immediate loading on implants inserted in fresh extraction sockets is shown in Figs 16 to 20.

The advantages of this novel technique can be summarized as follows: *(1)* The 2-piece radiographic guide is well-adapted to the mucosa, and the consequent surgical guide will therefore be stable in the mouth; *(2)* the guide carries the correct position of the desired final dentition independently of the existing teeth to be extracted; *(3)* it reproduces the gingival margin around the teeth; and *(4)* it will give optimal support to the guided sleeves with no restriction in the fabrication process of the surgical guide.

This method provides easy and precise virtual planning and flapless surgery for postextraction cases. The patient's desire to have a smooth and immediate transition from a residual hopeless dentition to a new stable dentition on implants is possible in a few hours with little discomfort.

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