CASE REPORT/CLINICAL TECHNIQUES

Endodontic Microsurgery Using Dynamic Navigation System: A Case Report

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ABSTRACT

Dynamic navigation systems were introduced to facilitate dental implantology by improving the accuracy of dental implant positioning. Dynamic navigation integrates surgical instrumentation and radiologic images by using an optical positioning device controlled by a dedicated computerized interface. These features could help in reducing the risk of unintentional iatrogenic damage to nearby anatomic structures and perform minimally invasive or flapless surgery, leading to reduced patient postoperative discomfort and improved healing. The present case report showed the use of the Navident dynamic navigation system (ClaroNav, Toronto, Ontario, Canada) by an undergraduate student for bone cavity preparation and root-end resection in the surgical endodontic treatment of a lesion in an upper lateral incisor. The system allowed precise localization of the root and precise apicoectomy with a minimal invasive cavity. The dynamic navigation system allowed the student to precisely direct the bur in 3 dimensions. The osteotomy and root-end resection were easily and quickly performed by the undergraduate student with a minimally invasive approach without iatrogenic errors. The navigation system allowed the operator to precisely perform a minimally invasive osteoctomy and root-end resection during endodontic surgery. The development of dedicated surgical navigation systems for endodontic surgery could facilitate the operator's maneuvers and reduce the risk of iatrogenic errors. *(J Endod 2019;■:1–6.)*

KEY WORDS

Apicoectomy; dynamic navigation surgery; microsurgery; Navident

SIGNIFICANCE

The dynamic navigation system allowed a nonexperienced operator to precisely perform a minimally invasive osteoctomy and root-end resection during endodontic surgery. Dynamic navigation is a promising technology aiming at facilitating the surgical procedures and reducing the risk of iatrogenic errors.

Dynamic navigation systems were introduced to facilitate dental implantology by improving the accuracy of dental implant positioning[1,2]. Dynamic navigation integrates surgical instrumentation and radiologic images using an optical positioning device controlled by a dedicated computerized interface. A clinical real-time interface displays and guides users to drill into the targeted position through the prefixed trace according to the output of the preoperative planning software[3].

Navident (ClaroNav, Toronto, Ontario, Canada) is an easy-to-use, accurate, portable system that offers dental surgeons an affordable way to plan implant placement on a virtual patient and then insert the fixture with greater accuracy and real-time 3-dimensional control provided by a computer-assisted procedure (Supplemental Figs. S1–S6). These features could help in reducing the risk of unintentional iatrogenic damage to nearby anatomic structures and perform minimally invasive or flapless surgery, leading to reduced patient postoperative discomfort and improved healing[4,5]. An *in vitro* study showed that the Navident dynamic navigation system allowed more accurate implant placement in comparison with the conventional freehand method, regardless of the surgeon's experience. However, the system seemed to offer more advantages to novice professionals because it allows them to reduce their deviations significantly and achieve results similar to those of experienced clinicians[6].

Even if the studies published to date were related to implant placement, with the exception of 1 *in vitro* study concerning locating canals in extracted teeth, the dynamic navigation system could also be used for endodontic procedures[7] regarding locating calcified canals, minimally invasive access cavity in orthograde endodontics, and surgical endodontics. To date, planned and guided endodontic procedures have been proposed only with static systems using 3-dimensional printed templates but only for nonsurgical procedures[8–10].

One of the main problems in surgical endodontics is preparing a minimally invasive bone cavity to allow enough space to perform a correct apicoectomy, retrograde filling, and mechanical elimination of the lesion. Surgical endodontics is a complex retreatment option that requires skill and experience[11].

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Optimal outcomes can only be achieved if the diagnosis is accurate, appropriate cases are selected, and the procedure is completed to a high standard[12]. Nevertheless, computer-aided technology could be helpful for both skilled and less experienced clinicians to plan and execute at least some of the procedural steps. Dynamic navigation systems were initially introduced to perform computer-aided implantology. The clinical advantage was to give clinicians an easy-to-use, accurate, and portable way to plan the desired implant placement on a virtual patient and then execute the plan on the real patient's jaw. These systems could theoretically be used in other dental fields, including endodontics, to perform drilling (ie, for calcified canals and fiber post removal) under dynamic guidance. The present case report showed the use of the Navident dynamic navigation system by an undergraduate student for bone cavity preparation and root-end resection in the surgical endodontic treatment of a lesion in an upper lateral incisor.

FIGURE 1 – (*A*) Two-dimensional and (*B*) CBCT sagittal view of the interested tooth; the images show the lesion from different views.

CASE REPORT

A 34-year-old male patient with a symptomatic (pain on chewing) upper lateral right incisor was referred to the endodontic department at Sapienza University of Rome, Rome, Italy. The tooth had been endodontically treated 3 years ago (Fig. 1*A*). The referring doctor had prescribed a cone-beam computed tomographic (CBCT) examination, which showed a periapical lesion on the tooth (Fig. 1*B*). The tooth was sensitive to percussion. The patient refused a nonsurgical retreatment to avoid any damage or change of the existing coronal restoration. Therefore, after collecting the informed consensus, a surgical endodontic treatment was planned. The patient consented to being treated by an undergraduate student under the supervision of a tutor with the aid of the Navident system (Fig. 2).

The Navident procedure can be briefly described in 3 steps:

1. Plan: a surgical approach plan is created using the CBCT image data to guide the burs for bone cavity access in 3 dimensions (Fig. 3*A*).
2. Trace: the CBCT image is matched with the real patient's jaw by registering the CBCT scan to the patient. The clinician must select 6 landmarks on the screen and trace around those landmarks in the mouth with a tracer tool (Fig. 3*B* and *C*). This trace registration system application, which was still in a prototype stage and now is commercialized, allowed the operator to

FIGURE 2 – The Navident navigation system device.

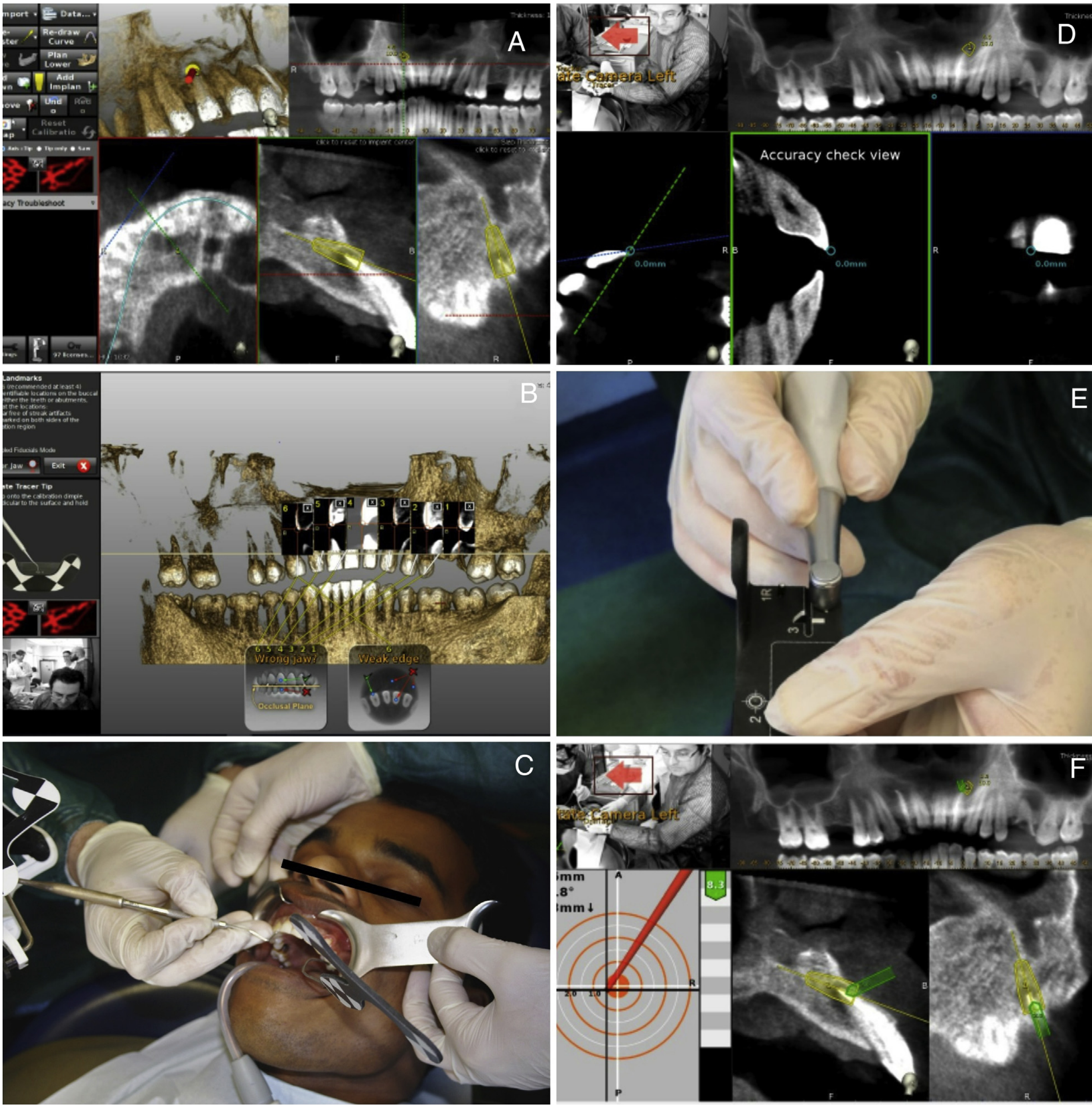

FIGURE 3 – (*A*) Treatment planning using the patient's previous CBCT scan. (*B*) Tracing: the system calibration phase is performed by selecting 6 different points on software reconstructions. (*C*) A fixed support is mounted on the patient's mouth, which can be recognized by the Navident's cameras, after which the 6 preselected points are traced using a tool that presents a support that can be recognized by the Navident to create matching between the CBCT scan and the patient's jaw. (*D*) Tracing is completed by an accuracy check view. (*E*) Before use, the handpiece and burs must be calibrated. (*F*) Drilling under dynamic guidance: the direction and the angulation of the bur during the surgical procedure can be checked on 3 different CBCT views.

use the previous CBCT scan and perform the tracing in a few minutes. An accuracy check was also performed to verify the matching by touching the incisal margin of the adjacent teeth (Fig. 3*D*).

3. Place: after a brief calibration of the handpiece and the burs (Fig. 3*E*), the therapy was performed. Originally, only software to calibrate implant drills was available; to perform the present case, the authors asked the manufacturer to modify the calibration software to allow the use of high-speed burs and, if needed, endodontic instruments and ultrasonic and piezoelectric tips. The Navident system dynamically shows in real time the deviation between the actual planned position and the orientation of the bur (Fig. 3*F*). The surgeon is also guided in the process by a target, which shows the ideal position of the bur. Unfortunately, at this stage of development, it was not possible to use the target window (which is very helpful for implant placement) because the original implant software did not allow for planning of horizontal angulations of the bur. Therefore, the operator had to refer to the bidimensional images in the 3 different planes to not leave the planned trajectory. The procedure was performed by "indirect

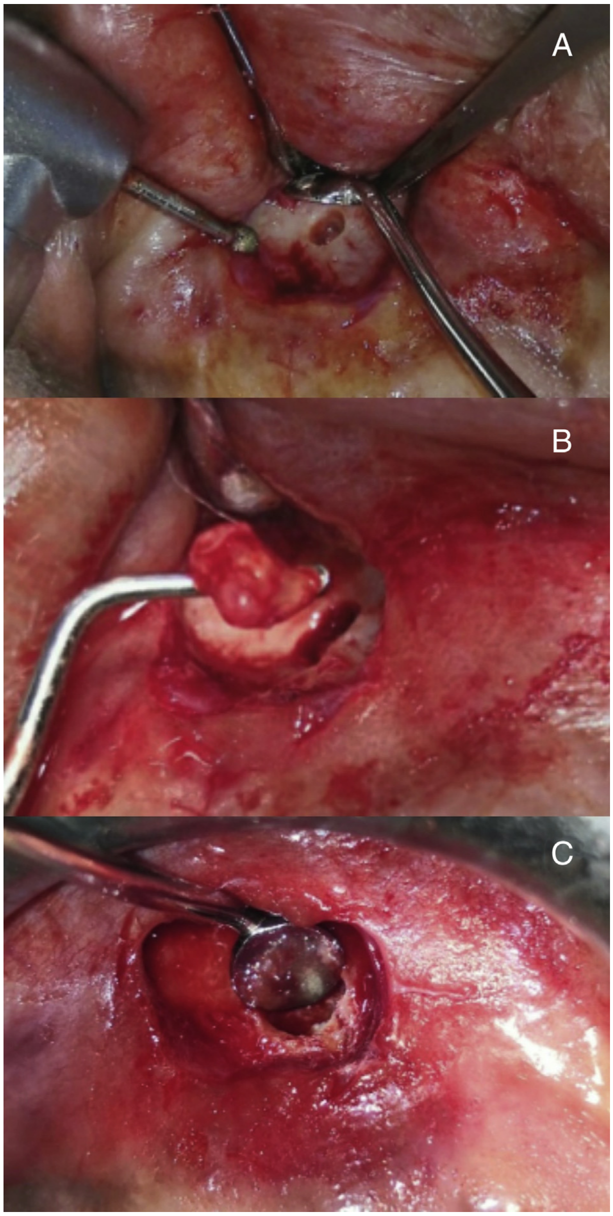

FIGURE 4 – (*A*) Minimally invasive surgical access of Ø ∼3 mm was possible by the use of the dynamic navigation surgery system using a round surgical bur mounted on a high-speed handpiece under 0.9% NaCl spray irrigation and visually checked on the Navident screen. (*B*) The removal of the lesion was performed very easily because of the precise access cavity. (*C*) The retrograde space was created using an ultrasonic tip for 3 mm in length; the minimal access cavity and the retrograde plug could be appreciated.

vision," just as it is used in 3-dimensional microscopy because the operator was mainly looking at the monitor while progressing inside the bone.

In the present case, a dynamic guided bone cavity access was performed to minimize cavity design and precisely locate the root apex for apicoectomy; the rest of the surgical procedure was performed with a traditional microsurgical approach. The treatment was performed by a nonexperienced operator (undergraduate student's first surgical case) under the supervision of a skilled endodontist. The operator had a previous short training session with the dynamic navigation system.

Two percent mepivacaine with 1:100,000 epinephrine local anesthesia was administered; a mucoperiosteal (trapezoidal type) flap was opened, and a minimally invasive osteotomy (Ø ∼3 mm) was performed using a round Revelation Diamond #801-018C bur (SSwhite, Lakewood, NJ) mounted on a high-speed handpiece 1:5 EXPERTmatic (Kavo, Biberach, Germany) (Fig. 4*A*). The tip of the bur was directed to the root apex, and the progression was visually controlled by checking the planned cavity simultaneously with 2 different CBCT views. Once the tip of the root was reached, a 3-mm root-end resection was performed with a 10° bevel. The computer-aided technology helped to precisely position the burs with the correct angulations. Removal of diseased tissue was performed manually under ×5 magnification (EyeZoom; Orascoptic, Madison, WI) (Fig. 4*B*). Ferric sulfate (Astringedent; Ultradent Products Inc, South Jordan, UT) was used for surgical hemostasis, and the surgical site was thoroughly rinsed with saline solution to remove it completely so that there was no complication or delay in healing. A conventional 3-mm retrograde cavity was made with an ultrasonic BK3-R tip (KerrEndo, Orange, CA) and filled with EndoSequence BC RRM sealer (Brasseler USA, Savannah, GA) (Fig. 4*C*). The surgical wound was sutured with resorbable 4-0 Vicryl Plus (Ethicon, J&J Medical, Somerville, NJ). No periapical radiographs were taken to assess the intraoperative procedure.

An immediate postoperative radiograph showed good clinical results, and postoperative symptoms were negligible. The 6-month follow-up revealed radiographic nearly complete healing with no clinical symptoms (Fig. 5).

RESULTS

The system allowed precise localization of the root and precise apicoectomy with a minimal invasive cavity, avoiding iatrogenic errors. The whole procedure was performed in less than 45 minutes. Overall, the outcome of treatment was considered a success with limited postoperative discomfort because of the minimally invasive technology. The healing was good at the controls after 1 month, 3 months, and 6 months.

DISCUSSION

It has been shown that there is a direct relationship between the size of the osteotomy and the speed of radiographic healing; a smaller osteotomy provides faster healing[13]. The dynamic navigation system is based on overhead tracking cameras relating the position of the patient's jaw and the clinician's bur. It allowed the operator to precisely direct the bur in the 3 dimensions (easily checking it in different CBCT planes), reducing the risk of iatrogenic errors[14]; this is important, especially when lesions are very close to noble structures because operators can control in real time many steps of the surgical procedure and eventually correct mistakes. A significant

FIGURE 5 – Postoperative prescription: a periapical 2-dimensional radiograph showing the treatment (*A*) immediately after surgery and (*B*) after 6 months showing a complete healing process.

advantage versus static guides is the possibility to modify the plan at any time of the clinical procedure[15]. Not considering the initial costs of the device, using the dynamic navigation system allows clinicians to avoid the fabrication of a stereolithographic template, resulting in a less expensive treatment.

A major clinical problem during osteotomy is to clearly distinguish the root tip from the surrounding bone[14]. If the apical lesion has not fenestrated the buccal bone, locating the apex can be a real challenge, even for an experienced surgeon. In the present case, the accuracy of the system allowed the operator to precisely locate the root tip; the osteotomy and root-end resection were easily and quickly performed with a minimally invasive approach without iatrogenic errors. This allowed proper management of apical curettage and orthograde cavity.

Based on the present case, dynamic navigation systems offered many advantages versus the conventional hand method in endodontic surgery. Using a conventional approach, it is not easy to precisely locate the tip of the root[16]. Dynamic navigation proved to be a valid, easy-to-use system to predictably reach this goal and keep the size of the osteotomy small. If the initial osteotomy is prepared by a nonexperienced operator, the chances are that the osteotomy will be too large, thus violating 1 of the main advantages of microsurgery[17]. Elimination or minimization of the bevel angle is another important benefit of microsurgery. Dynamic navigation allowed precise angulation of the bur to cut the root end with a 10% bevel angle and to visualize and control the cutting in real time on the display. Using the conventional hand method, these results could only be achieved by a skilled expert[15].

The dynamic navigation system offers many advantages versus static guides in endodontic surgical and nonsurgical treatments; because of the shorter surgical instrumentation, they can be more easily used in posterior regions and in patients who have a restricted opening. There is no specific drill system or surgical instruments needed for dynamic navigation systems in contrast to static navigation with their cylinders within the guides[15–18]. Because the clinician visualizes the surgery on a monitor in real time, any mistake, if any, can be immediately detected, and any change, if needed, could be immediately performed. Such a possibility is very helpful in surgical endodontics because the different steps usually need different orientation of the instruments, which cannot be provided by a single static guide[18]. During implant placement with dynamic navigation, fewer complications involving the inferior alveolar nerve or damages to adjacent tooth roots were observed because of the accuracy of the system (1, 2); the same advantages could be found in endodontic surgery. The accuracy of the Navident dynamic dental navigation system has been proven to be close to 0.71 for entry point and 1 mm at the apex. The mean angle discrepancy was 2.26°[19]. Moreover, the surgeon can maintain excellent posture during all procedures because his or her attention is mostly focused on the computer display. The learning curve is rapid; the treatment plan is easy to perform, and the trace registration system application is easy to learn and use.

In conclusion, the dynamic navigation system allowed the operator to precisely perform minimally invasive osteoctomy and root-end resection during endodontic surgery. The development of dedicated surgical navigation systems for endodontic surgery could facilitate the operator's maneuvers and reduce the risk of iatrogenic errors.

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The authors deny any conflicts of interest related to this study.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found in the online version at www.jendodon.com (https://doi.org/10.1016/j.joen.2019.07.010).

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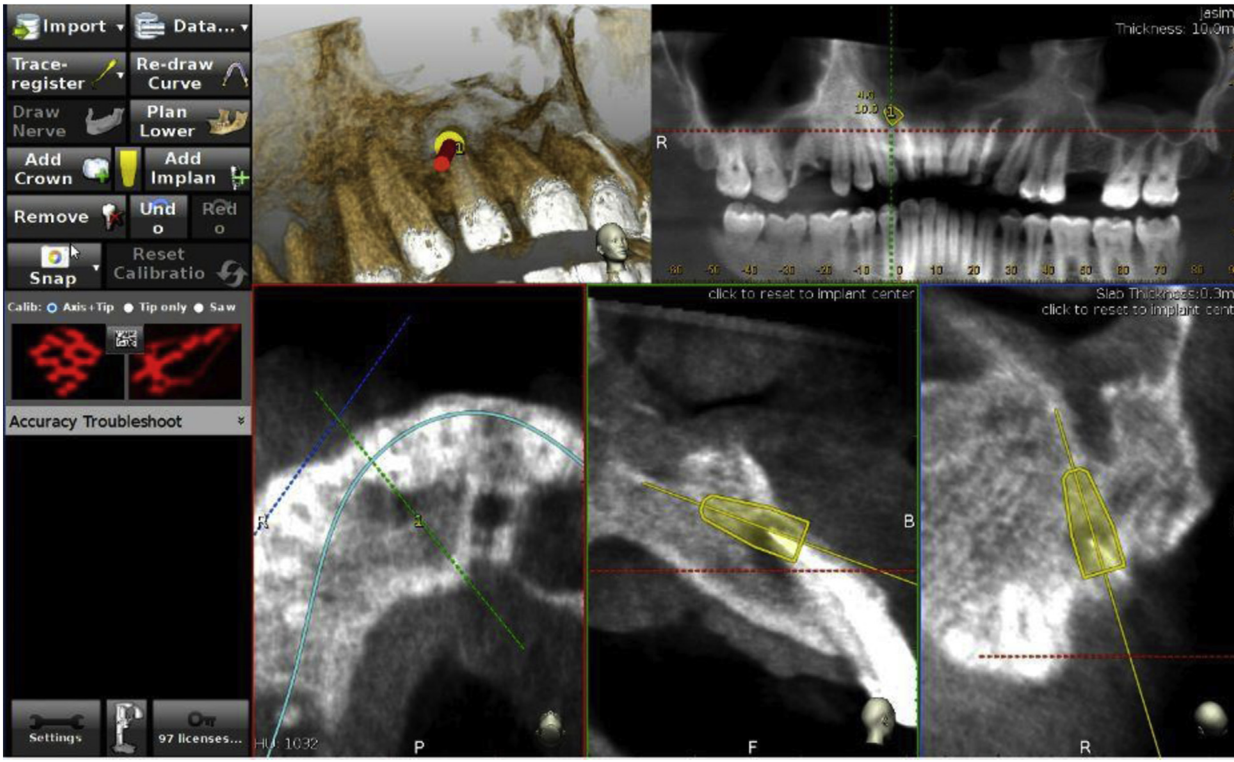
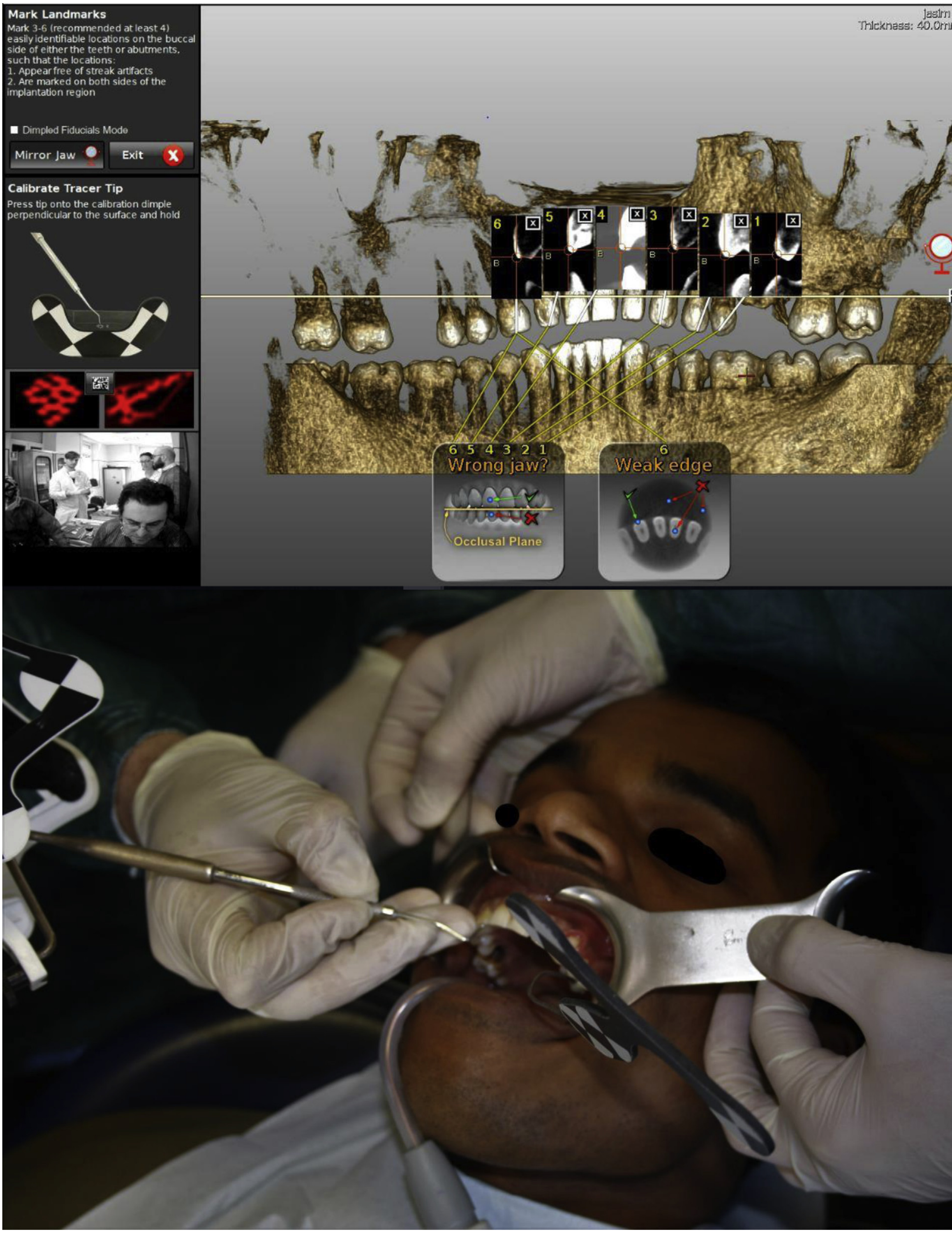


SUPPLEMENTAL FIGURE S1 – Surgical planning was performed using a previous CBCT scan and Navident planning software by an undergraduate student. The plan was than verified by a skilled tutor and approved. Any Digital Imaging and Communications in Medicine files can be imported and used for the navigation procedures into the dedicated software.

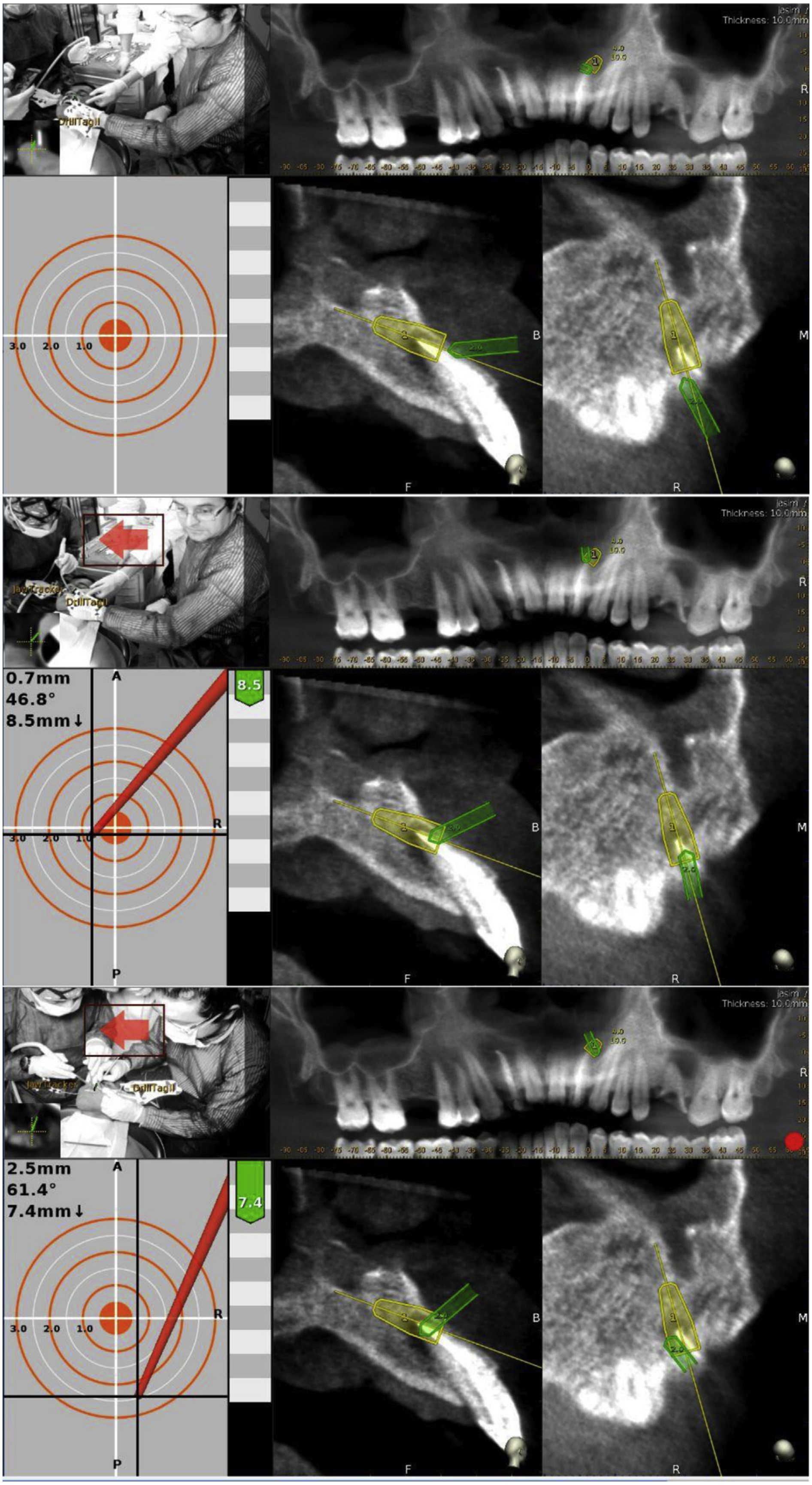
SUPPLEMENTAL FIGURE S2 – Patented Navident cart assembly combining a standard cart, MacBook computer (Apple, Cupertino, CA), micron tracker stereoscopic camera, and a light-emitting diode light box. Following the surgical plan, a trace registration process was performed to match the CBCT scan, the real patient's jaw, and the operating instruments (handpieces and burs).

SUPPLEMENTAL FIGURE S3 – Initially, a small optical tracker was positioned (using adhesive composite) in the contralateral upper jaw of the patient sensitive to the optical cameras of the main device.



SUPPLEMENTAL FIGURE S4 – The imported CBCT scan was registered to the patient by selecting 6 landmarks on the screen and tracing around those landmarks in the mouth with a tracer tool.

SUPPLEMENTAL FIGURE S5 – The drill tag trigger was connected to the surgical handpiece, and the 2 triggers were calibrated by means of a central stereo camera and a specific calibrating tool. An accuracy check was performed at the end of the tracing process.



SUPPLEMENTAL FIGURE S6 – Following the tracing process, clinical dynamic navigation was started; after the elevation of a full-thickness flap, the bone cavity was performed with burs under dynamic guidance. During clinical use, the screen was showing in real time the advance of the bur tip in the patient's jaw relative to the surrounding structures and the surgical plan. Moreover, it was displaying the deviation between the actual/plan position and the orientation of the drill, guiding the surgeon to accurately create a bone cavity. The images show progression of the bur.