Navigation-Guided Extraction of Impacted Supernumerary Teeth: A Case Report

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Supernumerary teeth usually result in retarded eruption, malocclusion, poor esthetics, and cyst formation. Management involves surgical extraction, which can be challenging in certain complicated cases owing to the risk of injury to young permanent tooth germs or fragile roots. The present report describes a novel preoperative computer-assisted and intraoperative navigation-guided surgical treatment for a case of complicated impacted supernumerary teeth. The report highlights accurate tooth location and minimal invasion with use of the navigation-guided system. Moreover, it discusses various treatment considerations during such a procedure.

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The reported prevalence of supernumerary teeth (STs) in primary and permanent dentition is 0.2 to 3%.[1,2] Impacted STs that can lead to impaction, retarded eruption, and malposition of permanent teeth, follicular cysts, and even infection should be surgically extracted.[3,4] Determining the location of STs is a critical step during surgical extraction of deeply impacted STs because it can affect the operation time, the surgeon's confidence, and the incidence of trauma or complications such as injury to an adjacent tooth germ or root. Cone-beam computed tomography (CBCT) provides 3-dimensional (3D) images at a lower radiation dose than spiral CT, which aids in the diagnosis and location of STs. However, to date, image-guiding systems have been rarely used during surgery to locate the position of complicated impacted teeth. Accordingly, the authors devised a treatment technique with the use of a CBCT-based computer-assisted design and an intraoperative navigation-guided system for the extraction of deeply impacted STs.

Report of Case

A 7-year-old boy was referred to the authors' hospital with complaints of malocclusion and space between the upper incisors. Intraoral examination showed a 4-mm space between the upper incisors and a rotated right incisor. No erupted STs were identified on clinical examination.

Panoramic radiography (Fig 1) and CBCT visualized 2 impacted STs located on the palatal side of the incisors. The left ST was inverted on the palatal side of the left incisor in proximity to the nasal floor. The right ST was located between an unerupted canine and the immature root of the lateral incisor. The operating surgeon devised a navigation plan before the surgery.

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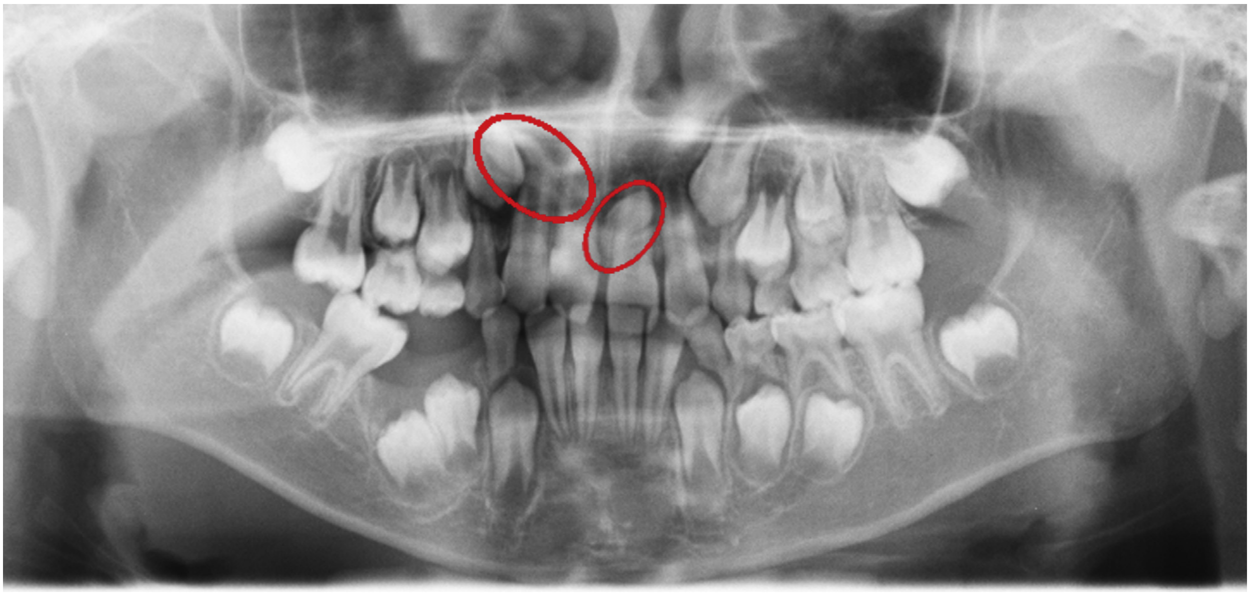

FIGURE 1. Preoperative panoramic radiograph shows the 2 supernumerary teeth (*red circles*).

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The patient underwent surgery under intravenous sedation according to predetermined navigation protocols, described in the subsequent section. The operation time was 30 minutes, during which the 2 STs were extracted. No intraoperative complications were reported.

When followed 1 day after surgery, the boy reported no pain, swelling, or bleeding from the extraction site. Moreover, no loose teeth, no pain on percussion, and normal gingiva were observed at the 3-month postoperative follow-up. Panoramic radiography at the 6-month postoperative follow-up showed that the space between the upper incisors decreased and the roots of the incisors and right canine grew continuously (Fig 2).

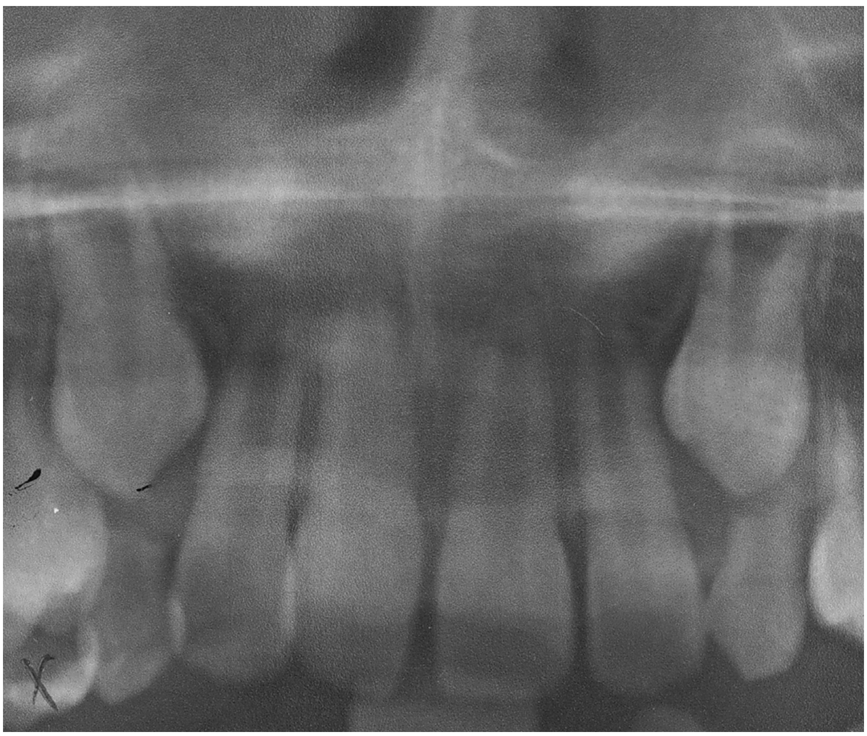

FIGURE 2. Panoramic radiograph at 6-month follow-up.

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SURGICAL PLANNING AND NAVIGATION

The authors developed a modified occlusion registrator (MOR; Fig 3) containing 5 radiopaque spheres (Brainlab, Munich, Germany) and connected to an occlusal fork with the patient's occlusal record on it. CBCT images were recorded with the MOR on, and the output was recorded in standard Digital Imaging and Communications in Medicine (DICOM) format. The MOR was intended for patient registration at the beginning of the navigation-guided surgery. Patient registration was a necessary step in navigation-assisted surgery, which referred to the process of matching the real patient exactly to the reconstructed 3D CBCT image.

The preoperative plan protocol was as follows. Data were input into iPlan CMF 2.1 software (Brainlab). Geometric centers of the 5 spheres on the MOR were identified as registration points. Based on the threshold, segmentation and reconstruction of the STs and the adjacent teeth were performed. Moreover, 3D images clearly displayed the location and positional relation of the STs with adjacent teeth and other structures, which guided the surgeons to be cautious to avoid injuring the apex of the lateral incisor, the unerupted canine, and the 0.6-mm nasal floor during surgery. A 1-mm safe region was secured between the STs and the canine follicle. Because there were no available landmarks for bony access to the STs other than the operating surgeons' experience, initial access points were added onto the CT slices and 3D images as important reference points during surgery (Fig 4).

A headband (Brainlab) with reflecting markers on it was tied on the patient's forehead. The headband and the MOR were used to register the preoperatively planned CBCT images with the patient by following the protocols of standard registration in the Brainlab ENT/CMF Navigation System. After registration, the patient was tracked by optically trapping the reflecting markers on the headband and the MOR was removed from the mouth. Registration accuracy was 0.25 mm, whereas positional accuracy of the landmarks ranged from 0.6 to 1.4 mm.

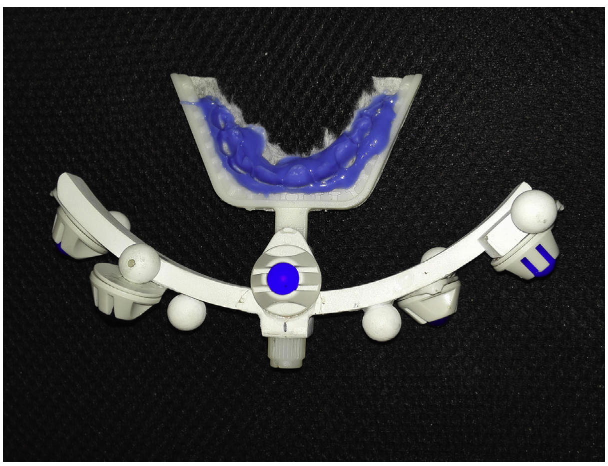

FIGURE 3. Modified occlusion registrator containing 5 radiopaque spheres.

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Mucosal reference points and the bony reference point for accessing the ST on the left side were located using the navigation-guided system. After confirming the access point, the surface bone was quickly removed without any hesitation, and the first ST was exposed and extracted.

The ST on the right side was located more deeply, and its extraction was more challenging than that of the left ST. The planned access point was visually located, and the superficial bone was removed using a navigation-tracked electric handpiece. Locations of the ST, the unerupted canine, and the root of the lateral incisor were confirmed using the pointer on real-time navigation-guided images (Fig 5), and then the second ST was extracted.

Discussion

Extraction of STs that are deeply impacted in the bone can be complicated and challenging. In such cases, 3D images showing the exact location of the STs and their positional relation with adjacent structures are crucial before and during surgery. Therefore, the authors introduced a navigation-guided system to help resolve these issues and promote confidence in surgeons during such surgeries.

Computer-assisted navigation-guided systems have been building a virtual-reality bridge for surgical procedures such as osteotomy, orthognathic surgery, reconstruction surgeries, dental implantology, temporomandibular joint arthroplasty, foreign body removal, and image-guided biopsy sampling. Such systems display real-time corresponding relations between a real scenario and the sectional anatomy recorded using CBCT, CT, magnetic resonance imaging, or any other medical imaging technique during surgery. Use of navigation-guided systems for extraction of impacted teeth could be a beneficial aid in complicated cases.

Navigation-guided systems can provide the following advantages in complicated extractions of impacted teeth:

1. To locate deeply impacted teeth for accurate selection of an access point and minimize bone loss and trauma
2. To distinguish ST and permanent tooth germs
3. To ensure that the preoperative design is accurately transferred to the surgical procedure. For example, surgeons might plan to divide a tooth

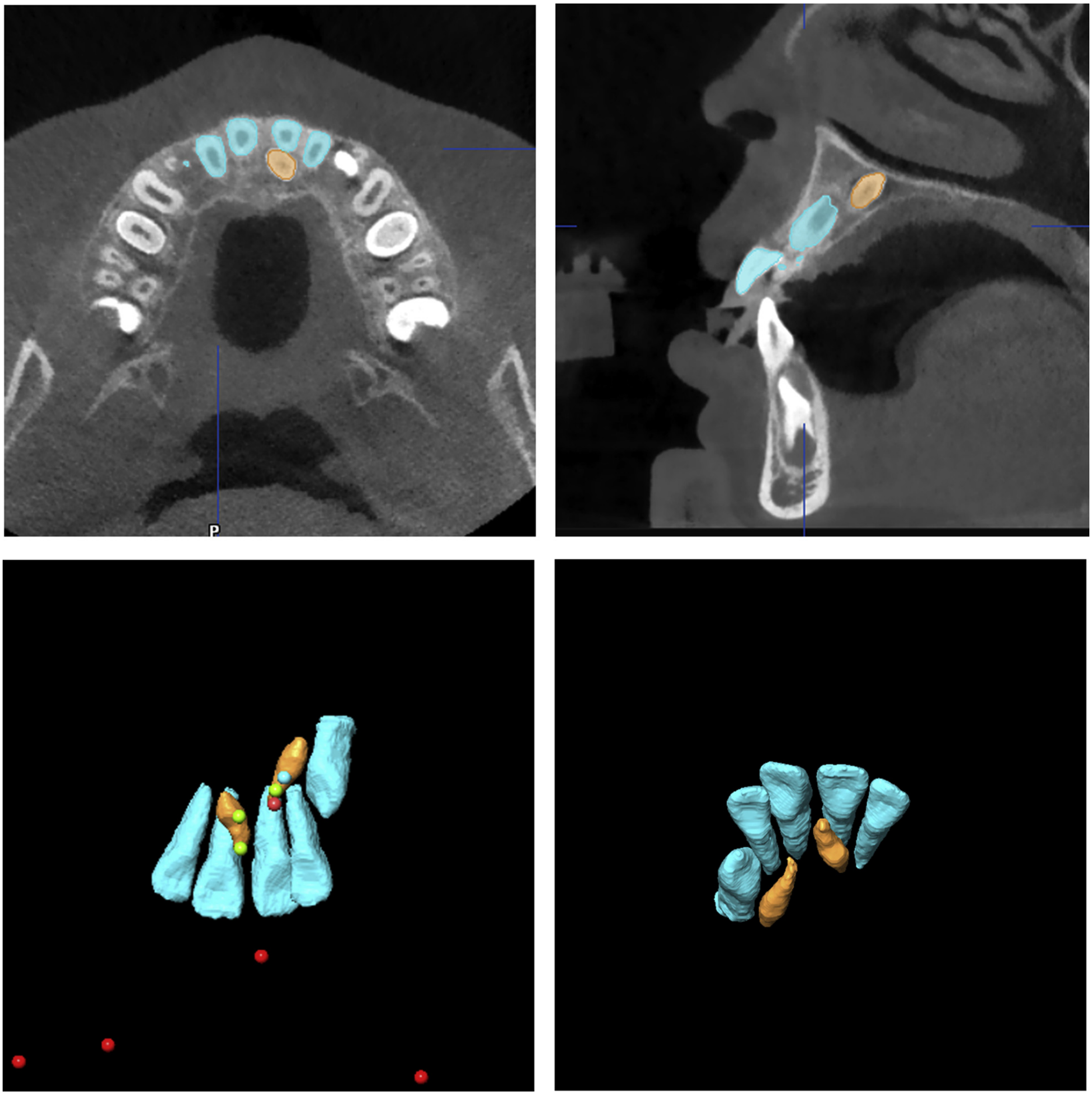

FIGURE 4. Preoperative computer-assisted planned palatal bony access to the supernumerary teeth (*green*).

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at a specific level to ensure the least risk and maximum convenience.

4. To mark safe margins for the incisive canal, apical papilla, or any other important structures to avoid complications

The most critical step during navigation-guided surgery is accurate registration and location, which should be carefully controlled during the entire procedure to ensure reliability of the navigation-guided system. Despite considerable variations among different navigation-guided systems, positional accuracy is typically less than 1.5 mm, if carefully controlled.[5] The crucial factors that affect the precision of navigation-guided systems include clinical registration methods, distance from the center of gravity of the reference markers used for patient registration,[6] the 3D distance between registration points,[7] and mobility of the noninvasive headband. The MOR designed by the authors used 5 registration points evenly distributed in the dentate and maxillary area to ensure precision of the registration. In principle, this device is similar to dental splint registration, which has been proved to be applicable.[8,9] MOR is more convenient than the dental splint because no cast is needed during the procedure. The positional

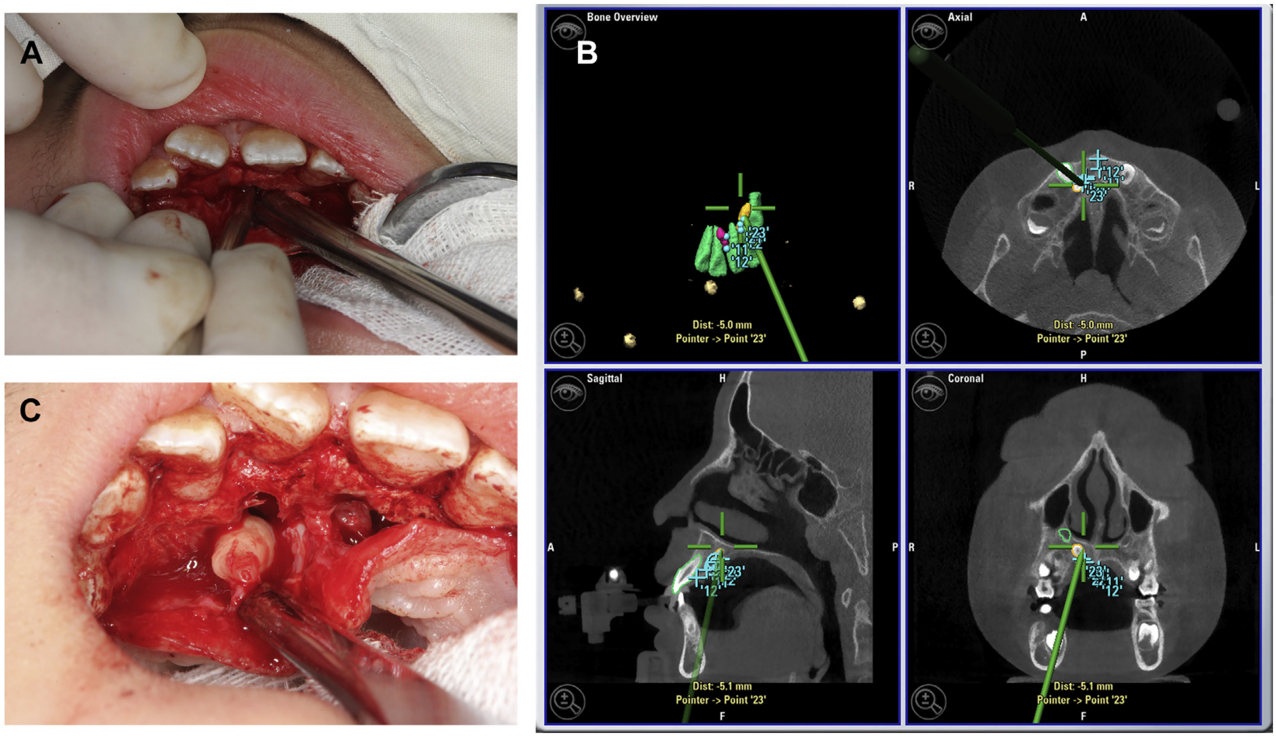

FIGURE 5. *A*, Probe position confirming bony access and the supernumerary teeth. *B*, Navigation-guided images confirming the edge of the supernumerary teeth. *C*, Residual osseous defects after tooth extraction.

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accuracy using the MOR should be measured in model experiments and patients in future studies.

Navigation systems require substantial monetary investment. Although the cost for using this technology for 1 patient is not unacceptable, appropriate indications should be considered carefully to prevent overuse of technology. The authors recommend that navigation should be used for complicated cases to achieve safer and more accurate results. In addition, navigation can offer greater benefit to younger or inexperienced surgeons in decreasing operative time. Appropriate indications, preoperative planning protocols, and details to improve the accuracy of navigation-guided positioning should be considered in future studies.

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