CASE REPORT

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Surgical extraction of a sublingually-displaced retained root with the aid of a magnetic field-based dynamic navigation system: a case study

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Abstract (J Korean Assoc Oral Maxillofac Surg 2024;50:367-372)

The submandibular displacement of a mandibular third molar residual root presents major challenges to oral and maxillofacial surgeons due to the proximity to critical anatomical structures such as the lingual nerve and sublingual artery. Preoperative imaging can approximate the location of the residual tooth root; however, accurately determining its exact position is difficult because of the dynamic nature of the mandible and the difficulty of real-time synchronization of imaging. This study presents the successful extraction of a residual mandibular third molar root in a 67-year-old female patient achieved using a magnetic field-based navigation system. The sublingually-displaced residual root was localized using the navigation system, marked using a virtual implant placement, and positioned by a hand piece using synchronized real-time sensor data. The root was successfully removed with a minimally-invasive approach. No complications occurred postoperatively, and follow-up showed no major issues. Due to the small size of the marker, ease of calibration, and independence from visual obstacles, magnetic field-based navigation systems are a promising tool for the removal of residual roots displaced into adjacent soft tissue.

Key words: Tooth extraction, Surgical navigation systems, Minimally invasive surgical procedures

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I. Introduction

The extraction of residual mandibular third molar roots, commonly known as wisdom teeth, remains a significant challenge in dental surgery. When not properly managed, these residual roots may cause complications such as infection, pain, and periodontal disease. To address these issues effectively, various surgical approaches continue to be developed and improved over the years.

In recent years, interest has grown in minimally invasive techniques for the extraction of retained roots. These methods aim to minimize incisions, reduce tissue damage, and shorten recovery times[1]. A critical aspect of these procedures involves accurately locating and identifying residual roots. Traditional imaging techniques such as orthopantomography (OPT) and cone-beam computed tomography (CBCT) are commonly employed to assess the position and relationship of residual roots to the surrounding anatomical structures.

OPT provides a panoramic view of the dental arches, offering a broad overview of the dentition. It is widely used due to its accessibility and ability to provide a general sense of root position and neighboring anatomical structures. However, its two-dimensional (2D) nature can limit the level of detail and precision required for complex extractions. Additionally, overlapping structures in the image may obscure critical details, potentially heightening the risk of complications during surgery[2].

In contrast, CBCT offers 3D imaging, delivering detailed visualization of the residual root's position in relation to surrounding anatomical structures, such as the inferior alveolar nerve. This precision aids in planning the surgical approach

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and minimizing the risk of nerve injury[3]. However, CBCT comes with drawbacks, including higher costs and increased radiation exposure compared to OPT.

An advanced method for locating residual tooth roots is endoscopy. Endoscopic techniques enable real-time visualization during surgery, significantly enhancing the precision of locating and extracting residual roots. They provide a magnified view and superior illumination of the surgical field, which is particularly useful in complex cases where visibility is limited. This method can reduce the risk of complications such as nerve damage and ensure more accurate removal of root fragments. However, the technique requires specialized equipment and training and is often more time consuming[4].

Despite the advancements in these traditional techniques, the introduction of navigation systems in dental surgery marks a major leap forward. These systems integrate preoperative CBCT scans with intraoperative tracking devices to offer a real-time, 3D representation of the surgical field. This allows for precise localization and removal of residual roots. Navigation systems improve surgical accuracy, reduce the risk of damaging surrounding structures, and enhance overall patient outcomes.

Navigation systems offer exceptional precision and real-time guidance, significantly reducing the risk of complications. These systems enable surgeons to plan and execute complex extractions with greater confidence. Their 3D visualization capabilities allow for a detailed and accurate assessment of the relationship between the roots and the inferior alveolar nerve, thereby minimizing the risk of nerve injury[4]. The newly developed magnetic field-based dynamic navigation system enhances surgical benefits by generating a magnetic field within the operating space without interfering with the operator's field of vision or requiring a bulky optical tracker. The magnetic field generator, which is equipped with a permanent magnet, emits a unique low-frequency magnetic signal and serves as the center of the tracking zone. It captures data across six degrees of freedom for each sensor. Sensors attached to the patient's oral cavity and the handpiece detect movements that modify the magnetic field. These variations are identified by the generator, enabling it to pinpoint the precise positions of both the plate and the handpiece. In this report, we present a case and review the literature on the successful surgical extraction of a residual tooth root that had migrated into the sublingual region. This procedure was accomplished using implant planning software in conjunction with a magnetic field-based navigation system.

II. Case Report

A 67-year-old female patient visited a local dental clinic in November 2023 and was subsequently referred to the Department of Oral and Maxillofacial Surgery at Hallym Sacred Heart Hospital for the extraction of a wisdom tooth, as one of its two roots had migrated into the sublingual area. During the initial examination, the patient reported pain in the left sublingual region, accompanied by swelling and tenderness in the left submandibular area. She was diagnosed with a retained root of tooth #38. Despite the administration of antibiotics and intravenous injections, there was no improvement in her symptoms.

Intraoral examination revealed no signs of incision or suturing, while extraoral examination showed mild swelling and induration in the submandibular area. The patient had no significant underlying medical conditions.

1. Preoperative imaging findings

Panoramic radiography revealed a radiopaque area posterior to the implant placement site in the left mandibular region #37. On the panoramic view, the position of the residual root appears superimposed on the trajectory of the mandibular canal.(Fig. 1) The CBCT also shows a root tip displaced medially to the mandible body. The root tip's dimensions are estimated to be approximately 2.5×4.2×5.2 mm.(Fig. 2)

2. Clinical course

First, local anesthesia was administered to the patient's left

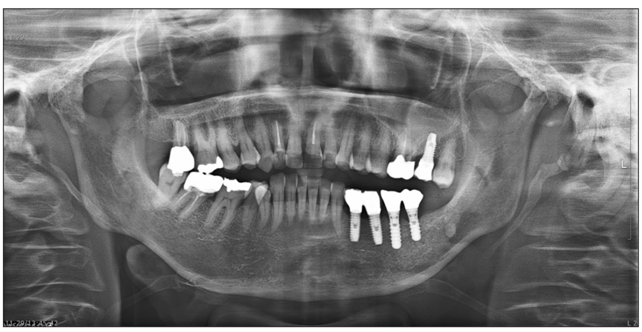

Fig. 1. Preoperative panoramic radiography. A well-defined root tip of #38 is visible in the left mandibular body.

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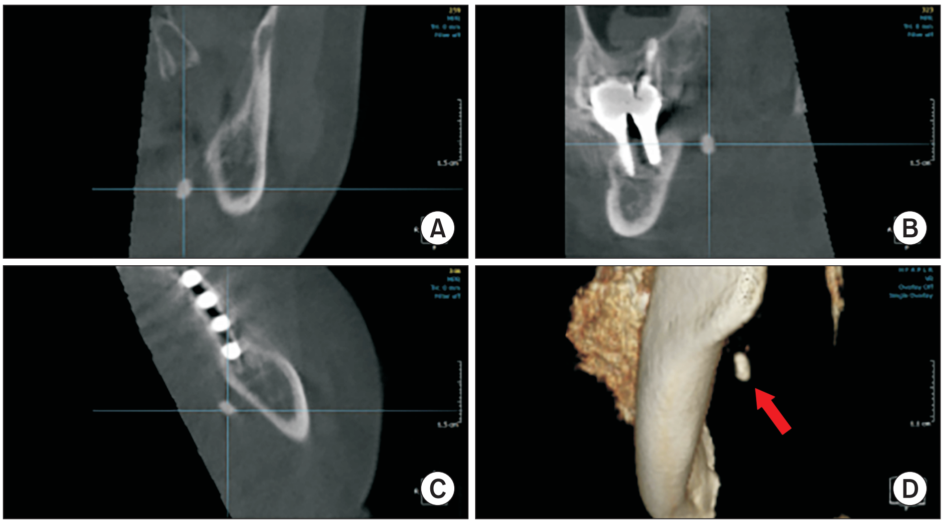

Fig. 2. Preoperative computed tomography images and cone-beam computed tomography (CBCT). CBCT images in the (A) coronal, (B) sagittal, and (C) axial planes showing the remnant root tip. D. A posterior view of the skull highlighting the residual root (arrow) in the left sublingual area.
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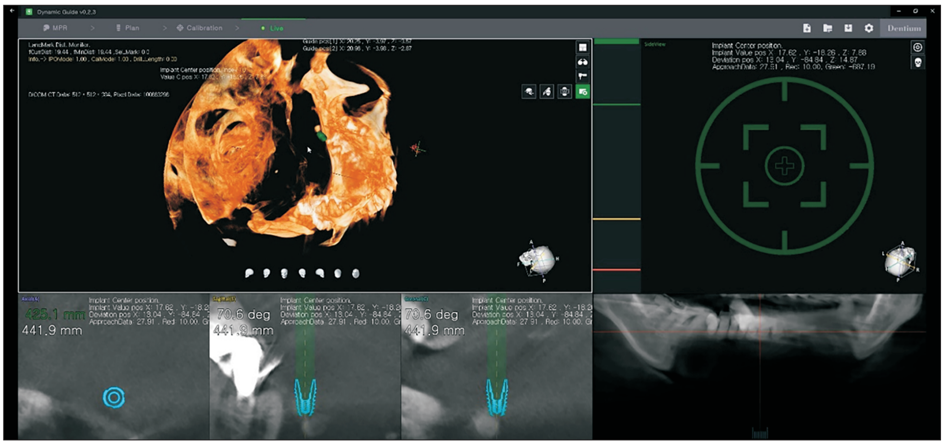

Fig. 3. Virtual implant placement aligned with the position of the residual tooth root.
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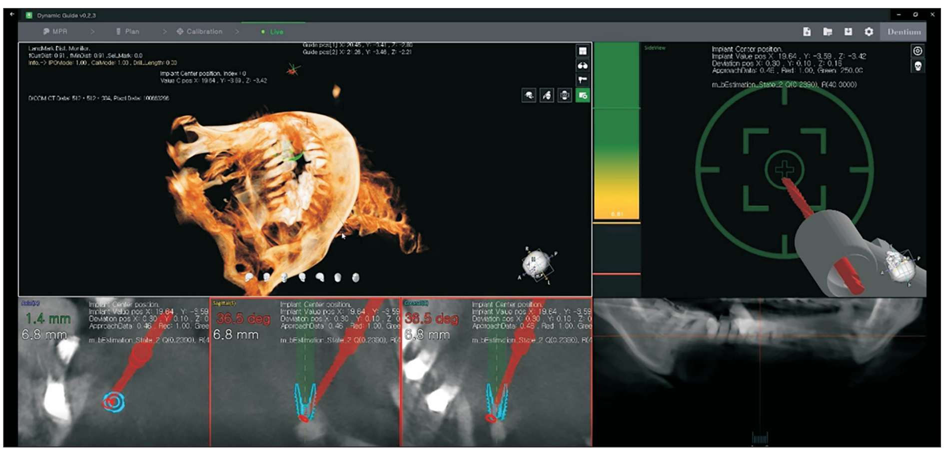

Fig. 4. A calibrated handpiece is used to locate the residual tooth root. The bur tip of the handpiece is aligned with the hypothetical implant site, enabling real-time tracking of the residual root`s position.
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inferior alveolar nerve and lingual nerves using 2% lidocaine. CBCT scanning was then performed and the data was imported into Digital Guide Software (DENTIUM). After the software identified the position of the residual root as a virtual implant placement site (Fig. 3), a sensor was connected to the handpiece for calibration between the oral cavity and the CT software. The bur tip of the handpiece was aligned with the virtual implant site to precisely locate the residual root in the oral cavity.(Fig. 4, 5) Subsequently, a crevicular incision was made in the #33-#38 area, and the lingual flap was elevated to remove the residual root, followed by suturing with 4-0 Dafilon. The root tip was successfully removed.(Fig. 6) After

Fig. 5. Intraoperative photo of identifying residual root position using a handpiece prior to incision. After confirming the location, the residual root was removed by making an extensive incision around the location.
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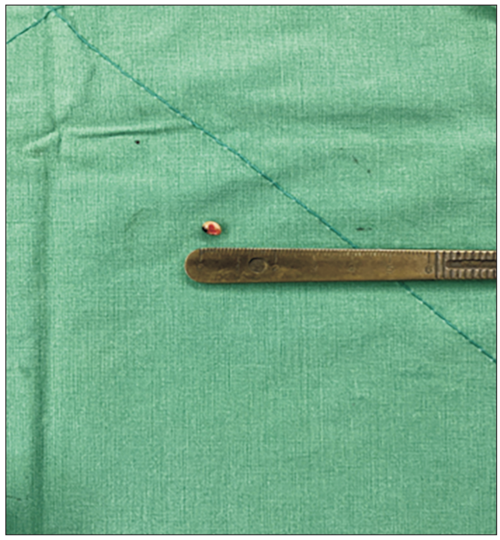

Fig. 6. Removed root tip of #38.
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the operation, a panoramic radiograph was taken to confirm that the root was completely removed. The sutures were removed 1 week later.

3. Postoperative imaging findings

A postoperative panoramic radiograph was taken to confirm the complete removal of the residual root. The absence of a radiopaque area indicates that the residual root was successfully removed.(Fig. 7)

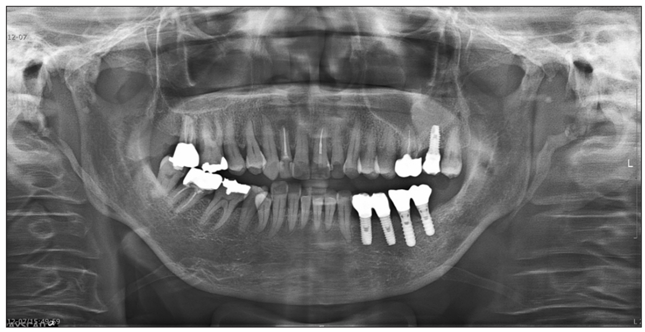

Fig. 7. Postoperative panoramic radiograph showing the successful removal of the #38 root tip.
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III. Discussion

The surgical extraction of mandibular third molars is a routine procedure performed by oral and maxillofacial surgeons as well as general dentists. However, an uncommon but potentially hazardous complication is the unintended displacement of dental roots into fascial spaces[5]. Particularly concerning are roots displaced into the sublingual space, as this region contains significant anatomical structures, including the lingual and sublingual nerves, branches of the lingual artery, and the ducts of the submandibular salivary glands. A dental root migrating into the sublingual area may result in pain, bleeding, and limited mouth opening. Furthermore, infections in this region can lead to severe, potentially life-threatening complications such as thrombosis of the internal jugular vein, carotid artery erosion, cranial nerve interference, mediastinitis, and airway obstruction[6]. Therefore, various strategies such as video endoscopy, ultrasonography and C-arm fluoroscopy have been explored to address the challenge of extracting roots displaced into the sublingual area. However, each of these devices has limitations, including decreased accuracy when embedded in soft tissue or obscured by anatomical structures, reliance on operator proficiency, and concerns about radiation exposure[7-11].

To address these challenges, an intraoperative navigation system was used to locate the broken dental fragment and assist in its removal. Initially developed for stereotactic interventions in neurosurgery, navigation technology has since been applied across various medical specialties. The use of a real-time trackable navigation system for the extraction of residual tooth roots has been previously reported[12]. Similarly, the extraction of displaced third molars using a navigation system equipped with light-emitting diodes has been reported[13]. However, this method required the placement of a mobile emitter on the patient's head under general anesthesia, the attachment of a non-invasive tracer to the patient's forehead, and the registration of a CT scan with a tracer point on a bulky mouth splint[14].

The mobility of the mandible poses a significant challenge in synchronizing its movements with preoperative imaging data during surgery, making navigation in mandibular surgery difficult. However, a magnetic field-based dynamic navigation system addresses this issue by establishing a magnetic field within the operating space. This approach offers several advantages, such as compact markers, simple calibration, and immunity to visual obstructions. The system's precise nature and compact design enable its use even in outpatient settings, serving as an efficient and accurate tool for surgeons. Additionally, it ensures the surgeon's field of vision remains unobstructed during procedures, eliminating the reliance on bulky optical tracking attachments.

The magnetic field-based navigation system shows considerable potential for use in oral and maxillofacial surgery, including complex surgical extractions as demonstrated in our case. While metals present in the operative field—such as dental crowns, amalgam fillings, and retractor tools—may redistribute the magnetic field and affect navigation accuracy, this limitation can be mitigated through further hardware refinements and procedural optimization. Additionally, clinical trials are crucial to validate its performance across varied clinical settings. Despite these challenges, the system's scalability and ability to precisely localize and remove residual roots underscore its potential as a transformative tool for guided surgical procedures, providing a precise real-time reference for complex and diverse cases.

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Authors' Contributions

Y.S.N. and S.Y. participated in writing – original draft, project administration. S.A.C., S.E.L., and S.Y.P. participated in data curation. S.H.B. and B.E.Y. participated writing – review & editing.

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Consent for Publishing Photographs

Written informed consent was obtained from the patient for publication of this article and accompanying images.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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