Submitted: 02 September, 2024 Accepted: 08 October, 2024 Published: 03 May, 2025 DOI:10.22514/jocpd.2025.068

Journal of Clinical Pediatric Dentistry

CASE REPORT

Application of a surgical guide for the extraction of impacted mesiodens: a case series

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Abstract

Background: Mesiodens frequently occur in an impacted state, which can hinder the eruption, growth, and development of adjacent permanent teeth. Surgical extraction is often necessary, especially in pediatric patients, where minimally invasive techniques are crucial due to their ongoing growth and development. **Cases**: This study presents the use of a customized surgical guide for the extraction of impacted mesiodens in pediatric patients under general anesthesia. The guide was designed to improve procedural accuracy and minimize trauma during surgery. **Conclusions**: The application of a customized surgical guide in pediatric oral surgery enhances precision, reduces surgical time, and improves patient outcomes. Despite certain limitations, this guide serves as a valuable tool in ensuring safer and more effective mesiodens extraction in children.

Keywords

Supernumerary teeth; Cone-beam computed tomography; Surgical extraction

1. Introduction

The dental anomalies encompass various abnormal conditions related to the number, shape, size, and position of teeth Supernumerary teeth are one such anomaly [1] and are defined as additional teeth that occur in addition to the normal number of teeth [2]. Although the etiology of supernumerary teeth is not fully understood, current evidence implicates both genetic and environmental factors in their development. Genetic influences, such as specific gene mutations, have been associated with the occurrence of supernumerary teeth. Environmental factors, including maternal nutrition during pregnancy, exposure to certain medications, and other prenatal conditions, may also play a role. Although the precise mechanisms remain unclear, it is likely that these factors interact in complex ways to induce the formation of supernumerary teeth [2]. Mesiodens are supernumerary teeth located in the midline area of the anterior maxilla, with a prevalence of approximately 0.15–1.9% [3, 4]. Mesiodens are more common in men, with a male-to-female ratio of 1.7:1 to 3.1:1 [5, 6].

Mesiodens can cause complications such as dentigerous cysts, root resorption of the adjacent permanent teeth, and disorders in the eruption patterns of the maxillary incisors [7]. Locating supernumerary teeth, especially when they are impacted or positioned atypically, presents a significant diagnostic challenge and procedural risk. The precise identification of their position relative to adjacent anatomical structures is often complicated, leading to variability in treatment planning. This uncertainty can result in diverse surgical approaches among clinicians, contributing to inconsistencies in treatment methods, which potentially affect the clinical outcomes. The complexity and attendant risks of accurately locating supernumerary teeth underscore the need for precise imaging and careful surgical planning [8]. Nevertheless, most studies suggest surgical extraction as the primary treatment method [9–11].

Impacted mesiodens are located near normal teeth and are critical anatomical structures that may be at risk of damage during surgery [12]. Surgeons primarily rely on preoperative cone-beam computed tomography (CBCT) scans to determine the position of the mesiodens [13]. CBCT facilitates valuable three-dimensional imaging of supernumerary teeth and the surrounding anatomical structures. However, translating CBCT data directly into the clinical milieu is beset by challenges. Discrepancies can arise between the CBCT representation and the actual surgical environment due to the distortion of spatial relationships, differences in tissue density, and dynamic nature of the oral cavity. These limitations can lead to disparities between the surgical plan and actual surgical execution, highlighting the need for enhanced methods of applying CBCT data in clinical practice [14]. When relying solely on the surgeon's clinical experience, there is a high possibility to be established a discrepancy between the visualized position and that the true position of mesiodens [15]. To secure an adequate surgical field of vision, surgeons may increase the flap area and extent of bone removal, leading to increased surgical trauma [15].

CBCT and intraoral scanners provide digital anatomical information on supernumerary teeth and adjacent structures [16]. Through computer-aided design and manufacturing, digital information can be accurately translated into actual surgical procedures [16]. Several studies have reported on the combination of these emerging technologies for the extraction of impacted supernumerary teeth [17, 18]. In this consecutive case series, we share our experience in designing several surgical templates for the extraction of palatally impacted supernumerary teeth in pediatric patients.

2. Case report

2.1 Common procedure

In all cases, the surgical guides were fabricated by scanning the maxillary arch using an intraoral scanner, and the resultant data were saved in the standard tessellation language (STL) format. R2GATE (MegaGen Implant Co., Ltd., Daegu, South Korea) was used for data processing, viz. converting CT (Computed Tomography) data into STL files, including segmentation of the roots, skull, and supernumerary teeth. FACEGIDE LITE (MegaGen Implant Co., Ltd., Daegu, South Korea) was utilized for diagnosing the integrated three-dimensional (3D) patient data. Freeform software was employed to accurately determine the position of the supernumerary teeth and design the guide templates. The guides were fabricated using a Raydent RAM600 printer (Ray Co., Ltd., Hwaseong, South Korea). Prior to clinical use, the guides were subjected to low-temperature sterilization using ethylene oxide gas to prevent surgical site infection.

The margins of the guide were determined based on the extraction range of the supernumerary teeth, with particular focus on the extraction angles. The guide thickness was set to 1.5 mm in the anterior region and 2.0 mm in the affected area. An offset value of 0.1 mm was applied to improve the fit of the guide. The anchorage teeth selected were #11, #12, #21 and #22 to ensure optimal stability during the procedure. The guides were manufactured using stereolithography, a method known for its precision in fabricating complex dental models and surgical guides through photopolymerization.

2.2 Case 1

A 7-year-old girl visited our clinic after a mesiodens was detected during routine examination at a private dental clinic. Panoramic radiography revealed an inverted impacted mesiodens (Fig. 1A). Orthodontic treatment was planned to correct the rotation of the maxillary central incisors, necessitating pre-orthodontic extraction of the supernumerary tooth. The impacted supernumerary tooth was located in the root growth area of the maxillary permanent central incisors (Fig. 1B–D). Therefore, precise and safe extraction of the supernumerary tooth was planned under general anesthesia using a surgical guide fabricated based on CBCT imaging (Fig. 1E). After administration of local anesthesia, a flap was raised from #53 to #63 in the palatal region. The surgical guide was placed intraorally, and bone removal was performed under irrigation until the crown of the supernumerary tooth was visible (Fig. 1F). The surgical guide and additional bone were removed, and the supernumerary tooth was extracted. The sutures were removed one week after the extraction, and periapical radiographs and CT scans were obtained to confirm extraction of the supernumerary tooth and ensure that the adjacent permanent teeth did not sustain any damage (Fig. 1G). Postoperatively, the patient exhibited no symptoms, and the surgical wound healed completely.

2.3 Case 2

A 12-year-old boy visited our clinic after being informed by a private dental clinic that the extraction of a mesiodens was necessary for orthodontic treatment. Panoramic radiography revealed an inverted impacted mesiodens (Fig. 2A). The impacted supernumerary tooth was not in contact with the adjacent permanent teeth, but due to its deep position, surgical extraction was planned using a surgical guide based on CBCT imaging to minimize bone removal under general anesthesia (Fig. 2B–D). The supernumerary tooth was impacted parallel to the left maxillary anterior teeth, with the root located posterior to tooth #21 and the crown positioned at the center of the maxillary anterior region. The surgical guide was designed to allow bone removal at a minimal distance from the mesiodens root, and the connector of the guide was designed to be thin to enhance the surgical field of view (Fig. 2E). After administration of local anesthesia, a flap was raised from #13 to #23. The surgical guide was placed intraorally, and bone removal was performed under irrigation until the root of the supernumerary tooth was visible (Fig. 2F). The surgical guide was removed, additional bone was removed around the area, and the supernumerary tooth was extracted. One week after extraction, the sutures were removed, and periapical radiographs and CT scans were obtained to confirm removal of the mesiodens and ensure that no damage had occurred to the adjacent permanent teeth (Fig. 2G). Postoperatively, the patient exhibited no symptoms, and the surgical wound healed completely.

2.4 Case 3

An 8-year-old boy with double mesiodentes was referred to our clinic after evaluation at a private dental clinic. Panoramic radiography revealed a normally erupted supernumerary tooth between the maxillary central incisors and an inverted impacted mesiodens above the upper right central incisor (Fig. 3A). The impacted supernumerary tooth was located deep and horizontally on the palatal side of the anterior maxillary region, adjacent to the nasal floor (Fig. 3B–D). Based on the CBCT scan, considering the anatomical relationship between the supernumerary teeth and adjacent permanent teeth, as well as the patient's level of cooperation, surgical extraction using a surgical guide under general anesthesia was planned. The surgical guide was designed to allow minimal access to the mesiodens crown during bone removal. To improve overall visibility, part of the retainer was removed, and the guide was designed to be 1.5 mm thick to minimize the risk of fracture (Fig. 3E). After administration of local anesthesia, a flap was raised from #54 to #64 in the palatal area. The surgical guide was placed intraorally, and, bone removal was performed using a high-speed round bur under irrigation, until the crown of the supernumerary tooth was visible (Fig. 3F). The surgical guide was removed, additional bone was removed around the area, and the supernumerary tooth was extracted. One week after extraction, the sutures were removed, and periapical radiographs and CT scans were acquired to confirm extraction of the supernumerary tooth and to ensure that the adjacent permanent teeth sustained no damage (Fig. 3G). After surgery, the patient showed no painful or inflammatory symptoms, and

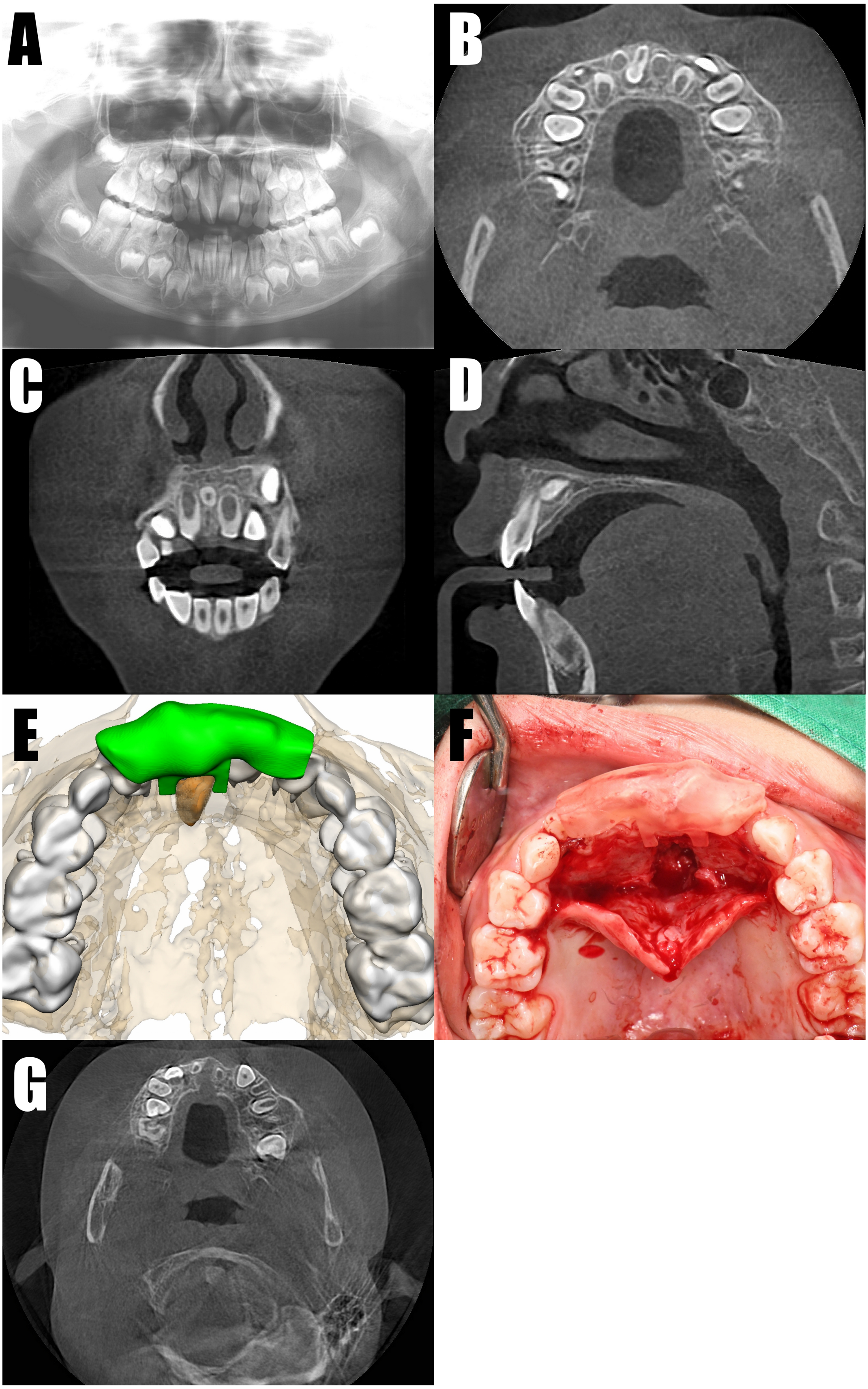

FIGURE 1. Preoperative panoramic, CT, appliance, clinical photograph, postoperative CT for case 1. (A) Initial panoramic view. (B) Initial axial view on CT. (C) Initial coronal view on CT. (D) Initial sagittal view on CT. (E) Surgical guide model. (F) Intraoperative intraoral photograph. (G) One-week postoperative CT view. CT: computed tomography.

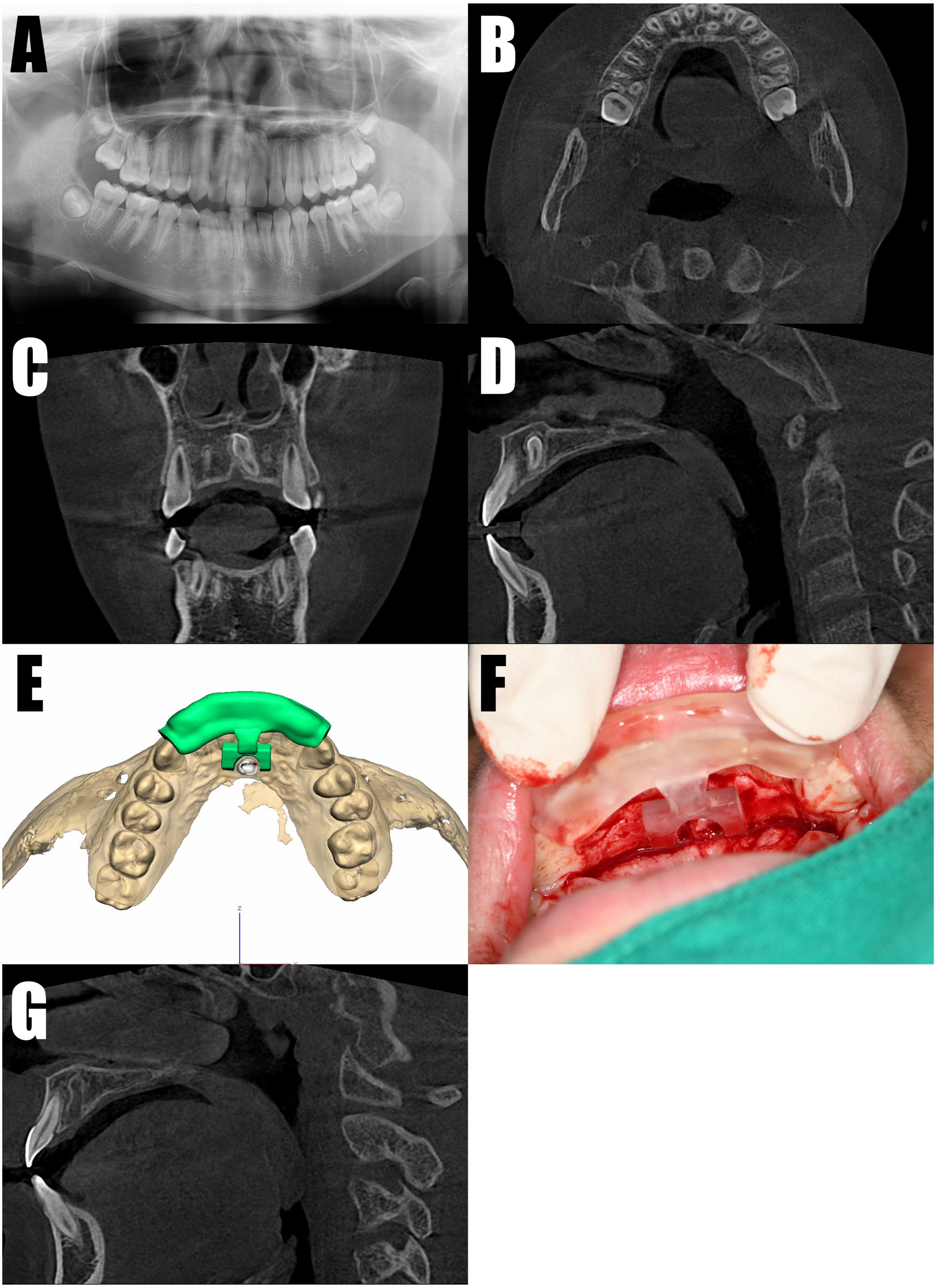

FIGURE 2. Preoperative panoramic, CT, appliance, clinical photograph, postoperative CT for case 2. Preoperative Panoramic, CT, Appliance, Clinical Photograph, Postoperative CT for Case 2: (A) Initial panoramic view. (B) Initial axial CT view. (C) Initial coronal CT view. (D) Initial sagittal CT view. (E) Surgical guide model. (F) Intraoperative intraoral photograph. (G) One-week postoperative CT view. CT: computed tomography.

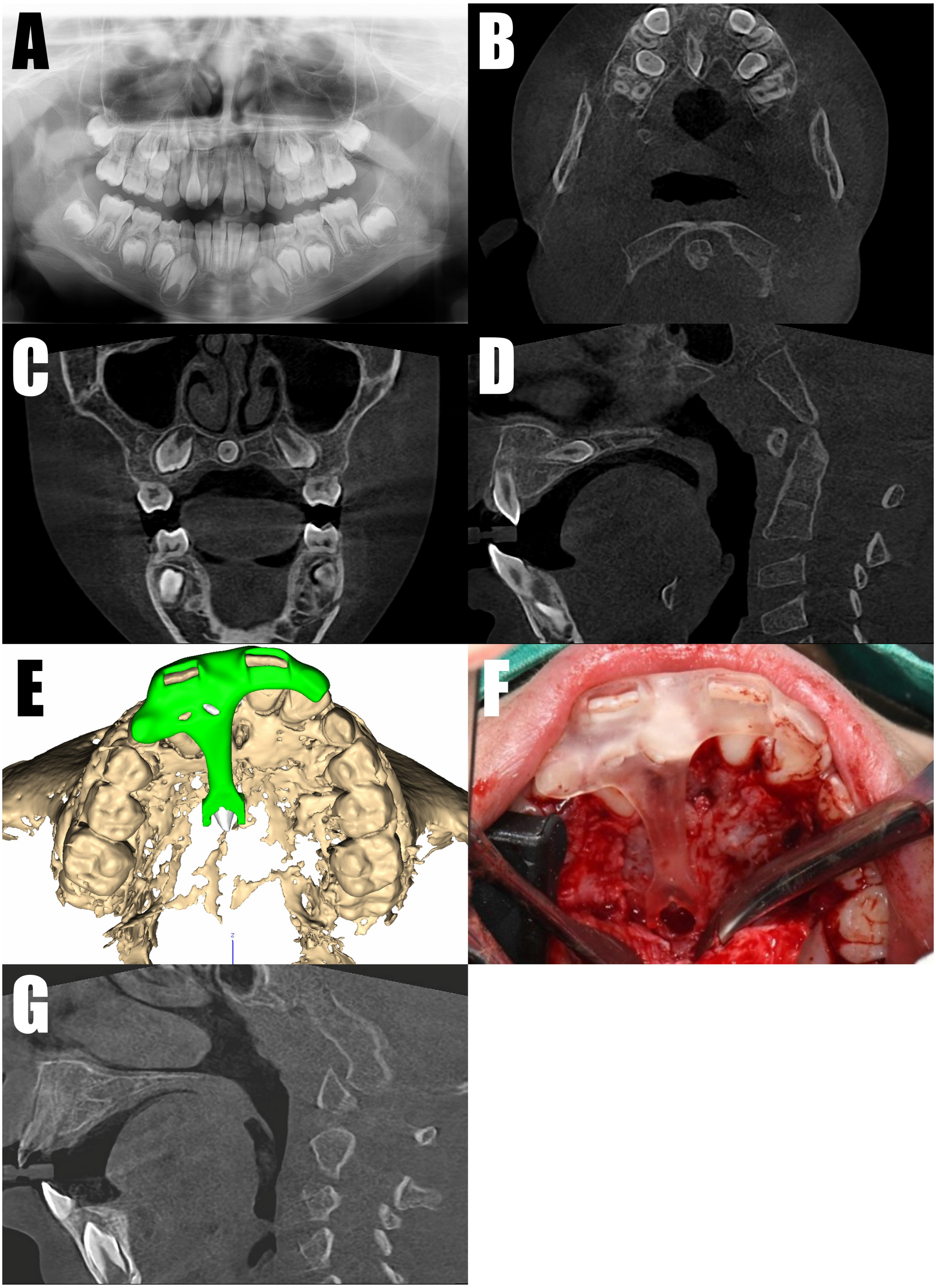

FIGURE 3. Preoperative panoramic, CT, appliance, clinical photograph, postoperative CT for case 3. Preoperative Panoramic, CT, Appliance, Clinical Photograph, Postoperative CT for Case 3: (A) Initial panoramic view. (B) Initial axial CT view. (C) Initial coronal CT view. (D) Initial sagittal CT view. (E) Surgical guide model. (F) Intraoperative intraoral photograph. (G) One-week postoperative CT view. CT: computed tomography.

the surgical wound healed fully.

3. Discussion

Accurate diagnosis and localization of the affected mesiodens are essential for more precise planning of treatment intervention [15]. This ensures that surgical procedures can be performed without damaging the adjacent structures, which is particularly important for the proper growth and development of the teeth and jaws in children [18]. Minimal invasiveness is the key objective of alveolar surgery. In this study, we utilized a method that superimposed digitally scanned files and CBCT images to maximize accuracy and minimize errors. Simultaneously, we simplified the guide fabrication process to enhance user convenience and reduce the number of patient visits. Over the study period (in which three patients were treated), the design of surgical guide evolved to maintain functionality while adapting to the surgeon's convenience. The thickness was gradually reduced to ensure minimal obstruction of the surgeon's view. In the third case, the guide was modified to remove the parts that obstructed the view of the cutting edge of the maxillary central incisor, resulting in a significantly more open view compared to the previous two cases.

The guided hole structure is frequently employed in implant surgery, where the use of surgical guides is widespread [19]. However, extraction guides differ from those used in implant surgery since the former require a certain amount of operating space for tooth removal [20]. Therefore, this study utilized a U-shaped open guide that indicated the initial bone removal area planned by the surgeon to accurately guide the target supernumerary tooth area while limiting the bone removal range to protect the adjacent teeth and anatomical structures of the maxilla. CBCT scans were obtained before and after surgery to verify the actual amount of bone removed during supernumerary tooth extraction. In all three cases, additional bone removal beyond the size of the supernumerary tooth was observed, with the first case involving greater bone removal than the others. This may be related to the surgeon's initial lack of familiarity with surgical guidance. However, relative to the first case, subsequent cases showed advancements toward minimally invasive surgery through customized guide device thickness adjustments and support area modifications, reflecting the surgeon's feedback.

The clinical benefits of using a surgical guide include a reduced operative time, minimal bone removal, reduced postoperative trauma, and increased confidence in safe treatment, which can reduce patient anxiety [21, 22]. This study included only general anesthesia cases, considering the complexity of the procedure and the level of patient cooperation. Although the surgical time was reduced in all three cases, the impact of general anesthesia on the results cannot be excluded. The use of surgical guides is not limited only to procedures performed general anesthesia; however, in pediatric patients, cooperation must always be considered, making their application more favorable during general anesthesia. Nevertheless, when the fixation of the guide is sufficient, its stability is maintained even in the event of patient movement, suggesting that surgical guides can be effectively utilized under local anesthesia as well. Postoperative pain was reported to be nonexistent in all three cases during follow-up consultations, and further studies in outpatient settings are needed to assess its impact on patient anxiety.

The As Low As Reasonably Achievable (ALARA) principle is a safety guideline used in radiology to minimize radiation exposure to patients and healthcare professionals by employing the lowest possible dose needed for diagnostic efficacy. Implementing the ALARA principle involves optimizing imaging techniques, using protective equipment, and ensuring that only necessary radiological procedures are performed to reduce unnecessary radiation exposure. Adherence to the ALARA principle is crucial in balancing the diagnostic benefits of imaging with the potential risks of radiation, particularly in vulnerable populations such as children and pregnant women [23]. In this study, CT was performed before and after the extraction of the supernumerary tooth to ensure the safety of the procedure and to confirm minimal bone removal. While this approach has its merits, it does not fully align with the ALARA principle, which emphasizes minimizing radiation exposure. Dental CT expose patients to radiation doses equivalent to approximately 3–5 days of natural background radiation per scan, which is relatively low. However, in the future, it is recommended that panoramic or periapical radiographs be used for simpler verification of supernumerary tooth extraction to further minimize radiation exposure.

The application of 3D scanning in surgical guide fabrication represents a significant advancement in the management of complex dental extractions, including those involving supernumerary teeth [17]. Compared to traditional methods, the use of customized surgical guides developed through 3D scanning and CBCT data offers precise localization of the supernumerary teeth, facilitating safer and more effective extraction procedures. The advantages of 3D scanning technology include highly accurate digital representations of the oral cavity, enabling the design of surgical guides tailored to the patient's individual anatomy. These guides define optimal paths for tooth extraction, minimizing surgical trauma and enhancing overall procedural safety. This approach addresses the limitations of conventional imaging techniques such as CBCT alone, which may not provide the same level of precision in guiding surgical interventions.

New approaches, such as ultrasonic surgery devices, two-stage guide plates, and navigation systems, have been explored [24–26]. However, despite generally positive outcomes, challenges such as the time required to set up these systems and equipment limitations still exist. Our study highlights how refining the guide fabrication process and adapting the design to the surgeon's needs can further improve clinical outcomes without the complexity associated with more advanced technologies. Compared to other new approaches, the customized surgical guide presented in this study is distinct due to its simplicity and effectiveness.

While the surgical guides showed promising results in reducing the operative time and enhancing procedural accuracy, the high cost of 3D scanning equipment remains a limitation. Future research should explore the application of surgical guides in various surgical fields, such as radicular cysts and odontogenic tumors. Further investigation is also needed to determine the applicability of these guides when the surgical site lies in areas beyond maxillary mesiodens and to assess whether patient discomfort under local anesthesia can be alleviated using this guide. Despite these limitations, this study contributes valuable insights into the benefits of customized surgical guides in pediatric oral surgery, aligning with the ongoing advancements in minimally invasive techniques.

4. Conclusions

The use of surgical guides created with 3D scanning technology was proven to be highly effective for the extraction of impacted mesiodens under general anesthesia. The design of these guides can be modified to suit the individual needs of patients, progressively becoming more convenient for surgeons. This adaptability suggests significant clinical value for its application in minor pediatric oral surgeries in the future.

ABBREVIATIONS

CBCT, cone-beam computed tomography; ALARA, As Low As Reasonably Achievable; 3D, three-dimensional; STL, standard tessellation language; CT, Computed Tomography.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analyzed during this study are included in this published article. Data supporting the findings of this study are available from the corresponding author upon reasonable request.

AUTHOR CONTRIBUTIONS

YJ and GK—designed the research study. YJ—performed the research. JL—provided help and advice. YJ, JL and GK—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Institutional Review Board (IRB) of Kyungbook University Dental Hospital (IRB No: KNUDH-2024-09-03-00). Informed consent was obtained from the patients and their parents.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research (or work) was supported by Kyungpook National University Research Fund, 2024. Number as 202421560000.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Youngeun Jang, Jaesik Lee, Gimin Kim. Application of a surgical guide for the extraction of impacted mesiodens: a case series. Journal of Clinical Pediatric Dentistry. 2025; 49(3): 208-215. doi: 10.22514/jocpd.2025.068.