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Short Communication

# Navigation-guided autotransplantation: A novel technique for precise and predictable tooth placement

Yang-Chih Chou [a], Wen-Hui Chen [a,b], Hui-Na Lee [c,d], Yu-Feng Chen [d,e*]

[a] *Division of Oral and Maxillofacial Surgery, Department of Dentistry, E-DA Hospital, I-Shou University, Kaohsiung, Taiwan*
[b] *School of Medicine for International Students, College of Medicine, I-Shou University, Kaohsiung, Taiwan*
[c] *Division of Conservative Dentistry, Department of Dentistry, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan*
[d] *School of Dentistry, College of Dental Medicine, Kaohsiung Medical University, Kaohsiung, Taiwan*
[e] *Division of Oral and Maxillofacial Surgery, Department of Dentistry, Kaohsiung Medical University Hospital, Kaohsiung, Taiwan*

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**Abstract** Autotransplantation (AT) is a promising alternative for restoring failed teeth. However, the success rate varies due to technique sensitivity and absence of standardized protocol. We present the first documented AT protocol utilizing a dynamic navigation system, including three core innovations: (1) navigation-guided socket preparation, (2) extra-alveolar retrograde filling, and (3) digital lingual stent fixation with flowable resin. A 55-year-old Taiwanese female with a vertical root fracture in tooth 36 underwent dynamic navigation-guided AT of tooth 38. The recipient area was prepared using a 2.5 mm wide round bur under the X-Guide® navigation. The X-Mark® probe was used to detect underprepared areas, and once preparation was deemed optimal, a three-dimensional (3D) replica was used for final confirmation. Tooth 38 was extracted and underwent retrograde filling, then transplanted into the socket of tooth 36 and fixed with a lingual stent. Postoperative image demonstrated ideal tooth positioning and favorable bone remodeling.

* Corresponding author. Division of Oral and Maxillofacial Surgery, Department of Dentistry, Kaohsiung Medical University Hospital, No. 100, Tzyou 1st Rd., Sanmin Dist., Kaohsiung City 80756, Taiwan.
*E-mail address:* omsyfchen@gmail.com (Y.-F. Chen).

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## Introduction

Autotransplantation (AT) in dentistry has been employed since 1950 with advantages including cost-effectiveness, preservation of the natural tooth's proprioception, and maintenance of alveolar bone height and gingival thickness. Furthermore, the transplanted tooth retains the potential for movement through orthodontic traction.[1] Proper recipient site preparation is one of the keys to successful AT, which helps to prevent mechanical and biological damage to the periodontal ligament (PDL), thereby improving the overall outcome.[2] The traditional method prepares the recipient socket using the donor tooth directly; however, this method is technique-sensitive, prolongs extra-alveolar time and often leads to unpredictable outcomes.[3] The use of three-dimensional (3D) replicas and customized surgical stents may overcome these challenges; however, these methods are still relatively blind operations that rely on the surgeon's experience. Therefore, we used navigation system technology to improve the precision of socket preparation and the success rate of AT.

## Materials and methods

A 55-year-old Taiwanese female presented with dull pain at the tooth 36. Intraoral examination showed a narrow distal periodontal pocket measuring 7 mm in depth. The periapical radiograph revealed a J-shaped radiolucent lesion at the periapical area of the tooth 36 (Fig. 1A and B). Percussion pain of the tooth 36 was also noted. The diagnosis was vertical root fracture of tooth 36. After reviewing the risks, benefits, and treatment options with the patient, she decided to receive AT from tooth 38 to tooth 36.

Preoperative planning incorporated digital design of the AT procedures. The outline of tooth 38 was digitally segmented and virtually positioned at the recipient site of tooth 36. The resulting file was then exported to the X-

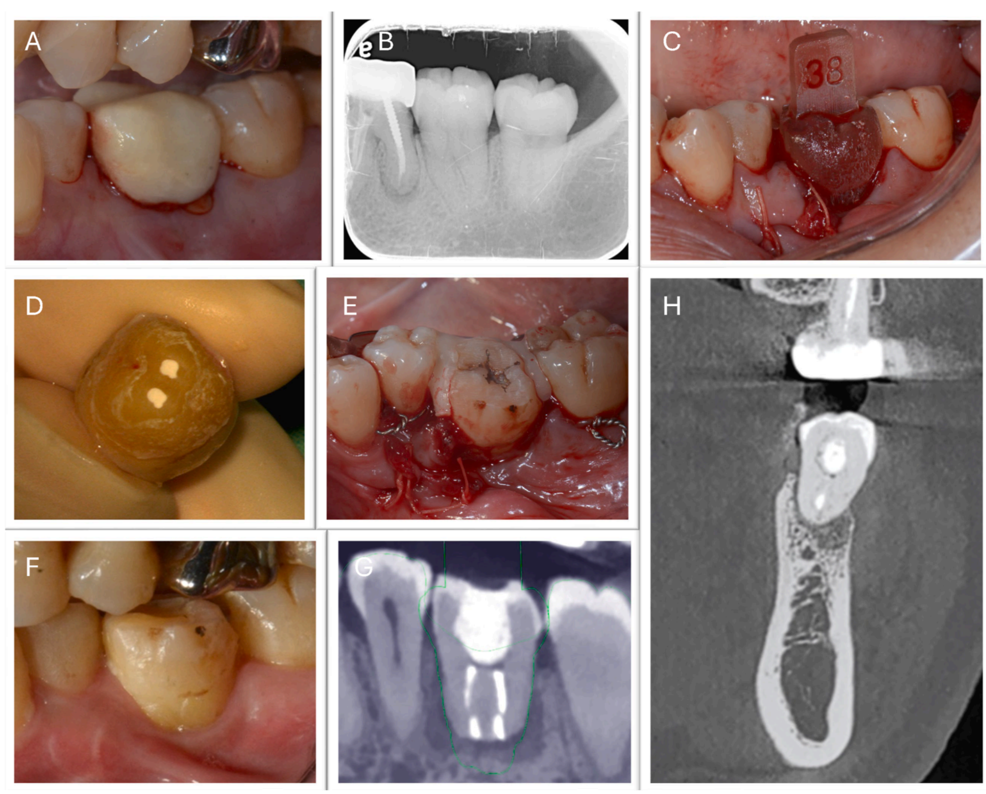


**Figure 1** Clinical conditions of autotransplantation (AT). (A) Clinical photograph of tooth 36. (B) Periapical film of tooth 36 with a J-shaped radiolucency over distal apical region. (C) 3D-printed replica try-in. (D) Apicoectomy and retrograde filling with mineral trioxide aggregate (MTA) for the tooth 38. (E) Digital lingual stent fixation with wire and flowable resin. (F) Two-month postoperative clinical photograph of AT. (G) Two-month follow-up cone beam computed tomography (CBCT): superimposition of AT demonstrates precision of ideal position. (H) Two-month follow-up CBCT image showing bone remodeling after AT.

Guide® navigation system (X-Nav Technologies, Lansdale, PA, USA). The individual roots of the donor tooth were divided into buccal and lingual components. A 2.5-mm-wide, parallel, tubing-shaped guide was designed to closely match the outer contours of each root and its apex. The furcation area was similarly separated into buccal and lingual aspects using the same 2.5-mm guide. From an occlusal perspective, a total of six guides were generated for precise socket preparation (Fig. 2A–C).

The procedure was performed under local anesthesia and with standard surgical draping. The reference device and tracking system were set up according to the manufacturer's instructions, followed by registration of the drill and handpiece. Tooth 36 was extracted using an intrasulcular incision. A 2.5-mm carbide round bur, matched to the size of the tubing-shaped guide, was used for drilling at a rotational speed of 1200 RPM under the guidance of the X-Guide® navigation system. The socket preparation sequence was in an order as follows: buccal furcation, lingual furcation, mesiobuccal root aspect, mesiolingual root aspect, distobuccal root aspect, and distolingual root aspect. After initial preparation, excess alveolar bone was refined using round and chamfer burs. The X-Mark® probe was employed to assess the quality of the socket preparation. It was inserted to the deepest point of the socket and then gradually moved outward and upward to detect any discrepancy between the planned and actual preparation (Fig. 2D–F).

A 3D-printed replica of the donor tooth was used to verify transplant stability and positioning (Fig. 1C). Tooth 38 was then atraumatically extracted to minimize PDL injury. During the extra-alveolar period, the endodontic surgeon performed apicoectomy and retrograde filling with mineral trioxide aggregate (MTA) (Fig. 1D). The total manipulation time was kept under 10 min. Following confirmation of a proper socket fit, the donor tooth was

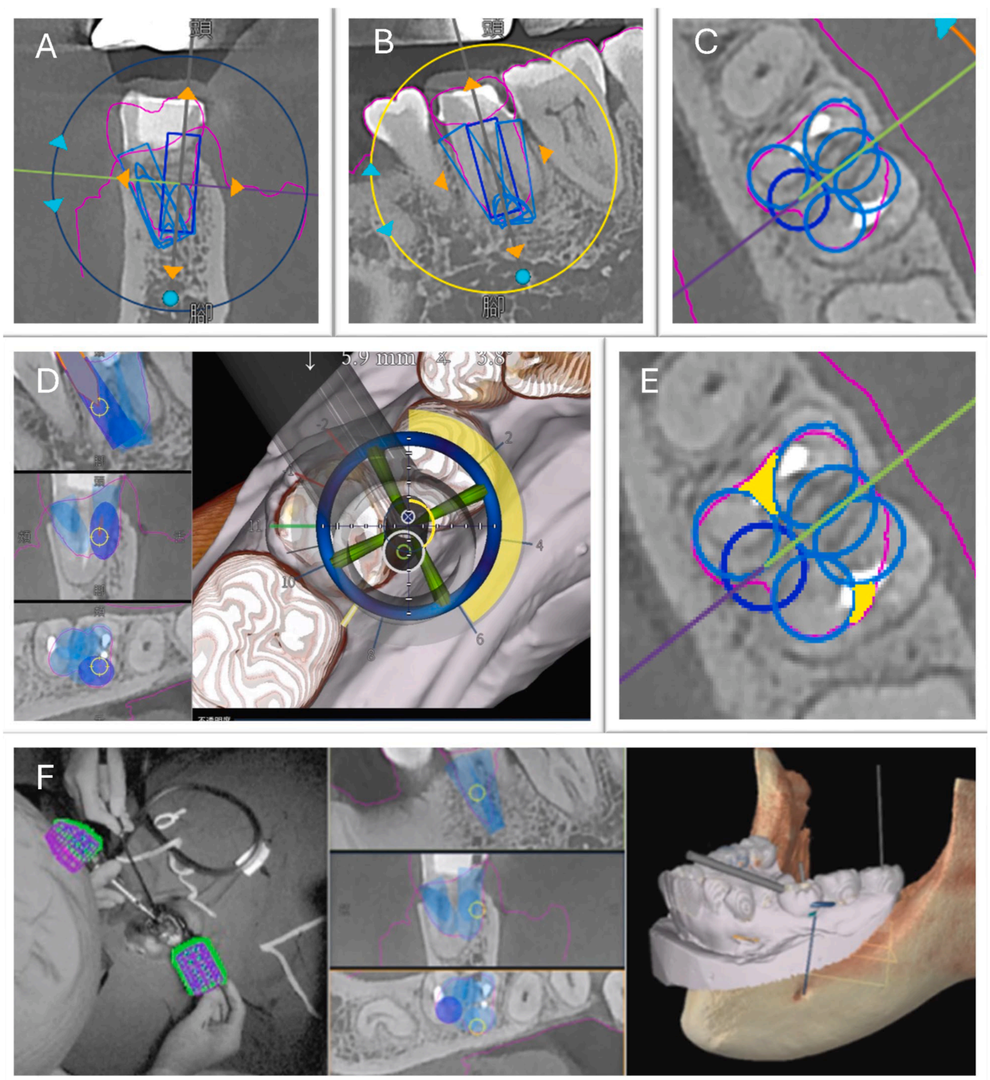


**Figure 2** Navigation procedures of autotransplantation (AT). (A and B) Surgical guides plan for mesial and distal roots and furcation of tooth 36. (C) A total of six surgical guides were designed. (D) Recipient site preparation with X-Guide® navigation system from coronal, sagittal, and occlusal views. (E) The yellow part indicates the removal of excess alveolar bone. (F) Recheck the preparation with an X-Mark® probe.

transplanted into the recipient site. Occlusal adjustment was performed to eliminate any premature contact. A lingual stent was fixed by circumdental wire and flowable resin relining to ensure semi-rigid fixation for the transplanted tooth (Fig. 1E).

## Results

Two weeks after surgery, the lingual splint was removed. Periapical radiography revealed ideal positioning of the transplanted tooth with adequate apical sealing. The patient received consecutive endodontic treatment one month later after ensuring stabilization of the transplanted tooth. She was subsequently recalled for regular clinical and radiographic follow-ups. Two months postoperatively, a clinical photograph showed a healthy periodontium. Tooth mobility was assessed using a damping capacity device (Anycheck®, Neobiotech, Seoul, Korea), with an implant stability test (IST) value of 69, indicating good stability. Probing depths ranged from 3 to 4 mm, with no evidence of bony destruction. Cone beam computed tomography (CBCT) demonstrated bone remodeling and superimposition analysis confirmed the precise placement of the transplanted tooth (Fig. 1F–H).

## Discussion

Previous studies have investigated the influence of various factors on the success of AT, including the extraoral time of the donor tooth, the type of tooth and stage of root development, and the preparation of the recipient site.[4] Traditionally, the recipient site is prepared using the donor tooth itself as a template. However, this method is technique-sensitive, often prolongs the extra-alveolar period and may result in unpredictable outcomes. Additionally, repeated trial fittings during preparation may traumatize the PDL, thereby increasing the risk of root or alveolar bone resorption.[5]

To address these challenges, 3D-printed replicas and customized surgical stents may help to reduce such difficulties. However, the replica-based approach remains a semi-guided technique that still depends on the surgeon's experience for socket preparation. Repeated try-ins may traumatize the PDL and decrease the success rate. Moreover, inaccuracies in surgical guides may arise from errors during the design, data conversion, or 3D printing process. During the procedure, surgical stents may lack sufficient stability or obstruct irrigation, increasing the risk of thermal damage to the surrounding tissues.

Dynamic navigation technology enables surgeons to perform real-time procedures with high accuracy and precision. In dentistry, the systems have been successfully applied in dental implant placement, management of obliterated canals, and apical surgery. In AT, dynamic navigation provides real-time instrument tracking and enhanced anatomical visualization, offering a more intuitive and precise approach compared to conventional freehand techniques. This method improves the accuracy of socket preparation, minimizes trauma to the PDL and enables the surgeon to adjust the preparation in real time according to the root morphology.[6] Consequently, the autotransplanted tooth can be positioned according to the preoperative plan, optimizing initial stability and promoting favorable bone healing.[7] However, several factors may affect the accuracy of dynamic navigation systems, including image quality of CBCT, stability of the registration and reference devices, and the operator's experience level.

Extra-alveolar retrograde filling simplifies the management of the complex canal system of third molars, thereby reducing the risk of endodontic failure. With a well-sealed apex, the deferral of canal access and shaping can provide additional time for increased stabilization of the autotransplanted tooth.[8]

Traditional stabilization methods, such as resin fixation with wire or sutures, often require repeated manipulation of the mobile tooth, increasing the risk of periodontal trauma. In contrast, digitally fabricated lingual stents combined with flowable resin provide a semi-rigid fixation method that offers excellent adaptation and ease of application.[9]

AT is a well-established but technique-sensitive procedure that offers an alternative option for failed tooth rehabilitation, particularly in adolescent patients. With the integration of digital workflow and a real-time navigation system, AT can reveal the potential to achieve highly patient-specific treatment while ensuring optimal preparation and procedural accuracy for successful outcomes.[10]

We presented a step-by-step procedure for AT using a navigation system. To the best of our knowledge, this is the first article to describe the innovative technique in detail. A limitation of this technique is the variability in donor tooth root morphology, which may complicate the design of navigation-guided preparations. Therefore, careful planning and appropriate case selection are essential. Longer-term follow-up and further prospective studies are needed to investigate the evidence and clinical benefits of this technique.

## Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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