Dynamic navigation system-guided trans-inferior alveolar nerve implant placement in the atrophic posterior mandible: A case report

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Abstract

BACKGROUND
In atrophic posterior mandibular areas, where the bone height superior to the inferior alveolar nerve (IAN) is less than 6 mm, short implants are not applicable. Conventional alternatives such as IAN transposition and various alveolar bone augmentation approaches are technically demanding and prone to complications.

CASE SUMMARY
Computer-guided dynamic navigation implantation improves the accuracy, predictability, and safety of implant placement. This case report presents a dynamic navigation system-guided trans-IAN implant placement technique, which can successfully treat a posterior mandibular dentition defect when the bone height is only 4.5 mm. The implant was inserted into the buccal side of the IAN and was 1.7 mm away from the IAN. The implantation deviations were controlled within a satisfying range, and the long-term restoration outcome was stable.

CONCLUSION
Dynamic navigation system-guided trans-IAN implant placement might be a recommended technique for patients with extremely insufficient residual bone height and sufficient bone width in the posterior mandibular area.

Key Words: Dental implant; Dynamic navigation system; Insufficient bone height; Inferior alveolar nerve; Posterior mandible; Case report

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Core Tip: In atrophic posterior mandibular areas, where the residual bone height (RBH) superior to the inferior alveolar nerve (IAN) is less than 6 mm, conventional operative treatments are no longer applicable. We present a computer-dynamic navigation system (CADNS) -guided trans-IAN implant placement technique, which successfully treat a posterior mandibular dentition defect when the bone height is only 4.5 mm, resulting with a satisfying implant-restoration. This case demonstrates a novel implantation solution taking advantage of the accuracy and safety of CADNS. CADNS-guided trans-IAN placement could be a recommended technique for patients with an extremely insufficient RBH but sufficient buccal bone width in the posterior mandibular area.

INTRODUCTION
Adequate bone height and bone width are essential for dental implant placement. In the posterior mandible, alveolar bone volume could be resorbed too severely to accommodate a dental implant due to persistent periodontal disease, early loss of teeth, or prolonged use of removable prostheses[1]. Short dental implants are recommended when the residual bone height (RBH) is more than 6 mm[2,3]. Vertical bone augmentation approaches [like onlay bone graft, guided bone regeneration, and distraction osteogenesis][1,4] and inferior alveolar nerve (IAN) reposition[5] are recommended when the RBH is less than 6 mm. However, these approaches are technically challenging and accompanied by complications, such as soft tissue dehiscence, barrier membrane exposure[6], infection, displacement of the transport segment[7], and neurosensory abnormalities[5]. Therefore, a minimally invasive, less risky, and more accurate technique is needed for severe atrophic posterior mandible edentulous patients.

Computer-assisted dynamic navigation systems (CADNSs) based on cone-beam computed topography (CBCT) navigation have been introduced into the field of dental implantology to improve the accuracy of implant placement and avoid potential complications[8,9]. A CADNS is a surgical navigation system which can design the location of a virtual implant according to CBCT data. In addition, it allows real-time tracking of implant drills in three dimensions (3D) on a monitor[10]. It is significantly predictable, accurate, and less risky than freehand implant surgeries[11]. Therefore, it is suitable for guiding implant insertion surgery in edentulous patients with critical alveolar bone volumes. This article reports a case using CADNS in the posterior mandible with severe bone resorption to avoid IAN injury. This article follows the recommendations of the CARE guidelines[12].

CASE PRESENTATION

Chief complaints
A 50-year-old woman was referred to our clinic with the chief complaint of loss of posterior mandibular teeth over 5 years. Oral examination showed that teeth 36 and 37 were missing (Figure 1A). Tooth 38 had erupted and was occluded with the upper teeth. The distance between the gingiva and maxillary teeth at the edentulous area was 6-7 mm, while the mesiodistal distance was about 18 mm (Figure 1B).

History of present illness
The patient reported no systemic diseases.

History of past illness
The patient had a free previous medical history.

Personal and family history
The patient reported no drug allergy, long-term medication family genetic disease, or smoking.

Physical examination
The patient’s temperature was 36.5 °C, heart rate was 84, blood pressure was 87/61 mmHg, without any other pathological signs.
Figure 1 Preoperative oral situation of a 50-year-old Chinese woman with posterior mandibular defect dentition. A: Mandibular occlusal view; B: Buccal view from the left side; C: Mandibular occlusal view with the U shape tube fixed to the left dentition defect; D: Panoramic radiograph with the U-shaped tube fixed to the dentition defect.

Figure 2 Arranging the proper position, length, diameter, and abutment for each implant. A: The cone-beam computed topography (CBCT) results showed that the distance from the inferior alveolar nerve (IAN) to the crestal ridge was 9.4 mm, and the distance from the IAN to the buccal cortical bone wall was 5.5 mm in the first molar position; B: The sagittal view of the designed implant for the first molar; C: The coronal view of the designed implant for the first molar; D: The CBCT results showed that the distance from the IAN to the crestal ridge was 4.5 mm, and the distance from the IAN to the buccal cortical bone wall was 8.1 mm in the second molar position; E: The sagittal view of the designed implant for the second molar; F: The coronal view of the designed implant for the second molar.

**Laboratory examinations**

The blood biochemistry analyses were normal.
Imaging examinations

CBCT images showed that the distance from the IAN to the crestal ridge was 9.4 mm, and the distance from the IAN to the buccal cortical bone wall was 5.5 mm at tooth 36 (Figure 2A). The volumes of tooth 37 were 4.5 mm and 8.1 mm, respectively (Figure 2D).

FINAL DIAGNOSIS

The final diagnosis of the presented case was Kenney III dentition defect.

TREATMENT

The vertical bone heights above the IAN at teeth 37 was insufficient for standard-length implant placement. The following treatment options were considered: (1) Short implants, although the shortest implant available was 6 mm, which was not applicable for tooth 37; (2) onlay bone augmentation, although excessive compression would encroach on prosthesis space, and vertical bone augmentation in the posterior area is challenging; (3) IAN reposition, although this approach can lead to neurosensory disturbances and spontaneous mandibular fractures; (4) trans-IAN implant placement guided by a 3D-printed surgical guide, although the upper surface of the 3D guide needs to be 5 mm away from the alveolar ridge, and the full length of the implant drill is 18-22 mm (since the defect site was rather posterior, the surgery would require the patient’s mouth to remain wide open for a long time, which can be challenging for patients); or (5) trans-IAN implant placement guided by a CADNS for tooth 37.

Based on these factors, a trans-IAN implant placement guided by a CADNS was used. Informed consent of the patient was obtained before the surgery.

Preoperative preparation

A U-shaped fixture was fixed at the edentulous region after filling with polyether impression material (Figure 1C). Subsequently, both jaws and the U-shaped tube were scanned using CBCT (Figure 1D). The volumetric data was converted into Digital Imaging and Communications in Medicine (DICOM) format. Surface images of dentition and occlusion were obtained by an intraoral optical scanner and were converted to standard tessellation language (STL) format. Both the DICOM and STL files were uploaded.
Figure 4 The navigation operation views are divided into dynamic and static views (Upper column is dynamic view, bottom columns are static views). Upper column: 2D dynamic view: slice maps of the implant drill location (axial, coronal and sagittal views); Bottom column left 1: 3D reconstruction graph: hard tissue model; Bottom column left 2: Distance graph of the drill tip deviates from the designed implant entry point; Bottom column right 2: Angle graph of the drill deviates from the designed implant axis; Bottom column right 1: Depth map of the drill tip in the designed implant direction, green indicates that it can continue drilling, yellow indicates vigilance, red indicates excess (tolerance value can be artificially set).

Prosthodontic treatment planning included evaluating the occlusion, placing the prosthesis (Figure 3C), choosing the implants below the crowns (Figure 3D), and arranging proper position, length, diameter, and abutment for each implant. Because of the insufficient bone height above the IAN, a 4.1 mm × 8 mm implant (ITI, BLT) and a straight abutment were planned for tooth 36 (Figure 2B and C). In addition, a 4.1 mm × 10 mm trans-IAN implant (ITI, BLT) on the buccal side and an angled abutment were planned for tooth 37 (Figure 2E and F). Screw-retained united crowns were designed. Then, the treatment plan was imported into the dynamic navigation software.

Dynamic navigation surgery
Routine operation disinfection and local infiltration anesthesia were performed. The Digital-care Implant Surgery Navigation System (Dcarer, Suzhou, China) was used to assist the surgery. The instruments were calibrated for tracking by the dynamic system. A reference plate was firmly fixed on the mandibular anterior teeth using self-curing resin. Next, the geometry of the patient-tracking array relative to the reference plate was also registered into the dynamic system. Afterwards, implant placement was conducted according to the preoperative planning (Figure 4) with the guide of a real-time navigation operation view on the monitor (Figure 5A-C). The reference plate was removed after implants insertion. Cover screws were connected, and the wound was sutured.

Accuracy verification
Postoperative CBCT (Figure 5D-F) showed that safe distances were ensured between implants and the IAN. The implant at tooth 37 was placed through the buccal side of the IAN, and the distance from the IAN to the implant was 1.7 mm (Figure 5F). The preoperative planning and postoperative CBCT images were imported into the navigation software and matched to calculate the deviation. The deviations at teeth 36 and 37 were 0.831 mm and 0.682 mm at the implant shoulders and 0.574 mm and 0.867 mm at the implant tips, respectively. The angular deviations at teeth 36 and 37 were 3.118° and 2.317°, respectively.
Figure 5 Implant placement surgery. A: Surgical process; B: Buccal view of the implants; C: Occlusal view of the implant entry points; D: Panoramic radiograph after the surgery; E: Sagittal view of the first molar; F: Sagittal view of the second molar. The implant was 1.7 mm away from inferior alveolar nerve.

OUTCOME AND FOLLOW-UP

After 4 mo, second-stage surgery was performed (Figure 6A). A 1.5-mm straight composite abutment was placed at the first molar site, and a 2.5-mm 17°-angled composite abutment was placed at the second molar site (Figure 6B). Restoration was finished with the screw-retained porcelain-fused-metal union crowns (Figures 6C and D).

Clinical and CBCT examination after restoration (Figure 7A) showed that the marginal bone was fine, the soft tissues around the implants were healthy, and the adjacency and occlusion were appropriate. CBCT examination at the 6-month follow-up (Figure 7B) revealed that the marginal bone was stable and that the implants’ osseointegration was healthy, which fulfilled the success criteria stated by Papaspyridakos et al[13].

DISCUSSION

It is challenging to restore a severely atrophic posterior mandible with dental implants. Short implants and vertical bone augmentation are recommended as the priority options in these cases[14]. IAN reposition is also an alternative option when the RBH is less than 6 mm. However, many complications are associated with these treatment options. In this case, the RBH at tooth 37 was 4.5 mm, while there was sufficient bone volume from the IAN to the buccal cortical bone (8.1 mm). Therefore, a tilted
Implant was inserted into the buccal side of the IAN with guided dynamic navigation. This technique is recommended for patients with sufficient residual alveolar bone width.

In the past decade, computer-guided implantology techniques have been used widely and play important roles in edentulous patients with severe bone resorption with a favorable accuracy and success rate. Computer-guided implantology technologies include static and dynamic navigation. Both can achieve a satisfactory accuracy in implant surgeries. Block et al. [15] reported similar accuracies between dynamic and static navigation. Mediavilla Guzmán et al. [16] reported no significant difference between dynamic and static navigation at the coronal and apical levels, but a significantly smaller angular deviation was observed in the dynamic system. In the present case, the deviations at the implant shoulder of teeth 36 and 37 were 0.831 mm and 0.682 mm, respectively; 0.574 mm and 0.867 mm at the implant apical level, respectively; and angular deviations of 3.118° and 2.317°, respectively. The results were consistent with preliminary studies on the accuracy of dynamic navigation surgeries [8,15, 17].

Compared to static navigation, dynamic navigation has many advantages. First, 3D-printed surgical guide plates are not needed, thus reducing expenses and surgical time [18]. Second, no special drills are
required. Third, it has a lower requirement regarding an open bite. Fourth, the risk of overheating is decreased due to sufficient irrigation. Finally, it allows for real-time feedback on the preparation and insertion on the implant in 3D[10]. Although a CADNS offers significant advantages, there are some disadvantages. One limitation is the huge initial investment in equipment (CBCT equipment, intraoral scan equipment, and dynamic navigation equipment) and training. Learning to use new software and adapting to virtual image-guided operation may also require effort. Many researchers believe that there is a learning curve to achieve proficiency in this technique. A study showed that dentists become statistically equivalent and proficient after 20 implant placements[15]. As for this case, there is a disadvantage of the CADNS-guided trans-IAN technique that it is not always possible to place an implant that provide an ideal prosthetic position.

CONCLUSION

CADNS can ensure the accuracy and safety of implant placement and avoid the risk of damaging the IAN. Therefore, CADNS-guided trans-IAN placement could be a recommended technique for patients with an extremely insufficient RBH but sufficient buccal bone width in the posterior mandibular area.

FOOTNOTES

Author contributions: Chen LW contributed to treatment planning and manuscript drafting; Zhao XE contributed to treatment plan implementation and photo collection; Yan Q contributed to treatment plan implementation and manuscript revision; Xia HB contributed to treatment plan implementation; and Sun Q contributed to manuscript revision and treatment planning.

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REFERENCES

1 Esposito M, Grusovin MG, Felice P, Karatzopoulos G, Worthington HV, Coulthard P. Interventions for replacing missing teeth: horizontal and vertical bone augmentation techniques for dental implant treatment. Cochrane Database Syst Rev 2009; CD003607 [PMID: 19821311 DOI: 10.1002/14651858.CD003607.pub4]
2 Jung RE, Al-Nawas B, Araujo M, Avila-Ortiz G, Barter S, Brodala N, Chappuis V, Chen B, De Souza A, Almeida RF, Fickl S, Finelle G, Ganeles J, Gholami J, Hammarle C, Jensen S, Jokstad A, Katsuyama H, Kleinheinz J, Kunavisarut C, Mardas N, Monge A, Papaspyridakos P, Payer M, Schiegnitz E, Smeets R, Stefanini M, Ten Bruggenkate C, Vazouras K, Weber HP, Weingart D, Windisch P. Group 1 ITI Consensus Report: The influence of implant length and design and medications on clinical and patient-reported outcomes. Clin Oral Implants Res 2018; 29 Suppl 16: 69-77 [PMID: 30328189 DOI: 10.1111/chi.13342]
3 Markose J, Eshwar S, Srinivas S, Jain V. Clinical outcomes of ultrashort sloping shoulder implant design: A survival analysis. Clin Implant Dent Relat Res 2018; 20: 646-652 [PMID: 29671933 DOI: 10.1111/cid.12608]

4 Felice P, Barausse C, Barone A, Zucchelli G, Piattelli M, Pistilli R, Ippolito DR, Simion M. Interpositional Augmentation Technique in the Treatment of Posterior Mandibular Atrophies: A Retrospective Study Comparing 129 Autogenous and Heterologous Bone Blocks with 2 to 7 Years Follow-Up. Int J Periodontics Restorative Dent 2017; 37: 469–480 [PMID: 28609491 DOI: 10.11607/prd.2999]

5 Vetromilla BM, Moura LD, Sonego CL, Torriani MA, Chagas OL Jr. Complications associated with inferior alveolar nerve repositioning for dental implant placement: a systematic review. Int J Oral Maxillofac Surg 2014; 43: 1360-1366 [PMID: 25128261 DOI: 10.1016/j.ijom.2014.07.010]

6 Todisco M. Early loading of implants in vertically augmented bone with non-resorbable membranes and deproteinised anorganic bovine bone. An uncontrolled prospective cohort study. Eur J Implant Dent 2010; 3: 47-58 [PMID: 20467598]

7 Zhao K, Wang F, Huang W, Wu Y. Clinical Outcomes of Vertical Distraction Osteogenesis for Dental Implantation: A Systematic Review and Meta-Analysis. Int J Oral Maxillofac Implants 2018; 33: 549-564 [PMID: 29763493 DOI: 10.11607/jomrn.6140]

8 Edelmann C, Wetzel M, Knipper A, Luthardt RG, Schnutenhaus S. Accuracy of Computer-Assisted Dynamic Navigation in Implant Placement with a Fully Digital Approach: A Prospective Clinical Trial. J Clin Med 2021; 10 [PMID: 33919257 DOI: 10.3390/jcm10091808]

9 Wei SM, Zhu Y, Wei JX, Zhang CN, Shi JY, Lai HC. Accuracy of dynamic navigation in a systematic review of dental implant surgery: A systematic review and meta-analysis. Clin Oral Implants Res 2021; 32: 383-393 [PMID: 33540465 DOI: 10.1111/cior.13719]

10 Cecchetti F, Di Girolamo M, Ippolito DG, Baggi L. Computer-guided implant surgery: analysis of digital navigation systems and digital accuracy. J Biol Regul Homeost Agents 2020; 34: 9-17. DENTAL SUPPLEMENT [PMID: 32618156]

11 O’Meara S. Commentary on Vermeulen H, Ubbink DT, Schreuder SM and Lubbers MJ (2007) Inter- and intra-observer (dis)agreement among nurses and doctors to classify colour and exudation of open surgical wounds according to the Red-Black-Yellow scheme. Journal of Clinical Nursing 16, 1265-1269. and Kitagawa A (2007) A study of the efficiency and convenience of an advanced portable wound measurement system (VISITRAK). Journal of Clinical Nursing 16, 1270-1277 and Sugama J, Matsui Y, Sanada H, Konya C, Okuwa M (2007) A study of the efficiency and convenience of an advanced portable wound measurement system (VISITRAK). Journal of Clinical Nursing 16, 1265-1269. [PMID: 18482135 DOI: 10.1111/j.1365-2702.2007.02108.x]

12 Gagnier JJ, Kienle G, Altman DG, Moher D, Sox H, Riley D. CARE Group. The CARE guidelines: consensus-based clinical case report guideline development. J Nutr Suppl 2013; 10: 381-390 [PMID: 24237192 DOI: 10.3109/13930211.2013.830679]

13 Papaspyridakos P, Chen CJ, Singh M, Weber HP, Gallucci GO. Success criteria in implant dentistry: a systematic review. J Dent Res 2012; 91: 242-248 [PMID: 22157097 DOI: 10.1177/0022034511431252]

14 Merli M, Moscatelli M, Pagliaro U, Mariotti G, Merli I, Nieri M. Implant prosthetic rehabilitation in partially edentulous patients with bone atrophy. An umbrella review based on systematic reviews of randomised controlled trials. Eur J Oral Implantol 2018; 11: 261-280 [PMID: 30246181]

15 Block MS, Emery RW, Lank K, Ryan J. Implant Placement Accuracy Using Dynamic Navigation. Int J Oral Maxillofac Implants 2017; 32: 92-99 [PMID: 27643585 DOI: 10.11607/jomi.5004]

16 Medivilla Guzmán A, Rued Deglow E, Zubizarreta-Macho Á, Agustin-Panadero R, Hernández Montero S. Accuracy of Computer-Aided Dynamic Navigation Compared to Computer-Aided Static Navigation for Dental Implant Placement: An In Vitro Study. J Clin Med 2019; 8 [PMID: 31810351 DOI: 10.3390/jcm122123]

17 Block MS, Emery RW, Cullum DR, Sheikh A. Implant Placement Is More Accurate Using Dynamic Navigation. J Oral Maxillofac Surg 2017; 75: 1377-1386 [PMID: 28384461 DOI: 10.1016/j.ijom.2017.02.026]

18 Van Assche N, Vercreussem M, Coucke W, Teghuls W, Jacobs R, Quirynen M. Accuracy of computer-aided implant placement. Clin Oral Implants Res 2012; 23 Suppl 6: 112-123 [PMID: 23062136 DOI: 10.1111/j.1600-0501.2012.02552.x]
