Int. J. Oral Maxillofac. Surg. 2019; 48: 1516–1519
https://doi.org/10.1016/j.ijom.2019.04.013, available online at https://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Technical Note
Reconstructive Surgery

Matching locating holes in multiple plates to record bone position for accurate reconstruction after segmental mandibulectomy

T. F. Wu[1,2], J. Y. Liu[2], Y. S. Li[2], B. Liu[1,2]

[1]Department of Oral and Maxillofacial Surgery, School and Hospital of Stomatology, Wuhan University, Wuhan, People's Republic of China; [2]The State Key Laboratory Breeding Base of Basic Science of Stomatology (Hubei-MOST) & Key Laboratory of Oral Biomedicine Ministry of Education, School & Hospital of Stomatology, Wuhan University, Wuhan, People's Republic of China

T. F. Wu, J. Y. Liu, Y. S. Li, B. Liu: Matching locating holes in multiple plates to record bone position for accurate reconstruction after segmental mandibulectomy. Int. J. Oral Maxillofac. Surg. 2019; 48: 1516–1519.

Abstract. Segmental defect areas in the mandible can change immediately following osteotomy due to muscular traction, impacting on accurate reconstruction. The purpose of this article is to introduce a new technique based on virtual surgery planning to record the position of the bony parts prior to mandibulectomy, for use in precise mandibular reconstruction after segmental osteotomy. The position information for the bony parts is transferred to a plate with complementary surface contact and locating holes with specific directions and angles. This technique was performed for six patients with segmental defects and the results were compared to those of six previous patients in whom the technique was not utilized. The design of the location holes shortened the average operation time from 406 minutes to 349 minutes ($P = 0.033$) and decreased the average, maximum, and minimum graft deviation from 1.21 mm to 0.88 mm ($P = 0.015$), 1.28 mm to 0.99 mm ($P = 0.027$), and −1.15 mm to −0.77 mm ($P = 0.077$), respectively. The design of the locating holes in multiple plates shortened the time taken for the bony repositioning step and hence significantly shortened the total operation time. More importantly, it also increased the reconstructive accuracy.

Key words: mandibulectomy; mandible reconstruction; osteotomy; virtual surgery planning; reconstructive efficiency and accuracy; segmental mandibulectomy; bone defect; bony reposition.

Accepted for publication 17 April 2019
Available online 16 May 2019

The mandible is important for facial appearance, mastication, and language. Its bilateral joint, multiple muscles and ligaments contribute to its complexity and its ability to conduct extraordinarily subtle movements. This complexity increases the difficulty of precisely reconstructing bone defects following segmental mandibulectomy, as the spatial relationship of the bony parts after mandibulectomy is instantly displaced due to muscular traction, hence changing the shape of the defect area[1,2].

Conventional treatment methods such as locking occlusion, pre-bending titanium

plates[3], and surgical navigation can have issues of low accuracy, are time-consuming, and can be difficult to master[4,5]. New methods to restore the position of the bony parts have been reported, including virtual surgery planning (VSP), and these can improve accuracy and efficiency[6]. However, there are still some existing problems[1,7,8].

This technical note presents a new VSP-based method to record the position of the bony parts prior to osteotomy. The relative position of the bony parts is transferred to the plate based on complementary surface contact and locating holes with specified directions and angles (Fig. 1A). The surface of the bony parts is closely fitted with a guide plate, and the relative position of each part is recorded by drilling through the plate and the bone (Fig. 1B). Following osteotomy, the positions of the resident parts are rapidly restored according to the surface information with the guide plate and the drill holes are matched between the bone and the guide plate.

The procedure reported above provides a fast and accurate method to reconstruct a bony defect following segmental mandibulectomy. This special pre-surgery design is easily divided into three steps. First, the traditional cutting guide is drawn onto the two edges of the mandibular lesion with sufficient surgical margins[9,10] (Fig. 2A). Second, the main part of the two pieces of the cutting plate and the bony graft are combined into a reconstructive plate that connects the two bony parts (Fig. 2B). Third and most importantly, the locating holes on both the cutting guide and the reconstructive guide are drawn and arranged in the corresponding positions of the mandible, ensuring that at least two locating holes are placed on each bony part (Fig. 2).

As shown in Fig. 2A and Fig. 2B, the locating holes of the cutting guide plate and the reconstructive plate are in the same position (as indicated by the yellow arrow). The locations of the holes can be confirmed during the software design process before the operation.

During the operation, the bony parts can easily be cut and restored in three steps (Supplementary Material, Fig. S1). First, the cutting plate is placed into position and fixed using screws through the locating holes. The osteotomy is then performed with a saw. Second, the reconstructive plate and the titanium plate are placed together on the surface of the bony stumps and fixed with the holes that were

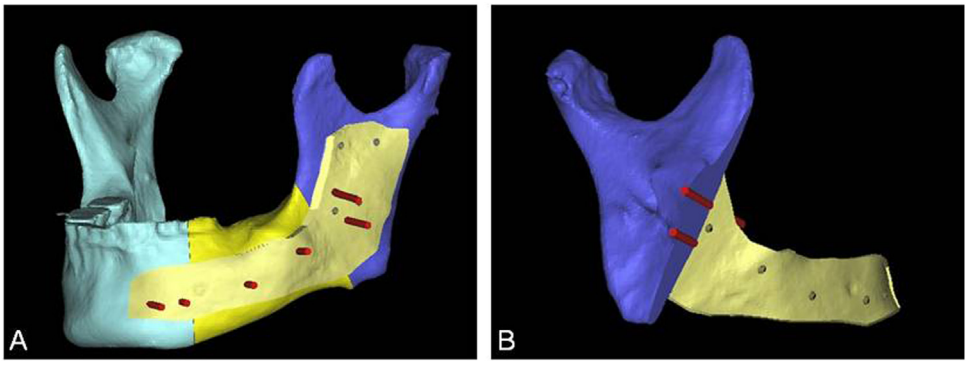

Fig. 1. (A) Schematic diagram showing the positions of the mandible segments, which are restricted to the plate by complementary surface contact and locating holes. Each segment has at least two locating holes, and these are drilled using screws (red). (B) Cross-section showing the relationship of the bony segment, plate, and screw channels. The bone position is recorded using the unique channel direction in the plate and in the bone.

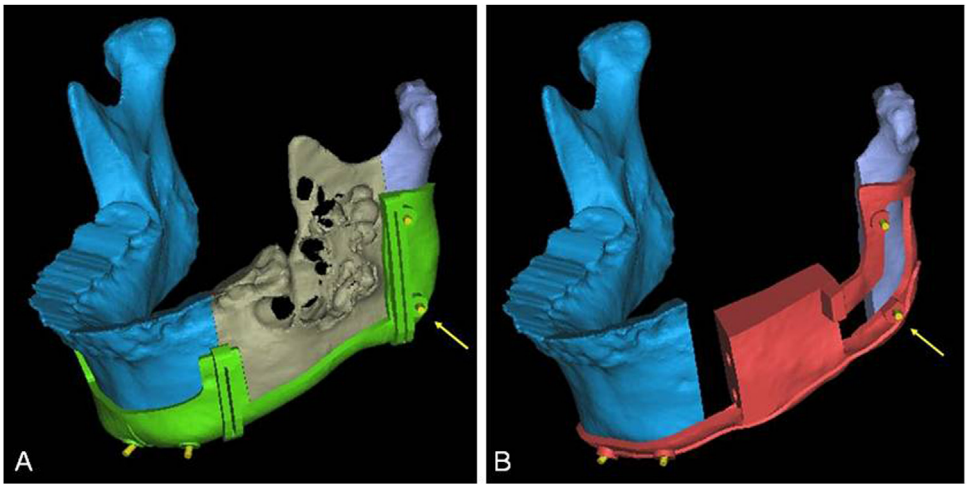

Fig. 2. (A) The integrative cutting guide plate with two locating holes on each side, as indicated by the yellow dots. These holes are also used to fix the plate before the osteotomy. (B) The reconstructive plate has the same locating holes as those in the cutting guide plate. After mandibulectomy, the displaced bony parts can be restored into the correct relative position in one step using the drilled holes left in the bone.

Table 1. Comparisons between the group without locating holes and the group with locating holes.

Groups	Average operation time (min)	3D systematic deviation (mm)		
		Average	Maximum	Minimum
Without locating holes ($n=6$; segmental osteotomy, reconstruction with iliac crest)	406	1.21	1.28	−1.15
Design with locating holes ($n=6$; segmental osteotomy, reconstruction with iliac crest)	349	0.88	0.99	−0.77
Comparison (P-value[a])	0.033*	0.015*	0.027*	0.077

3D, three-dimensional.
[a] The asterisk (*) indicates a P-value of <0.05.

previously drilled during the cutting plate fixation. Using this method the relative position of the bony parts is immediately restored. Third, the titanium plate is fixed and the reconstructive plate removed, and the microvascular anastomosis can be performed and the graft placed into its position.

For patients undergoing this surgery, the deviations were analyzed at the three-dimensional (3D) level using Geomagic Qualify 2013 (3D Systems, Inc., Research Triangle Park, NC, USA). An example is given in the Supplementary Material (Fig. S2), which shows that the deviation of the bony parts on both sides was 0.47 ± 0.7 mm. The total average deviation after defect reconstruction compared with the virtual surgery was 0.67 ± 0.99 mm. The comparison pictures show that the largest deviation was located in the titanium plate area.

This 'pre-plating' technique is comparable in part to the double-plating technique reported by Marchetti et al.[3], but has the advantages of just using the outer cortex of the mandible and not requiring the destruction of the inside muscular attachment. Furthermore, it can also be used in other situations that require vestibular pre-plating, lingual pre-plating, or the Luhr method[3]. Additionally, the use of this design removes the need to restore the bony parts according to the pre-bent titanium plate. Thus, the titanium plate can be inserted following restoration and can also be combined with the reconstructive plate. As a result, the traditional deviation from titanium plate-based shaping, such as displacement, distortion, and deformation, are limited.

In an additional investigation, six segmental mandible defects that were restored with a vascularized iliac bone flap were compared with previous cases in which the method of locating holes was not used. As shown in Table 1, the average operation time in the 'locating holes' group was less than that in the 'no locating holes' group (349 min vs. 406 min, $P=0.033$). Furthermore, the average 3D systematic deviation was significantly decreased from 1.21 mm to 0.88 mm ($P=0.015$); the maximum deviation was decreased from 1.28 mm to 0.99 mm ($P=0.027$); and the minimum deviation was decreased from −1.15 mm to −0.77 mm ($P=0.077$).

In conclusion, we have simplified the complicated process of mandibular reconstruction into a fast three-step method through the utilization of the locating holes design in the integrative cutting and reconstructive plates. This method increased the efficiency and accuracy of jaw reconstruction after mandibulectomy.

Funding

This study was supported by a grant from the Wuhan Morning Light Plan of Youth Science and Technology (No. 2017050304010305) and the National Natural Science Foundation of China (No. 81702705) to Tianfu Wu.

Competing interests

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

Ethical approval

The Ethics Committee of the School and Hospital of Stomatology of Wuhan University approved this study (judgement reference number [2018]/B(16)).

Patient consent

Before surgery, written informed consent was obtained from all patients to publish the clinical photographs.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijom.2019.04.013.

References

1. Deek NF, Wei FC. Computer-assisted surgery for segmental mandibular Reconstruction with the osteoseptocutaneous fibula flap: can we instigate ideological and technological reforms? *Plast Reconstr Surg* 2016;**137**:963–70.
2. Wang YY, Zhang HQ, Fan S, Zhang DM, Huang ZQ, Chen WL, Ye JT, Li JS. Mandibular reconstruction with the vascularized fibula flap: comparison of virtual planning surgery and conventional surgery. *Int J Oral Maxillofac Surg* 2016;**45**:1400–5.
3. Marchetti C, Bianchi A, Mazzoni S, Cipriani R, Campobassi A. Oromandibular reconstruction using a fibula osteocutaneous free flap: four different "preplating" techniques. *Plast Reconstr Surg* 2006;**118**:643–51.
4. Kraeima J, Steenbakkers R, Spijkervet FKL, Roodenburg JLN, Witjes MJH. Secondary surgical management of osteoradionecrosis using three-dimensional isodose curve visualization: a report of three cases. *Int J Oral Maxillofac Surg* 2018;**47**:214–9.
5. Hu L, Yang X, Han J, Wang Y, Wang X, Zhu M, Liu J, Yu M, Zhang C, Xu L. Secondary mandibular reconstruction for paediatric patients with long-term mandibular continuity defects: a retrospective study of six cases. *Int J Oral Maxillofac Surg* 2017;**46**:447–52.

6. Pfaff MJ, Steinbacher DM. Plastic surgery applications using three-dimensional planning and computer-assisted design and manufacturing. *Plast Reconstr Surg* 2016;**137**:603e–16e.
7. Efanov JI, Roy AA, Huang KN, Borsuk DE. Virtual surgical planning: the pearls and pitfalls. *Plast Reconstr Surg Glob Open* 2018;**6**:e1443.
8. Largo RD, Garvey PB. Updates in head and neck reconstruction. *Plast Reconstr Surg* 2018;**141**:271e–85e.
9. Steinbacher DM. Three-dimensional analysis and surgical planning in craniomaxillofacial surgery. *J Oral Maxillofac Surg* 2015;**73**:S40–56.
10. Rodby KA, Turin S, Jacobs RJ, Cruz JF, Hassid VJ, Kolokythas A, Antony AK. Advances in oncologic head and neck reconstruction: systematic review and future considerations of virtual surgical planning and computer aided design/computer aided modeling. *J Plast Reconstr Aesthet Surg* 2014;**67**:1171–85.

Address:
Bing Liu
Department of Oral and Maxillofacial Surgery
School and Hospital of Stomatology
Wuhan University
LuoYu Road #237
Wuhan 430072
People's Republic of China
Tel.: +86 27 87686215.
Fax: +86 27 87873260
E-mail: liubing9909@whu.edu.cn