Mandibular Reconstruction With a Deep Circumflex Iliac Artery Flap Using Computer-Assisted and Intraoral Anastomosis Techniques

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This study aimed to evaluate intraoral anastomosis of a deep circumflex iliac artery (DCIA) flap in combination with computer-assisted techniques for mandibular reconstruction. Between December 2015 and March 2018, 4 patients with mandibular discontinuity defects caused by ablative tumor surgery were included in the study. Mandibular reconstruction was performed with a DCIA flap using computer-assisted and intraoral anastomosis techniques. A computer-aided design–computer-aided manufacturing cutting guide, a reconstruction stereomodel, and a prebent reconstruction plate were used for mandibular reconstruction in each patient. Anastomosis was performed on the facial artery and vein using the deep circumflex iliac vessels through an intraoral approach. The resulting error-grade color map was used to evaluate repeatability between the preoperative design and postoperative results. Mandibular reconstruction with a DCIA flap using computer-assisted and intraoral anastomosis techniques was successful in all 4 patients. All flaps survived with no severe complications. Satisfactory cosmetic outcomes and occlusion with sufficient bone height for implants were achieved postoperatively. Repeatability between the virtual plan and postoperative result was 81.1% ± 8.2% within 1 mm, 85.8% ± 8.1% within 2 mm, and 89.6% ± 6.7% within 3 mm. The use of intraoral anastomosis and computer-assisted techniques with DCIA flaps for mandibular reconstruction without additional facial scarring is feasible and advantageous. However, the findings should be interpreted cautiously owing to the relatively short follow-up time and limited number of patients involved in this study.

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The goal of mandibular reconstruction after segmental mandibulectomy is to achieve good esthetics and functional outcomes for the mandible.[1-3] Therefore, an ideal reconstruction of the mandible remains a surgical challenge. The application of microvascular bony reconstruction with computer-assisted techniques after mandibular segmental resection is a well-established method for achieving good functional and esthetic results.[4-7] In addition, there is an intense focus on scarless facial surgery when performing microvascular reconstruction of the oral and maxillofacial region; Gaggl et al[8] first introduced intraoral anastomosis of free flaps in alveolar ridge reconstructions to avoid extraoral incisions. However, intraoral anastomosis of a deep circumflex iliac artery (DCIA) flap combined with computer-assisted

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Table 1. DEMOGRAPHIC DATA AND CLINICAL CHARACTERISTICS OF PATIENTS

Patient No.	Age, yr	Gender	Diagnosis	Defect	DCIA Segments/ Length, cm	Repeatability, %* Within 1 mm	Within 2 mm	Within 3 mm
1	26	M	Ossifying fibroma	Body	1/5.0	90.2	94.5	96.2
2	32	F	Osteosarcoma	Body	1/7.0	80.3	85.4	89.9
3	28	F	Ameloblastoma	Body	2/6.0	83.4	88.3	92.1
4	12	F	Ossifying fibroma	Body	1/4.5	70.5	75.1	80.3

Abbreviations: DCIA, deep circumflex iliac artery; F, female; M, male.
* Total repeatability was 81.1% ± 8.2% within 1 mm, 85.8% ± 8.1% within 2 mm, and 89.6% ± 6.7% within 3 mm.

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techniques for mandibular reconstruction has not been reported in the literature.

If mandibular reconstruction must be performed, a combination of intraoral anastomosis and computer-assisted techniques with a DCIA flap appears to be a precise and ideal reconstruction technique that does not cause extraoral scarring. This technique is presented.

Materials and Methods

PATIENT CHARACTERISTICS

From December 2015 to March 2018, 4 patients (1 male and 3 female patients) aged 12 to 32 years (median age, 25 years) with mandibular defects due to tumors were included in the study at Peking University School and Hospital of Stomatology in China. These patients met the following inclusion criteria: all had a mandibular body defect (type B) after mandibulectomy; the length of the mandibular defect was no more than 8 cm; the location of the facial artery and vein near the mandibular border could be confirmed using a Doppler flowmeter; and mandibular reconstruction using a DCIA flap was possible. Of the patients, 3 had benign tumors of the mandible whereas 1 had a low-grade osteosarcoma of the mandible. All patients had undergone a segmental mandibulectomy. The mandibular defects were type B in all patients according to the classification of mandibular defects of Urken et al.[9] The characteristics of the 4 patients are shown in Table 1. This study was approved by the Ethical Committee of Peking University School and Hospital of Stomatology. Written informed consent for the clinical data and images was obtained from all patients before participation.

PREOPERATIVE DESIGN

The preoperative computed tomography (CT) images (1.0-mm slice thickness) were imported into ProPlan CMF1.4 (Materialise, Leuven, Belgium). Mandibulectomy and reconstruction were performed in accordance with clinical and 3-dimensional radiographic findings (Fig 1). The resection margins were at least 0.5 cm beyond the radiographic tumor margin for the benign tumors and 1.0 cm for the malignant tumor. The unaffected side of the mandible was mirrored across the midplane to simulate the defect caused by the mandibulectomy. An individual model was made via a rapid prototyping technique, and a 2.0-mm mandibular reconstruction plate (AO CMF locking plate system; Synthes, Solothurn, Switzerland) was prebent to fit the contour of the mandibular model (Fig 2). The reconstructed segment was then separated from the model (Fig 3).

SURGICAL PROCEDURE

A segmental mandibular resection was performed with the guidance of a cutting segment (Fig 4). After mandibulectomy, occlusion was fixed by an arch bar, and the ipsilateral submandibular gland was removed. The reconstruction segment was then precisely placed with the reconstruction plate in the defect site (Fig 5). Afterward, we removed the reconstruction

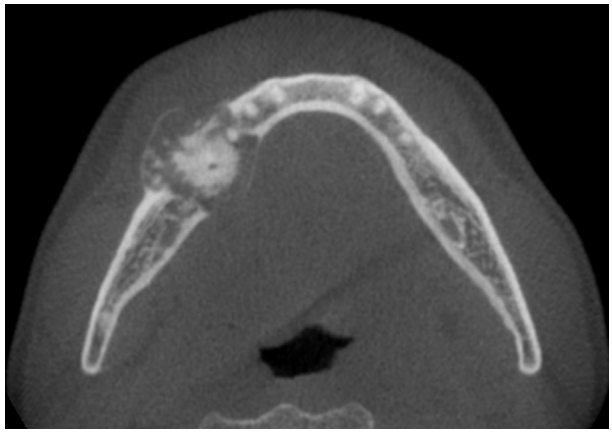

FIGURE 1. Mandibular lesion on preoperative computed tomography.

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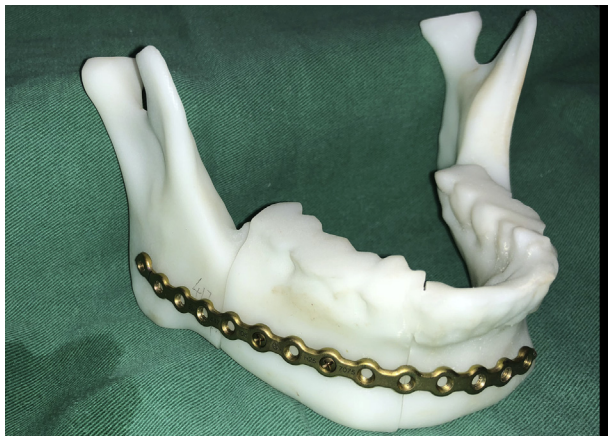

FIGURE 2. Individual model made through rapid prototyping technique and prebent reconstruction plate.

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FIGURE 4. Cutting guide of rapid prototype model.

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segment and used transbuccal instruments to fix the reconstruction plate in a bicortical manner to the residual mandible.

Two goiter retractors and one tongue retractor were used to maximize space during the preparation and intraoral anastomosis of the recipient vessels (Fig 6). We identified and preserved the marginal mandibular branch of the facial nerve, which ran laterally to the vessels. The facial vessels were prepared at a length of more than 4 cm to ensure that subsequent transposition to the angle of the mouth was possible.

The harvested DCIA flap was shaped according to the dimensions of the reconstruction model and fixed to the remaining mandibular bone. The reconstruction plate was temporarily removed to provide room for the intraoral anastomosis procedure. Anastomosis was performed on the facial artery and vein using deep circumflex iliac vessels through an intraoral approach. Excellent inflow and outflow were confirmed. The grafted bone was then once again fixed to the same position using the same reconstruction plate and transbuccal instruments (Fig 6).

A postoperative CT scan was performed in all patients, and the CT data were imported into Geomagic Studio 2012 (3D Systems, Valencia, CA) and matched with the preoperative CT data. Applying the "3D comparison" in the software, the deviations between the postoperative CT data and the preoperative design were illustrated in a deviation spectrum. The resulting error-grade color map was used to provide a direct impression of the registration of the preoperative design and postoperative results.

FIGURE 3. Rapid prototype reconstruction model and fixed reconstruction plate.

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FIGURE 5. The reconstruction segment was precisely placed with the reconstruction plate in the defect site.

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FIGURE 6. The iliac-crest flap was transferred to the recipient site after the reconstruction model was removed.

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Results

All 4 patients underwent the aforementioned procedure successfully. It took 30 to 60 minutes to prepare the facial vessels through the intraoral approach. All DCIA flaps were harvested successfully. The pedicles were 4.5 to 6.0 cm in length. The length and height of the iliac crest were 4.5 to 7.0 cm and 2.5 to 3.0 cm, respectively (Table 1). Anastomoses were accomplished successfully, and all DCIA flaps survived in the 4 patients. All patients had unrestricted positions. The recipient sites healed well with no complications. Moreover, no severe donor-site complications, including bone fracture, hernia, and gait disturbances, were observed during follow-up. All 4 patients exhibited satisfactory facial symmetry (Figs 7, 8) and mandibular configurations with good occlusion (Figs 9-11).

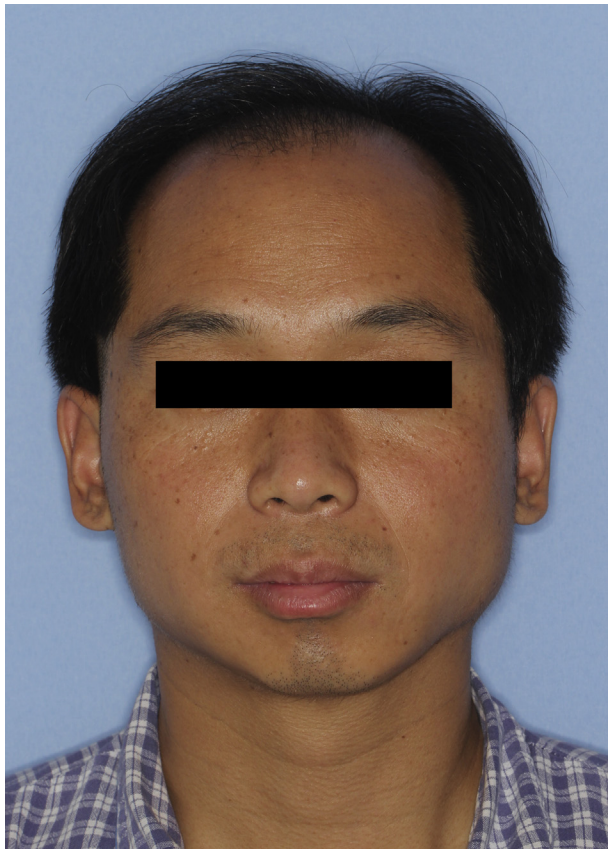

FIGURE 7. Preoperative facial profile.

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FIGURE 8. Postoperative facial profile.

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All the cases showed good repeatability between the postoperative CT data and the preoperative design. The repeatability between the preoperative and postoperative models was 81.1% ± 8.2% within 1 mm, 85.8% ± 8.1% within 2 mm, and 89.6% ± 6.7% within 3 mm (Fig 12).

Discussion

Mandibulectomy is a conventional modality for managing mandibular tumors. However, jaw defects due to the surgical procedure have been associated with

FIGURE 9. Postoperative panoramic radiograph showing good mandibular configurations. L, left.

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destructive functional and esthetic consequences. Microvascular free bone transfer has proved to be a very reliable solution for mandibular reconstruction and provides better functional outcomes.[10-12] However, in addition to the functional outcomes, more attention should be paid to the esthetic results. The advantages of intraoral anastomosis include avoiding incisions made on the skin of the neck and identifying and preserving the facial nerve branches. Gaggl et al[8] first described this technique for the reconstruction of alveolar defects of the maxilla and mandible in 2009. Nkenke et al[13,14] subsequently reported 2 cases of intraoral anastomosis through the application of fibula flaps for mandibular reconstruction. In addition, high esthetic demands and low levels of donor-site morbidity were 2 key points in the decision-making process of mandibular reconstruction. The DCIA flaps were a satisfactory choice because of the large amount of available bone and acceptable donor-site morbidity.[15,16] Furthermore, the iliac-crest flap has recently emerged as an excellent choice for mandibular reconstruction owing to its appropriate shape and height.[2,17-20] In this study, the DCIA flaps were used to reconstruct the mandible, which resulted in hidden donor-site incisions and less donor-site morbidity.

FIGURE 10. Preoperative occlusion.

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FIGURE 11. Postoperative occlusion.

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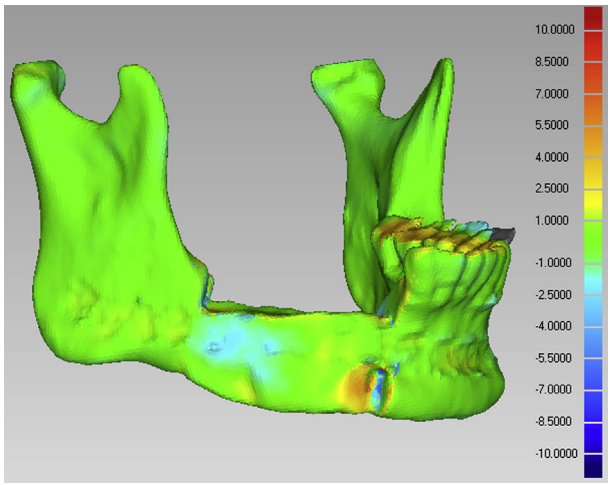

FIGURE 12. Deviation between preoperative visual plan and postoperative result on color spectrum.

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The bridging reconstruction plate was applied to fix the iliac crest to the residual mandible correctly.[4] However, for mandibular reconstruction, it is often challenging to place the plate in the correct place without any anatomic orientation. Because the remaining proximal segments of the mandible are unstable, it is quite difficult to ensure the exact 3-dimensional configuration of the mandibular defect, especially given the condition that all operative procedures are in the oral cavity. Computer-assisted techniques can provide faster and more precise treatment planning and reconstruction.[5,6] In this study, a computer-aided design–computer-aided manufacturing cutting guide and reconstruction stereomodel were used for the reconstruction of the mandible. The reconstruction stereomodel, with an affixed reconstruction plate, was used to control the mobility of the residual mandible, making it more straightforward for surgeons to achieve a suitable position for the mandible. Although these techniques and flaps already have a place in mandibular reconstruction, the intraoral anastomosis technique has advantages for mandibular reconstruction using a DCIA flap.

This study illustrates that use of intraoral anastomosis and computer-assisted techniques with DCIA flaps for mandibular reconstruction without additional facial scarring is feasible and advantageous. However, these findings should be interpreted cautiously owing to the relatively short follow-up time and limited number of patients involved in this study.

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