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Temporomandibular joint reconstruction with medial femoral condyle osseocartilaginous flap: a case series

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Abstract. Reconstruction for large-scale temporomandibular joint (TMJ) defects can be challenging. We have used the medial femoral condyle (MFC) osseocartilaginous flap for repair of TMJ defects. The aim of this paper was to describe our technique and to present the preliminary results. The MFC osseocartilaginous flap was used as a free vascularized graft for TMJ defect in four patients who had undergone resection for benign tumor of the TMJ region ($n = 2$) or TMJ ankylosis ($n = 2$). A computer-assisted technique was used in all cases. Symmetry of the mandible was objectively evaluated by postoperative computed tomography. Complications were recorded during follow-up visits. Lower extremity functional status was assessed by the Lower Extremity Functional Scale (LEFC) questionnaire. The MFC osseocartilaginous flap success rate was 100%; bony union was obtained in all four patients, and normal occlusion was achieved within 6–11 months after surgery. No flap-related complications occurred. All patients were satisfied with their postoperative facial symmetry and oral function. The LEFC score ranged from 72 to 80, indicating normal lower extremity function. Vascularized MFC osseocartilaginous flap appears to be a reliable option for reconstruction of large-scale TMJ defects.

Key words: temporomandibular joint; temporomandibular ankylosis; mandibular reconstruction; microsurgical free flaps; femur.

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The temporomandibular joint (TMJ) plays an important role in mastication, speech and facial aesthetics, hence accurate reconstruction for large-scale defects of the TMJ is essential[1]. Traditional surgical approaches include non-vascularized autogenous reconstruction, vascularized autogenous reconstruction, and alloplastic reconstruction. Each method has limitations; for example, bone grafting is often associated with severe resorption and vascularized bone flap surgery with a number

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of donor-site morbidities, while alloplastic prosthesis is either not available or not affordable in many countries. Hence, it is important to identify alternative methods.

The medial femoral condyle (MFC) flap, which incorporates cortical bone, cancellous bone, periosteum, muscle, tendon, cartilage, and skin, is well suited for complex reconstructions[2]. In addition, donor-site morbidity is reported to be acceptable, with a good level of postoperative function[3,4]. However, the vascularized MFC flap, carrying with it articular cartilage tissue, has not been previously used for reconstruction for large-scale TMJ defects. We have recently developed a technique for condyle reconstruction using the MFC osseocartilaginous flap and have used it to treat four patients at our hospital. The aim of this paper was to describe the technique and present the preliminary results.

Materials and methods

Between 2019 and 2020, we used the MFC osseocartilaginous flap to perform TMJ reconstruction for four patients. The patients (three females, one male) were in the age range of 40–59 years (mean, 49.8 years). The primary diagnoses included condylar osteochondroma ($n = 1$), condylar osteoma ($n = 1$), and type IV TMJ ankylosis ($n = 2$)[5]. The patients were followed up for periods ranging from 6 to 11 months (mean, 8.5 months). Table 1 lists the demographic and clinical characteristics of the four patients. Written informed consent was obtained from patients before their surgeries.

Virtual surgical planning

All patients underwent spiral computed tomographic (CT) scanning of the maxillofacial and knee joint regions (field of view, 20 cm; pitch, 1.0; slice, 0.75 mm; 120Y280 mA). The scan data were imported into ProPlan CMF software (Materalise, Leuven, Belgium), to produce a direct three-dimensional (3D) model. The resection margin was determined according to the clinical and 3D radiographic findings, and the condylectomy was simulated using software.

An MFC osseocartilaginous flap was planned based on the defect shape and size, and arranged to reconstruct the TMJ region on the 3D radiographic image. To shape the bony flap to resemble the native condyle as much as possible, 3D patient-specific surgical templates were designed, based on mirror images of the unaffected side, and then fabricated using computer-assisted design and manufacturing techniques (Figs 1 and 2).

Surgical procedure

A preauricular incision was used to expose the TMJ region, and osteoarthrectomy or condylectomy was performed from the top of the glenoid fossa to the residual mandibular ramus. Resection of the coronoid process was performed, if needed, to ensure that >40 mm of passive maximal mouth opening (MMO) was achieved. After condylectomy, the main surgical team (the authors) focused on the ipsilateral neck to identify and prepare adequate recipient vessels for microvascular anastomosis. Meanwhile, a second team harvested the ipsilateral osteochondral MFC flap, along with a pedicle containing the descending genicular artery. Because the transverse branch of the artery courses anteriorly towards the medial condyle and is invested intimately with the maximum range of the cartilage, it was preserved such that this convex cartilaginous surface could be harvested as a free vascularized flap. A pre-made surgical guide was used when necessary to confirm the shape of the flap before the osteotomies were performed on the femoral condyle (Fig. 3).

The flap was transferred to the head, where the pre-made guide was used to adjust the position of the flap in relation to the glenoid fossa and to adapt it to the native mandible before it was fixed in place with two miniplates. The temporal muscle myofascial flap was used to obliterate the soft tissue defect and also to separate the bony flap from the skull base. Microvascular anastomosis was completed under the operating microscope, and the wound was closed after placement of a suction drain (Fig. 4).

All the surgeries were performed by the same team, comprising experienced senior surgeons in the fields of reconstructive surgery.

Postoperative management

Patients were required to perform mouth opening exercises regularly over 3 months, starting at 1 week after the surgery. Facial symmetry was self-evaluated and scored by the patient on a scale of 0 to 10; the results were classified as good (8–10), fair (4–7), or poor (0–3).

Lower extremity functional status was assessed by postoperative knee radiographs and a validated condition-specific measure – the Lower Extremity Functional Scale (LEFC) questionnaire[6]. The items

Table 1. Demographic and clinical characteristics of the four patients, and the postoperative outcomes.

Patient	Sex	Age (years)	Affected side	Primary diagnosis	Size of defect (mm)	Size of bone Flap (mm)	MMO (mm)	Self-evaluation of appearance (0–10)	LEFC score at T1 (0–80)	LEFC score at T2 (0–80)	Follow-up (months)
1	F	46	Left	Condylar osteochondroma	40.7 × 22.5	50.3 × 32.1	30	9	15	80	11
2	M	40	Left	Condylar osteoma	34.6 × 16.8	51.5 × 31.9	36	7	13	72	9
3	F	54	Left	TMJ ankylosis	35.1 × 21.9	46.3 × 39.5	24	9	12	80	8
4	F	59	Right	TMJ ankylosis	33.6 × 22.8	45.5 × 36.9	36	8	17	73	6

F, female; LEFC, Lower Extremity Functional Scale; M, male; MMO, maximal mouth opening; TMJ, temporomandibular joint; T1, 1 week after surgery; T2, follow-up time.

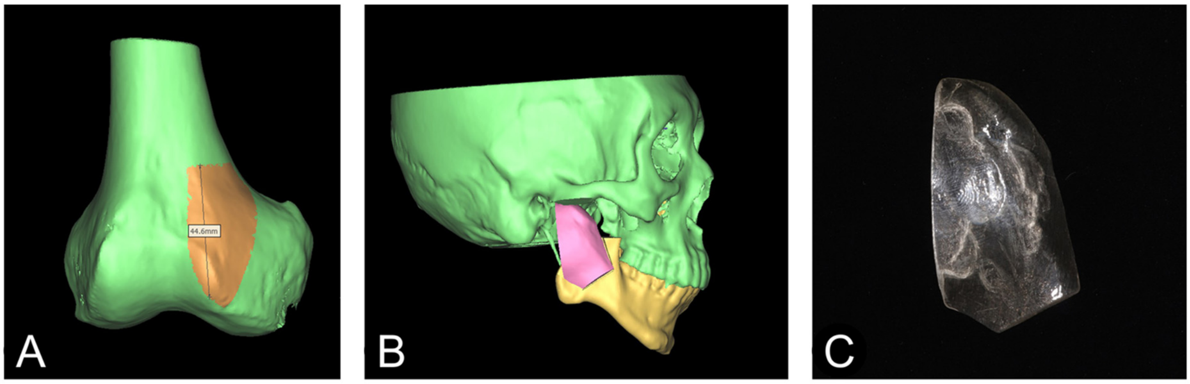

Fig. 1. Virtual surgical planning. (A) Simulation of the bony flap on the three-dimensional radiographic image of the femur. (B) Arrangement of the bony flap to reconstruct the defect, using mirror images of the unaffected side for guidance. (C) Fabrication of individualized surgical templates of the bony flap.

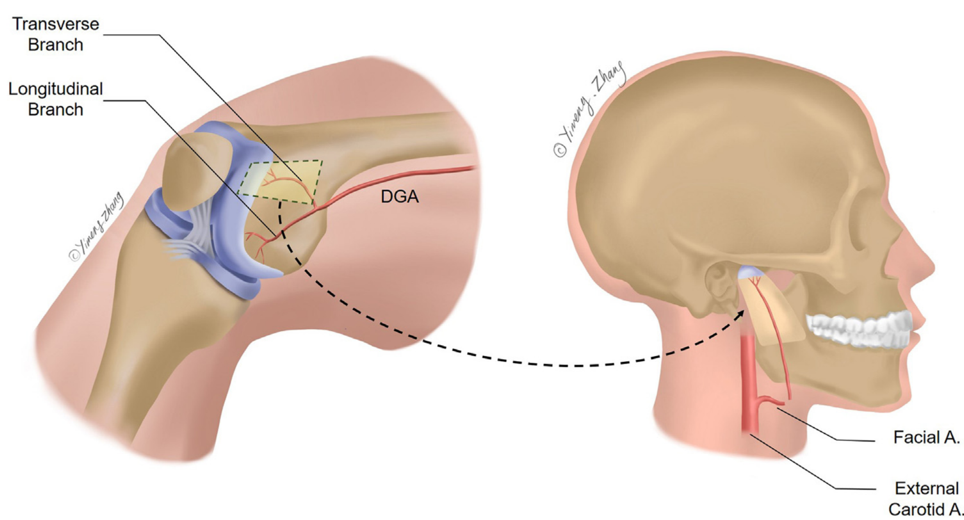

Fig. 2. Transfer of the planned medial femoral condyle osseocartilaginous flap to the temperomandibular joint region. DGA, descending genicular artery.

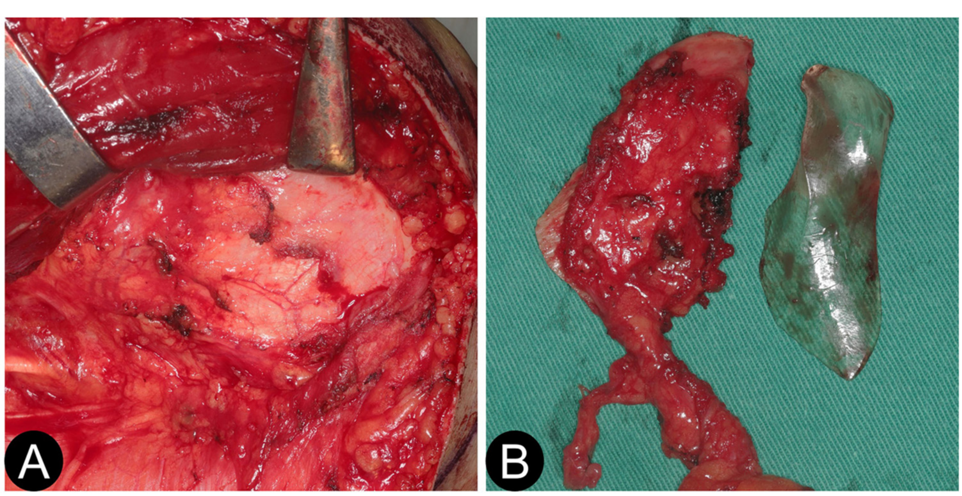

Fig. 3. Harvesting of the medial femoral condyle osseocartilaginous flap. (A) Exposure of the medial femoral condyle with its articular cartilage surface. (B) Shaping of the bony flap according to the surgical template.

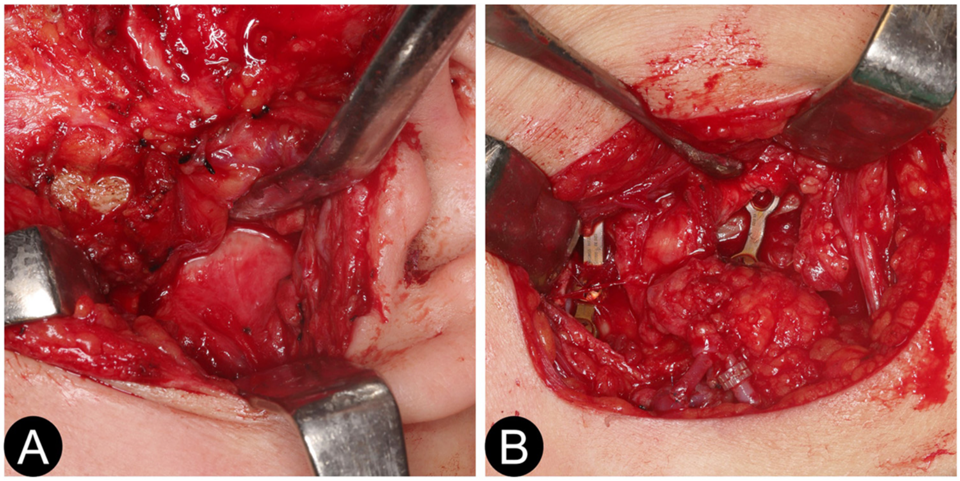

Fig. 4. The medial femoral condyle osseocartilaginous flap is transplanted to the defect. (A) The bony flap is positioned at the buccal side of the mandibular ramus, with the articular cartilage surface located in the glenoid fossa. (B) Bony suture with two miniplates, and microvascular anastomosis to the appropriate vessels in the recipient area.

in the questionnaire investigate the degree of difficulty in performing different physical activities. The LEFC score can range from 0 (maximal disability) to 80 (no disability).

Results

Postoperative hospital stay was 8–10 days. There were no intraoperative or postoperative complications such as infection, haemorrhage, or facial nerve injury. MMO at the last follow-up ranged from 24 to 36 mm (mean, 31.5 mm). All patients had slight deviation of the mandible to the affected side during mouth opening. The facial symmetry achieved was self-evaluated as 'good' by three patients and as 'fair' by one patient.

Postoperative CT scans and 3D reconstructed images showed excellent anatomic restoration with the bony flaps. The flap success rate was 100% (4/4) for patency and achieving osseous union. There were no flap-related complications such as postoperative haematoma, vascular thrombosis, or flap necrosis. All patients achieved normal load-bearing occlusion within 6–11 months after surgery.

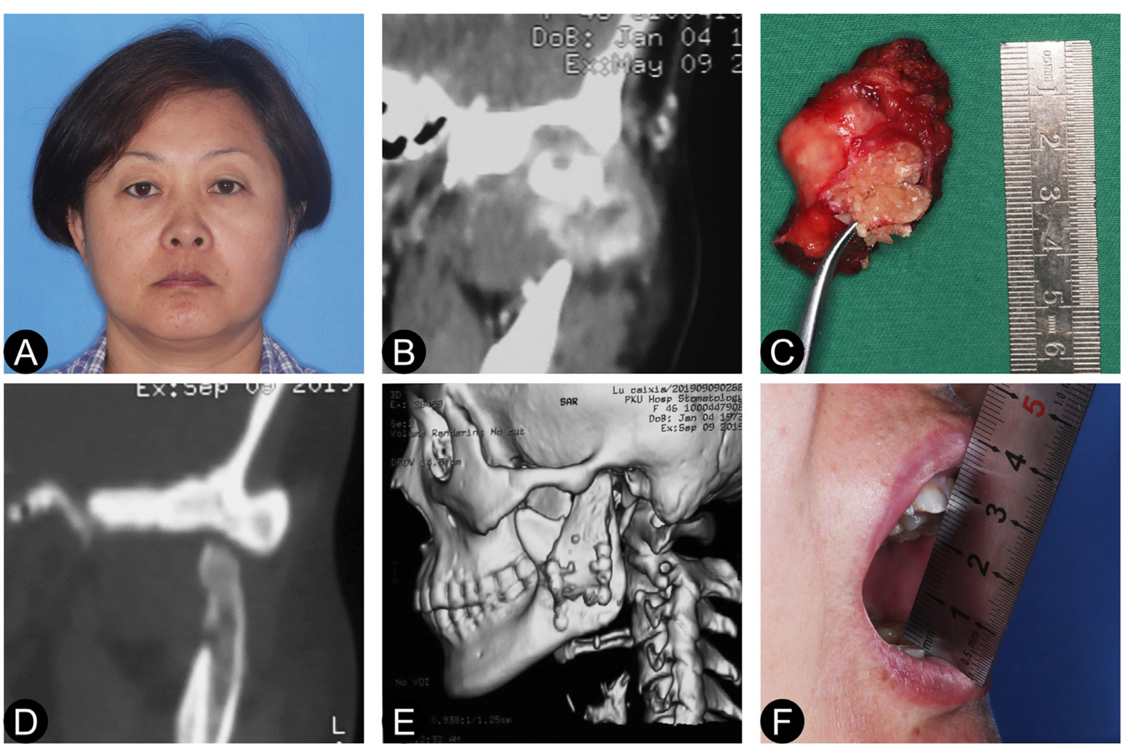

Fig. 5. A representative patient. (A) A 46-year-old woman was referred to us with complaint of swelling and discomfort in the left preauricular area. (B) The condyle was severely damaged by a tumor. (C) A condylectomy of >4 cm was performed. (D) At follow-up 9 months after surgery, the mandibular contour is intact. (E) There is a well-integrated bone graft without significant resorption. (F) Mouth opening is also satisfactory.

While all four patients experienced pain and numbness of skin on the anteromedial aspect of the knee region after surgery, the symptoms resolved without treatment within 3 months. LEFS score at the last follow-up ranged from 72 to 80 (mean, 76.3); two of the four patients scored 80, indicating normal level of function.

Fig. 5 presents a representative case.

Discussion

Traditional methods for reconstruction of large-scale TMJ defects include non-vascularized autogenous reconstruction, vascularized autogenous reconstruction and alloplastic reconstruction. Each method has disadvantages.

Alloplastic prosthesis, especially the custom-made total TMJ prosthesis, is a safe and predictable way to restore acquired TMJ defects[7,8]; unfortunately, in several regions of the world such prosthesis is either not available or not affordable.

The greatest drawback of non-vascularized autogenous bone graft in TMJ reconstruction is the severe degree of bone resorption, especially in cases where a large bone defect has been reconstructed. Huang et al.[9] found a high frequency of bone resorption with both the free coronoid process graft and the costochondral graft in adult patients undergoing condylar reconstruction. Although costochondral graft is considered suitable for children because of its intrinsic potential for growth, it is limited by the unpredictability of the growth pattern; resorption, failure to grow, and overgrowth have all been reported[10].

In addition, our previous research[11] found that the heights of condyles reconstructed by transport distraction osteogenesis of the mandibular ramus were not stable in the long term, and the mean resorption rate was as high as 59.4%. Chen et al.[12] tackled the problem of shortage of blood supply using the superior half of the sternoclavicular joint, pedicled with the clavicular head of the sternocleidomastoid muscle and sternocleidomastoid branch of the superior thyroid artery; however, this approach was associated with high risk of donor-site morbidity, and the remaining clavicle had to be fixed with a thick titanium plate to avoid fracture.

These problems can be overcome with the use of vascularized bone flaps, which have lower bone resorption rates and superior bony quality[13]. The free fibula flap – a workhorse flap for mandibular reconstruction – is the first choice when bony length is required, as in reconstruction of subtotal or total mandibulectomy[14]. However, the fibula flap is more suitable for the reconstruction of a total mandibular defect and for defects that cross the midline, than for large-scale TMJ defects. It is very difficult to confirm whether the top of the transferred fibula is inserted precisely into the glenoid fossa when fossa exposure is inadequate. With the conventional free fibula flap there is no real cartilage-covered condyle. If the fibula head (with a branch of the anterior tibial artery) and the syndesmosis is taken for condyle reconstruction, a different situation results. The problems then include possible peroneal nerve damage and donor site morbidities such as ankle instability/stiffness, motor weakness or clawing of the great toe, and tendon exposure secondary to skin graft loss[15].

The MFC flap has many advantages. It has been used for reconstruction at various head and neck sites, from the orbit, maxilla, and mandible, to the laryngeal and tracheal scaffolds[16–18]. Lee et al.[19] have used the MFC bone flap for treatment of malunion after subcondylar fracture. In addition, Zeman-Kuhnert et al.[4] reported minimal donor site morbidity after harvesting MFC for maxillofacial indications; no patient in their study developed knee joint instability or limitation of range of motion.

The importance of subchondral blood supply for the nutrition of the chondrocytes in articulating cartilage is well known. Higgins et al.[20] showed that articular reconstruction performed using vascularized osteochondral flaps yields superior cartilage organization and architecture than reconstruction performed using non-vascularized osteochondral grafts. In addition, Benlidayi et al.[21] showed in an experimental study that the bone resorption rate is greater in non-vascularized femur grafts than in vascularized osteoperiosteal femur flaps.

The usefulness of the vascularized MFC, harvested with the convex cartilaginous surface, was first demonstrated in 2008 in a patient requiring scaphoid reconstruction[22]. Subsequent studies have described the use of the MFC carrying cartilaginous tissue for carpal reconstruction[23], advanced Kienbock disease[24], and scaphoid and lunate reconstruction[25]. Cadaver studies[26,27] have shown that the descending genicular artery could provide good and reliable periosteal perfusion, suggesting that corticocancellous MFC might provide the benefits of vascularized bone for large intercalary nonunion defects that have conventionally been treated with fibula flaps.

Surgical repair of large TMJ defects is difficult mainly because of the complex tissue reconstructions required, including that of the condyle, ramus, and soft tissue. All of our patients had undergone large resections for tumor or extensive bony ankylosis. Free bone grafts will not be enough to repair such defects. Our technique of using the MFC osseocartilaginous flap for reconstruction of large-scale TMJ defects offers the following advantages: (1) the MFC flap contains sufficient cortical and cancellous bone to pack such a bony defect; (2) the articular cartilage tissue in the flap resembles the TMJ cartilage anatomically; and (3) preservation of the transverse branch of descending genicular artery prevents postoperative bone resorption of the grafts and ensures the success of functional rehabilitation.

In 2018, Enzinger et al.[28] performed mandibular condyle reconstruction using an osteochondral lateral femoral condyle flap, which is harvested from almost the same region as the flap we used. Our method had some notable advantages: (1) we combined preauricular and submandibular approaches to ensure better exposure, more extended resection, and more choices for internal fixation; (2) we chose the facial arterial as the recipient vessel to make microvascular anastomosis, and thus there is no need to fold the DGA for anastomosis with the temporal superficial artery; and (3) we aim to obtain a triangle-shaped bony flap, with the narrow side as condyle and the wider side as mandibular body, which allows reconstruction of relatively large defects.

To our knowledge, this is the first report of the use of the MFC flap, carrying articular cartilage, for TMJ reconstruction. The preliminary results suggest satisfactory restoration of mandibular height and facial symmetry, and good recovery of function (mastication, articulation, speech). However, the technique has limitations. The transplanted bone flap will inevitably thicken the affected side of the face, as was observed in one of our patients. Ideally, we should have investigated the histological transformation of osseocartilaginous flap; however, this was not done because of ethical considerations.

Vascularized MFC osseocartilaginous flap appears to be a reliable option for reconstruction of large-scale TMJ defects. Large prospective studies with long follow-up are needed to determine long-term outcomes and the risk of late lower extremity functional problems.

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Competing interests

None.

Ethical approval

This study was approved by the ethics committee of Peking University School and Hospital of Stomatology (No. PKUSSIRB-201949133).

Patient consent

All patients or their legal guardians have signed informed consents for publication of clinical photographs.

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