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Case report

Free composite medial femoral trochlea osteochondral cutaneous flap for wrist scaphoid and lunate cartilage lesions: Advantages of a skin paddle

Lambeau libre composite ostéo-chondro-cutané de trochlée fémorale médiale dans les lésions cartilagineuses du scaphoïde et du lunatum: avantages d'une palette cutanée

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ABSTRACT

The medial femoral trochlea flap is a chondrocorticoperiosteal flap. It has recently been described in the context of cartilage lesions. It is mainly used for reconstruction in non-union of the scaphoid's proximal pole and Kienböck disease. The medial femoral trochlea flap may be harvested with a skin island flap to monitor its vascularization. The surgical technique has been extensively described for its primary osteochondral form. However, the corticoperiosteal form has not been thoroughly studied and described. Here, we describe and report the early results of three cases of the composite medial femoral trochlea flap, with a skin paddle for postoperative monitoring, being used to reconstruct the injured proximal scaphoid and lunate.

RÉSUMÉ

Le lambeau du versant médial de la trochlée fémorale est un lambeau chondro-cortico-périosté. Il s'agit d'une nouvelle technique décrite pour la reconstruction des lésions cartilagineuses au poignet. Il est principalement utilisé pour la reconstruction des pseudarthroses du pôle proximal du scaphoïde et dans la maladie de Kienböck. Ce lambeau chondro-cortico-périosté peut être prélevé avec une palette cutanée permettant sa surveillance vasculaire. La technique chirurgicale de ce lambeau dans sa forme initiale, ostéochondrale, a été étudiée et décrite de manière approfondie. En revanche, il existe très peu de description de la technique chirurgicale de prélèvement de ce lambeau dans sa forme chondro-cortico-cutanée. Nous décrivons et rapportons les résultats préliminaires de trois cas de lambeau composite cartilagineux du versant médial de la trochlée fémorale, avec une palette cutanée pour la surveillance postopératoire, afin de reconstruire le pôle proximal du scaphoïde et la partie proximale du lunatum.

1. Introduction

The free medial femoral condyle (MFC) flap is a corticoperiosteal flap, vascularized by the descending genicular artery (DGA), initially described in the late 1980s [1,2]. Thereafter, the MFC flap was improved and used for various bone reconstructions, mostly scaphoid non-union, with good results [3]. Derived from the MFC flap, a cartilage–bone graft with the same vascularization (by the DGA) was described in 2008 [4–6]: the free medial femoral trochlea (MFT) flap.

The MFT flap is a composite chondrocorticoperiosteal flap. It was developed for the reconstruction of cartilage lesions and can be used

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Table 1
Summary of preoperative, intraoperative and postoperative data from our series of 3 cases of MFT skin paddle.

	Case 1	Case 2	Case 3
Age (years)	31	19	25
Disease (classifications)	Scaphoid nonunion (Schoenberg 3, Alnot 4)	Kienböck (Lichtman 3A)	Scaphoid nonunion (Schernberg 1, Alnot 2A)
Smoker	No	Yes	Yes
Dominant hand	Yes	Yes	No
Preoperative			
Arc F–E (%/Clt)	60°–65° (84%/Clt)	50°–50° (74%/Clt)	75°–70° (97%/Clt)
Arc RD–UD (%/Clt)	15°–50° (84%/Clt)	25°–35° (85%/Clt)	20°–40° (100%/Clt)
Pronation-supination	90°–90° (100%/Clt)	60°–90° (83%/Clt)	90°–90° (100%/Clt)
Grip strength (%/Clt)	25 kg (39%/Clt)	26 kg (52%/Clt)	40 kg (80%/Clt)
Pain on VAS	6	7	1
Last follow-up	15 months	9 months	13 months
Arc F–E (%/Clt)	50°–50° (68%/Clt)	60°–35° (70%/Clt)	50°–50° (68%/Clt)
Arc RD–UD (%/Clt)	10°–44° (70%/Clt)	20°–30° (71%/Clt)	30°–10° (67%/Clt)
Pronation-supination	90°–90° (100%/Clt)	90°–90° (100%/Clt)	90°–90° (100%/Clt)
Grip strength (%/Clt)	35 kg (55%/Clt)	40 kg (74%/Clt)	38 kg (86%/Clt)
Pain on VAS	1	0	0
Skin paddle			
Size	2 × 2 cm	5 × 3 cm	6 × 3 cm
Vascularization	DGA-CB	SAB	DGA-CB and SAB
MFT flap			
Size (length × wide × height)	3 cm × 1 cm × 8 mm	1.5 cm × 1.5 cm × 8 mm	3 cm × 1 cm × 8 mm
Vascularization	longitudinal and transverse periosteal branches	transverse periosteal branches	longitudinal and transverse periosteal branches
Anastomoses			
Arterial	End-to-side on radial artery	T-shaped anastomosis on radial artery	End-to-end on radiopalmar artery
Venous	End-to-end on superficial vein	End-to-end on superficial vein	End-to-end on superficial vein
Relevant surgical details	Preservation of dorsal portion of scapholunate ligament	Preservation of dorsal scapholunate and lunotriquetral ligaments	Detachment and reinsertion of radial part of scapholunate ligament
Bone fixation	1 compression screw 2 K-wires (1 trans-scapholunate and 1 trans-scaphocapitate)	3 K-wires (1 trans-scapholunate and 2 trans-triquetrolunate)	1 compression screw 2 K-wires (1 trans-scapholunate and 1 trans-scaphocapitate)
Skin paddle monitoring	After 15 hrs, venous thrombosis was found and repaired. Skin paddle was removed (damage and obvious ecchymosis).	No problems	After 16 hrs, arterial thrombosis was found and repaired (caliber disparity). Skin paddle was preserved.
Union time	12 weeks	10 weeks	8 weeks
Time to restart walking	1.5 months	3 months	2 months
Knee range of motion (%/Clt)	0°–150° (94%)	0°–165° (100%)	0°–155° (97%)

Schernberg: Schernberg classification [15]; Alnot: Alnot classification [16]; Lichtman: Lichtman classification [17]; Preop: pre-operative; Postop: post-operative; VAS: visual analog scale; Clt: contralateral; F: flexion; E: extension; RD: radial deviation; UD: ulnar deviation; Grip: hand grip; *kg*: kilogram; cm: centimeter; mm: millimeter.

for various articular defects [7]. The most common application is the reconstruction of non-union of the scaphoid's proximal pole [4–11] and advanced avascular necrosis of the lunate in Kienböck disease [5–7,9,10,12]. MFC and MFT flaps may be associated with a skin island flap to monitor its vascularization. This surgical technique has been thoroughly studied and described [3,11,13]. However, only 10 studies (totalling 50 patients) briefly reported the postoperative outcome of the skin paddle in MFC flap cases and only one on 2 patients [14] for the MFT flap. The few studies examining the MFC flap assessed the success of the flap for bone union without considering good flap vascularization. Only one study has related the immediate postoperative condition and utility of the skin paddle.

We report three cases of the MFT flap being used with a skin paddle to replace an injured proximal scaphoid and lunate pole.

2. Cases reports

Between May 2017 and August 2017, three males were treated with a free osteochondral cutaneous graft harvested from the MFT (Table 1) [15–17]. None of the patients had undergone previous surgery. Avascularity of the proximal pole of the scaphoid was present in both cases of scaphoid non-union (Fig. 1).

In all three cases, the flap was designed and removed according to the technique described by Iorio et al. and Bürger et al. [8,13]

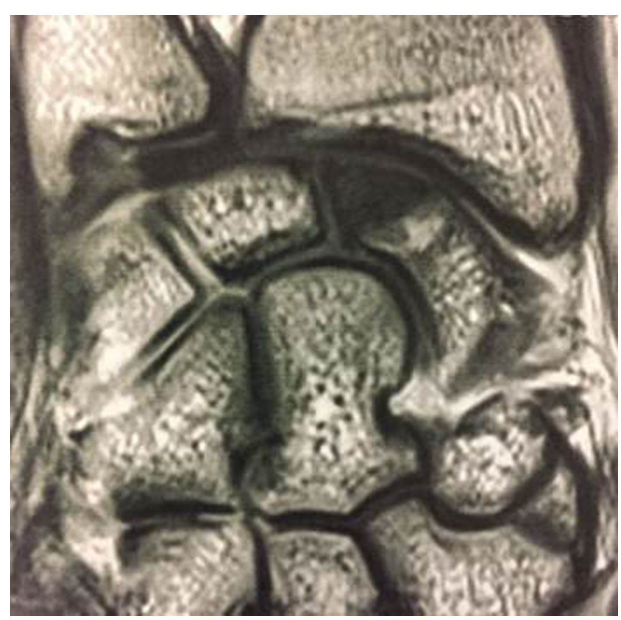

Fig. 1. Wrist scaphoid nonunion in a 25-year-old man with avascular necrosis of the proximal pole (case 3) shown on MRI.

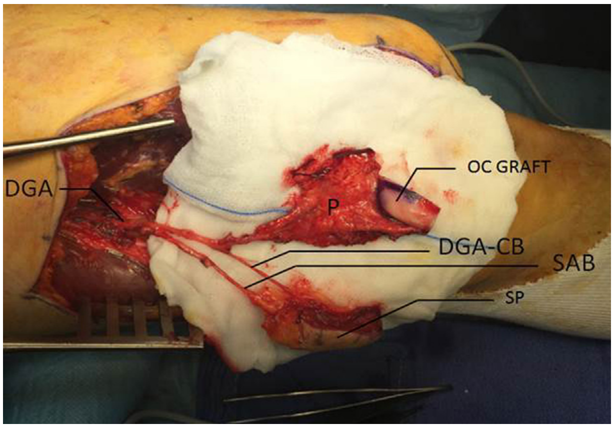

Fig. 2. Composite osteo-chondro-cutaneous graft with bipedicled skin paddle vascularization (case 3). DGA: descending geniculate artery; P: periosteum; OC GRAFT: osteochondral graft; DGA-CB: cutaneous branch from the DGA; SAB: saphenous artery branch; SP: skin paddle.

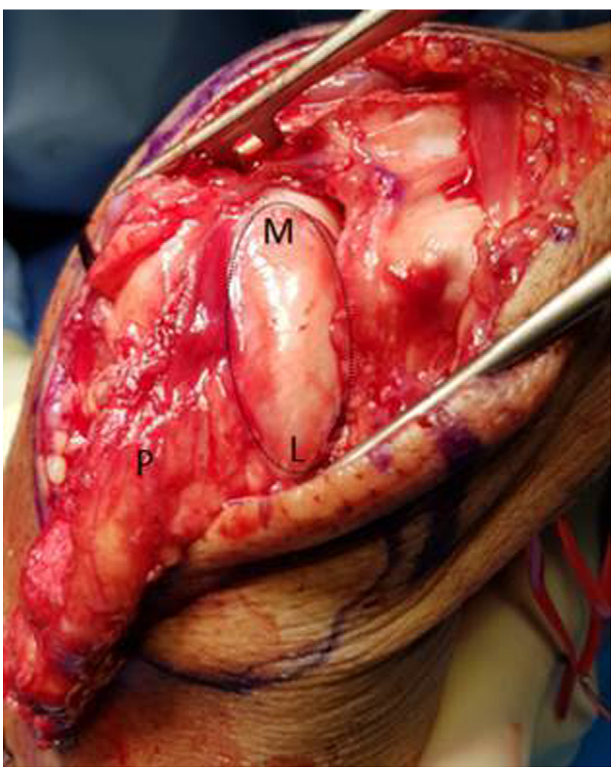

Fig. 3. Placement of oriented osteochondral graft after scaphoid resection (case 3). Hatched line: outline of osteochondral graft; M: medial part; L: lateral part; P: graft periosteum. The resected portion of the scaphoid was used as a pattern and was slightly oversized to avoid appearance of dorsal intercalated segment instability [9].

(Table 1) (Figs. 2 and 3). All donor sites were closed directly. At the wrist, the approaches were dorsal (between the second and third extensor compartments, to set the graft) and radial (according to the Henry approach, for vascular anastomosis) with a pedicle tunnelled between the two.

Each patient followed our postoperative free flap protocol consisting in wrist immobilization in a loose window bandage, 250 mg of acetylsalicylic acid daily, 300 mg of piribedil twice a day, and 40 mg of enoxaparin sodium daily until walking was resumed. Patients were instructed to have strict bed rest for 5 days, no cold

Fig. 4. Postoperative CT 3 months after surgery (case 3). Note the radiographic appearance of step off between the lunate and reconstructed scaphoid due to the thickness of the trochlea cartilage layer [8].

exposure, no stimulants or other arterial blood pressure variators. Skin color was monitored every 2 hours for 5 days with evaluation of paddle coloring, pulse, heat, bleeding, and Doppler signal (if spotted preoperatively). Knee physical therapy was started on the first postoperative day.

After a mean of 10 weeks postoperative, CT scan showed complete healing and the pins were removed (Fig. 4).

3. Discussion

3.1. Vascular anatomy and consequences

MFT flap vascularization originates proximally to the medial condyle from the descending genicular artery (DGA), which is the last branch of the superficial femoral artery (SFA). The DGA originates proximally or distally to the adductor hiatus and divides into three different vessels with great anatomic variability, classified by Dubois et al. [18] into seven types. There is the muscular branch (to the vastus medialis), the saphenous artery branch (SAB) (which is cutaneous), and the osteoarticular branch, commonly called the DGA. The osteoarticular branch divides as well into three branches: the cutaneous branch from the DGA (DGA-CB), the longitudinal periosteal branch, and the transverse periosteal branch. The latter transverse branch supplies the convex cartilage-bearing trochlea of the medial patellofemoral joint, where the MFT flap is harvested.

In about 90% of cases, a skin island flap, overlying the medial area of the knee, could be combined with the MFT flap [13,18,19]. Its vascularization can arise from the SAB or the DGA-CB or sometimes both (20% of cases). The skin paddle is most often based on the DGA-CB because it is easy to expose and dissect [13]. In about 10% of cases, a skin paddle cannot be combined with the MFT flap because neither the SAB nor the DGA communicating branch is adequate for perfusion of a skin segment [1,13,18–22].

The DGA-CB most commonly arises from the longitudinal periosteal branches, but it can also leave the osteoarticular branch at the supracondylar region. The DGA-CB always arises distally to the SAB origin and can always be elevated anteriorly to the sartorius muscle and adductor tendon. These distal skin-carrying vessels seem to be present in about 94% of cases but cannot always be used [13]. The DGA-CB has a small skin-vascularized area (70 cm^2) on the inner side of the knee joint. The SAB exists in around 97% of cases, and its origin is 14 $\pm$ 2.1 cm from the joint line.

Three types of anatomic variations of the SAB origin were identified by Dubois et al. [18], which impact flap harvesting. The type-1 pattern (around 70% of cases) will not affect raising the flap because the SAB and the osteoarticular branch originate from the same trunk. Type-2 patterns (around 20% of cases) make it difficult to raise all flaps on a single suitable-length pedicle because the SAB or the osteoarticular branches originate separately from the SFA. This type is manageable with technical adaptations and requires careful distal dissection because the SAB runs anterior or posterior to the sartorius muscle and adductor tendon, close to the saphenous nerve. A type-3 pattern (10% of cases) does not always allow association of a skin paddle because the SAB and the osteoarticular branch originate separately from the SFA. The SAB has a large vascularized territory, particularly distally, which overlaps the DGA-CB territory (361 cm^2) [13]. The variability of the DGA branching means the feasibility and difficulty of harvesting a skin flap with the MFT (or MFC) flap is difficult to predict [18,19]. However, in about 70% of cases, the skin paddle on the SAB is feasible [13,18,19] with short harvest time (about 28 min) [23]. No study has assessed the presence and availability of a skin paddle on the DGA-CB, but it seems to be at least as frequent as on the SAB [13,18,19].

3.2. Advantages of skin paddle on the MFT flap

The DGA's vascular tree is the source vessel for a large number of reconstructive flap options. Its numerous branches have led to the description of free skin, tendon, nerve, periosteal, corticoperiosteal, and osteochondral flaps [5–7,24]. This flap is particularly well suited for conservative reconstruction of small bone defects and non-union, such as in the wrist, with an excellent bone union rate [23,24]. It allows larger bone defects to be filled than with Zaidemberg's vascularized radial graft [25] and the vascularized bone graft pedicle on the volar carpal artery described by Kuhlmann et al. [26].

A skin paddle allows monitoring of flap viability, clinically and with Doppler, which are ideal to monitor the buried osteochondroperiosteal graft during the immediate postoperative phase. The literature includes a dozen studies reporting cases of a skin paddle being associated with a MFC flap and only one study with a MFT flap, reporting 50 cases. Except Tremp and al. [14], the best of these studies briefly describes the skin paddle mostly at the end of follow-up (Table 2) [3,13,14,21,27–33]. None describe the surgical recovery in cases of vascular abnormality of the skin paddle and a possible delay of bone union in case of skin paddle necrosis. The paddle serves as an early beacon of the vascular anastomosis. This is one element of the immediate postoperative monitoring of the microsurgical anastomosis. It provides an indirect indication of the perfusion status of the flap of interest (the chondrocortical flap); any deviation must be carefully interpreted. Skin paddle vascular damage does not necessarily mean the osteochondral graft is avascular; the flap may end up being a valuable, non-vascularized, bone reconstruction graft. Indeed, small osteochondral grafts can heal without being vascularized by a pedicle [34–36]. Unfortunately, there is no data on this subject in the literature, particularly about MFC and MFT flaps.

If flap vascularization fails, without a skin paddle, the graft could behave like a conventional graft, with the risk of cartilage degradation and then osteoarthritis. In addition to the ability to monitor the flap, the skin paddle ensures the graft is vascularized, potentially allowing rescue, and therefore the graft's success. It serves an early means of evaluating union, before and as a supplement to bone union imaging.

The skin segment is mostly harvested as an ellipse, centered over the MFC flap. Tremp et al. published a good description of two skin paddles associated with a MFT flap [14]. Closure of the skin over the anastomosis without excessive tension is facilitated, preventing vessel compression by the periosteum and edema. Furthermore, the gain of skin area transferred seems ideally suited for post-radiation-induced fractures or chronic bone non-union with a concomitant small skin defect or damaged and scarred skin. The paddle could easily cover the skin defect given the large rotation arc with thin and flexible skin.

Table 2
Published studies of MFC and MFT skin paddles.

Study	Reconstruction target	Type of flap	Number of patients with skin paddle (/Number of patients in study)	Vascularization of skin paddle (Dubois type)	Size of skin paddle (cm)	Outcome of skin paddle	Bone union rate	Bone union time (months)*
Sakai et al. [27]	Fracture nonunion of the upper extremity	MFC	1 (/6)	1 SAB	–	–	–	2.3
Martin et al. [21]	Mandibular reconstruction	MFC	2 (/2)	1 SAB 1 DGA–CB	10 × 6–	2 survived	100%	1.8
Kobayashi et al. [28]	Orbital bony defects	MFC	5 (/5)	5 SAB	–	5 survived	100%	–
Doi and Sakai [29]	Fracture nonunion of a metacarpal bone and a clavicle	MFC	2 (/11)	2 SAB	–	2 survived	73%	3.5
Doi et al. [3]	Scaphoid nonunion	MFC	5 (/10)	5 SAB	–	5 survived	100%	3
Del Pinal et al. [30]	Difficult nonunion or other bone problems in the upper limb	MFC	2 (/6)	2 SAB	–	–	100%	<3
Gaggle et al. [31]	Alveolar ridge of the maxilla or mandible	MFC	3 (/3)	3 SAB	–	3 survived	100%	4–6
Pelzer et al. [32]	Bone nonunion in the lower limb	MFC	4 (/4)	2 DGA–CB 2 SAB	–	4 survived	75%	1–5.6
Iorio et al. [13]	Mostly for nonunion of the upper extremity	MFC	18 (/20)	17 DGA–CB 1 SAB	$<4 \times 8$	18 survived	90%	–
Elgammal et al. [33]	Scaphoid nonunion or humpback deformity	MFC	6 (/30)	–	–	4 survived 2 necrosis	80%	–
Tremp and al [14]	Scaphoid and talus nonunion	MFT	2 (/2)	1 SAB 1 DGA–CB	1 × 13 × 1	2 survived	100%	–

*All patients in studyMFC: medial femoral condyle; MFT: medial femoral trochlea; SAB: saphenous artery branch; probable DGA–CB: unnamed branch originating from the DGA.

A sensory skin flap using the saphenous nerve seems feasible in cases of bone and soft tissue loss around the hand.

3.3. Composite osteochondrocutaneous MFT flap consolidation and complications

Skin paddle vascularization can be compromised for several reasons; excessive pedicle traction, vessel plication area, caliber disparity and the proximity to a collateral vessel causing hemodynamic turbulence, appear to be related to the vessels' anastomosis thrombosis. Repositioning the pedicle after vessel thrombosis as a shortcut to re-anastomosis in a healthy zone eliminated the risk of new thrombosis.

The literature reports an approximately 6% rate of major complications, with flap loss or unplanned reoperation in MFT and MFC flaps used for upper extremity reconstruction [24]. At the recipient site, the scaphoid and lunate bone union rate is 97.8% and 94%, respectively, with an average of 3.2 months without major complications [24]. In 4.4% of cases, there are heterotopic calcifications, not affecting wrist motion, due to the periosteum's strong osteogenic capacity. This can be avoided by meticulous dissection of the vascular bundle to the graft and by not leaving a periosteal sleeve under the vessels at the graft's margin [37].

Windhofer et al. [11] reported low donor site morbidity of the MFT flap in 45 patients. No early postoperative donor site complications were found (infection, hematoma, iatrogenic fracture, wound dehiscence). At the last follow-up of 27 months, all patients had stable operated knee and patella, range of motion was equal to that of the contralateral side, and the functional outcome scores were very good. Patients reported an average of 56 postoperative painful days and 3 months before the knee returned to normal. One patient could not kneel down and 50% of the patients had physical therapy after surgery. There were no pathological changes on the X-rays and MRI taken on 35 patients; the MFT harvest site appeared completely filled and resurfaced with fibrocartilage [11].

3.4. Early clinical and radiological results

At a mean of 1 year postoperative, our three patients no longer had wrist pain (VAS = 0.5/10) and had no discomfort in their knee. While they still had restricted wrist mobility (68% flexion–extension range of the opposite side), but this is expected to improve over time. Loss of postoperative wrist mobility is probably caused partly by adhesions created by the flap's periosteum bulk. Therefore, to decrease periosteum volume, it seems useful to dissect the pedicle a little more or keep only one periosteal artery of the two. Also, considering the excellent bone union rates and the possibility of performing stable bone fixation, rehabilitation could be started earlier to improve postoperative Range Of Motion (ROM).

We reconstructed the scaphoid with an osteochondral graft larger than the original size of the proximal pole and tried to preserve most of the scapholunate ligament. This overstuffing is intended to make up for the lack of scapholunate ligament integrity and participate in preventing DISI [8,9,12]. In our two cases, there was no misalignment of the first carpal row, which theoretically should protect wrist joint against the onset of osteoarthritis [8].

4. Conclusion

The MFT flap is indicated for conservative surgical treatment of small osteocartilaginous defects and non-union. It is suitable in hand reconstruction with excellent bone union rates. Associating a skin paddle is often easy and has numerous benefits such as flap monitoring, preventing vessel compression, and replacing damaged skin without high donor site morbidity. The MFT flap with a cutaneous skin paddle may contribute to preventing carpal arthritis following wrist bone non-union or necrosis in the presence of cartilage destruction.

Disclosure of interest

The authors declare that they have no competing interest.

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