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Case report

Extensor digiti minimi muscular flap: From a clinical case to an anatomical study

Lambeau de muscle extensor digiti minimi : du cas clinique à l'étude anatomique

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ABSTRACT

We present a case report of a failed posterior interosseous flap with distal pedicle rescued by an extensor digiti minimi (EDM) island pedicle flap supplied by the posterior interosseous artery (PIOA) in reverse flow to cover a soft tissue defect in the hand of a 25-year-old man. We subsequently performed an anatomical study on 5 cadaver limbs to determine the EDM muscle's vascularization: it was segmental, multiple and came from the PIOA. The rotation arc reached the dorsal side of the metacarpophalangeal (MCP) joints, as well as the distal part of the thumb. The indications selected are the same as those of the distal pedicle flap: defect on dorsal side of the hand and MCP joints, coverage of carpal tunnel, failure of posterior interosseous flap. This study describes a new flap and adds to our understanding of the EDM muscle's vascularization.

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R É S U M É

Il s'agissait d'un échec de couverture par lambeau interosseux postérieur à pédicule distal de la face dorsale de la main chez un homme de 25 ans sauvé par un lambeau de muscle extensor digiti minimi (EDM) pédiculé à retro sur l'artère interosseuse postérieure (AIP) en îlot. Nous avons, par la suite, mené une étude anatomique de la vascularisation du muscle EDM sur 5 membres cadavériques : elle est segmentaire, multiple et provient de l'AIP. L'arc de rotation atteint la face dorsale des articulations métacarpo-phalangiennes (MCP) et l'extrémité du pouce. Les indications retenues étaient celles du lambeau à pédicule distal : les pertes de substance de la face dorsale de la main et des articulations MCP, la couverture du canal carpien, l'échec d'un lambeau interosseux postérieur. Cette étude présente un nouveau lambeau et permet une meilleure compréhension de la vascularisation du muscle EDM.

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1. Introduction

Axial and perforator flaps, such as septocutaneous flaps vascularized by the posterior interosseous artery (PIOA) [1] are now in widespread use for reconstructive surgery of the hand and upper limb [2]. However, their reliability depends on two factors:

inter-individual anatomical variation of the perforating arteries and the technical level of the sampling [3]. In case of early intraoperative failure when approaching these pedicles, the surgeon must have other options available close to the surgical site [4].

We present the case of failed harvesting of a distally pedicled posterior interosseous flap rescued by an island pedicled muscular flap of the extensor digiti minimi (EDM) vascularized by the PIOA in reverse flow to cover a dorsal defect on the hand. The success of this procedure was the starting point for an anatomical study on the vascularization of EDM muscle on cadaveric upper limbs.

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2. Case report

The patient was a 25-year-old man suffering from a 2×3 cm skin defect on the right hand dorsum with imminent osteotendinous exposure in a chronic wound, initially infected and trimmed, which had undergone several failed autologous cutaneous grafts. Due to the prior procedures, local solutions were not suitable. The technique we chose was a thin perforating fascio-cutaneous flap supplied by the PIOA in reverse flow (Fig. 1). The perforating pedicle was located at the junction of the proximal one-third and distal two-thirds of a line joining the bony prominence of the lateral epicondyle to the distal radioulnar joint. The size of the skin pad, marked around this point, was adapted to the defect after debridement (4×5 cm). Dissection began from the radial approach. Our search for the perforating pedicle supplying the cutaneous pad failed. We decided to continue the procedure by dissecting the PIOA along its entire course to identify its perforating branches. No direct septo-cutaneous artery from the PIOA was found during dissection. However, numerous arteries

supplied the EDM muscle. We incised a 4×5 cm patch into the muscle around the largest of these arteries from the PIOA (Figs. 2 and 3). This reverse flow supplied island pedicle muscular flap was tunneled into the subcutaneous space on the dorsal side of the wrist to the recipient site on the dorsum of the hand. The incised cutaneous pad was excised, thinned out and then grafted onto the muscle flap (Fig. 4). At postoperative day 15, the dorsum of the hand was healed. At 6 months, the patient recovered active extension of the fifth metacarpophalangeal (MCP) joint (Figs. 5, 6 and 7).

2.1. Anatomical study

A red-colored latex solution was injected into the lumen of the humeral artery on five cadaver limbs (less than 5 days after death). The upper limb was placed on the trunk in supine position, elbow flexed at 90° , in neutral pronation-supination, with the hand on the abdomen. Palpation of the first muscle mass in the radial direction from the ulna identified the extensor carpi ulnaris muscle. A line

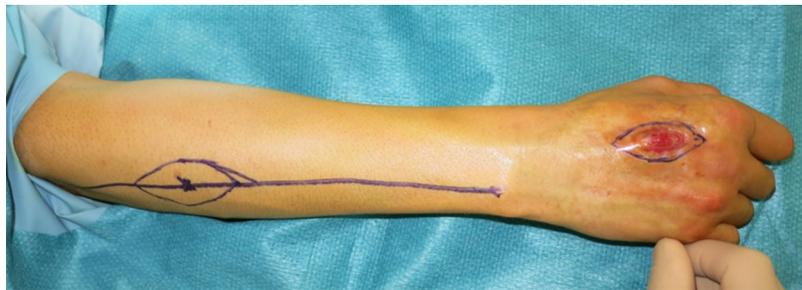


Fig. 1. Skin defect on dorsal side of right hand. Preoperative marking of a perforating fascio-cutaneous flap supplied by the posterior interosseous artery in reverse flow.

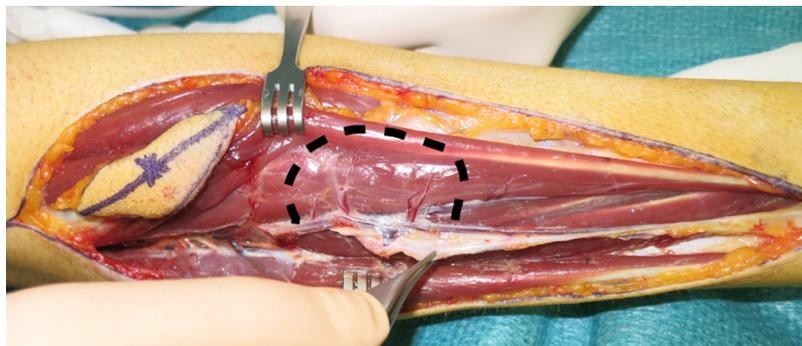


Fig. 2. Muscle patch pattern around muscular arteries supplying the EDM.



Fig. 3. Reverse flow supplied island pedicle muscular flap of the EDM.



Fig. 4. The cutaneous pad was excised, thinned out and then grafted onto the muscle flap.

was made from the lateral epicondyle of the humerus to the distal radioulnar joint, which was the projection of the posterior interosseous vascular axis. At the junction of the proximal and middle thirds, the skin pad of the distally pedicled posterior interosseous perforating flap was marked (7 cm wide) in order to capture the direct cutaneous arteries from the pedicle and to guide dissection. The incision was not linear but followed the radial edge of the pad which was dissected to the aponeurosis of the EDM muscle. Dissection of the pedicle continued all along the intermuscular septum separating the EDM and carpi ulnaris muscles. A contra-incision was made on the axis, 3 cm upstream of the distal radioulnar joint to identify the tendon of the EDM muscle and the anastomosis of the PIOA with the perforating branch of the anterior interosseous artery beneath the tendon of the extensor indicis proprius muscle. The arteries leading to the muscle were identified.

The reference frame used to measure the location of each muscular artery reproducibly was the distance from the prominence of the lateral humeral epicondyle to the distal radioulnar joint line. Once the muscle and its pedicle were isolated, the flap was lifted by sectioning its proximal insertion and ligating the PIOA upstream of the bifurcation with the recurrent interosseous artery.

The distally pedicled EDM muscular flap is a type 4 flap in the Mathes and Nahai classification [5]. Its vascularization is segmental, plentiful and results from the PIOA. We found an average of $n = 6.4$ (4–8) arteries per muscle leading to the EDM, for a total of 32 arteries in the five limbs studied. These arteries were directly from the PIOA in 75% ($n = 24$) and from the recurrent interosseous artery in 25% ($n = 8$). On one limb, vascularization was derived solely from the PIOA (Fig. 8).

The vast majority of these arteries (93.8%, $n = 30$) were clustered 31 to 137 mm from the lateral epicondyle, with a



Fig. 5. Appearance of hand at 6 months postoperative.



Fig. 7. Functional finger extension at 6 months postoperative.



Fig. 6. Functional finger flexion at 6 months postoperative.

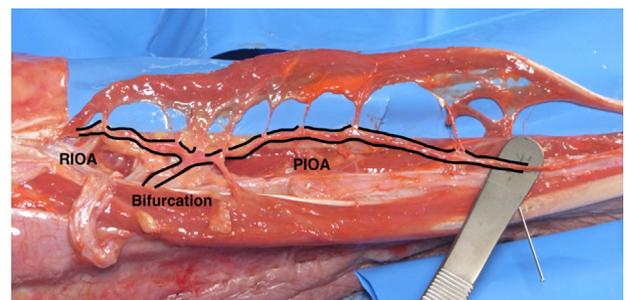


Fig. 8. Bifurcation of the recurrent artery (RIOA) and posterior interosseous artery (PIOA).

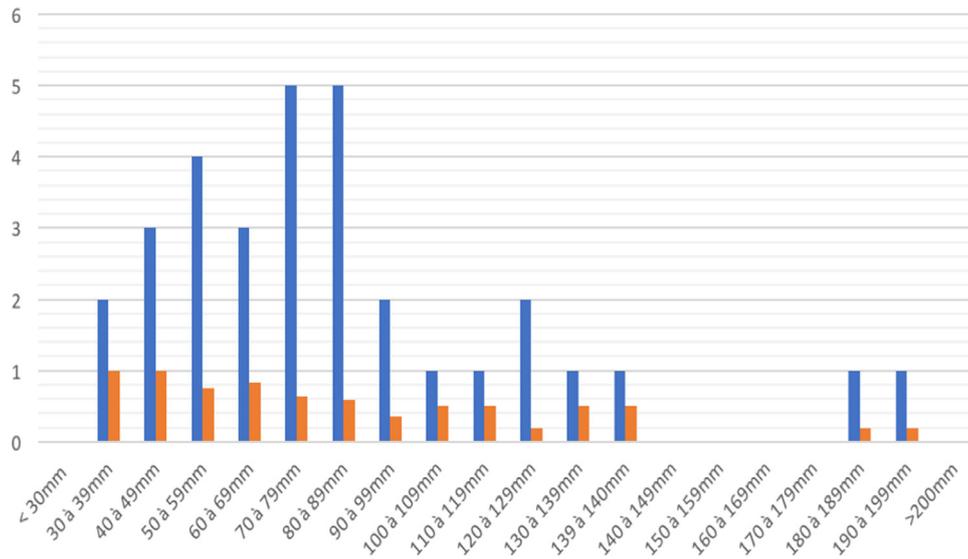


Fig. 9. Average number of arteries leading to the muscle (blue) and their average diameter in cm (orange) relative to their distance from the lateral epicondyle.

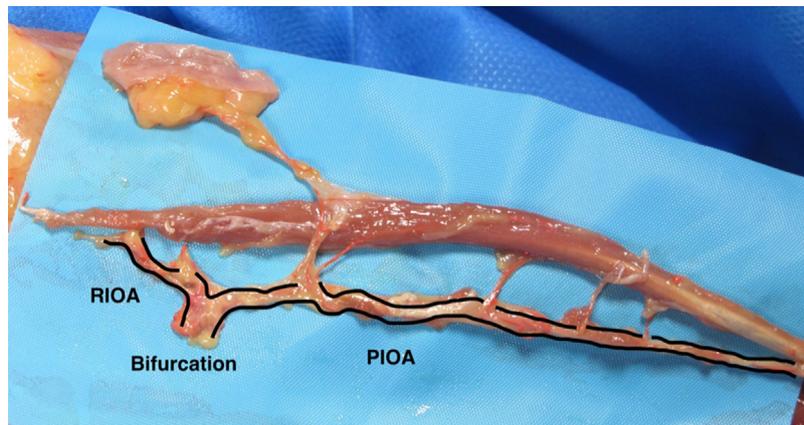


Fig. 10. Peninsular musculocutaneous harvesting. RIOA: recurrent interosseous artery; PIOA: posterior interosseous artery.

median at 75.6 mm (SD = 26.6 mm). The bifurcation between the recurrent and posterior interosseous arteries was on average 60.2 mm (51–72 mm) from the lateral epicondyle. On each limb studied, the PIOA gave off an average of 2.6 (1–4) direct septocutaneous perforations, emerging from the artery on average at 68.2 mm (47–86 mm) from lateral epicondyle. The emergence point came from the PIOA (n = 4), or from the recurrent interosseous artery (n = 1) (Fig. 9).

The average diameter of the arteries leading to the EDM muscle was 0.62 mm (SD = 0.44 mm). The average diameter of arteries emerging from the recurrent interosseous and posterior interosseous arteries was 0.90 mm (SD = 0.54 mm) and 0.51 mm (SD = 0.38 mm), respectively. The deep venous drainage was by the satellite veins of the pedicles leading the muscle.

The flap can be peninsular or island-shaped, in a muscular or musculocutaneous configuration by carrying a skin perforator

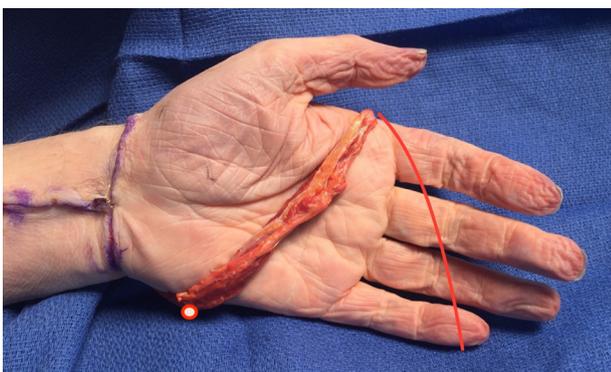


Fig. 11. Volar rotation arc (red line).



Fig. 12. Dorsal rotation arc (blue line).

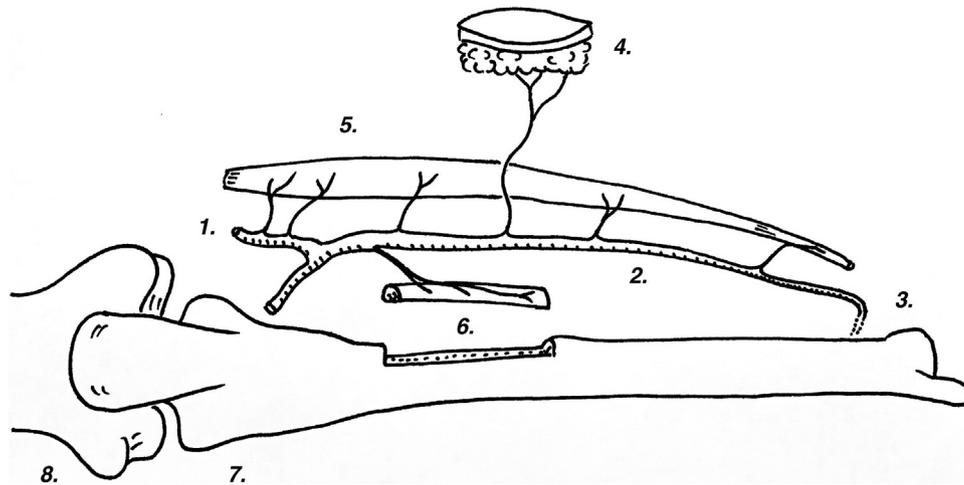


Fig. 13. Chimeric flaps that could be harvested with the interosseous posterior artery. 1: Recurrent interosseous artery; 2: posterior interosseous artery; 3: vascular anastomosis with the anterior interosseous artery; 4: cutaneous part of the flap; 5: extensor digiti minimi muscle; 6: vascularized bone part of the flap; 7: ulna; 8: radius.

artery (Fig. 10). The pivot point was located 3 cm upstream of the distal radioulnar joint (Figs. 11 and 12). The arc of rotation reached the dorsal side of the MCP joints of the fingers, as well as the ulnar distal part of the thumb on every case (Fig. 12). The maximum thickness of the muscle was 26.8 mm (29–23 mm).

3. Discussion

The main objective of this study was to explore the vascularization of the EDM muscle. Like the sartorius and tibialis anterior muscular flaps, it has multiple segmental pedicles (Mathes and Nahai type IV). The origin of these arteries to the EDM muscle was located on either side of the bifurcation between recurrent and posterior interosseous arteries. Nevertheless, no elements were found to differentiate a main pedicle from accessory pedicles. The anatomical peculiarity of the bifurcation in recurrent and posterior interosseous arteries is a Y-shaped artery flow-through [6]. It is feasible to harvest the artery as a bypass flap to improve or recover distal perfusion of terminally vascularized extremity [7]. We did not find any recent studies on this subject. Salmon and Dor [8] described the vascularization of fingers extensors in one muscular group, coming from the “ascendant branch” (a.k.a. the recurrent interosseous artery) and the “descendant branch” of the PIOA. The PIOA is a major provider of vascularized tissue and that the possibilities of chimeric flaps with low functional price (Fig. 13). The flap described separately by Masquelet and Penteado [9] and Zancolli and Angrigiani [10] in 1987 is an example of a cutaneous posterior interosseous flap. In 2015, Kamrani described seven cases of septic nonunion of the forearm bones managed by an ulnar bone graft supplied by the PIOA [11]. In 2002, Akin described the use of a vascularized osteocutaneous flap on the posterior bone axis for complex reconstruction of the metacarpals [12]. From a functional point of view, the loss of the little finger’s independent extensor, attributed to the removal of the EDM muscle, is compensated by the extensor digitorum communis. This loss can be moderate and transient if only a patch of the muscle is removed to perform an island pedicle flap. From an esthetics point of view, the approach to the most visible side of the forearm and the need to graft the flap results in scar tissue needing physical therapy, massage and compressive sleeve.

The indications we have retained are similar to those of distally pedicled flaps: defect on the dorsal side of the hand and MCP joints,

5 cm in width; coverage of carpal tunnel; defect on the ulnar distal part of the thumb.

4. Conclusion

This new flap is an innovative solution for small multitissue defects. This study improved our understanding of the EDM muscle’s vascularization, which is a vital component of the EDM muscle flap described here.

Disclosure of interest

The authors declare that they have no competing interest.

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