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Versatility of the Posterior Interosseous Artery Flap in Outpatient Handsurgery.

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Abstract

The posterior interosseous artery flap is a valuable tool and should be included in every upper extremity surgeon's armamentarium. The versatile and reliable posterior interosseous artery flap, also referred to as the dorsal interosseous artery flap, has been used for over 30 years to reconstruct defects about the hand. However, few authors describe its use in reconstructing defects about the elbow, despite its proximity. In the right setting, the posterior interosseous artery flap can be performed as an outpatient procedure, reducing exposure to nosocomial infection, avoiding unnecessary inpatient testing, and reducing cost to the patient.

Keywords: *Posterior interosseous artery flap; Outpatient; Hand; surgery; Dorsal interosseous artery flap; Flap.*

Introduction

Historical Perspective

The posterior interosseous artery (PIA) flap, first described in the 1980's by both Masquelet and Zancolli [1, 2] is one of the most widely used flaps in reconstructive hand surgery today. The PIA flap can be performed as an outpatient procedure with few complications. The typical and notable variant anatomies have been described extensively in the literature [3, 4]. Contrary to the radial forearm flap and ulnar artery flap, the PIA flap does not sacrifice the ulnar or radial artery. Thus, it can be harvested with less risk in patients with anomalous vasculature to the hand, and may protect the patient from potential adverse consequences described when removing a major arterial supply to the hand [5, 6]. The donor site can often be closed primarily, particularly when it is less than 4-5cm wide, obviating the need for skin grafting, and yielding superior cosmetic results. Because the dorsal forearm subcutaneous layer is thin, secondary debulking procedures are rare.

Over the years, the PIA flap has proven to be a solution to a variety of reconstructive dilemmas, including (but not limited to): post-traumatic wound coverage; treatment of oncologic defects; as a spacer in first web contracture release; as a reconstructive option for 3D wound defects; and even as an osteofasciocutaneous flap for thumb reconstruction [7]. Despite the literature's focus on distally based applications for the PIA flap, our institution feels that it is also a superior technique for defects about the elbow. Unlike most descriptions of the procedure, we feel that the PIA flap can be performed safely in the outpatient setting. Close postoperative follow-up is needed, and patients must be properly instructed on elevation technique, and self-monitoring. Compared with inpatient surgery, outpatient surgery provides several benefits including reduced exposure to nosocomial infection, convenience, and reduced cost.

Anatomy

The posterior interosseous artery (PIA) is a branch of the common interosseous artery, which originates from the ulnar artery. In rare cases, the PIA arises directly from the ulnar artery [8]. It enters into the proximal forearm dorsal compartment under the supinator and continues distally towards the hand, along the intermuscular septum between the extensor carpi ulnaris (ECU) and the extensor digiti quinti (EDQ). More proximal in the forearm, it travels close to the posterior interosseous nerve (PIN). This nerve then divides into multiple branches in a complex pattern with many variations, which the surgeon must approach carefully. Roughly midway down the forearm, a fasciocutaneous perforator artery, the artery of Salmon [9], emerges. This artery is the most proximal perforating branch of the PIA and is most important for irrigation of this flap's territory. The PIA courses distally in its septum, anastomosing with the anterior interosseous artery (AIA) just proximal to the distal radioulnar joint (DRUJ) at the level of the ulnar neck. A cadaveric study done by Costa, et al. showed that the anastomosis was formed by a dual network in just 3% of cases. In 3 out of 102 clinical cases in the same study, this anastomosis could not be identified and the PIA "appeared to terminate in the middle third of the forearm." In all 3 cases, the PIA flap was abandoned. Angrigiani et al. also found this variation in 2 out of 120 cases in their study [3]. Distal to the typical anastomosis, the PIA greatly reduces in size. It then reaches and merges with the dorsal carpal vascular arch. During most of its course, the artery has a constant diameter averaging ~1.7mm with corresponding small caliber branches [10].

Indications/Contraindications

The PIA flap has a long and consistent distal pedicle that allows rotating the flap to the dorsum of the hand. It will reach far enough

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distally to cover the metacarpophalangeal joints of all the digits and resurface the first webspace. The PIA flap is most often harvested on its distal pedicle as a reverse flow axial flap. It can also be harvested on its proximal pedicle as a direct flow axial flap, and will reach to cover defects over the olecranon [Figure 1a]. However, the distal pedicle PIA flap is most commonly used to cover cutaneous defects on the dorsum of the hand [Figure 1b], particularly when tendons are exposed and when more simple alternatives such as skin grafts or local flaps are in sufficient. In our practice, these defects result from trauma such as rollover hand injuries, excision of squamous cell carcinomas, and infections. In addition, this flap is very useful for reconstructing the thumb web space after its release, whether due to traumatic or congenital reasons [11]. Prior trauma to the dorsum of the wrist or forearm, which may have injured the PIA, contraindicate the use of this flap. Another contraindication to using this flap is the absence of vascular connection between the AIA and PIA, although this is rare [3]. This is because the reverse PIA flap greatly relies on native anasto-mosis between the AIA and the PIA, which allows for retrograde flow through the PIA once it is ligated from its proximal blood supply.

Figure 1a: Dorsal elbow defect with presenting exposed olecranon; status post debridement of necrotic tissue.

Figure 1b: Dorsal hand defect with presenting exposed tendon; status post debridement of necrotic tissue.

Methods

Setup

The patient was positioned supine. A hand table and a proximal tourniquet was used. Simple arm elevation was performed instead of exsanguination prior to tourniquet inflation to ensure adequate visualization of the vasculature.

Exposure

Reverse (retrograde) PIA flap (Hand)

The axis of the PIA was determined by drawing a straight line from the lateral epicondyle to the DRUJ [Figure 2]. The estimated location of the most proximal perforator (MPP) was marked on the midpoint of the axis [9]. Next, the distal end of the axis was marked where the pedicle was to rotate [Figure 3a]. The length of the pedicle needed to reach the defect was determined. Then, the flap was designed to be centered over the axis, making an effort to include the first perforator in it. A small defect with a short pedicle may not include the first perforator. However, if the flap is small, the more distal but smaller perforators will suffice. The recipient defect was debrided, ensuring removal of all nonviable, infected, or grossly contaminated tissue. The incision was started distally, with inclusion of the widest possible fascial base to maximize skin perfusion, such that the flap was almond shaped. The surgeon dissected underneath the deep fascia towards the axis until the fasciocutaneous septum between the ECU and the EDQ was identified [Figure 4]. Then, the septum was harvested as a unit; the artery was not dissected out from it. On the proximal aspect of the dissection, the location was noted with careful attention to branching patterns, and preservation of the posterior interosseous nerve (PIN) and the PIA [Figure 5]. The septum was exposed from the radial and ulnar sides, alternating as needed. Due to varying anatomy, it may be useful to extend the dissection proximally in order to safely manage anatomy. The surgeon observed the PIA crossing the interosseous plane, into the extensor compartment, and followed it distally until it cleared all branches of the PIN, but before it gave rise to the MPP. This point is where the PIA was ligated and cut to elevate the distally based flap. During pedicle dissection, there was careful attention to preserve cutaneous perforating arteries; only the muscular perforators were cauterized. Lidocaine was applied to the underside of the flap to aid in vasodilatation and prevent vasospasm prior to dropping the tourniquet. The pedicle was dissected distally to the level of the DRUJ, where the PIA dives deep through the IOM to anastomose with the AIA [Figure 6a].

Direct (anterograde) PIA flap (Elbow)

This flap proved useful to cover defects over the tip of the olecranon. In contrast to the retrograde technique, the flap was designed around the more distal cutaneous perforators [Figure3b], such that it was eye shaped. For primary closure, the flap width was maintained to less than 3-4 cm. It should be noted that inclusion of the MPP in the flap is preferred if possible. The surgeon harvested the flap in a fashion similar to the flap above (see Exposure > Reverse (retrograde) PIA flap above). He identified the septum and PIA distally and dissected out the pedicle in a distal to proximal direction. The PIA was ligated distally, including at least 3-4 cutaneous perforators in the pedicle. Then, the surgeon dissected the pedicle proximally until the PIA was no longer separable from the PIN branches and ended the dissection there [Figure 6b].The flap easily covered the tip of the olecranon.

Figure 2: By pinching the skin we can estimate the maximum flap width that can be closed primarily.

Figure 3a

Figure 3b

Figure 3a and 3b: Mark the forearm along the axis of the DIA from the lateral epicondyle to a point just proximal to the DRUJ; arrow points to the MPP, also known as the artery of Salmon.

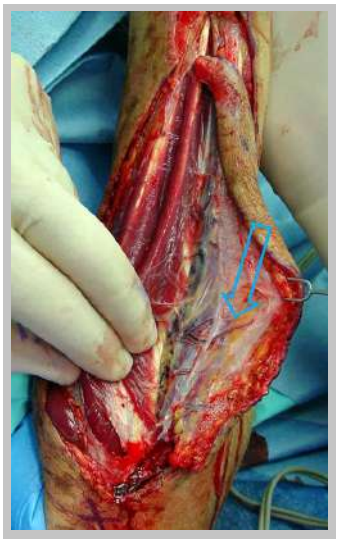

Figure 4: Proximal pedicle dissection shows the septum between the EDQ and ECU and containing the PIA; the arrow shows the MPP.

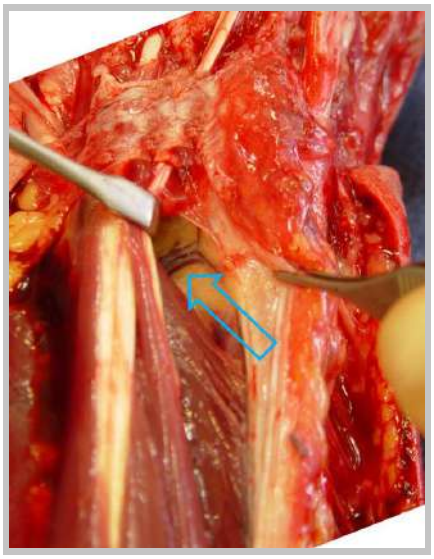

Figure 5: Distal pedicle dissection. The arrow shows anastomosis between the PIA and AIA.

Figure 6a

Figure 6b

Figure 6a and 6b: Fully dissected flap.

Reconstruction

Reverse (retrograde) PIA flap

Once the PIA flap was completed and adequately mobilized, the surgeon made an incision (subcutaneous tunnel) in line to the dorsal hand defect. The flap reached the intended site without undue tension and the pedicle did not end kinked or twisted. The flap was returned to its original bed and the tourniquet was deflated to allow reperfusion. Flap viability was assessed prior to transferring it. It should be noted that microvasculature acts like a balloon: opening pressures are higher than the pressures needed to maintain patency (and subsequently perfusion); therefore, it is important to remain patient when waiting for the flap to "pink up". Venous bleeders were addressed with bipolar electrocautery. Once adequate perfusion of the flap was confirmed, the flap was transposed to the recipient site. Lidocaine was applied to aid in vessel patency. Certain cases may require further shaping of the flap to perfectly fit the defect.

Direct (anterograde) PIA flap

Once the PIA flap was adequately mobilized, a subcutaneous tunnel was made from the proximal pedicle to the elbow defect. The tourniquet was deflated, flap perfusion was assessed, and the same technique regarding perfusion and hemostasis was used (see Reconstruction > Reverse (retrograde) PIA flap above). Finally, the flap was transposed and inlayed onto the recipient site.

Closure

Reverse (retrograde) PIA flap

The flap was secured to its recipient site using a tension-free closure [Figure 7a]. The donor site was repaired by primary closure. To confirm flap perfusion, a "prick test" was performed by piercing the center of the flap with a fine cutting needle and watching for bleeding. The surgeon applied loose sterile dressings and protected the flap with a well-padded postoperative hand dressing. He ensured that the dressings were not constrictive or compressive in any way. The wrist was then supported in slight extension to minimize flap tension.

Direct (anterograde) PIA flap

The flap was closed in a similar fashion to the retrograde flap (see Closure > Reverse (retrograde) PIA flap above). Loose sterile dressings were applied and the elbow was supported in extension to minimize flap tension [Figure 7b, 7c].

7a

7b

Figure 7a, 7b and 7c: Secure the flap to its recipient site using a tensionfree closure.

Rehabilitation

Initial follow up was performed at one week. In the clinic, the sterile operative dressings were removed to assess flap viability, as well as donor site healing. No concerns were noted. Hence, the patient was allowed to commence early rehabilitation, as island flaps have no risk of disturbing a vascular anastomosis.

Discussion

The PIA flap usually provides good skin coverage with excellent cosmetic appearance and is seldom bulky or needs defatting, as the dorsal forearm subcutaneous fat layer is usually thin [Figure 8a, 8b]. In one study, 50/50 consecutive flaps survived with mild oedema and minimal complications [12]. Known complications of this procedure include: flap necrosis, hematoma, infection, and donor site morbidity [1, 2, 12-15].

In a study done by Shahzad, et al. flap necrosis occurred in 4% of patients [12]. This necrosis can be due to poor inflow and is most often partial and limited to the most distal part of the flap. It may result from overzealous harvesting of tissue distal to the territory irrigated by the MPP, excessive tension placed transversely across the flap during closure, kinking or twisting of the pedicle, or by iatrogenic injury to the pedicle. Flap necrosis can also be due to congestion or poor venous out flow resulting from poor pedicle management technique. Little can be done to reverse tissue ischemia when the problem is poor inflow, but reversing venous congestion is possible by improving the environment around the pedicle, removing tension or compression, or even by the use of leeches. The best way to prevent flap necrosis is to ensure that the flap is well-perfused after completing closure. Avoiding the use of subcutaneous tunnels and skin grafting, rather than closing tight skin over the pedicle, are both recommended for the procedure.

Adequate hemostasis prior to closure significantly reduces hematoma formation. However, if at the end of the procedure, there is concern for excessive bleeding, a drain should be used. Avoiding hematoma formation will prevent excessive tension on the flap and subsequent flap necrosis. The drain should be removed at the first postoperative visit. If a significant hematoma is detected under the flap, a return to the OR is suggested for evacuation of the hematoma, drainage and proper hemostasis. As hematomas of this nature swell further with time, they increase flap tension and the likelihood of flap necrosis.

Skin flap infections are manageable, as one study presented only 1/50 patients with infection that resolved with antibiotics after causing necrosis [12]. When flap reconstruction is performed over a previously infected site, it is important to continue post-operative antibiotic therapy, based on culture results and sensitivities after the infection has been irrigated and debrided thoroughly. The PIA flap is reliable through anterograde or retrograde flow and the choice of flow depends on the location of the defect to be covered. Retrograde PIA flaps are ideally suited for distal defects such as those on the dorsum of the hand [3]. Conversely, anterograde flow PIA flaps are useful in proximal defects such as those around the elbow joint [15]. The pedicle pivot point is at the junction of the proximal and middle third of the forearm. Therefore, reach must be adequate. The width of the anterograde flap, with respect to the retrograde flap, is less, as the donor site is at a more distal forearm location with a smaller cross section. Both procedures are reasonable procedures for their respective indications.

Figure 8a

Figure 8b

Figure 8a and 8b: Fully healed flap and functional result. A: Full finger extension. B: Full finger flexion.

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