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ORIGINAL ARTICLE
Hand

Microsurgical Resection of Vascular Malformations of the Upper Extremity

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Background: Vascular malformations that circumferentially surround end or near-end arteries are challenging to manage. Minimally invasive treatment options such as sclerotherapy can directly damage these vessels and cause ischemia. Surgical resection is desired without sacrificing or injuring a patent artery, especially in end organs like the upper limb. Microsurgical resection of these lesions provides a viable option for treatment.

Methods: The records of nine patients who presented with vascular malformations that circumferentially surrounded an artery in the upper limb were reviewed. The main indications for surgical intervention were pain or persistent growth. In each case, microsurgical technique using a microscope and microsurgical instruments was used to dissect the lesions free from the affected end arteries. Four digital arteries, three radial arteries, one brachial artery and one palmar arch were involved.

Results: There were six venous malformations, two fibro-adipose vascular anomalies, and one lymphatic malformation. There were no cases of distal ischemia, bleeding, or functional compromise. Two patients experienced delayed wound healing. After a minimum follow-up of 1 year, only one patient experienced a small area of recurrence but had no pain.

Conclusions: Microsurgical dissection using a microscope and microsurgical instruments is a viable technique for resection of difficult vascular malformations that surround major arterial channels in the upper limb. This technique allows preservation of maximum blood supply while treating problematic lesions. *(Plast Reconstr Surg Glob Open 2023; 11:e4974; doi: 10.1097/GOX.0000000000004974; Published online 10 May 2023.)*

INTRODUCTION

Vascular malformations are rare lesions that exhibit a defect in vascular morphogenesis, and may originate in any of the vascular beds in the human body.[1] Vascular malformations can differ considerably in their location, type, and clinical severity. These lesions can be problematic, particularly if they circumferentially surround end or near-end arteries due to the possibility of compromising distal limb blood flow.

Management of vascular malformations involving the hand and wrist in particular can be a significant surgical challenge, often due to the diffuse and infiltrative nature of the lesions and the need to maintain normal hand and wrist function.[2] Less invasive options such as sclerotherapy, cryo-ablation, and embolization are routinely utilized and can be quite effective; however, they have their limitations, especially in lesions that abut important vessels and nerves. Surgery may be indicated in cases of persistent pain, disproportionate growth, uncontrolled limb swelling, nerve compression, or existing or impending functional impairment, and is especially suited for localized lesions.

Often vascular malformations completely circumscribe end arteries in the limbs; this is especially true for venous malformations that arise from the venae comitantes vessels that run adjacent to arteries. In these cases, minimally-invasive ablative procedures such as sclerotherapy can be problematic. Any extravasation of the utilized caustic agent in these procedures can cause injury of the artery, and thereby compromise blood supply, leading to ischemia and necrosis. Surgical intervention may be a better option in these cases where a more precise delineation of normal and abnormal tissue can be made. However, operative intervention can also be risky, as poor visualization and bleeding may lead to direct surgical injury to limb-critical vessels.

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Received for publication October 17, 2022; accepted March 8, 2023.

DOI: 10.1097/GOX.0000000000004974

Disclosure statements are at the end of this article, following the correspondence information.

In this study, we describe a microsurgical approach of subtotal resection of problematic malformations that circumscribe end arteries in the upper extremity, while preserving the arterial blood supply.

METHODS

Institutional review board approval was obtained to review the medical records of patients who underwent microsurgical resection of a vascular malformation of the upper extremity at our institution from June 2012 to July 2018. All patients were evaluated by a multidisciplinary team that involved a radiologist and pediatric hand surgeon. Medical records were reviewed for patient characteristics, clinical presentation, operative findings and technique, and early postoperative outcome.

Takeaways

Question: Is microsurgical resection of vascular malformations that surround end arteries effective and safe?

Findings: Six venous malformations, two fibro-adipose vascular anomalies, and one lymphatic malformation were removed using this technique. There were no cases of distal ischemia, bleeding, or functional compromise. After a minimum follow-up of 1 year, one patient experienced a small area of recurrence with no other symptoms.

Meaning: A technique of using a microscope and microsurgical instruments to remove vascular malformations that surround end arteries in the upper extremity is effective and safe, and avoids risks incurred by other techniques.

Operative Approach (Surgical Technique)

Preoperative Planning

Preoperative planning is critical prior to surgical treatment. Planning should include correlation of the size, extent, and involvement of structures with physical examination and imaging. Imaging modalities include radiographs, ultrasound (US), magnetic resonance imaging (MRI), and angiography. MRI findings in all patients included the presence of a vascular malformation surrounding an end artery in the upper extremity.

Operative Technique

The broad conceptual goal of this technique is to preserve maximum arterial blood supply while performing subtotal resection of the diseased tissue.

All patients (n = 9) were put under general endotracheal anesthesia and operated on following the same approach and microsurgical technique. Each operation was performed under tourniquet control.

The initial incision was planned to include extension distal and proximal to the lesion for vascular control. Peripheral exposure of the lesion was initially achieved, and immediately thereafter, the proximal and distal extents were dissected and the arterial inflow and outflow(s) were tagged/controlled (Fig. 1–2).

The entirety of the lesion was then dissected from the surrounding tissues keeping the arterial inflow and outflow intact while clipping or cauterizing the (multiple) venous channels to the main lesion. Once fully dissected and only connected to the patient via the arterial inflow and outflow vessels (and nerves in a few instances), the lesion is ready to be removed. The operating microscope is brought into the field, and microsurgical instruments are used to gently dissect the lesion from the artery. The vascular malformation needs to be incised longitudinally along the path of the artery as the first step, before the remainder is removed. The procedure is done under tourniquet control to minimize bleeding and optimize visualization. Microbipolar forceps on low-setting are critical for cauterizing all arterial feeders/branches. Traction and countertraction greatly aid in the dissection process.

After the lesion is removed, the tourniquet is released. It is not uncommon for the artery to display spasm initially. This can be overcome with application of plain lidocaine or papaverine. It is prudent to allow the artery to become fully engorged to ensure no bleeding branches have been missed. Hemostasis is obtained, and the skin is closed.

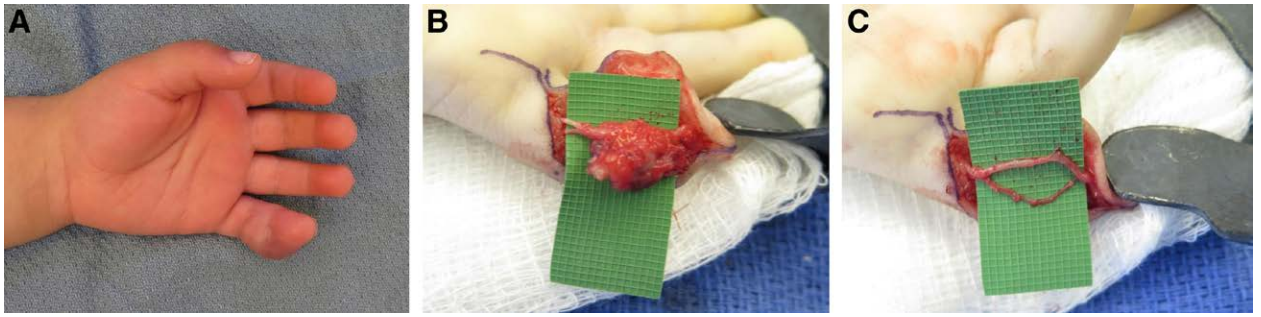

Fig. 1. A 10-month-old male child with a venous malformation of the left fifth digit present at birth. A, The lesion had recurred after a previous resection operation. It bled and demonstrated rapid growth. B, The lesion was approached via a midlateral incision. The ulnar digital artery and nerve were surrounded by the venous malformation. C, The malformation was completely excised using microsurgical technique to carefully dissect the nerve (palmar) and the artery (dorsal) from the lesion. A large feeding distal arterial branch (to the malformation) was cauterized but the main branch to the fingertip was preserved.

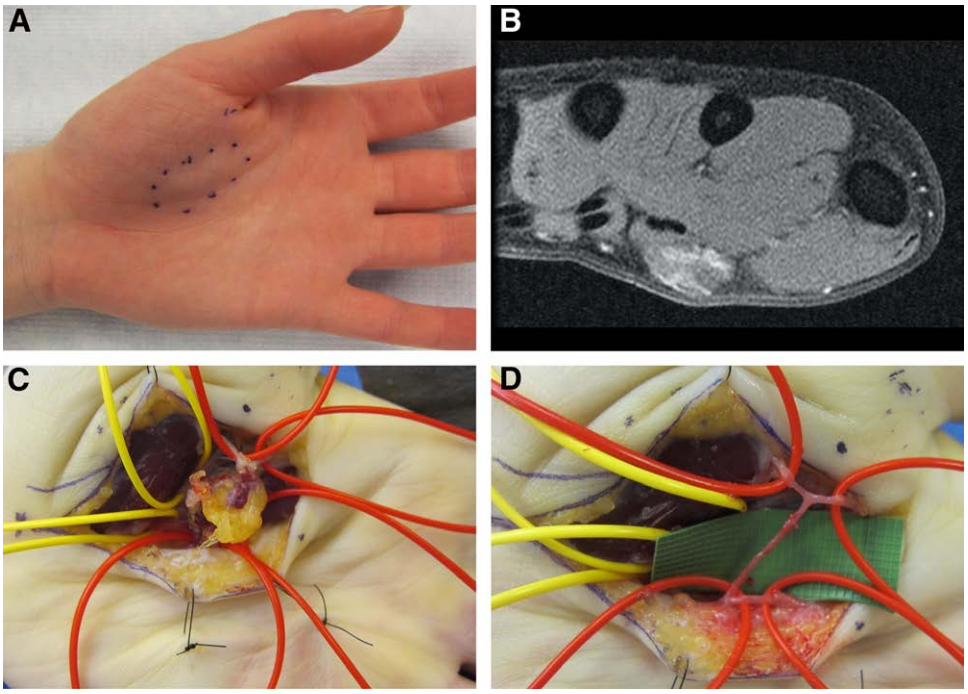

Fig. 2. A, A 16-year-old girl presented with a painful mass in the left palm. B, Imaging studies (MRI) demonstrated a venous malformation surrounding the superficial palmar arch. C, The venous malformation seemed to surround the most distal extension of the palmar arch involving the digital vessels to the thumb and the first and second web spaces. Nerve branches are tagged with yellow vessel loops, and arteries are tagged with red ones. D, The entirety of the venous malformation has been excised from the surrounding tissues, leaving a clean distal palmar arch.

Postoperative Management

Patients are immobilized for several weeks, in a cast for young children or a splint for older adolescents and adults. The immobilization is then discontinued and gentle range of motion exercises begin. The patient is monitored long term for recurrence.

RESULTS

The series includes a total of nine patients, of which five were female (n = 5) (Table 1). The average patient age at the time of surgery was 13 years, with a range of 1–27 years. Four digital arteries, three radial arteries, one brachial artery, and one palmar arch were involved. All patients underwent imaging studies, including MRI and ultrasound. Preoperatively, six patients experienced pain; two, tenderness while putting pressure on the malformation; and one patient experienced multiple bleeding episodes and rapid growth. Pathology confirmed imaging findings of six venous malformations, two fibro-adipose vascular anomalies (FAVA),[3] and one lymphatic malformation. There were no cases of distal ischemia, bleeding, or functional compromise postoperatively. Two patients experienced delayed healing of the skin wound; none experienced infections. Patients were assessed by history and physical examination after a minimum follow-up of 1 year. All patients experienced complete relief of the primary symptom(s) for which they underwent surgery without occurrence of any other major symptoms, such as bleeding, open wounds, pain, or functional compromise. Only one patient experienced a small area of recurrence, less than 1 cm in diameter, which remains asymptomatic and is being observed. All patients had normal range of motion of the hand and wrist before the operation and at final follow-up. None experienced cold intolerance or sensory compromise.

DISCUSSION

Vascular malformations involving the hand and wrist can pose unique treatment challenges. Even though the great majority of malformations in the body are amenable to treatment with sclerotherapy and other minimally-invasive techniques, lesions of the hand can be more problematic. In particular, sclerotherapy can create a zone injury effect, as the caustic agent may extravasate and injure important abutting structures. This can be particularly troublesome in the palm where critical structures lie in close proximity. Even seemingly distinct venous malformations can have small extensions (not seen on imaging) that intimately surround or hug digital nerves or arteries.

The degree of injury due to sclerotherapy depends on operator technique, integrity of vascular channels (extravasation), and the agent used. Among others, sclerotherapy agents include alcohol, 3% sodium tetradecyl sulfate, and 5% ethanolamine oleate. Of these, alcohol is by far the most problematic and most likely to cause surrounding injury. Nerve injury typically results in numbness,

Table 1. Patient Characteristics

	Gender	Diagnosis	Location	Artery	Imaging	First Noted	Reason	Age at Surgery	Size	Complications
Pt 1	Woman	FAVA	Left forearm	Radial artery	MRI, US	9 y	Painful	10 y	4 cm	None
Pt 2	Man	Venous malformation	Right hand	Digital artery	MRI, US	5 y	Painful	7 y	3 cm	None
Pt 3	Man	Venous malformation	Left hand	Digital artery	MRI, US	Unknown	Painful	13 y	3 cm	Delayed healing
Pt 4	Woman	Lymphatic malformation	Left wrist	Radial artery	MRI, US	17 y	Painful	19 y	3.5 cm	Small recurrence
Pt 5	Man	FAVA	Right arm	Brachial artery	MRI, US	11 y	Painful	12 y	3 cm	None
Pt 6	Woman	Venous malformation	Right wrist	Radial artery	US	10 y	Painful	11 y	0.6 cm	None
Pt 7	Man	Venous malformation	Left fifth finger	Digital artery	US	At birth	Multiple bleeding episodes	1.5 y (recurrent)	2 cm	None
Pt 8	Woman	Venous malformation	Left hand	Palmar arch	US	8 y	Painful (when patient started birth control)	16 y	3 cm	None
Pt 9	Woman	Venous malformation	Right hand	Digital artery	US	At birth	Painful (with job activities)	27 y	3 cm	Delayed healing

paresthesias, and motor deficits.[4] Although most of these injuries are transient, they can cause significant long-term sequelae such as chronic pain and long-term disability if they do not resolve. The more concerning problem is injury to end arteries, as this can cause distal ischemia. Admittedly, this is a rare complication, but the authors have observed more than a few of these, which have ultimately resulted in distal amputation.[5–7]

Vascular malformations that surround end arteries in the upper limb are thus difficult to approach. In cases where imaging has confirmed circumferential involvement around an end artery, sclerotherapy has an even higher potential risk of injury and possible distal ischemia. In these cases, surgical excision is preferred to sclerotherapy, but even operative intervention poses its own risks. More specifically, direct surgical injury to an end artery is a real possibility. Although dividing a redundant artery may be worth consideration (eg, one-side of a digit) and may avoid distal ischemia, in many cases this is suboptimal because it may cause cold intolerance, growth disturbance, or complicate future interventions, especially in younger patients where re-expansion and regrowth of the malformation is the rule.

We propose a new technique of microsurgical approach to these lesions to minimize risk of injury to end arteries. Tourniquet control and magnification with a microscope

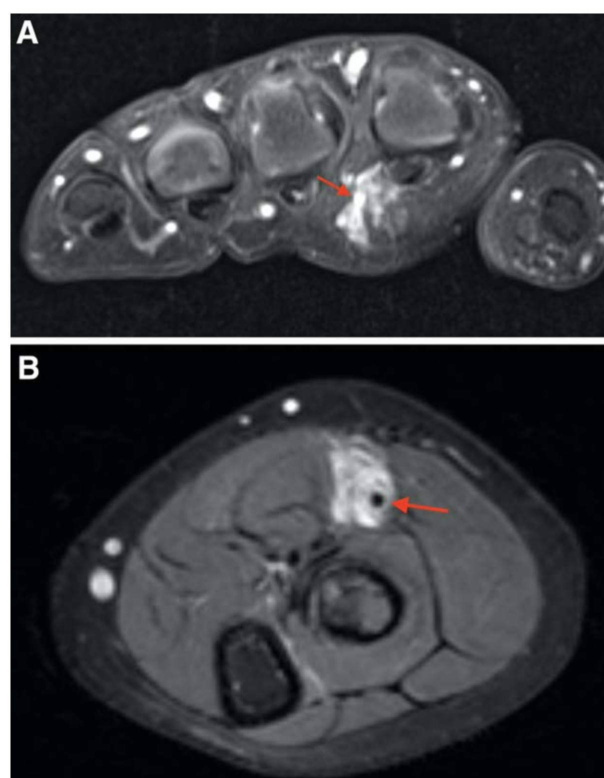

Fig. 3. Representative MRI images from two patients in this series. A, A 7-year-old boy with a palmar venous malformation, the most proximal image of which demonstrates the common digital artery entering its mid substance (red arrow). B, A 10-year old girl with a forearm fibro-adipose vascular anomaly surrounding the radiolucent radial artery (red arrow).

create good visualization of the vessels. Microsurgical instruments allow precise control of small structures, even pediatric digital arteries. This approach makes it safer to perform subtotal resection of these symptomatic lesions.

A multidisciplinary approach is important to ensure accurate diagnosis and treatment in all but the most trivial vascular anomalies. All of the patients in this series underwent evaluation by a minimum of two specialists: a hand surgeon with microvascular expertise and an interventional radiologist. Other specialties included general surgery, dermatology, and hematology for patients with multifocal lesions. The lesions to undergo surgical excision via this method were chosen after a full review, including clinical examination and imaging review (Fig. 3), and discussion with the team.

A major limitation of this study is that the retrospective analysis may introduce bias and other confounding factors. As all patients were treated at a tertiary care hospital, outcomes may not be generalizable. Additionally, due to the rare nature of this condition the sample size was small. There are no similar studies that we know of in the literature for comparison between studies. Moreover, there was heterogeneity in diagnosis, location, and extent of involvement, thus making comparisons difficult within this study. Lastly, patients were only followed for at minimum a year, so it is difficult to comment definitively on long-term recurrence. Nevertheless, recurrence or regrowth of these lesions is common and does not necessarily negate the need for intervention. Patients should be counseled about recurrence possibility before excision of any vascular anomaly, and should be followed long term with serial examination and imaging.

CONCLUSIONS

Vascular malformations may cause great concern and uncertainty for patients and their families, but also for the treating physicians. Proper identification of the lesion and knowledge of the clinical aspects and intervention options of each subtype will enable appropriate care to be provided and results to be maximized. We propose a safer microsurgical treatment option to dissect difficult vascular malformations that surround major arterial channels in the upper limb using a microscope and microsurgical technique, resulting in preservation of maximum blood supply.

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