MRA of the hand at 3 Tesla: Technical considerations and spectrum of findings

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Learning objectives

1. Recognize the role and utility of MR Angiography (MRA) in assessing the vasculature of the hands.

2. Develop an understanding of basic but important technical factors which enable the successful performance of high-quality MRA imaging of the hands.

3. Review normal vascular anatomy and common pathologic findings seen on MRA examinations of the hands performed on at 3T MR system.

Background

Introduction

Noninvasive evaluation of the vasculature of the hand is technically challenging, and digital subtraction angiography (DSA) remains the reference standard for the evaluation of the hand vasculature. DSA is, however, an invasive procedure and is associated with a risk not only of vessel injury but also pain, vasospasm or complications related to contrast administration.

The primary limitations of noninvasive imaging techniques in assessing the vasculature of the hands are due to the small caliber of the vessels and the rapid arteriovenous transit time of the vessels in the hand. These factors require that any imaging technique which aims to accurately evaluate the small vessels in the hands have both excellent spatial and temporal resolution.

Advances in magnetic resonance (MR) scanners and imaging techniques have made MR increasingly useful in the assessment of vascular anatomy and pathology in the hands. Contrast-enhanced magnetic resonance angiography (ce-MRA), in particular, has been shown to be a useful tool for accurately and reproducibly studying the vessels in the hands without subjecting patients to the risks or discomfort of DSA.

The introduction of 3Tesla (3T) MR scanners has dramatically improved the spatial resolution achievable with MR, increasing the utility of MR imaging in imaging vascular conditions of the hands. Additionally, new imaging techniques and methods which employ high resolution 3D imaging capabilities and time-resolved postcontrast imaging are further increasing the utility of MR in evaluation of the vasculature of the hands and will likely augment the clinical use of MR in patients with suspected vascular pathologies affecting the hands. Thus, an understanding of the technical factors requisite to performing MRA of the hands as well as the spectrum of imaging findings is necessary.
for recognition and accurate diagnosis of conditions affecting the vasculature of the hands.

Imaging findings OR Procedure details

MRA of the Hand: Technical Considerations

For assessment of the vasculature of the hands with MR, imaging is most often performed employing the use of a multichannel, phased-array surface coil. The use of a phased-array surface coil specifically designed for the extremity, wrist or hand allows for the signal to noise ratio to be maximized, an important consideration in MR angiography of the hands where the vessels being studied can be less than a millimeter in diameter.

Most commonly, patients are positioned prone in the MR scanner with the extremity to be studied raised directly above the head. Alternatively, if the patient can not tolerate sustained positioning of the arm above the head, the exam may be performed with the arm and hand positioned at the side of the patient. Regardless of the position of the arm, the palm of the hand being imaged should be positioned flat along the surface of the scanner table, thereby minimizing the possibility of distortion of the vessels and reducing the risk that any portion of the hand may end up extending outside of the field of view.

The basic MR imaging sequences employed in MR angiographic evaluation of the hands are radiofrequency spoiled gradient echo sequences. While 2D and 3D time of flight imaging techniques have been commonly used and can still be used to study the hands, these techniques are time-intensive and increase the likelihood that patient motion will be introduced and degrade image quality. Advances in data acquisition techniques have made possible parallel acquisitions, reducing scan time and the risk of motion.

The gradient echo sequences in an MR angiogram of the hands are commonly acquired in the coronal plane, often with mask images obtained prior to contrast administration to allow for the generation of subtracted, contrast-enhanced images which highlight the contrast-filled vessels in the hands. Additional imaging sequences may also be obtained depending on institutional protocol or additional, exam-specific clinical questions that need to be addressed. At our institution, we routinely acquire a high-resolution T1-weighted 3D imaging sequence in addition to gradient echo images.

An important additional consideration when imaging the hands in patients being evaluated for suspected vasospastic conditions and/or Raynaud’s disease is to insure that hands are kept warm during scanning so as to maximize blood flow and supply to the distal extremities.

MRA of the Hand: Spectrum of Imaging Findings

Normal Anatomy
The normal arterial anatomy of the hand is extremely variable, and multiple anatomic variants are encountered upon imaging of the hands. The basic anatomic pattern consists of deep and superficial palmar arches with are supplied by the distal radial and ulnar arteries. These palmar arches subsequently give rise to metacarpal arteries, common digital arteries and proper digital arteries. As a general rule, the ulnar artery and its terminal branches are primarily responsible for the blood supply to the fourth and fifth digits in the hand, while the terminal radial artery most commonly supplies the vessels to the first through third digits.
Fig.: Maximum intensity projection image (MIP) from an MRA of the right hand in a patient with chronic finger swelling after trauma demonstrates normal arterial anatomy of the hand. The palmar arches can be seen arising from the radial and ulnar arteries and subsequently giving rise to the digital arteries supplying the fingers.

Significant variability exists in the palmar arches in the hands, and one of the arches -- most commonly the superficial palmar arch which arises from the ulnar artery -- is often incomplete. Variations in the palmar arches subsequently give rise to additional anatomic variations in the branch vessels arising from the arches.

**Vascular Pathology**

Aneurysms

Aneurysms of the vessels in the hands may be associated with a history of atherosclerosis, infection, vasculitis, or trauma. True aneurysms in the hands are traditionally seen as a result of repetitive trauma, while false aneurysms may also be caused by trauma but are more likely to be caused by other etiologies.
**Fig.**: MIP MRA image demonstrating an aneurysm arising from an anomalous median artery.
**Fig.**: 3D T1-weighted postcontrast image showing the aneurysm and a small quantity of associated thrombus within the aneurysm.

Aneurysms in the hands may be a source of microemboli distally to the digits.

**Emboli**

Emboli to the hands most commonly originate from a central, cardiac source, although roughly 25% of emboli to the hands originate from a source in the more proximal vasculature of the upper extremity. Depending on the origin of the embolic material, emboli may present with abrupt occlusion of the larger vessels in the hands such as the distal radial and ulnar arteries, or may manifest as multiple filling defects within the smaller, more distal vessels arising from the palmar arches. Microemboli to the hands may occasionally result from repetitive trauma, causing multiple small, segmental occlusions within the digital arteries.
Fig.: A MIP MRA image in a patient with a history of repeated occupational trauma to the hand shows multiple focal and segmental occlusions involving the digital arteries representing microemboli.
Trauma

MR angiography can be performed for assessment of the hand vasculature after trauma to look for evidence of post-traumatic aneurysm formation, devascularization or other changes, but MRA is typically not indicated in the setting of acute trauma or vascular injury to the hand.
**Fig.**: This MIP MRA image from a patient who endorsed a history of penetrating trauma to the interspace between the first and second digits shows no flow within the digital arteries along the radial aspect of the second digit.
**Fig.** A postcontrast image from the same patient as in Figure 4a shows enhancing scar tissue at the interspace between the first and second digits, at the site of the prior injury.

**Vascular Malformations**

MRA is an excellent tool in the assessment of vascular malformations of the hands, providing information about size, extent, degree of vascularity, feeding vessels and flow characteristics of these lesions. This information is important for treatment planning, whether surgical or endovascular.
**Fig.**: STIR image from a young boy with a palpable nodule along the radial aspect of the second digit of the hand showing increased signal intensity along the proximal phalanx of the second digit.
**Fig.**: Corresponding T1-weighted image demonstrates an abnormal focus of low to intermediate signal intensity along the radial aspect of the proximal phalanx in the second digit.
Fig.: MIP MRA image shows no abnormal arterial vasculature in association with the soft tissue mass of the second digit but abnormal venous blood flow was noted.
at the site of this lesion as well as along the radial side of the thumb, compatible with venolymphatic malformations.
**Fig.**: Postcontrast 3D T1-weighted image depicts the enlarged venous channel running along the radial side of the thumb in association with the venolymphatic malformation.
Fig.: A MIP MRA image reveals several faint "blushes" of contrast opacification along the digits in this patient with known hobnail hemangiomas.
**Fig.** In this postcontrast 3D T1-weighted image, the hobnail hemangiomas appear as discrete foci of enhancement within the soft tissues of the hand.
**Fig.**: High resolution postcontrast 3D T1-weighted image in a patient with a known, complex arteriovenous malformation reveals a portion of the vascular lesion in the dorsal aspect of the hand.

Raynaud Disease

Vasospastic disorders such as Raynaud disease can be distinguished from other causes of vaso-occlusive disease in the hands by MRA. MRA also circumvents the risk of exacerbation of the vasospastic symptoms that can be seen in patients with Raynaud disease who undergo DSA with contrast injection.
**Fig.** A MIP MRA image in a patient with pain and discoloration of the hands reveals relatively normal proximal vaculature in the hands but no filling of the proper digital arteries to the first through fourth digits, compatible with Raynaud’s disease.
Connective Tissue Disorders and Vasculitides

Connective Tissue Disorders represent a heterogenous group of conditions which are characterized, at least in part, by abnormalities of the arteries in the distal upper extremities. This group of diseases includes scleroderma, systemic sclerosis, CREST, systemic lupus erythematosus, dermatomyositis and polyarteritis nodosa, to name a few. The underlying pathology is related to the development of an obliterative endarteritis, and these conditions may result in multifocal narrowing of the vessels of the distal forearm and hand or may be seen to cause multifocal vessel occlusions.
**Fig.**: MIP MRA image in a patient with a long history of chronic digital ulcers secondary to vasculitis reveals multiple vascular occlusions involving the distal radial artery, the palmar arches and the digital arteries. Several hypertrophied collaterals are noted supplying the hand as well.
Fig.: Thick MPR of a postcontrast T1-weighted image again shows the multiple vascular occlusions and the relative paucity of blood flow to the distal digits.
Fig.: Multiple segmental occlusions are seen in the distal ulnar artery, superficial palmar arch, common digital arteries and proper digital arteries on this MIP MR angiogram image from a patient with CREST.

Conclusion

MR Angiography of the hands performed on 3T scanners takes advantage of the improved spatial resolution at the higher field strength and allows for the use advanced imaging techniques which allow for an excellent depiction of the small vessels and soft tissues of the hands, enabling assessment of normal vascular anatomy and a wide range of vascular pathology. However, performing high-quality, diagnostic MR angiographic studies of the hands still remains technically challenging and requires an understanding of the technical considerations which play an important role in optimizing MR imaging techniques in order to maximize the clinical utility of the examinations.

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References

