Ultrahigh field MRI after upper extremity transplantation.

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Target audience: Researchers and clinicians who are interested in ultrahigh field (UHF) MRI after upper extremity transplantation (UET).

Purpose: Reconstructive transplantation is a clinical reality with more than a dozen countries across the world performing unilateral and bilateral transplantation [1]. Statistics indicate that upper extremity (UE) trauma constitutes 39% of combat injuries [2-4]. As of 2005, 1.6 million civilians suffer from limb loss in the US alone. Of these, 34,000 had major loss of an UE [2]. These numbers are expected to go up to 3.6 million by 2050 [1-2]. If only 1% of this population qualifies to undergo transplant surgery, that mandates the need for additional transplant infrastructure in addition to standardized pre and post-surgical evaluation and monitoring methods. Over the past 15 years, 17 patients have undergone UET in United States. Multiple conventional imaging modalities have been used to screen patients as well as monitor outcomes after UET. These include X-ray (lungs, respiratory tract, bone density), CT angiogram (vasculature, adjacent bone and soft tissue (injecting IV through blood vessel), MRI (fMRI post-transplant brain assessment). Commercially (<=3T) available MR lacks the capability to provide critical anatomical resolution compare to ultra-high field scanners (>=7T) which enable significantly superior signal-to-noise ratio (SNR), higher image resolution, and reduced scan time [5]. To our knowledge, the current study is the first ever report of 7T imaging after UET. We present results from a bilateral UET subject 4 years after surgery as part of post–transplant clinical MR assessment.

Methods: All the MR experiments were performed on a 7T Siemens Magnetom scanner, under an IRB approved consent protocol. In-vivo images were acquired using an actively detuned TEM resonator (two ports quadrature hybrid drive) in conjunction with inductively decoupled 8-channel receive only insert array (each one is 18x8 cm^2) designed for UE. 3D T1VIBE, T2DESS, TOF MRI, SWI, and DTI were optimized (this paper focuses on first three sequences) to utilize the multi-planar capabilities for evaluating and identifying the size, location, and 3D contextual anatomy of interest. T1VIBE was optimized to provide high-resolution spatial anatomical detail. T2DESS was optimized to improve higher spatial resolution and CNR/SNR. Non-contrast enhanced (ToF) MR angiography technique was used to provide the advantage of longer T1 relaxation constant at 7T.

Results: T1VIBE (Patient: Figure 1 [a(axial), b, d, e(coronal)]: Right hand, [i(axial- veins and arteries), j(sagittal)]: left hand, [q, r (axial), s(sagittal)]: Volunteer) shows exquisite high resolution anatomy for assessing phalangeal, metacarpal and carpal bone edema, erosion, cartilage, tendon and other soft tissue anatomy in patients, as well as neurovascular anatomy [proper palmar digital (PPD) arteries] and its branches (including capillaries on finger pulps (b,d,e)). T2DESS (Patient: 1[f]: Right hand (eight PPD/PDP), [m-o]: left hand) shows much more contrast in identifying the vessels and nerves. TOF images ([g, h]: Right Hand, [k, l, p]: Left hand, Volunteer: [t, u]) clearly shows not only digital arteries but its branches and capillary bed all the way towards finger tips. Figure 2 shows comparison of vessel diameter of PPD artery between volunteer and patient's index (Figure 2i) and middle finger(Figure2m). The mean diameter in all four fingers are listed below: Ring finger: 2±0.6mm(V),1±0.4mm(P),MiddleFinger:2.6±0.6mm(V),1.55±0.4mm(P),Index finger:1.4±0.4mm(V),0.97±0.4mm(P),Baby finger: 1.55±0.6mm(V), 1.23±0.4mm(P).

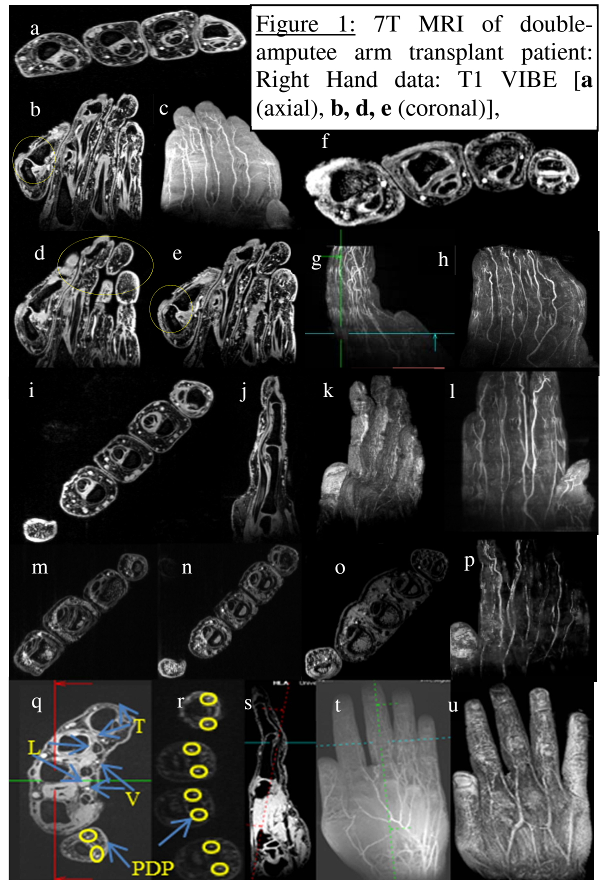

Figure 1: 7T MRI of double-amputee arm transplant patient: Right Hand data: T1 VIBE [**a** (axial), **b, d, e** (coronal)],

Figure 1 (continue): T2DESS [**f**], and TOF [**g, h**]; Left hand: T1VIBE [**i, j**], T2DESS [**m, n, o**], and TOF [**k, l, p**]. Volunteer 7T MRI: T1VIBE [**q, r, s**] (L: ligaments, T: tendons, V: vessels), and TOF [**t, u**].

The following Acquisition Parameters were utilized.		
Sequences	FOV(mm)	TR/TE (ms)
T2DESS (294x 448)	105x160	18/5.2
T1VIBE (304x512)	95x160	12/4.5
TOF (236x640)	85x208	12/4.5

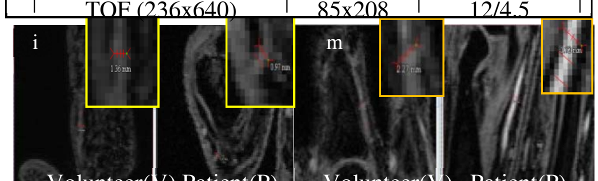

Figure 2: Vessel dia. comparison for patient and volunteer

Conclusion: This study shows a potential of not only using UHF-MRI in post-transplant evaluation after UET but more importantly could be implemented to great value in hand surgery practice in diagnosis and interpretation of scaphoid fractures, avascular necrosis, carpal dislocations, triangular cartilage tears and multiple other vascular abnormalities, connective tissue disorders or micro-vascular disease conditions.

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