Preliminary Study for Systemic Sclerosis Staging with MRI

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Introduction:

Systemic sclerosis (SSc) is a rare disease that causes systemic proliferation of connective tissue in the skin and internal organs such as the gastrointestinal tract, lungs, heart, and kidneys [1]. With Raynaud phenomenon occurring in almost all patients, this disease is characterized by digital artery vasospasm and cold hands [2]. However, although the nomenclature and classification system is effective for the diagnosis of SSc, no established system has been proposed for the staging and quantification of this disease by an imaging method. A non-invasive, highly reproducible imaging method would increase knowledge about this debilitating disease and improve treatments for it. MRI has the potential to study this disease through the evaluation of soft tissue and vascular involvements. The goal of this prospective is to establish a comprehensive high resolution MRI technique that can study sub-skin layer soft tissue conditions, and blood supply and vessel wall thickness in human forearms and fingers.

Material and Methods:

Patients All imaging for this study was performed on a 1.5T MR scanner (GE Healthcare, Milwaukee, WI). All human subjects, including 6 volunteers and 3 patients (Limited type), participated in the study after giving their written informed consent. During the scanning, distal part of the forearm was scanned with a phased-array wrist coil.

MRI Protocol In this study, phase-contrast (TR/TE=23/2.7ms), double inversion recovery black-blood T1-weighted (TR/TI/TE=800/320/10ms) and Time of Flight (TOF, TR/TE/FA=23/2.7/20) images were obtained. Other imaging parameters are the same for all images: FOV 8cm*8cm, matrix size: 256*256, slice thickness 2mm, NEX = 2.

Flow quantification Blood flow information was obtained based on the phase contrast images on a pixel-by-pixel fashion, according to the method described previously [4]. Lumped flow velocity was used in each vessel by averaging all pixels in the lumen.

Vessel morphological information Contours of the lumen and outer wall of interested vessels were manually drawn on the MR images by an experienced MR radiologist. The following morphological information was then extracted with custom-made software: lumen diameter and wall thickness of interested arteries and veins.

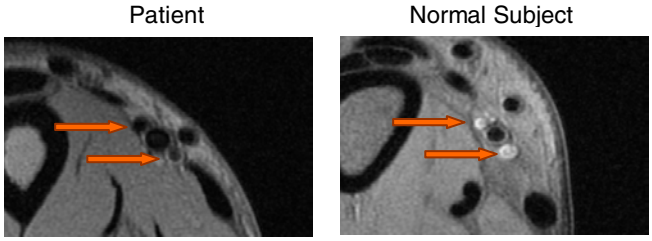

Fig. 1 Comparison of blood flow signal in radial veins (arrows). Good blood suppression in SSc patients indicates higher blood flow

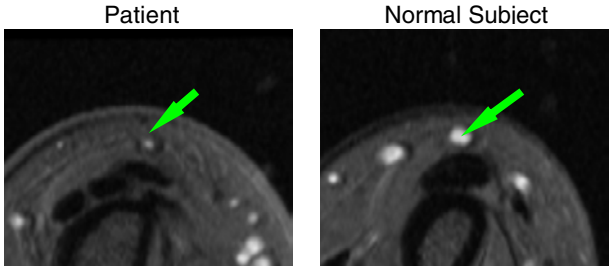

Fig. 2 Comparison of blood flow signal in cephalic veins (arrows). Decreased signal in SSc patients indicates lower blood flow

Results and discussion:

Venous flow redistribution effect

With an in-plane resolution of 0.31*0.31mm^2, this effect is consistently observed in all patients. In DIR black blood T1-weighted images, flow suppression in patients' radial veins indicates a much higher blood flow compared with normal subject (Fig. 1). Besides, an accompanying blood flow decrease was observed in cephalic vein, as shown in TOF images (Fig. 2). This venous blood flow redistribution effect was also quantified in two patients with phase contrast technique. Quantified results again confirmed this venous redistribution effect (Table 1).

As SSc is believed to start from fingers, imperative needs existed to apply this flow quantification technique in finger vasculatures. To achieve that aim, a higher spatial resolution will be desired.

Table 1 Venous flow comparison

(cm/s)	Radio vein	Cephalic vein
SSc	13.4	22.5
Normal	2.3	32.7

Table 2 Vessel morphology comparison

(mm)	r_{lumen}	$r_{outerwall}$	thickness
SSc	1.11	1.46	0.35
Normal	0.88	1.32	0.56

Morphological parameter comparison in arteries

Lumen radius and wall thickness of the radial arteries were quantified in all subjects according to the method described above. SSc patients present both larger lumen size and thinner wall thickness (Table 2). Also a higher spatial resolution will benefit the quantification process, facilitating the application in finger imaging.

Conclusions:

To our best knowledge, it is the first time that MRI was used as a quantitative tool to study SSc. A spatial resolution of 0.31*0.31mm^2 is used in *in-vivo* patient imaging, which allows the quantification of blood flow and morphological information in forearm. Strong trend has been shown by venous flow and vessel morphology quantification. Results show that MRI will be a powerful tool for future SSc study.

Reference:

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