A VOLUME COIL AND A MULTICHANNEL RECEIVE ARRAY FOR HIGH RESOLUTION HAND/WRIST IMAGING AT 7 T

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Introduction: High resolution MR imaging of hand is mandatory both to improve early diagnosis and for our understanding of diseases like Rheumatoid Arthritis and Osteoarthritis of wrist and finger joints. This requires RF coils optimised for different regions within the hand; for e.g., optimised wrist coils cannot be expected to provide high resolution images of finger joints [1]. While 7 T promises excellent SNR for high resolution imaging of the hand, the usual approach of transmit or transceive arrays may not be the best solutions here, since arrays with a very high density and filling factor are required. This is due to the fact that the hand is a relatively small object (compared to head/abdomen imaging) and sample noise domination is not necessarily achieved. Constructing a high density transmit array is also infeasible. We present a combination of a volume transmit coil and a 12 channel high density receive (Rx) array for wrist imaging at 7 T. The coil is electrically characterised and images from initial studies are presented.

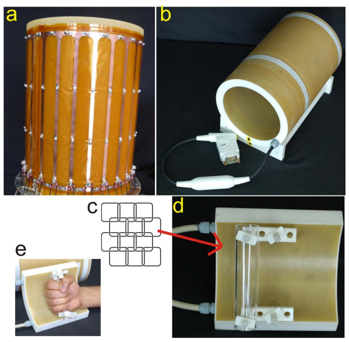

Fig.1: 'a' and 'b' show the constructed birdcage. The receive array schematic shown in 'c' is distibuted over the curved plate, seen in 'd', which is the finished Rx array. The optional hand holder can also be seen and as shown in 'e' the patient can wrap their hand around the holder.

Materials and Methods: A volume transmit coil was constructed for the whole hand as a relatively homogeneous B_1^+ profile can be obtained (due to low dielectric effects unlike head) and it allows the possibility to use high density receive arrays in combination.
A 24 leg quadrature band-pass birdcage (internal diameter 18 cm, length 21 cm) was constructed as the transmit coil (fig 1). The relatively large number of legs ensures a manageable tune capacitance of 14 pF while the band-pass configuration reduces the electrical length of the legs and hence radiation losses. PIN diodes in all legs actively decouple the transmit coil during reception. The coil is completely shielded and a quadrature hybrid is used instead of a transmit/receive switch, to enable reception through the volume coil, for localisers/scout scans.
For reception, 12 elements of size 35 mm x 35 mm are distributed over a curved plate as shown in fig 1, to image the wrist and metacarpal region. The elements are actively decoupled and furthermore, passive decoupling, along with fuses are incorporated for added safety. The preamplifiers for the individual channels are located in a separate housing to minimise the electronics inside the coil which might shield/distort the transmit field. Multiple cable traps are placed in every channel as the electrical distance from the elements to the preamplifiers is large (nearly 1/3rd of λ in air). The patient has to be positioned in the 'superman' position. Here to reduce the stress caused by the same, an optional hand holder (fig.1) can be attached to the Rx array so that the patient can hold the Rx array vertically or horizontally inside the transmit coil.

Results and Discussion: While the receive elements showed a good Q drop of 7 (350/50), the transmit coil showed a drop of just above 2 (250/120) due to the large size of the transmit coil compared to the load (i.e. hand). There was no significant change in the reflection (S_{11}) at the transmit ports with and without the presence of the array at the operating frequency (297.2 MHz). The manual pulse angle calibration voltages at the scanner and flip angle maps also showed no significant change with and without the high density array. These measurements show that the transmit coil need not be retuned for the receive array and that other receive arrays, when properly decoupled, can be used in combination with the transmit coil. The average noise correlation between the receive elements is 19% when loaded with human hand. High resolution images ($0.14 \times 0.14 \times 0.5$ mm^3) (fig 2) reveal excellent contrast to noise ratio and fine anatomical details. The Rx array configuration allows an acceleration [2] of up to 4 in Head-Feet (average 'g' factor over ROI being 1.29) and 3 in Left-Right (avg 'g' of 1.75 over ROI) directions with a reduction in SNR that can be tolerated.

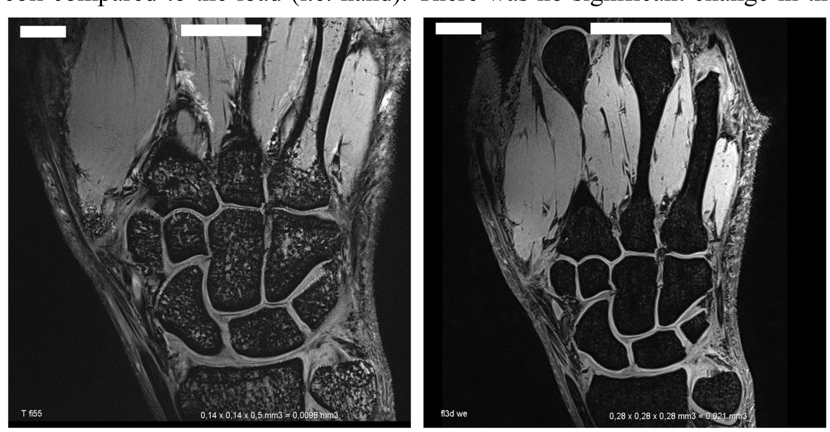

Fig.2. In vivo images of healthy volunteer. Left: 2D-FISP image with spatial resolution of 0.14 x 0.14 x 0.5 mm^3 (TR 235 ms, TE 7.16 ms, BW 170 Hz/Pix and FA 52°, Acquisition time 6:44 minutes). Right: 3D-GRE image with water excitation and resolution of 0.28 x 0.28 x 0.28 mm^3 (TR 13 ms, TE 5.61 ms, BW 220 Hz/Pix, FA 8°, Acquisition time 8:08

Conclusion: The constructed volume transmit coil along with the optimised receive array for wrist/metacarpal region, has been shown to be an excellent combination to produce images of ultra-high resolution and high SNR. Construction of other arrays for use with the transmit coil is in progress.

References: 1. Kwok et.al. JMRI 31:240–247(2010) 2. Breuer et. al.,MRM 62: 739-46 (2009)