Improved Fat Suppression with the Use of CHESS and Natural Rubber Pad

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Introduction

Rapid change of magnetic susceptibility at air/tissue interface such as neck can lead to incorrect chemical shift-selective (CHESS) fat suppression on MR imaging [1]. Applying pad devices with CHESS to shift air/tissue interface away from the skin have been used to improve the incomplete fat suppression [2]. The content of the devices was made from various tissue-susceptibility equivalent materials such as water bags, attapulgite, Japanese rice, and perfluorocarbon [3-5]. Each of these materials has pros and cons. We propose a new material for building a neck pad to improve local magnetic field inhomogeneity which was made from Hevea rubber or is so called Natural rubber (NR). NR is an elastic hydrocarbon polymer [6] and has several decent properties including magnetic susceptibility matching to human tissue, hypointense in both T1 and T2 Weighted images, and excellent flexibility to closely attach to any surface of body parts.

Materials and Methods

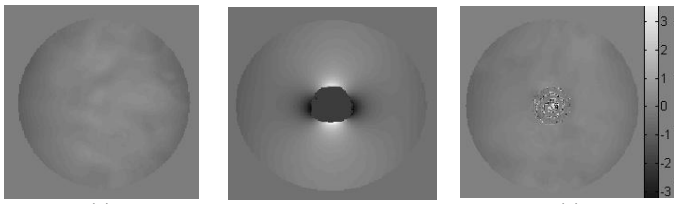
Magnetic susceptibility induced by materials was evaluated by measuring field inhomogeneity in ppm on a cylindrical water phantom (with the height of 20 cm, and diameter of 16 cm.) doped with 0.5% by volume of Gadolinium-based contrast agent. The phantom was scanned in 3 series: with an NR-filled insert, with an air-filled insert and with no insert. The diameter of the insert was 4 cm. The scanner used in this study was a GE 1.5T., Signal Excite HD. Protocol setting includes 2D SPGR pulse sequence, TR 100ms, FA 80°, FOV 22 cm, slice thickness 5 mm, matrix, 256×256 and NEX 1, TE 10 ms and TE 12 ms. The field-map is estimated from k-space data by equation (1) using MATLAB version 7.0.1

$$\Delta B_0(ppm) = \angle[I_{TE2}.I^*_{TE1}]/2.\pi.\gamma.\Delta TE.1.5 \quad (1)$$

,where ΔB_0= Magnetic field inhomogeneity in ppm., two complex images I_{TE1} and I_{TE2} at two different echo time (*TE1* and *TE2*) , ΔTE is the different Echo time between *TE1* and *TE2* in ms., and γ is Gyromagnetic ratio = 42.58 MHz/T. An NR pad was molded with approximately 1 cm-thick throughout the neck and shoulder of the GE head and neck phantom. The device was tested on 5 normal volunteers. Informed consent for MRI was approved by an institutional review board. The CTL phase array 8-channel coil was used to image the neck with fast spin echo T1- and T2-weighted along with CHESS for fat suppression. The images data were collected with and without NR pad.

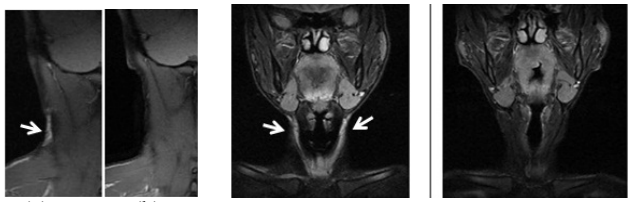
Results

Figure1. (a)-(c) shows images of the uniform phantom, air-filled insert and NR-filled insert respectively. The uniform phantom in Fig. 1(a) simulated no susceptibility effect condition. Fig. 1(b) and Fig.1(c) imitated air/tissue interface and NR pad/tissue interface conditions. The phantom result demonstrated that the NR filled image improved the field inhomogeneity due to susceptibility effect of air/water interface from 3.223 ppm down to 0.401 which is close to that of the uniform phantom, 0.237 ppm. Figure 2 shows example images in coronal views of neck in both T1W and T2 W images of a volunteer. Figure 2 (a) and (c) the lingering fat signal was still exist (white arrow) when used only CHESS for fat suppression. In contrast, Figure 2(b) and (d) shows completely fat suppression images when applied CHESS along with the NR pad. The NR pad was also invisible.



(a) (b) (c)

Figure 1 (a) shows a uniform phantom image. The calcualted field inhomogeneity was 0.237ppm. Figure1 (b) and (c) were the air-filled and NR-filled insert images. The field inhomogeneity was reduced from 3.223 ppm. at air/water interface to 0.401ppm. at pad/water interface



(a) (b) (c) (d)

Figure 2(a) and (c) the lingering fat signal (white arrow) in coronal views of neck in both T1W and T2 W images when used only CHESS for fat suppression was still remain. Figure 2(b) and (d) shows completely fat suppression images when applied CHESS along with the NR pad.

Discussion and Conclusion

This proof-of-concept was successful. The NR pad was inexpensive material which is promisingly practical to use for magnetic susceptibility reduction. It provided completely fat suppression with invisible of the device in both T1 and T2 weighted when applied along with CHESS at the air/tissue interface of neck. With an excellent flexibility property of NR, it can be closely attach to the interface. With this property, the use of NR pad is potentially extended to other parts of body. However, if the pad was poorly prepared, it could have air bubble inside and may cause susceptibility artifact particularly in the higher field strength MRI.

References [1]Anzai Y, *et al.* Am J Neuroradiol. 1992(3):879-84. [2] Eilenberg SS, et al. Artif Cells Blood Substit Immobil Biotechnol. 1994;22(4):1477-83. [3] Cox H,et al. Am J Neuroradiol, 1995. 16(6): p. 1367-9. [4] Moriya S, et al. Acta Radiol. 51(2): 175-8. [5] Moriya S, et al. J Magn Reson Imaging. 31(6): 1504-7. [6] Tavares M.I.B., et al. Polymer Bulletin, 1996. 37(2): 215-220.