A Method for De-scalping Human Brain MRI Data using Lipid Ratio Map

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INTRODUCTION: De-scalping the brain is a very critical step in MRI data post-processing and analyzing [1-7]. Most common areas of application are visualization, surface rendering, image registration, DTI and perfusion MRI data post-processing, and decreasing the complexity of subsequent processing algorithms. Many applications related to brain MRI either require, or benefits from the ability to accurately segment brain from the non-brain tissue. De-scalping is one of the interesting and challenging problems in MRI and a number of techniques have been developed for accomplishing it. A recent study published by Fennema-Notestine et al. (2006) concluded that existing algorithms had both strengths and weaknesses, but that no single algorithm was robust enough across different sequences. There is still a need for simple and robust methods for accurate de-scalping. Here we present a new simple technique for brain de-scalping. This technique is based upon lipid ratio map computed using with and without lipid saturation images, which are routinely acquired on most of the clinical scanners.

MATERIALS AND METHODS: ***Patients:*** Three healthy volunteers participated in current study. Written consent was taken from all subjects before scanning. MRI was performed on different Siemens clinical scanners (1.5T and 3T). ***MRI:*** We acquired both single slice and multiple-slices PD weighted images with and without lipid saturation. We employed Spectral Selection Attenuated Inversion Recovery (SPAIR) technique for lipid saturation. Imaging parameters used for scanning at1.5T: TR-4000 ms, TE-13 ms, turbo factor = 7, fov = 240*240, ST = 4mm and at 3T: TR=5000 ms, TE= 9 ms. ***Method:*** Brain scalp contains a very high lipid content compared to brain tissues, and this is the basis of our de-scalping procedure. First step is to compute Lipid ratio using formula: *Lipid Ratio = 100*(LipidSatOff-LipidSatOn)/LipidSatOff*, where *LipidSatOff* and *LipidSatOn* are MRI images acquired without and with frequency selective lipid saturation (SPAIR) pulse. In the second step, set a threshold to remove scalp pixels. In the present study, a threshold of LipidRatio =35 (%) is used. This value is observed to works well for de-scalping. Some isolated scalp pixels may still remain which can be removed by morphological operations. Here we applied morphological operation opening with circular disk, kernel of size 7 and this step was followed by retaining only largest connected component (which is brain). These operations may leads to small holes inside brain, which can be filled by applying some hole filling operation.

RESULTS AND DISCUSSIONS: Figure 1 shows MRI brain images without (A) and with lipid saturation (B), and computed Lipid Ratio map (C), respectively. An overlay of de-scalped brain over original brain without lipid saturation is shown in **figure 2**. Different de-scalped slices are shown in figure 3. Results show that de-scalping was accurately achieved through current procedure for data acquired at both scanners. The de-scalping has to be applied on PD-weighted data for better results and de-scalped-brain data mask so obtained has to be used for other sequences images. Here important thing to note is that lipid saturation has to be done using frequency selective saturation pulses, like SPAIR, that are normally available on most of the clinical scanners. While the current threshold value (Lipid Ratio = 30) is observation based and works well for our all data sets, it may need to be tweaked appropriately for different applications. In multi-slice data, Lipid ratio of brain was found to be higher compared to single slice imaging. This may be due to partial lipid saturation in the case of multi-slice acquisition. Current procedure worked well for both single and multi-slice acquisition. Morphological operation's kernel size and type may require changes depending upon quality of MRI data. In conclusion, we presented a simple brain de-scalping procedure, which is fast, robust and can be applied to data gathered on any clinical scanner.

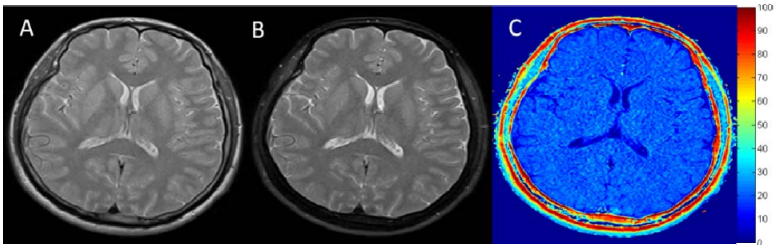

Figure 1. PD-Weighted without (A) and with (b) LipidSat and computed Lipid-Ratio

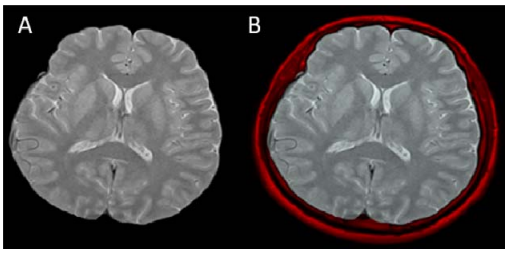

Figure 2. De-scalped brain (A) and overlay of brain and non-brain part (B).

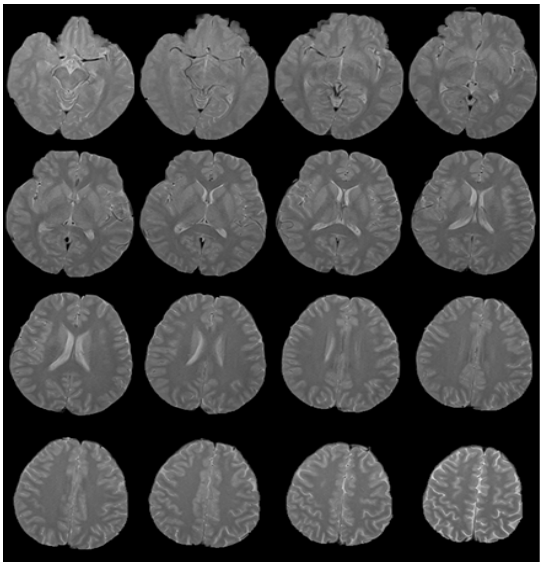

Figure 3. De-scalped multi slices of human brain.

REFERENCES: [1] Woods et al., 1998, 1999; [2] Grachev et al., 1999; [3] Grabowski et al., 2000; [4] Wells et al., 1996; [5] Rusinek et al., 1991; [6] Jernigan et al., 2001; [7] Mazziotta et al., 2001.

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