A Qualitative Comparison of Magnetic Resonance Images of Brain Acquired using Phased-array Head coils with 32 and 12 Array Elements at 1.5 Tesla

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Introduction: A phased-array coil consists of multiple array elements spatially arranged in a desired geometry. Application of phased-array coils improves the image quality and also provides an opportunity to apply parallel imaging. Dedicated phased-array head coils with many elements are commercially available and the FDA has approved the use of a phased-array head coil with 32 elements for clinical brain imaging. Images acquired using this coil have a higher signal-to-noise ratio (SNR) than those acquired using a head coil with lower number of elements (1). While SNR is a reliable quantitative parameter, increase in SNR does not always predict improvement in diagnostic value for complex imaging studies (2). Therefore, to investigate whether use of this 32 element head coil would provide any additional advantage in terms of clinical utility of the resultant images, we qualitatively compare the head MR images acquired using this coil with those acquired using a commercially available head coil with 12 elements.

Methods: This prospective study was approved by the Institutional Review Board. The study population consists of those 21 patients (M/F 9/ 12, mean age 51.6 yrs) who came to our hospital for brain imaging and who were willing to participate in the study. MRI images of these patients were obtained on one of the 1.5T scanners (MAGNETOM Espree/Avanto, Siemens) available at our institute. Two sets of MR images of each subject were separately and sequentially acquired in single setting using the 32 element head coil (coil A) and the conventional 12 element head coil (coil B). Both the coils are manufactured by Siemens Medical Solutions, Erlangen, Germany**.** Each image set consisted of axial T_1-, T_2- and diffusion-weighted (DWI), and fluid-attenuated inversion recovery (FLAIR) images; yielding 4 pairs of images of each kind for every subject. For each pair, images from the two coils were compared side-by-side by three neuroradiologists in terms of the image quality, extent of artifact and visibility of the lesion, if any. The image quality was determined in terms of the following factors: differentiation of grey and white matter at the level of central sulcus (CS), lateral ventricles (LV) and middle cerebral peduncle (MCP); smoothness of white matter tracts of the centrum semiovale (WMT); differentiation of basal ganglia and internal capsule (BG/IC) and mid brain structures and red nucleus (MB/RN); and overall evaluation of the optic apparatus (CNII) and facial and vestibule-cochlear nerves (CNVII/VIII). For the pairs of DWI images WMT, CN II and CN VII/VIII were not evaluated. Each pair was assigned a rating that was determined by the following criteria: 0 (no difference between the two images), +1/ -1 (apparently better quality of the image from coil A/B), and +2/ -2 (markedly better quality of the image from coil A/B). The ratings from all the parameters for a pair of images were combined together to determine the overall rating for the pair. Similarly, each pair was assigned rating for visibility of the lesion (if present) and image artifacts (motion, pulsation or susceptibility artifact) in images from the two coils by the criteria given as follows: 0 (same quality in the two images), +1/ -1 (better quality without improvement in diagnostic value of the image from coil A/B), and +2/ -2 (better quality with improved diagnostic value of the image from coil A/B). The scores assigned to each pair by the three neuroradiologists were combined together to obtain the average value for each parameter for the pair. Trends of score of all the pairs for all the parameters were analyzed using 2-tailed t-test (a P-value of 0.05 was taken as reference for significance).

Results: The image quality was better for coil A (32 elements) in 20 out of total of 30 evaluated parameters, whereas, no significant difference was observed between the two coils for the remaining 10 parameters. Coil B (12 elements) was never preferred over coil A (Table 1). There was no significant difference between two coils in terms of image artifacts. Out of total of 41 identified lesions, 25 were in the cortex or subcortical white matter, 6 in the deep brain structures, 3 in the cerebellum or brainstem and 7 were extra-axial. There was a significant preference of coil A for lesion visibility in the cortical and sub-cortical white matter, and deep brain structures, no significant difference was observed for lesions in extra-axial space, cerebellum and brainstem. The mean (± standard deviation) rating for all the lesions, cortical and subcortical white matter, and deep brain lesions is 0.55±0.40, 0.65±0.28, and 0.67±0.30, respectively.

Parameter	Trend of preference in the images			
	T_1	T_2	FLAIR	DWI
CS	A (0.30±0.56)	A (0.49±0.33)	A (0.81±0.46)	A (1.19±0.39)
LV	A (0.42±0.52)	A (0.73±0.36)	A (0.98±0.49)	A (1.23±0.38)
MCP	None	A (0.70±0.39)	A (0.83±0.60)	A (0.83±0.84)
WMT	A (0.78±0.41)	A (0.97±0.39)	A (1.2±0.39)	n/a
BG/IC	None	A (0.79±0.49)	A (1.06±0.29)	A (1.03±0.55)
MB/RN	None	None	None	A (0.43±0.84)
CN II	None	A (0.33±0.62)	A (0.17±0.36)	n/a
CN VII/VIII	None	None	None	n/a
Overall	None	A (0.86±0.29)	A (0.96±0.35)	A (1.06±0.49)

Table 1: Results showing trend of preference of a coil for various parameters of image quality and mean ± standard deviation of the rating for those parameters for which a significant preference was observed. n/a: not analyzed; A: images acquired using the coil A were preferred; none: no significant trend of preference was observed.

Discussion: The results demonstrate a preference for the coil with 32 elements in particular for FLAIR, T_2- and diffusion-weighted images (Figure 1). Application of this coil improved image quality without increasing image artifacts. This 32-element coil has been reported to improve the SNR and the g-factor as compared to commercial 8-element head coil. However, the SNR improvement is not uniform from the entire imaging volume and is higher from the peripheral regions as compared to the central regions (1). Results of this study demonstrate that application of this head coil improves the image quality even from the central regions of the brain. The results confirm that use of this head coil with 32 elements can provide brain images with better quality and also improve their diagnostic utility. This can potentially enable one to generate image quality at 1.5T similar in many ways to improved images seen at 3T though with much greater availability and diminished cost.

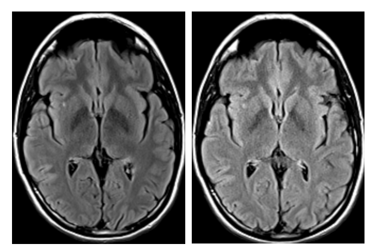

Figure 1: FLAIR images of a patient obtained using the 32 (left) and 12 (right) array elements coil. Grey and white matter can be better differentiated on the left image.

Conclusion: A preference for the head coil with 32 elements in terms of image quality as well as lesion visibility in the cortical and sub-cortical white matter and deep brain structures without any increase in the image artifacts confirm a clinical improvement in MR images produced using this coil.

References: 1. Wiggins, G.C., et al. Magn Reson Med, 2006. 56(1): 216-23. 2 Chapman BE, et al. Comput Biomed Res. 1999; 32:530-556.

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