SAR around uni- and bi-lateral metal-on-metal hip implants at 1.5 and 3T

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INTRODUCTION

There is a predicted increase of hip arthroplasties, with the demand estimated to grow by 174% between 2005 and 2030 in the United States [1]. This has lead to the widespread use of MRI in patients with orthopaedic implants which is further aided by the development of new MRI sequences aimed to reduce artefacts associated with metal implants. The sequences mostly used clinically [2] are turbo spin echo sequences that utilize closely spaced 180^o RF pulses leading to increase in the Specific Absorption Rate (SAR). There is also an interaction between the RF field and the prosthetic devices that may lead to localised increase in SAR and tissue heating in areas surrounding the prosthesis. Furthermore, there is a significant increase 3T MRI clinical systems. High field MRI systems cause more susceptibility artefacts and SAR increases with the transmit frequency.

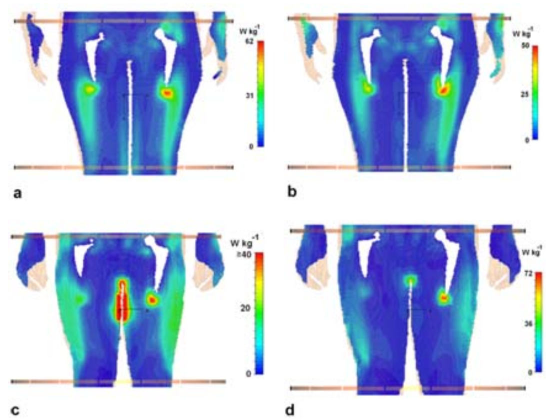
METHODS

A commercial electromagnetic field solver software package was used to predict SAR distributions for the case of a CoCr hip prosthesis placed uni- and bilaterally within an anatomically realistic adult male voxel model (NORMAN) and exposed to the RF field from at 60cm body coil at 1.5T and 3T at various positions within the coil [3]. The spatially dependent SAR10g distribution was calculated and values were scaled to 2 W/kg whole body SAR.

RESULTS

Results are shown for bilateral hips in the table and figures below. All situations exceeded the local SAR limits of 10 W/kg in trunk for 6 mins exposure [4]. However in several situations, the global maximum SAR_{10g} occurred at locations remote from the implant. In cases where the hip implant was external to the RF transmit coil, no significant localised SAR increases were predicted. SAR for uni-lateral implants were not significantly different.

Model	Maximum SAR_{10g} at prosthesis		
	64 MHz	128 MHz	Location
$NAOMI_{shaft}$	61.3 (a)	49.3 (b)	shaft
$NAOMI_{ball}$	43.4	43.9	ball
$NORMAN_{shaft}$	38.4 (c)	72.8 (d)	shaft
$NORMAN_{ball}$	27.3	39.9	shaft
$NORMAN_{out}$		6	shaft



DISCUSSION

Resulting temperature increases in excess of 1^oC may occur from these SAR levels. Compliance with limits is likely to require a reduction in whole body SAR (SAR_{wb}) or in the time averaged (over 6 minutes) SAR_{10g}. To comply with local limits, SAR_{wb} needs to be below 0.27 W/kg (averaged over 6 mins). Apart from reduction of flip angle and number of slices, all other parameters that can be changed to reduce SAR, i.e. increase in TR, reduction of turbo factor etc, lead to increase in scan time. The model did not account for tissue cooling, and is not applicable to wide bore systems.

References

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