PERCUTANEOUS LASER DISC DECOMPRESSION (PLDD) IN AN OPEN HIGH-FIELD MRI

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Introduction:

Over the last two decades, percutaneous laser disk decompression (PLDD) has become increasingly popular, as treatment for persistent low back pain, caused by lumbar disc prolapse. Several authors have reported on promising results for PLDD under CT guidance and fluoroscopy. [1;2]. The few complications of PLDD are associated with excessive heat deposition within the disc, causing thermal damage and subsequent scarring or even necrosis of the surrounding structures [3].

MRI enables not only interactive navigation, but also permits online monitoring of the temperature spread. Previous studies reported on MR thermometry strategies in an open low-field MRI (0.5 and 0.3 Tesla) based on T1 effects [4;5].

Purpose:

To assess the feasibility and technical properties of guidance and thermal monitoring of laser disc decompression in an open high-field MRI at 1.0 T.

Material and Methods:

The study was performed ex vivo on 30 disks in ten cadaveric lumbar spines. A fluoroscopic PD-w Turbo Spin Echo (TSE) sequence (TR/TE 600/10ms; TF 36; FA 90°; res. 0.9x1.9x5 mm; scan duration 3.0 s) was used for interactive positioning of a laser fiber and a temperature probe within the targeted disc. The following laser procedure with a 1064nm Nd:YAG laser (medilas fibertom 5100, Dornier Med Tech, Wessling, Germany) was monitored with T1 effects and subsequently evaluated with proton resonance frequency (PRF) data from 3D gradient echo sequences with a resolution of 2.78x2.94x4.00 mm and three different echo times (Table 1)[6]. PRF data sets were used to calculate the temperature from phase images after data export to a temperature-mapping tool based on IDL. To correlate the calculated temperature maps with the actual temperature data, the MR-compatible fiber-optic thermometer (reFlex, Neoptix Inc., Québec, Canada) recorded the temperature throughout the laser procedure. Both temperature curves were then plotted and correlated. A correlation coefficient was calculated for each disc. Macroscopic lesion sizes and final lesion size on MR images post PLDD were measured and compared to investigate the precision of each GRE sequence.

GRE	TR/TE	FA	Scan duration	Slices
a)	4.3/2ms	27°	4.6 sec	7
b)	10/7ms	27°	13.1 sec	7
c)	6.7/10ms shifted echo	35°	13.4 sec	5

Table 1: *Evaluated GRE sequences and parameters.*

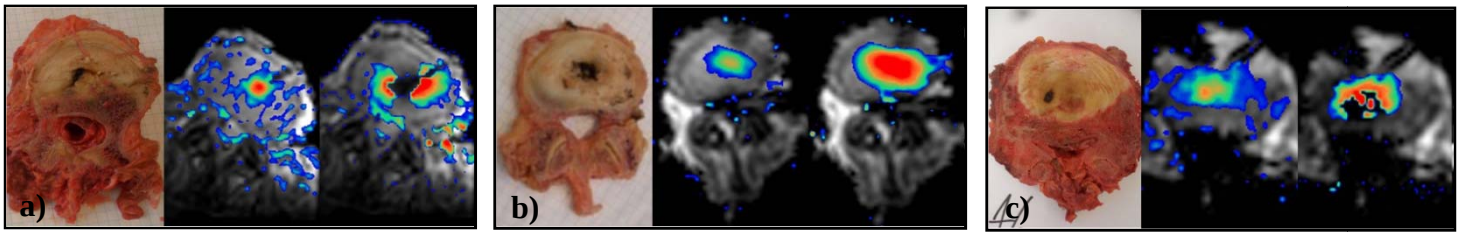

Image 1 a) b) c): *PRF data from the three GRE sequences. a) TE 2ms; b) 7ms; c) TE 10ms (shifted echo) (each series from left to right: actual lesion post PLDD; temperature map at 1min; at 9min)*

Results:

MR-guided placement of the laser fiber into the targeted disk was precise. Laser effects were depicted online on MRI in all cases. A strong correlation between MR-guided PRF thermometry and actual temperature was established for the GRE sequences, especially with a TE of 7ms (r^2 = 0.81 for a); 0.94 for b) and 0.77 for c): Table 2). The macroscopic size of necrosis correlated well with the monitored temperature spread (Image 1).

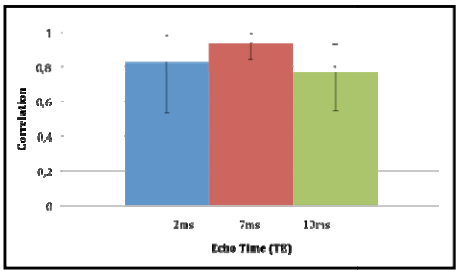

Table 2: *Correlation of actual temperature and PRF calculated temperature and standard deviation for each GRE sequence.*

Discussion:

The T1 effect is useful in direct visual monitoring of the temperature spread within the cadaveric disc and can be somewhat objectified when plotting the signal decrease in the treated ROI over time. The color-coded technique (PRF) was found to be valuable in addition to conventional magnitude images (T1). Moreover, we had expected the GRE with a TE of 10ms to show superior temperature correlation (Image 1c). However, the decreased image quality in the 10ms TE GRE images, although not statistically significant, made temperature correlation with more difficult (Table 2). We assume this is owed to additional phase shifts, which are caused by susceptibility differences between the disk and the surrounding tissue. This may also cause signal voids. The complications associated with PLDD are associated to uncontrolled temperature spread and ensuing thermal lesions or necrosis of spinal ganglia, nerve roots, vertebral endplates or spinal cord. Therefore, it is important to investigate means to limit such risks. Thermometry with MRI data sets is a promising prospect in pursuing this goal.

Conclusion:

Instrument guidance and laser monitoring in the open high-field MRI at 1.0 T is accurate with rapid image updates using fast TSE and GRE sequence designs, which may render PLDD more safe and controllable compared to CT and fluoroscopy navigated procedures. This technique may be a promising minimally invasive alternative to open spinal surgery to some patients.

References

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