

First human application of laser interstitial thermal therapy in GBM using MR Guided AutoLITT system

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INTRODUCTION

Glioblastoma (GB) is the most frequent primary brain malignancy in adults, usually resulting in death in 1-2 years despite decades of research. Although treatments such as surgery, chemotherapy, and radiation each extend survival by 2-3 months, recurrence is inevitable. Retreatment-related morbidity must be weighed against expected benefit. Therefore, a minimally invasive treatment such as LITT is attractive. The recently developed Laser Interstitial Thermal Therapy (LITT) treats tumors by using laser energy to heat tissue, producing coagulation and necrosis. AutoLITT (Monteris Medical, Winnipeg, Canada) refines this concept with a complete system using a directional and controllable laser probe, with feedback magnetic resonance thermometry providing real-time prediction of tissue necrosis. Here we describe the first human application of AutoLITT which is now undergoing FDA approved phase 1 trials. AutoLITT was recently applied to a 47 year old man with recurrent GBM in the left temporal lobe, and represents the first human application of AutoLITT. Further, work builds on previous efforts in Germany^{1,2} and Boston³ that used LITT. This work differs, however, by incorporating a controllable system featuring real-time monitoring of thermal dose. FDA IDE followed extensive animal testing, and an IRB-approved protocol was followed. AutoLITT is anticipated to have FDA clearance for human use in 2008.

METHODS

Figure 1 is a cartoon of the AutoLITT system, showing a gas-cooled laser assembly inserted through a burr hole into a patient's brain. The entire head assembly is moved within the MRI bore and treatment begins. The AutoLITT system centers on a probe, encompassing a side-firing laser within a gas-cooled sleeve, which is inserted into the brain through a standard burr hole. After burr hole creation and stereotactic biopsy within the operating room, the patient was transferred into a Siemens 1.5 T Espree MRI, and his head secured in a 3-pin head fixation device. The 3.3 mm diameter laser assembly was inserted to a prescribed depth within the tumor. The device was fiberoptically coupled to a 1064 nm laser. Following an initial complete series of clinical images, the neurosurgeon prescribed a treatment profile centered within an enhancing portion of the large recurrent tumor. To treat this profile, the laser was fired in 7 azimuthal directions, at 3 different levels, depositing 6410 J of energy. A special real-time MRI thermometry sequence was acquired during every moment of laser firing, whose essential component is a phase map to determine the tissue temperature. In addition to temperature, the time-history at each voxel is compared moment-to-moment in real time using a proprietary algorithm, to provide an effective thermal dose that can be compared to previously determined tissue reaction thresholds⁴. Based on these, predictive maps of tissue death are displayed in real time to assess treatment progression, which is essential for successful LITT treatment. Immediately following treatment, a second complete series of clinical images was obtained. General anesthesia was used throughout the procedure. Subsequent imaging was obtained after 24 and 48 hours, and 8, 14, 22, and 28 days.

RESULTS

Figure 2 shows a series of four slightly off-axis transverse images, which are both orthogonal to the axis of the laser probe, and within the treatment plane of the side-firing laser. Recurrent GBM is seen in the medial left temporal lobe adjacent to a previous resection cavity on a pretreatment T1W post-contrast image (Fig 2A). Figure 2B shows an overlay of the maximally desired treatment margin (green line), and final post-treatment profiles showing predicted boundaries for no effect (yellow line), partial effect (blue line), and total necrosis (white line). Figure 2C shows corresponding 48 follow-up post-contrast T1W image, showing new rim-enhancing cavity within the treatment zone. Superimposed are the predicted contours from Fig 2B, showing high correspondence. Fig 2D shows 48 hour DWI images, revealing matched reduced diffusion within the treatment zone, consistent with coagulative infarct and necrosis.

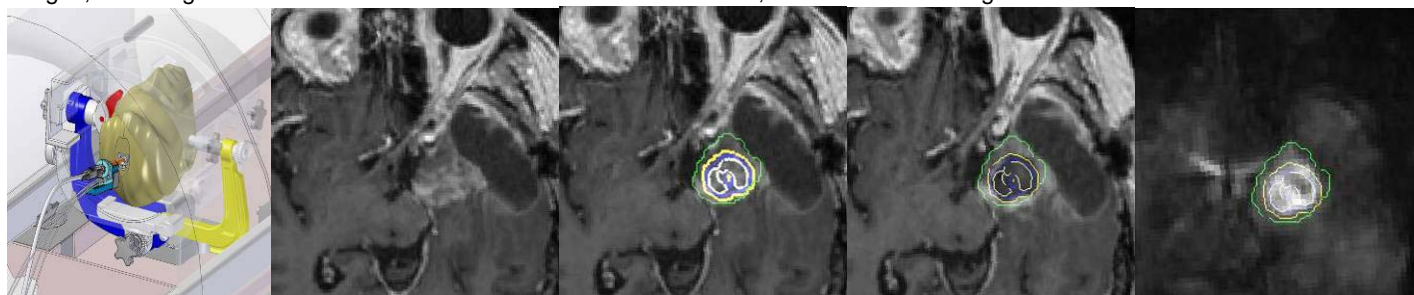


Figure 1

Figure 2A

Figure 2B

Figure 2C

Figure 2D

CONCLUSION

We describe the first human application of laser interstitial thermal therapy (LITT) of a GBM using the Monteris AutoLITT system. This system is unique in using real-time MRI thermometry to contour treatment precisely within the confines of the tumor. The AutoLITT produced thermal lesion appeared to stabilize after 48 hours and was accurately predicted by the AutoLITT software.

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