

Does the thickness of anterior abdominal wall fat affect the treatment of uterine fibroids treated with Magnetic Resonance guided Focused Ultrasound Surgery (MRgFUS)?

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INTRODUCTION

MR-guided Focused Ultrasound Surgery (MRgFUS) is a noninvasive method of thermal ablation. The ability of the focused ultrasound beam, or sonication, to penetrate through soft tissues and focus on a tissue target without damaging overlaying tissues has been shown (1). The effect of a sonication on various tissues such as fat and muscle in the abdominal wall have also been studied (2, 3). It is known that the focused ultrasound beam can be distorted by intervening fat layers and lead to aberrations in the focal point (4). Therefore the thickness of the fat layer can potentially contribute to the distortion of the ultrasound beams. In addition, if the fat layer is thick, the focal plane will likely be located further from the transducer, which reduces the gain of the transducer and increases the required power level. We have noted that in several patients treated at our institution, there are areas of abnormal enhancement with Gadolinium in the anterior abdominal wall seen after treatment.

Thus this study has 2 aims: 1) to determine whether the thickness of abdominal wall fat affects treatment patterns which are characterized by the following parameters: depth of treatment plane, mean rate of sonications delivered, and number of sonications reaching thermal dose and 2) to determine if a difference exists in the correlation of these parameters between patients with post-procedure skin abnormalities versus patients without skin abnormalities.

MATERIALS AND METHODS

45 consecutive patients (age 36-58 years) enrolled in a prospective clinical trial studying MRgFUS for treatment of symptomatic uterine fibroids were reviewed. Three patients were excluded (1 technical failure, 2 patients with 2 treatments to same fibroid). Eight patients had two fibroids treated, and one patient had three fibroids treated, yielding 60 fibroids for analysis. All patients underwent MR imaging with a 1.5 T standard whole body system (Signa; GE Medical Systems, Milwaukee, WI). T2-weighted images on the day of treatment were used to measure the thickness of abdominal wall fat from the surface of the abdominal wall to the anterior surface of the rectus sheath, in the area where the path of the focused ultrasound beam traveled during treatment. Coordinates of the surface of the abdominal treatment pad and the center of the sonications administered were obtained to calculate the depth of the treatment plane. All measurements were performed using tools on the GE Advantage Workstation. All sonications were performed with a clinical MR imaging-compatible focused ultrasound system (ExAblate 2000; Insightec Inc., Haifa, Israel). The depth of the focal plane is controlled with the phased array transducer. Total sonication time and number of sonications were collected for each fibroid treated. These values were calculated to determine the mean rate of sonications delivered. The number of sonications reaching thermal dose was defined as sonications reaching a focal temperature greater than 55 degrees Celsius. Patient with skin abnormalities were defined as those with abnormal enhancement of the abdominal wall fat on post-procedure, post-gadolinium T1-weighted images. Statistical methods used Spearman's rank coefficient and independent samples T-tests.

RESULTS

There is no correlation between the thickness of abdominal wall fat and sonications delivered ($r = 0.11$; 95% CI= -0.15 to 0.35) and number of sonications reaching thermal dose ($r = 0$; 95% CI = -0.26 to 0.25). There is a moderate correlation between the thickness of abdominal wall fat and depth of treatment plane ($r = 0.62$; 95% CI = 0.43 to 0.75). No statistically significant difference was seen in treatment parameters between the patients with skin abnormalities versus the patients without skin abnormalities.

Parameters	Skin abnormalities (mean \pm SD)	No abnormalities (mean \pm SD)	P
Fat thickness	18.1 \pm 8.8	14.7 \pm 8.8	0.34
Depth of treatment plane	71.9 \pm 15.0	63.7 \pm 20.7	0.31
Rate of sonication	2.5 \pm 0.28	2.6 \pm 0.42	0.68
Number of sonications with focal temperature above 55° C	39.1 \pm 13.8	48.9 \pm 22.1	0.26

CONCLUSIONS

It appears that the treatment pattern of MRgFUS does not vary based on thickness of the abdominal wall fat despite potential focal aberrations caused by distortion of the focused ultrasound beam through fat layers. Increased central adiposity is associated with increased levels of bioavailable estrogen. Uterine fibroid growth is known to be stimulated by estrogen. Thus, it is important to establish that patients with thicker abdominal wall fat can benefit from MRgFUS without adverse effects. Further correlations should be investigated such as thermal dose related to higher powers, dynamic sound-speed profiles in layered tissues, and repeated high thermal doses causing energy deposition or buildup in skin and fat.

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