MRgFUS treatments of uterine fibroids: role of non perfused volume

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Purpose

In 43 patients and 52 fibroids treated with Magnetic Resonance guided Focused Ultrasound Surgery (MRgFUS) the Non Perfused Volume (NPV) was evaluated six months after the treatment. The patient underwent an MR examination with T1<sub>w</sub>, T2<sub>w</sub> multi planar and contrast enhanced images before and immediately after the treatment and in the follow up. The reduction of the NPV evaluated with dynamic sequences was significant and it is responsible of the important shrinkage of the lesion.

Methods and Materials

Uterine fibroids (leiomyomas or myomas) are benign clonal tumours that arise from the smooth-muscle cells of the human uterus and affect about 25-30% of the reproductive-age women (35 - 50 years old). (Figure 1) The etiology of myomas is not well understood, but genetic predisposition, as well as steroid hormone concentrations, has a role in formation and growth of these tumours.

Only about 30% of women affected have symptoms such as:

- heavy and long menstrual bleeding associated with anemia;
- frequent urination or incontinance (anterior fibroids);
- abdominal pain or pressure;
- pain during sexual intercourse;
- reproductive dysfunction;
- constipation (posterior fibroids).

Fibroid treatment is indicated only for symptomatic cases. The possibilities are:

- hormonal therapy;
- hysterectomy;
- myomectomy;
- embolization (UAE);
- focused ultrasound such as MRgFUS.

Indications for MRgFUS treatment:

- small number of fibroids (max 3);
- fibroid size from 3 to 10 cm;
- hypointense fibroids in T2w images.

Contraindications for MRgFUS treatment:

- pedunculated fibroids;
• presence of abdominal scars;
• interposition of the small bowel between the abdominal wall and the fibroid.

All patients underwent an MR examination to evaluate the feasibility of the MRgFUS treatment.

MRgFUS is a technique that combines the power of a focused ultrasound beam to locally heat biological tissue over a necrotic level and an MRI performed at the same time. Although not necessarily required, MR imaging equipment provides several advantages, such as the guidance of the ultrasound beam in order to bypass critical anatomical structures and makes it possible to evaluate the necrotic volume after the treatment (contrast-enhanced imaging). However, the main potential of a MRgFUS system is the real-time monitoring of temperature. The quantification of heating generated by the ultrasound wave and the determination of its exact location allows the control of clinical effects, even before exceeding the necrotic threshold.

Images for this section:
Fig. 1: Fibroid classification.
Results

The system used is ExAblate 2000 (Insightec). This system consists of a circular (12 cm in diameter) phased array transducer with 208 active independent piezoelectric elements capable of generating an ultrasound beam with a frequency ranging from 0.95 to 1.35 MHz (in the uterine fibroid mode). The transducer of ExAblate 2000 is placed inside a modified MRI table and the entire system is fully integrated into an MRI scanner (SIGNA HD EXCITE 1.5 T, General Electric Medical Systems). (Figure 2)

During a uterine fibroid treatment the patient is positioned prone inside the MRI scanner with the lesion facing the transducer. (Figure 3)

Each US sonication has a duration of between 20 s and 30 s and causes a cylindrical-shaped thermal lesion in the focal point.

The treatment phases are described in Figures 4-9. The evaluation of the treatment efficacy is performed on the post-contrast sequence by selecting the fibroid area without contrast enhancement that correspond to the necrotic coagulative treated regions (NPV) (Figure 10). Six months after the treatment patients undergo an MR study with the same protocol standard and the NPV is again evaluated.

From September 2010 to December 2011 52 fibroids in 43 patients were treated with MRgFUS.

Patients underwent pelvis MRI pre and post treatment with T1w and T2w multiplanar sequences and a dynamic study with contrast agent. On these images fibroid initial volume and, at the end of the treatment, NPV was evaluated.

21 patients underwent a follow up MRI exam 6 months after the treatment to calculate the residual volume and the persistency of the necrotic area. An example of an entire procedure is shown on Figures 11-16.

The mean NPV after the treatment resulted to be 57% of the initial volume (standard deviation: 22%) (Figure 17).

In the follow up tests a significative volume reduction of 42 ± 19 % (p value <0.001) was measured, along with a significative reduction of the NPV (68 ± 21%, p value<0.001) and a slight increase of the perfused volume (PV) (5 ± 65%, p value<0.001).

Images for this section:
Fig. 2: Patient position during a uterine fibroid treatment. The transducer is placed inside the cradle.
Fig. 3: Ultrasound beam generated by the transducer is focalised in the lesion.
Fig. 4: T2w images acquired before the treatment in order to localize the fibroid.
Fig. 5: Detailed planning of the treatment: the target (yellow line) is selected in a coronal plane while in sagittal orientation the sensitive anatomical structures such as bowel (pink line), pubic bone (light blue line), skin (red line) and bone in the far field (yellow line) have to be highlighted in order to prevent negative effects. Fiducials (red crosses) are placed to monitor an eventual organ motion.
Fig. 6: Multiple spots are planned, based on the target selection, in order to cover all the volume.
Fig. 7: During the sonication the ultrasound beam and the sensitive anatomical structures are highlighted.
Fig. 8: Real time monitoring of the patient and temperature. During the sonication, thermal images are acquired with the aim to monitor the temperature inside the target and in the surrounding structures.
Fig. 9: Post treatment sequence: multi planar post-contrast T1 FAT-SAT sequence for NPV evaluation.
**Fig. 10:** Manual segmentation of the NPV (red line) compared to the fibroid volume (blue line) on post-contrast images immediately after the treatment (left) and in the follow up (right).
Fig. 11: Example of a case: T2w sequence before the treatment.
Fig. 12: Example of a case: post-contrast acquisition before the treatment.
Fig. 13: Example of a case: T2w sequence during the treatment.
**Fig. 14:** Example of a case: post-contrast acquisition immediately after the treatment.
Fig. 15: Example of a case: T2w sequence in the follow up.
Fig. 16: Example of a case: post-contrast acquisition in the follow up.
Fig. 17: Mean fibroid volume in post treatment and in follow up.
Conclusion

The necrosis determined by the MRgFUS treatment produces at six months follow up a significative reduction of the lesion volume ($p<0.001$) mainly due to shrinkage of the NPV with a non relevant increase of the PV.

References

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