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CASE REPORT

# Improved Treatment Response Following Magnetic Resonance Imaging–Guided Focused Ultrasound for Lumbar Facet Joint Pain

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## Abstract

Magnetic resonance imaging–guided focused ultrasound (MRgFUS) is a noninvasive modality that allows for precise tissue ablation with sparing of surrounding structures. Early reports of the use of MRgFUS for the treatment of facet joint osteoarthritis are promising. We present a case of facet joint pain treated successfully by MRgFUS at our institution. Magnetic resonance imaging–guided focused ultrasonography may be a useful modality for patients with facet joint–mediated low back pain, particularly in the setting of limited or refractory response to conventional treatments.

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Low back pain is one of the most common health problems around the world, with lifetime prevalence reported as 38.9%.[1] Globally, low back pain represents the leading cause of disability and may result in difficulty performing activities of daily living or occupational tasks.[2] Although there are many potential causes of chronic low back pain, facet joint osteoarthritis is responsible for 15% to 45% of cases.[3-5]

Current therapeutic techniques for facet joint–mediated pain include conservative therapy such as oral medications, intra-articular corticosteroid injections, radiofrequency (RF) neurotomy, and facet joint rhizotomy.[6,7] Intra-articular injections have been reported to provide approximately 3 to 6 months of relief.[6] Radiofrequency neurotomy has provided pain relief for 6 to 12 months, but success rates are highly variable because of technical and patient selection challenges.[6] Both of these techniques are invasive and are associated with risks of postprocedural discomfort or complications.[7]

Diagnosis of facet joint pain requires a positive response to comparative medial branch blocks (MBBs) according to the Spine Intervention Society guidelines.[8] In our clinical experience, there is a subset of patients who respond positively to comparative MBBs but report insufficient or short-duration pain relief with subsequent RF ablation, particularly in the setting of multiple prior RF ablations. According to a review article, the 3 main reasons that RF ablation fails are misdiagnosis, poor patient selection, and technical failures.[9]

The limitations of currently available treatment modalities have sparked recent interest in potential alternative treatments for facet joint pain, although published data are currently sparse.[7,10] A potential alternative treatment for patients with insufficient response to conventional treatments is magnetic resonance imaging–guided focused ultrasound (MRgFUS).[7]

Magnetic resonance imaging–guided focused ultrasound is a modality that utilizes a phased array transducer integrated within the magnetic resonance imaging (MRI) scanner to focus numerous high-energy ultrasound waves on a small focal spot in the body.[11,12] The summation of ultrasound waves causes local heating and induces rapid coagulative

necrosis.[11-13] This technique allows for extremely precise ablation of targeted tissue with sparing of surrounding structures.[11-13] The technique requires no needles or incisions because ultrasound waves are generated by a transducer outside the body.[11] Magnetic resonance imaging allows for treatment planning and guidance with direct visualization of the target, real-time thermal monitoring of the ablation zone, and postprocedural imaging.[13]

Numerous applications of MRgFUS are currently in use, largely focused on the treatment of both benign and malignant soft tissue and osseous tumors.[11,13] It has also been utilized for the treatment of other painful conditions such as facet and large joint osteoarthritis.[7,12,14]

Magnetic resonance imaging–guided focused ultrasound for the treatment of facet joint osteoarthritis has been reported in a few small human series and swine models, with promising early results.[7,15-17] The procedure is currently being performed as part of routine clinical care at selected centers in Europe and Asia.[18] Published reports evaluating the ability of MRgFUS to improve treatment response in patients with proven facet joint pain but limited durability of response to other treatments are lacking. The purpose of this report is to share our experience with such a case, with MRgFUS performed at our institution and 12 months of clinical follow-up.

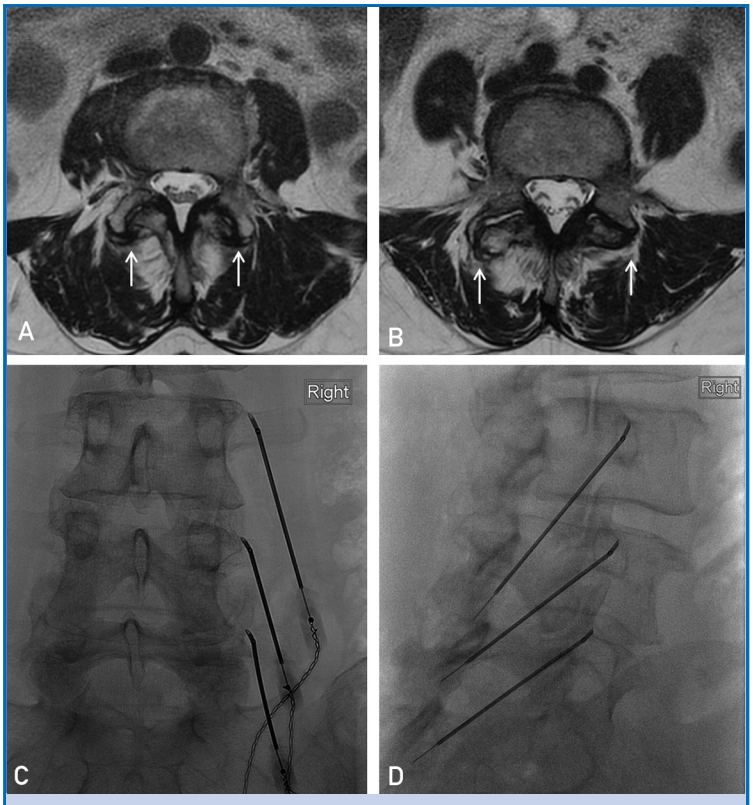


**FIGURE 1.** Axial T2-weighted magnetic resonance images showing facet joint arthritis at the L3-4 (A) and L4-5 (B) levels (arrows). Selected fluoroscopic images (C and D) showing one of the patient's prior radiofrequency ablations.

## REPORT OF CASE

The patient is a 64-year-old woman with a history of chronic low back pain. She was first evaluated at our institution approximately 8 years ago but reported that the pain had been present for about 25 years. Clinically, the pain was described as axial low back pain, without radicular features. Pain was worst with standing, walking, lifting, and bending. This pain impacted activities of daily living, including her work as a teacher, which required her to be active. On examination, lumbar spine extension and facet joint loading maneuvers yielded positive results, and facet joint loading caused ipsilateral low lumbar pain. Tenderness was noted on palpation in the lumbar paraspinal region.

Diagnostic comparative MBBs of the bilateral L3-4 and L4-5 levels both provided 90% relief of her pain, confirming the lumbar facet joints as the patient's pain generator. The patient subsequently underwent RF ablation or intra-articular corticosteroid injection approximately every 6 months for 7 years. Although these treatments provided good relief of her pain, duration of response was limited as her pain and disability would return to baseline prior to each procedure. The durability had become more limited over time. Specifically, the patient reported that the most recent RF denervation of the bilateral L3-4, L4-5, and L5-S1 facet joints provided approximately 4 months of relief. Imaging studies, including radiographs and MRI, confirmed degenerative arthritis at the lumbar facet joints (Figure 1).

As an attempt to increase efficacy and duration of treatment, the patient underwent MRgFUS of the lumbar facet joints using the ExAblate 2100 (Insightec) system as part of her routine clinical care. The ExAblate device is approved by the US Food and Drug


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Administration for the treatment of uterine fibroids. Ablation of the lumbar facet joints is considered an off-label use of the device.

The patient was placed in a supine position on the treatment table, which contains the embedded ultrasound transducer and docks in the MRI scanner. Her lumbar spine was centered over the transducer with an interposed water basin (Figure 2). The interposed water basin was utilized to mitigate the risk of skin burns that can be caused by ultrasound waves traveling through potential air pockets present at the skin surface.

Preprocedural MRIs were obtained in 3 planes for treatment planning. Axial, coronal, and sagittal T2-weighted, non—fat-saturated images were acquired for anatomic guidance and subsequently transferred onto the ExAblate workstation, which is coupled with the standard MRI console. The posterior facet joint capsule was targeted for ablation by the treating physicians using the ExAblate software on this console. This structure was identified using the axial pretreatment sequences. A small region of treatment was manually drawn along the posterior margin of the facet joint. The software then automatically generated a projected ultrasound beam overlay to treat this area. Prior to sonication, the beam path was assessed in the axial and sagittal planes and manually adjusted by the proceduralist in order to avoid nontargeted structures, such as the spinous process and exiting nerve root (Figure 2). The osseous facet joint prevented any ultrasound waves from traveling beyond the ablation zone and affecting deeper structures, such as the spinal canal and lumbar nerve roots.

The bilateral L3-4, L4-5, and L5-S1 facet joints were treated, as had been done in the patient's prior procedures. Target accuracy was confirmed with a low-energy test dose. Treatment dose was between 1000 and 1400 J, with 4 sonications per joint lasting 20 to 25 seconds each based on parameters described in prior publications and discussions with individuals at other institutions who routinely perform the procedure.[7,15,19] During each sonication, MRI thermometry maps were generated approximately every 3 seconds by the software and reviewed in real time by the proceduralists. Based on the temperature elevation history of each voxel, thermal dose estimation was automatically computed by the ExAblate software and overlaid a blue color on ablated patient anatomy. This thermal dose overlay indicated whether adequate ablation of targeted tissue was achieved with sparing of surrounding structures. After 4 sonications were performed per facet joint, the axial MRIs with blue thermal dose overlay were reviewed to assess for complete treatment of the posterior facet joints, with the goal being to ablate the entire posterior margin of the joint. The treatment was performed under moderate sedation. Representative images from the treatment are shown in Figure 2.

Following the procedure, the patient reported subjectively reduced "healing time"

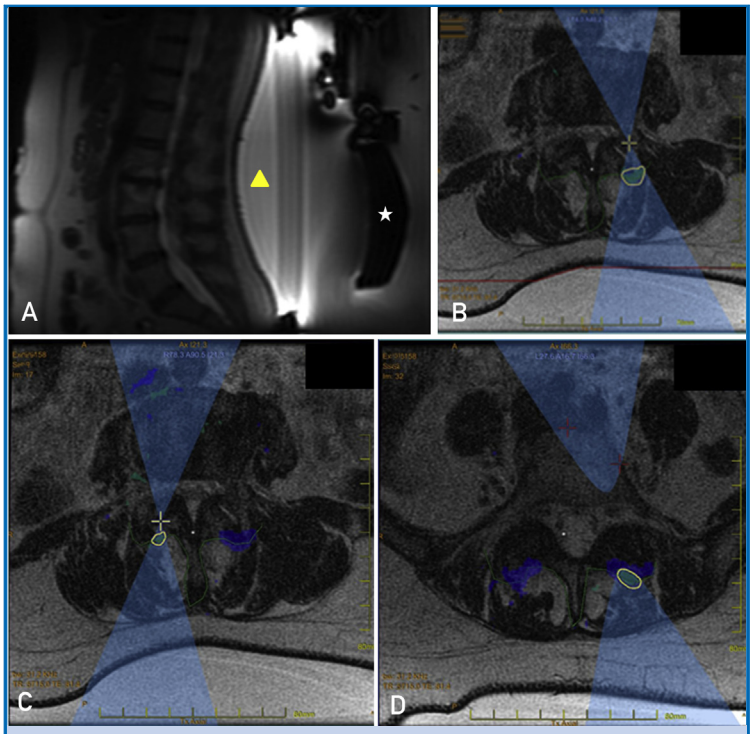


**FIGURE 2.** A, Sagittal T2-weighted scout magnetic resonance (MR) image obtained prior to MR imaging—guided focused ultrasound. The patient is lying supine on the treatment table, with the ultrasound transducer (star) directly below the lumbar spine. Water is interposed between the transducer and the patient's skin in order to prevent skin burns (arrowhead). B-D, Selected axial MR images showing ablation targets (yellow ovals) that were placed along the posterior facet joint capsule by the proceduralist. The light blue shaded areas demonstrate nonablated tissue along the path of the ultrasound beam; this path can be manually adjusted to avoid structures such as the spinous process that would block the ultrasound waves from reaching the desired target. Dark blue color is generated by the treatment software and indicates previously treated tissue along the posterior facet joint capsules.

compared with prior RF ablation treatments of the facet joints. She noted reduced postprocedural muscle "tightness and guarding." She was treated as an outpatient and did not require anything other than acetaminophen for treatment of postprocedural discomfort.

Follow-up patient-reported outcomes surveys were provided to the patient at 2 weeks, 3 months, 6 months, and 12 months following the procedure. This series is part of routine clinical care for all patients who undergo a therapeutic spine intervention at our institution. Surveys consisted of a visual analog pain scale, the Patient-Reported Outcomes Measurement Information System Global Health scale, the Oswestry Disability Index, and the Patient Health Questionnaire-4. At 2-week follow-up, the patient's average low back pain was rated as 0 to 2 on a scale of 0 to 10. At 3-month follow-up, she reported no pain attributed to her lower back and was "extremely satisfied." At 6 and 12 months, the patient reported a minimum numerical low back pain rating of 0 and maximum pain of 2 over the preceding 7 days. On the Global Health scale at all time frames, she reported being "completely" able to carry out her everyday physical activities and being "able to do as much work as I want to." The Oswestry Disability Index was notable for no limitations on walking or standing due to pain. At a routine clinical follow-up 11 months following the treatment, the patient reported "ongoing excellent benefit" from the MRgFUS procedure, with no substantial mechanical low back pain.

## DISCUSSION

Magnetic resonance imaging—guided focused ultrasound is a safe, relatively noninvasive thermal ablation method that can be used for the treatment of lumbar facetogenic pain. Unlike intra-articular injections and RF ablation, no ionizing radiation is necessary and the technique does not require needles. As with these treatment methods, several joints can be targeted in one session, and the treatments can be repeated if symptoms recur. Additional advantages of MRI guidance include direct visualization of the treatment target and real-time treatment monitoring with MRI thermometry to depict the treated regions.

This patient had sustained benefit from MRgFUS lumbar facet joint ablation and no recurrence of low back pain or related disability at 12-month follow-up. Prior to MRgFUS, her low back pain had repeatedly returned within this interval after RF ablation or corticosteroid injection. The MRgFUS was successful in terms of a short recovery after the procedure, an improved degree and durability of pain relief and functional scores, and high patient satisfaction.

This experience builds on that of prior publications. One study treated and followed up 13 patients with prior positive responses to facet joint interventions with MRgFUS.[7] These patients had a 60% decrease in numerical pain rating 6 months posttreatment and 46% improvement on the Oswestry Disability Index without adverse events.[7] The inclusion criteria for this study did not require comparative MBBs, as our patient had. It is therefore possible that this difference could account for the presence of some patients without pain relief at 6 months, possibly due to pain from other etiologies. Additionally, the current case report demonstrates efficacy specifically in a patient with limited response to RF ablation while the prior study had more general selection criteria. However, there are some prior reports of efficacy in patients who were resistant to treatment. In a meeting abstract, Squarcia et al[19] reported 50% pain reduction at 12 months in 7 such patients. Additionally, in another abstract, Dux[15] reported benefit in 28 of 35 patients treated with MRgFUS for facetogenic pain, with 70% reduction in average pain score at 2 to 9 months.

A key difference between MRgFUS and other facet joint denervation procedures in this case is that MRgFUS targets the posterior facet joint capsule rather than the medial branches of the dorsal ramus. Denervation procedures for treatment of lumbar facet joint pain must target one of these 2 structures in order to be successful.[20] We believe that targeting the posterior capsule is the safer option for MRgFUS because the osseous facet joint prevents further penetration of ultrasound waves and therefore protects deeper neural structures. Additionally, targeting the posterior capsule represents a change in treatment strategy in patients with unsatisfactory response to medial branch denervations.

Challenges for this technique include the complex nature of low back pain, with


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numerous potential contributing etiologies. It is therefore important to ensure appropriate patient selection. Patients must not have any contraindications to MRI, such as nonapproved implants, claustrophobia, or inability to lie still. Additionally, because of size limitations based on the MRI bore and ExAblate system, not all patients are physically able to undergo this treatment. Finally, there is a risk of skin burn if there are air bubbles between the transducer and the patient's skin. Care must be taken to ensure continuous monitoring of the treatment field for air bubbles. Because the technique induces coagulative necrosis of the targeted tissues, care must be taken by the proceduralist to identify the desired target on MRI and to assess the safety of the beam path in order to avoid damage to tissue outside the treatment area.

## CONCLUSION

Magnetic resonance imaging–guided focused ultrasound ablation of the lumbar facet joints is a promising therapy for facet joint–mediated low back pain. It may be of particular benefit in patients with limited or refractory response to conventional treatments. Because there is currently very little peer-reviewed evidence, continued research is needed to confirm the safety and efficacy of the procedure. Depending on future results, it has the potential to make a substantial impact on the treatment model for this extremely common and burdensome problem.

**Abbreviations and Acronyms:** **MBB** = medial branch block; **MRgFUS** = magnetic resonance imaging–guided focused ultrasound; **MRI** = magnetic resonance imaging; **RF** = radiofrequency

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