Magnetic resonance imaging of the ankle performed on an InterStim patient

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Patients undergoing InterStim implantation often have comorbidities, which require magnetic resonance imaging (MRI) for diagnosis. Although MRI of the head has been recently approved for use with the InterStim neurostimulator, imaging of other regions remains controversial. We present a case of Achilles tendinitis diagnosed on MRI of the ankle in a patient with an InterStim device. The neurostimulator was deactivated, and using a transmit/receive extremity coil, the left ankle was imaged without any adverse events. At 9 months post-imaging, the patient continued to have good control of symptoms with InterStim, with no negative effects from MRI. MRI of the ankle is feasible in patients with InterStim implants using transmit/receive coils. Further evaluation is warranted to study the safety of MRI of other body region in InterStim patients.

Key Words: sacral neuromodulation, InterStim, MRI, overactive bladder

Introduction

The use of sacral neuromodulation for the treatment of bladder dysfunction has grown rapidly over the years since its approval by the FDA.[1] It has also been used off-label for patients with non-obstructive urinary retention, stool incontinence, and pelvic pain. The success of this device is hampered when other comorbidities necessitate the use of magnetic resonance imaging (MRI). Currently, the FDA and the manufacturer only recommend the use of a head MRI under specific conditions due to concerns related to over-heating or dislodgement of leads and the internal pace generator.[2]

Similar concerns have been raised regarding MRI use in patients with other implanted devices. However, a growing number of studies have shown that certain circumstances allow for MRI to be used with no serious adverse effects in patients with implanted devices, including cardiac pacemakers and spinal neurostimulation systems.[3,4] More specific to this case, other studies have demonstrated the safety of using MRI to image the head, lumbar spine, and pelvis in patients with implanted Interstim devices.[5,6] However, to the best of our knowledge, studies on the feasibility of MRI of the ankle in patients with implanted sacral neuromodulators have not been reported.

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TABLE 1. **Protocol used to perform MRI foot on patient with Interstim**

1.5-Tesla (T) horizontal closed bore (cylinder)
Maximum spatial gradient of 19 T/m (1900 gauss/cm)
Radiofrequency (RF) transmit/receive extremity coil (no RF transmit body coil)
Gradient slew rate* limited to 200 T/m/s
Normal operating mode (scanning frequency of approximately 64 MHz only)
Patient was awake under monitored anesthesia care

MHz = Megahertz; T/m/s = Tesla/meter/second
*the speed rate of ascent a gradient from zero to its maximum amplitude.

Case report

A 72-year-old female underwent a successful two-stage implantation with bilateral InterStim (Medtronic Inc, Minneapolis, MN, USA) for refractory urge urinary incontinence secondary to neurogenic bladder dysfunction. The patient had a history of spinal stenosis, multilevel thoracic laminectomy, and lysis of arachnoidal adhesions for cerebral hydromyelia resulting in complex motor/sensory deficits. The neuromodulation leads were successfully positioned in the third sacral foramen confirmed intraoperatively with fluoroscopy and positive bellows and toe reflexes. Postoperatively, the patient reported relief of overactive bladder symptoms of more than 50% (3-4 pads versus 1 pad/day). Three months postoperatively, the patient presented with severe left ankle pain concerning for Achilles tendon injury. Her podiatrist recommended an MRI study of the ankle for further evaluation.

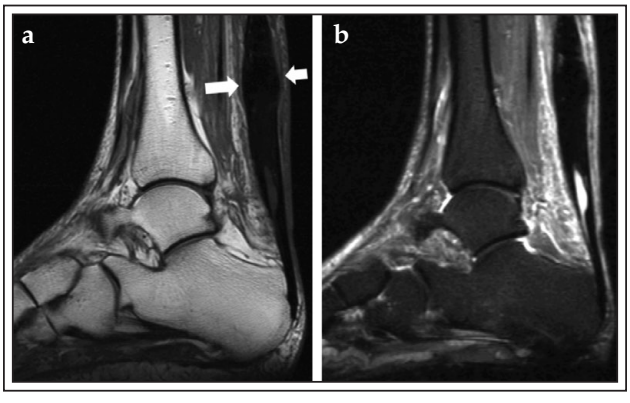

Figure 1. a) T1 sagittal image reveals a thickened and edematous Achilles tendon. **b)** Sagittal T1 Inversion Recovery (STIR) image shows fluid signal intensity consistent with partial tear of the tendon.

After a review of the literature, consultation with physicists from Medtronic and the radiologists it was deemed safe to pursue with the MRI of the ankle under special modifications, Table 1. The patient was consented and alternatives, such as watchful waiting or explantation of the Interstim device were explained. The patient decided to pursue with an ankle MRI.

Before undergoing the MRI study the InterStim device was turned off and the device settings were changed, Table 2. Manufacturer recommendations regarding MRI parameters, including specific absorption rate (SAR) and gradient strength, were reviewed and adhered to for the examination. The patient successfully underwent a 1.5 Tesla MRI study of the left foot using a transmit/receive extremity coil (Siemens Medical Solutions, Erlangen, Germany) without any adverse events.

Postoperatively, the patient denied any pain, heat sensation, or sensory disturbances. The MRI demonstrated the finding of severe Achilles tendinitis in the posterior aspect of the ankle, Figure 1. The neurostimulator was restored to pre-MRI settings and at 9 months post-imaging, the patient continued to have good control of urinary symptoms with InterStim therapy.

TABLE 2. **InterStim settings for magnetic resonance imaging**

Parameter	Setting
Amplitude	0 Volt
Stimulation output (IPG)	Off
Magnetic switch	Off (disabled)
Other parameters (pulse width, rate)	No change

Discussion

Concerns regarding MRI use in patients with implanted devices stem from experimental evidence demonstrating magnetic pull, device malfunction, and electrode heating.[2] Initial reports were published describing successful MRI examination of the head, cervical vertebrae, and pelvis without detrimental effect on the InterStim device. Following these reports, the FDA approved the use of head MRI in patients with InterStim devices. However, the device was labeled "MRI-conditional," restricting its use to very specific parameters.[2]

To avoid any failure of the device settings were changed, Table 2. It was confirmed that the device was turned off and the magnet switch was disabled to avoid any hazard to the future function of the device. Chermansky et al reported a device failure in a patient who underwent lumbar MRI while the magnetic switch was not disabled.[6]

Manufacturer recommendations were reviewed by the radiologist and physicist to ensure that the procedure protocol was within recommended parameters:[2]

- Scans were performed on a 1.5-Tesla horizontal closed bore MRI system. There are no available data on the safety of other MRI systems (such as open bore or 3.0-T MRI).
- Normal operating mode was used to avoid any shocking sensations/uncomfortable stimulation or unusual sensations, which might have occurred using other modes (e.g., first level controlled operating mode).
- Gradient slew rate, which is the acceleration from zero to its maximum amplitude, was reviewed to insure that it would not exceed 200 Tesla/meter/second (T/m/s). Exposure to gradient systems with a gradient slew rate exceeding 200 T/m/s may result in overstimulation or shocking.
- There are no available data on the effects of other frequencies than scanning frequency of approximately 64 megahertz (MHz), which the scanner utilized for this exam conformed to.
- A transmit/receive extremity coil was used to minimize exposure of the neurostimulator and leads to the magnetic field.[7]

Postoperative recommendations by the manufacturer were followed with our patient:

- The neurostimulator settings were restored to pre-MRI ankle scan values.
- The patient was asked to report any adverse effects as a result of the MRI scans.
- The patient was instructed to see the implanting physician or managing physician for any questions about neurostimulator function or if assistance was required to return program parameters to pre-MRI scan settings.

Careful review of the conditional parameters with the radiologist and MRI physicist allowed for imaging of the left ankle without complications as well as keeping the function of the device.[2]

Current data is limited regarding the use of MRI in InterStim patients.[4-6] We do not advocate the use of MRI outside of the recommended guidelines. Further research is prudent to address the increasing number of InterStim patients being referred for MRI examinations. Further studies with longer follow up after MRI are recommended to show long term effects on the impedances and battery life of the device.

Conclusion

MRI of the ankle is feasible under appropriate conditions in patients with InterStim implants using transmit/receive coils. Further study is warranted to study the safety of MRI in InterStim patients □

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