Piriformis and Related Entrapment Syndromes: Diagnosis & Management

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KEYWORDS

- Piriformis syndrome • Pudendal neuralgia
- Sciatica • Neurography • Open MRI

In the United States alone, there are over 1.5 million lumbar MRI studies performed annually for sciatica, yet only 200,000 patients per year obtain relief from discectomies and other surgeries directed at relieving pressure on the spinal roots – just under 15% of those with persistent severe sciatica.[1] Out of the remaining 1.3 million patients, there are as many as 100,000 for whom a nerve root compression is diagnosed but surgery fails to affect the pain, or in whom the compression does not appear to be an entirely convincing etiology. For 1.2 million patients, the lumbar MRI does not reveal any credible cause of the sciatica at all.

When a diagnostic paradigm fails more than 85% of the time, it is difficult to understand why no other diagnosis should be considered. There are now three large-scale formal class A study design peer-reviewed publications involving more than 1000 patients in total that find treatable sciatic nerve entrapments in the pelvis to be a frequent cause of sciatica.[1–3] Every day, neurosurgeons see patients with mixed L5 and S1 radicular pain, no back pain, readily detectable sciatic notch tenderness, and no correlating lumbar MRI findings, and yet every day they refuse to consider piriformis syndrome. The important question, becomes: why do neurosurgeons persist in resisting the need for education and training for managing pelvic sciatic entrapments?

The answer has more to do with anthropology and behavior issues than with medical science. Physicians believe that their training constitutes a magnificent edifice in which all medical knowledge more or less has been arrayed and organized perfectly. They believe that their professors are wonderfully knowledgeable and have a comprehensive understanding of the relevant pathologies, diagnostic methodologies, and surgical treatments they will need to deploy in their work. They then are enthusiastic about opportunities to pass along this worldview to their own students. How shocking and disturbing to hear that their professors were wrong 85% of the time about sciatica, the most common diagnosis that neurosurgeons treat. How could the wise elders have gotten it so wrong? If piriformis syndrome really existed, would not these professors have taught about how to diagnose and treat it?

Aside from reverence for the existing canon of neurosurgical knowledge, neurosurgeons have

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a serious financial concern. "If sciatica is caused by piriformis syndrome—which I do not know how to diagnose or treat—will the insurance companies stop paying for the discectomies that are my bread and butter? What will become of me? What can I do personally to help stop this diagnosis from becoming known? Can I take concrete steps to guarantee that residents and fellows evaluating patients for sciatica are discouraged from considering piriformis syndrome?"

It is time for retraining. The relevant question has to be: how can I best help patients?

When confronted with excellent research publications that meet the most stringent requirements of evidence based medicine one cannot say: "But my professor told me that his professor 40 years ago told him that piriformis syndrome does not exist. Not only that, but I once talked to a neurosurgeon who knew an orthopedist who once operated on a case of supposed piriformis syndrome, and the patient did not get better. Therefore I am going to ignore the whole thing."

It is understood that where nerve elements traverse mobile joints in narrow pathways, entrapments occur. One accepts this for the ulnar nerve at the elbow, the median nerve at the wrist, the peroneal nerve at the knee, and the tibial nerve at the ankle. Neurosurgical textbooks also typically cover an extensive array of less common nerve entrapment syndromes covering nearly every named nerve in the body. The sciatic nerve, however, is expected to be immune to entrapment, no matter how much evidence there is to support the existence of pelvic sciatic entrapment syndromes. This is despite the fact that unlike other nerves, modern people spend thousands of hours every year with much of their body weight resting on the sciatic nerve as they sit or sleep. Further, there are few regions of the human body that have undergone such dramatic transformation and reorganization during the course of human evolution as the posterior pelvis.[4]

Moving on from the polemics, one should look at the data.

High reliability evidence for piriformis syndrome[1] and other pelvic sciatic syndromes[5] arises from three major categories of data: magnetic resonance neurography diagnostic imaging, open magnetic resonance-guided injection studies, and patient treatment outcome studies. This article reviews the evidence in each category.

DIAGNOSTIC MAGNETIC RESONANCE NEUROGRAPHY IMAGING

Although neurosurgeons have been slow to incorporate nerve imaging into their diagnostic armamentarium, there has been considerable progress in this area. Data from the use of both T2 neurography and diffusion tensor nerve tract methodology have been accumulating for more than 15 years,[6–10] and there are now thousands of imaging examinations from which to draw lessons. **Fig. 1** shows the anatomy of nerve elements in the pelvis. **Fig. 2** shows the normal T1 anatomy of the sciatic nerve as it descends, and a matching T2 image with a normal sciatic nerve with no hyperintensity or irritative changes. **Fig. 3** demonstrates the appearance of the sciatic nerve in a magnetic resonance neurography image in a typical pelvic sciatic entrapment case in which hyperintensity caused by irritation of the sciatic nerve makes it more conspicuous than surrounding tissues along its ischial course.

The sciatic nerve can suffer from entrapments of various severity. In mild cases, there is only a short segment of hyperintensity. In more severe entrapment, not only is the linear extent of hyperintensity

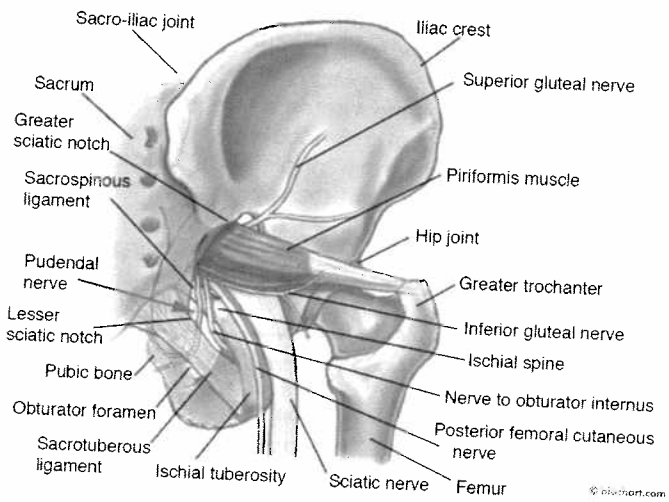

Fig. 1. Anatomy of nerve elements in the posterior pelvis.

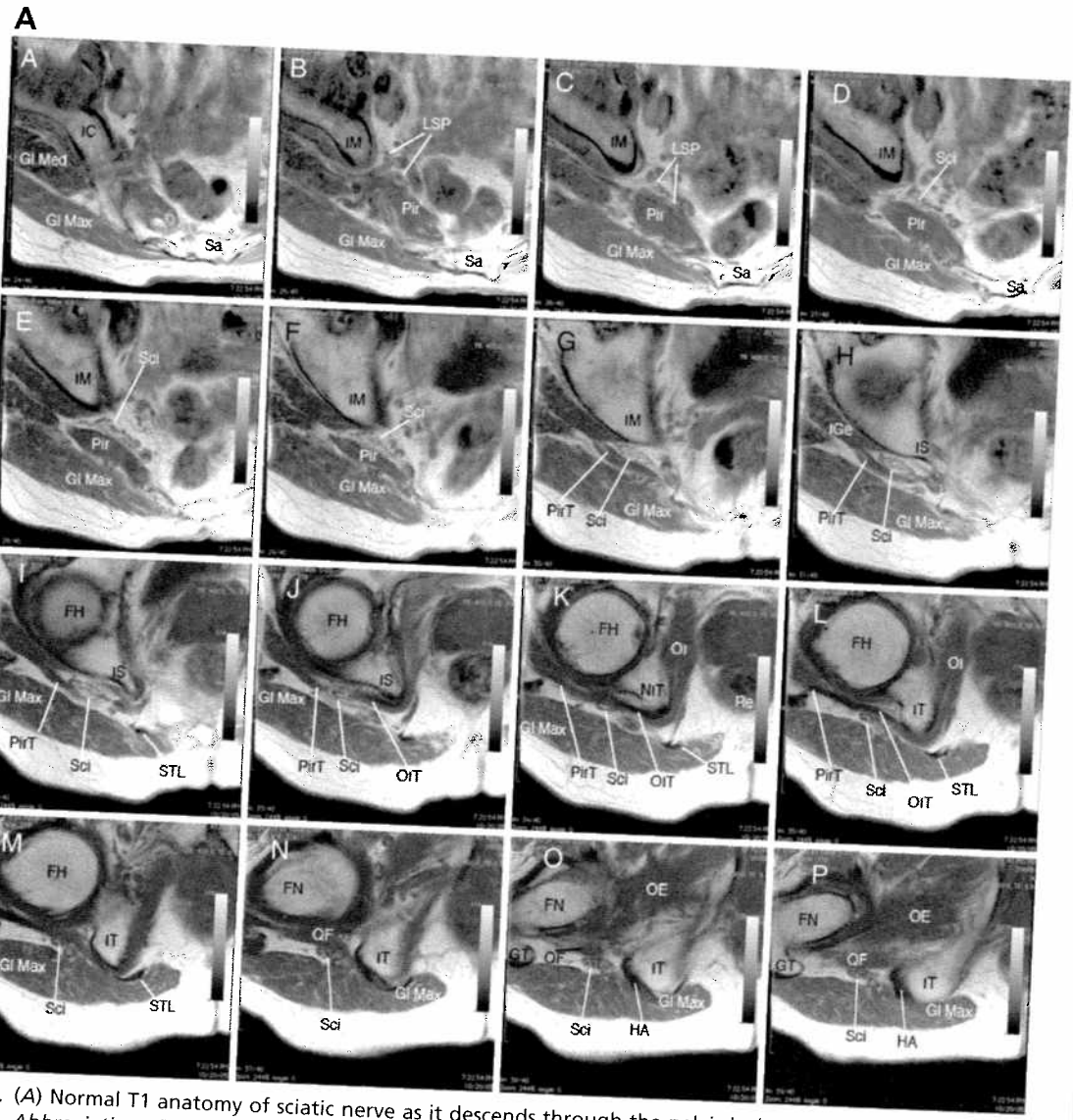

Fig. 2. (*A*) Normal T1 anatomy of sciatic nerve as it descends through the pelvis in (nerve perpendicular oblique view). *Abbreviations:* FH, femoral head; Ge, superior gemellus; Gl max, gluteus maximus; Gl med, gluteus medius; GT, greater trochanter; HA, hamstring tendons; IC, iliac crest; IM, ischial margin; IS, ischial spine; IT, ischial tuberosity; LSP, lumbosacral plexus elements; NIS, neck of ischial spine; OE, obturator externus; OI, obturator internus; OIT, obturator internus tendon; Pir, piriformis muscle; Pir T, piriformis tendon; QF, quadratus femoris; Re, rectum; Sa, sacrum; Sci, sciatic nerve; STL, sacrotuberous ligament. (*B*) Normal neurographic appearance of the sciatic nerve in the same individual with no hyperintensity or nerve irritation. The nerve is difficult to distinguish, because it is iso-intense, with many structures or has lower image intensity. Arrows indicate sciatic nerve or precedent lumbosacral plexus elements.

greater, but there also may be fascicular-level irritative changes (**Fig. 4**).

In addition to entrapment at the sciatic notch, the sciatic nerve may be compressed by fibrous bands (**Fig. 5**) or by dilated venous varices when the dilated vein arises inside the perineurial sheath (**Fig. 6**A). It may suffer entrapment caused by fixation by an artery passing through the nerve (**Fig. 6**B). It may be simulated by acetabular pathology or affected by such pathology (**Fig. 7**).

It is appreciated that the sciatic nerve may be entrapped by portions of the piriformis tendon or muscle passing through the nerve, and it is very important to perform magnetic resonance neurography as a preoperative test on all cases of pelvic sciatic entrapment because of the special risks and requirements this imposes upon the surgical plan (**Fig. 8**). In some individuals, the sciatic nerve does not contact the tendon of the obturator internus, but in others, it may be entrapped

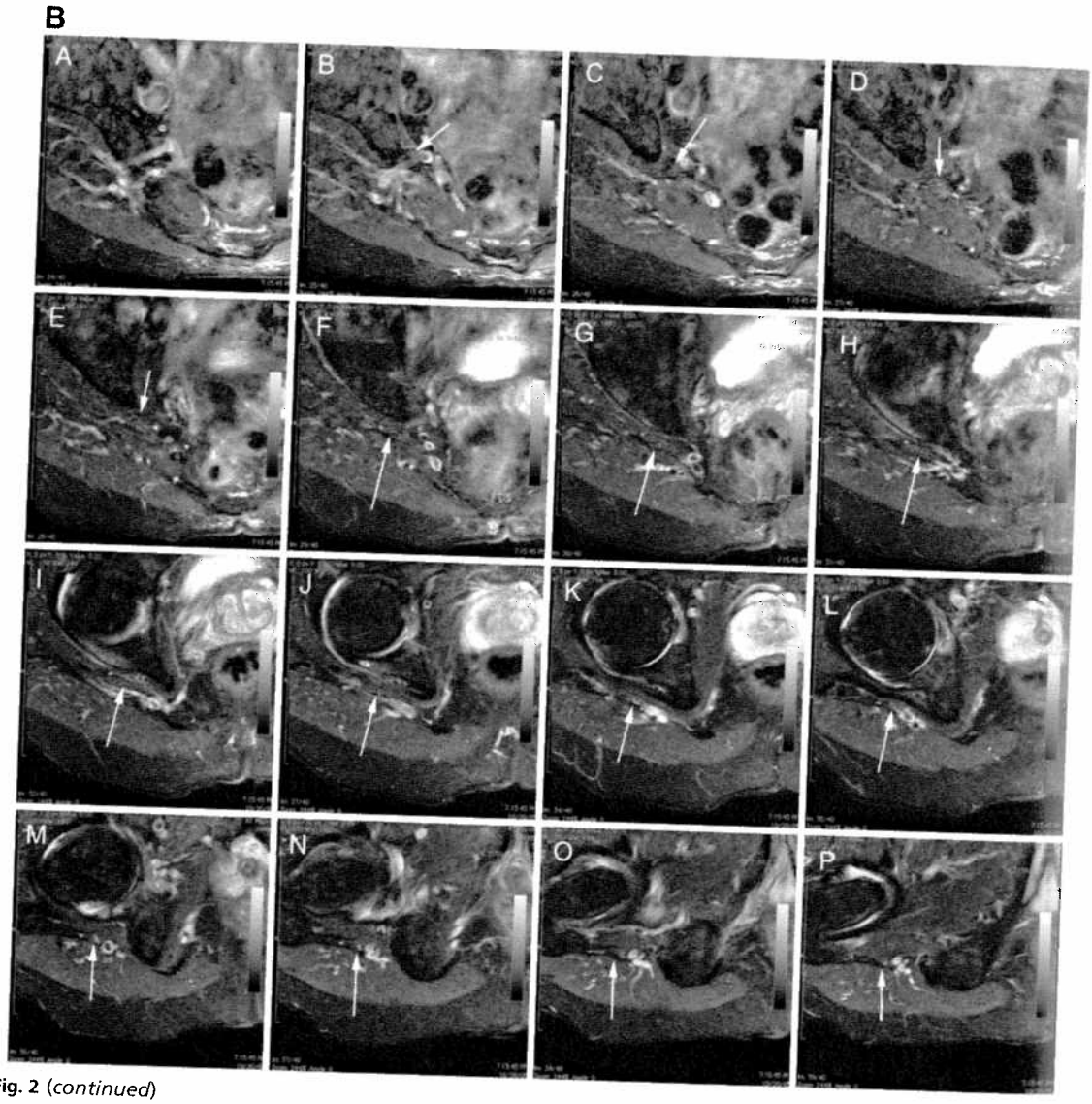

Fig. 2 (*continued*)

by that tendon (**Fig. 9**). Entrapments also occurs in the lower ischial tunnel adjacent to the hamstring attachments or at the quadratus femoris muscle.

The suggestion that all these image findings are caused by magic angle effects[11] is ill informed, because those can only occur if echo times below 40 milliseconds are used for the imaging. Clinical magnetic resonance neurography studies are usually performed at 70 to 100 millisecond echo times. The need to rule out tumors of the sciatic notch (**Fig. 10**) is another compelling reason to image before proceeding with treatment.

OPEN MAGNETIC RESONANCE-GUIDED INJECTIONS

One major cause of confusion about the existence of piriformis syndrome has been the extraordinary unreliability of piriformis muscle injections. This is mostly a matter of injectionists who are equipped and trained to do spinal injections trying to extend their existing system to include piriformis injections. When one does a fluoroscopically guided spine injection, it is possible to use sets of two-dimensional images from different planes to determine the position of the needle tip relative to various spinal structures with great precision. That is because of the fine detail in which the bony elements are seen. One also can shield the gonads in reproductive-age patients.

In patients who have piriformis syndrome, however syndrome, the relevant muscle and nerve are completely invisible on radiographs. The only effect of using fluoroscopy on these patients is to pour large doses of radiation into the gonadal

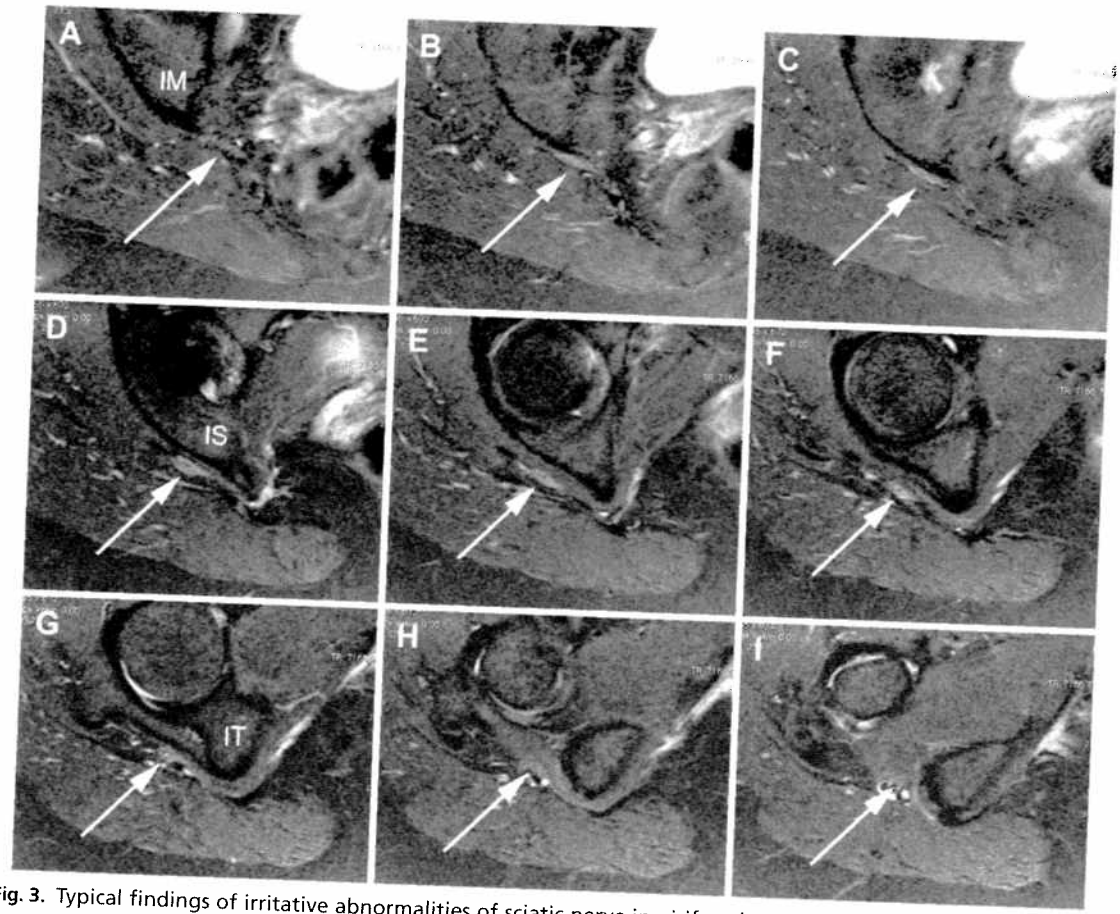

Fig. 3. Typical findings of irritative abnormalities of sciatic nerve in piriformis syndrome. (*A*) Sciatic nerve bowed over medial surface of piriformis muscle. (*B*) Increase in nerve image intensity as nerve passes between piriformis tendon and the ischial margin. (*C–F*) Image intensity increase persists as nerve descends through ischial tunnel. (*G–I*) Progressive normalization of nerve image intensity becoming iso-intense with surrounding muscle as it descends into the upper thigh. Arrows indicate sciatic nerve (nerve perpendicular oblique view, magnetic resonance neurographic acquisition sequence). *Abbreviations:* IM, ischial margin; IS, ischial spine; IT, ischial tuberosity.

area for no useful effect. CT scanning provides tissue sensitivity that allows for visualization of the piriformis muscle, but this leads to direct gonadal radiation equal to hundreds of radiographs or the equivalent of over 1000 chest radiographs in some cases. This is because as many as 15 or 20 CT scans of the pelvis are required to complete a single injection. Why are so many images required?

In most cases, an effective treatment requires total filling of the muscle. This involves 10 to 12 mL of anesthetic. In most patients who have piriformis syndrome, there is sufficient spasm or fibrosis in the muscle that a single site of injection cannot fill the muscle. Also more than 50% of piriformis patients have a multipartite muscle, so that a single injection fills one compartment and has no effect on any second or third compartment. Often, the regions causing the most pain and pressure are resistant to filling with medication because of spasm and intramuscular fibrosis. To manage this, the needle typically needs to be repositioned several times as the introduction of treatment agents is performed. Further, although Marcaine provides the best chance of permanent relief from injection, it should be injected in small steps of 1 to 2 cc per injection to minimize the risk of a large intravascular injection, which can cause respiratory or cardiac arrest.

Because the piriformis muscle is often no more than 1 or 2 cm thick (**Fig. 11**), and because the bowel is often adjacent just deep to the muscle, it is necessary to reimage once or twice with each movement of the needle. All of this is safe and convenient with an open magnetic resonance interventional system but is time-consuming and dangerous to the patient under CT.

The use of ultrasound and electromyogram (EMG) to guide piriformis injections avoids the risks of radiographs[12] but provides no definitive

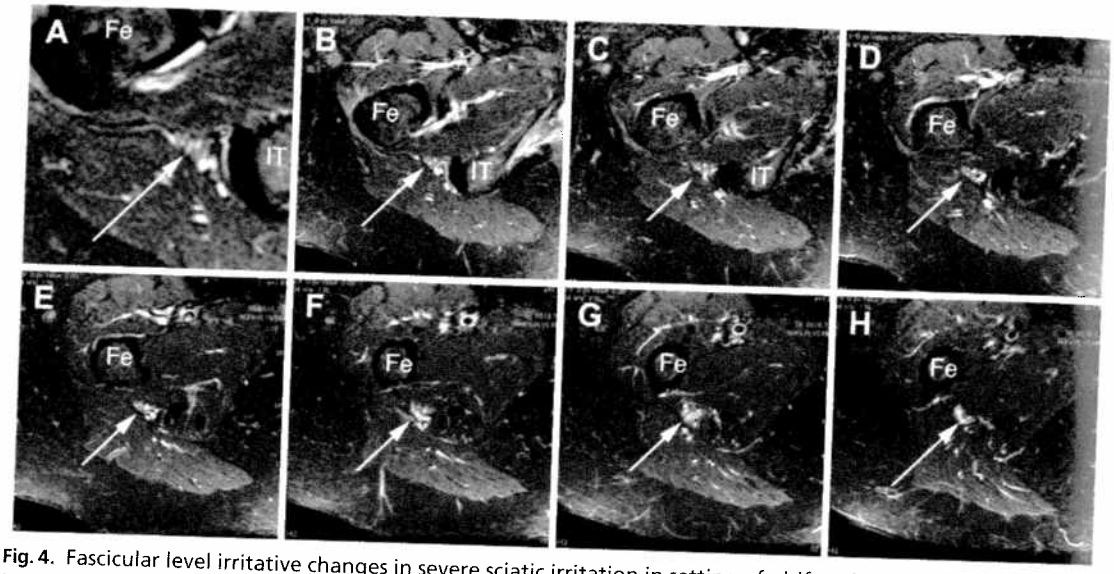

Fig. 4. Fascicular level irritative changes in severe sciatic irritation in setting of piriformis syndrome. (*A*) Enlarged image showing several very bright fascicles within sciatic nerve (*arrow*). The fascicular level hyperintensity persists as the nerve traverses the gluteal crease and descends across the posterior surface of the quadratus femoris as it descends into the upper thigh (nerve perpendicular oblique view, magnetic resonance neurographic acquisition sequence). *Abbreviations:* Fe, femur; IT, ischial tuberosity.

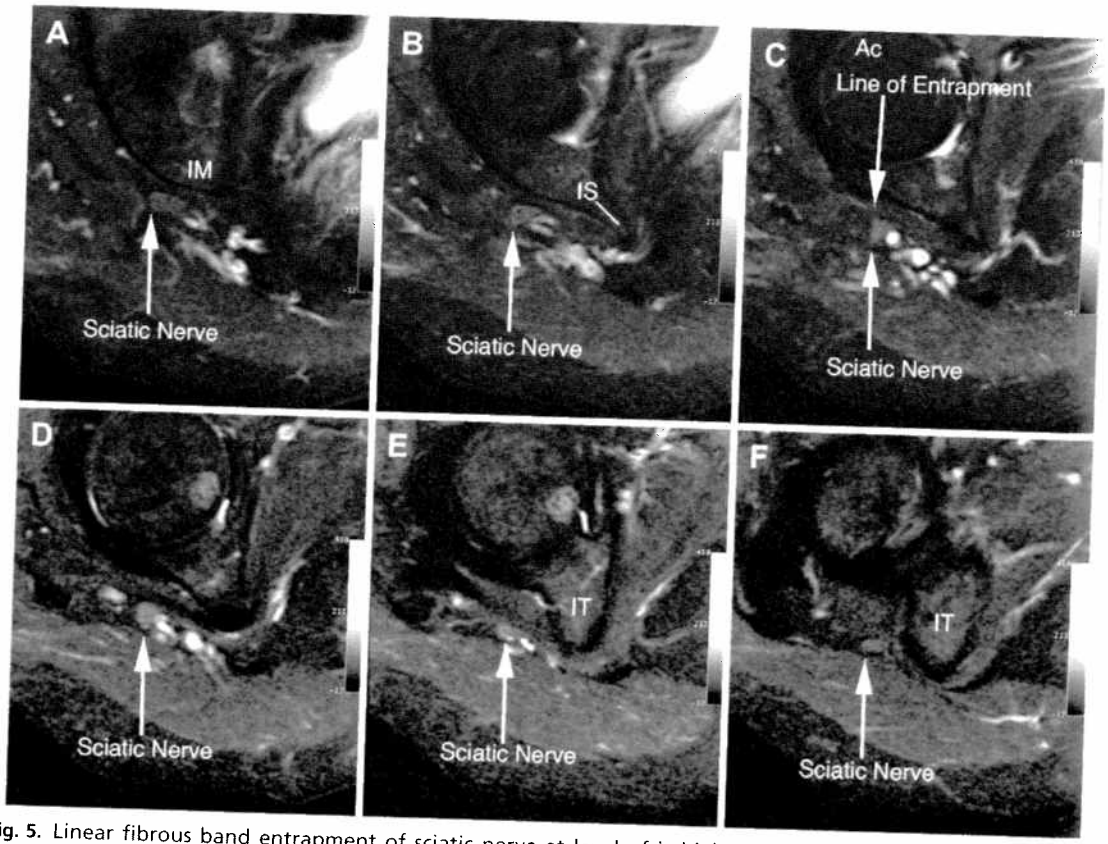

Fig. 5. Linear fibrous band entrapment of sciatic nerve at level of ischial margin (nerve perpendicular oblique view, magnetic resonance neurographic acquisition sequence). *Abbreviations:* Ac, acetabulum; IM, ischial margin; IS, ischial spine; IT, ischial tuberosity.

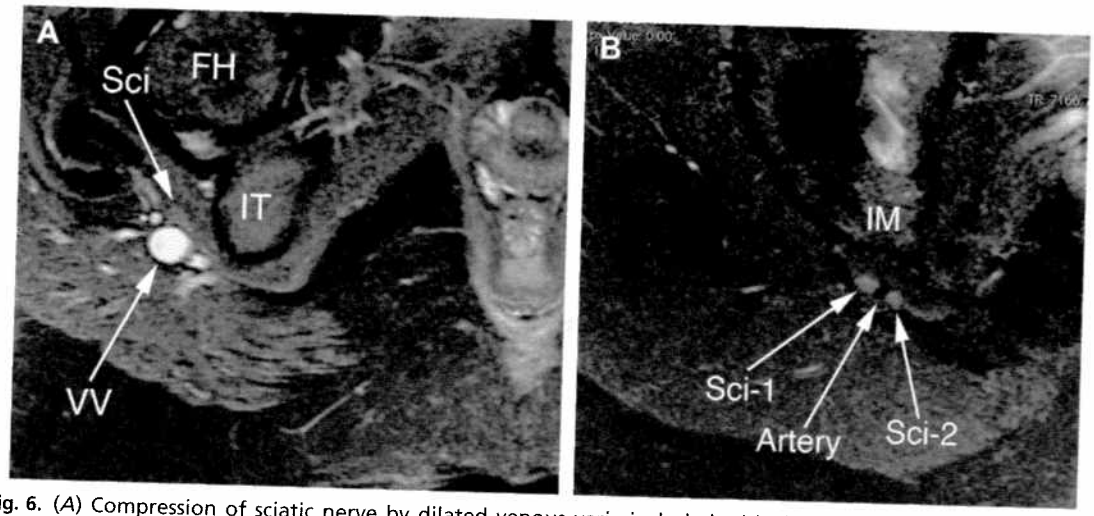

Fig. 6. (*A*) Compression of sciatic nerve by dilated venous varix included with the nerve in perineurial sheath. (*B*) Artery traversing sciatic nerve (nerve perpendicular oblique view, magnetic resonance neurographic acquisition sequence). *Abbreviations:* FH, femoral head; IT, ischial tuberosity; IM, ischial margin; Sci, sciatic nerve; VV, venous varix.

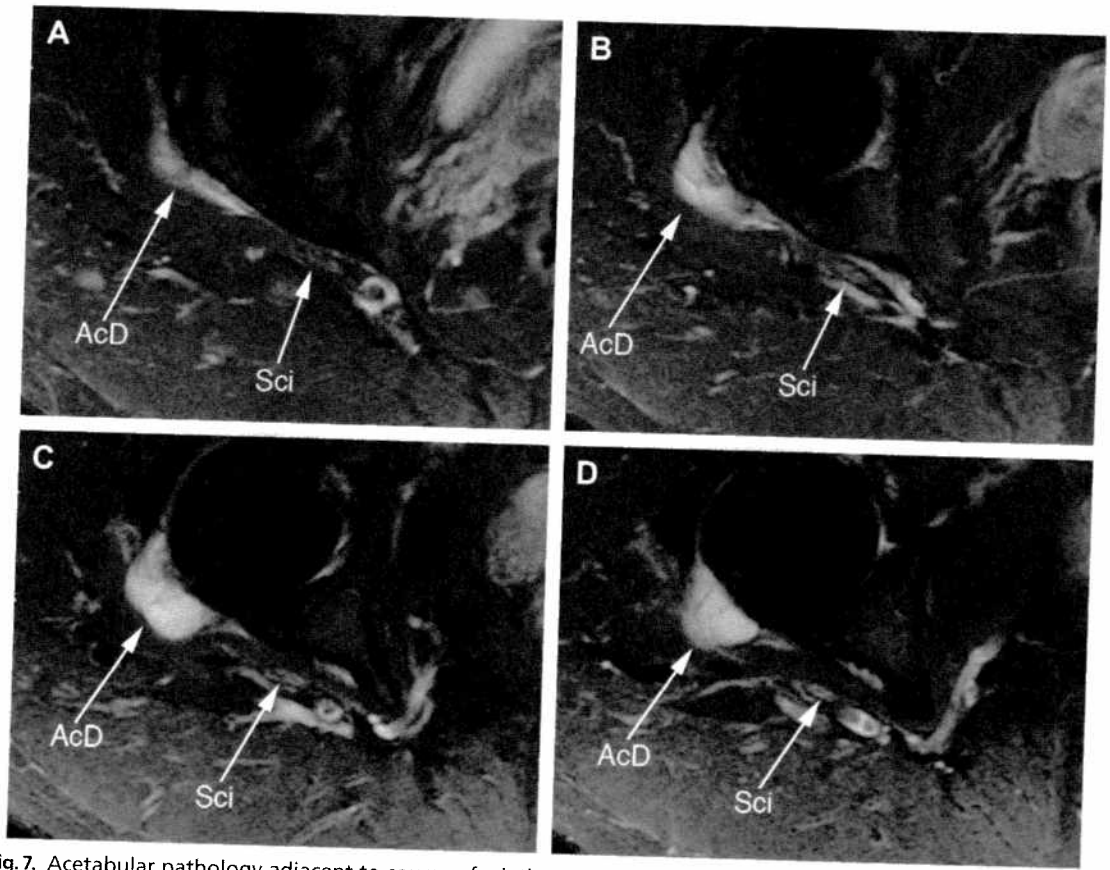

Fig. 7. Acetabular pathology adjacent to course of sciatic nerve. Synovial arthritic collection and membranes near sciatic nerve with mild local sciatic irritation. The nerve increases in image intensity as it traverses the area of inflammation (nerve perpendicular oblique view, magnetic resonance neurographic acquisition sequence). *Abbreviations:* AcD, acetabular degenerative changes; Sci, sciatic nerve.

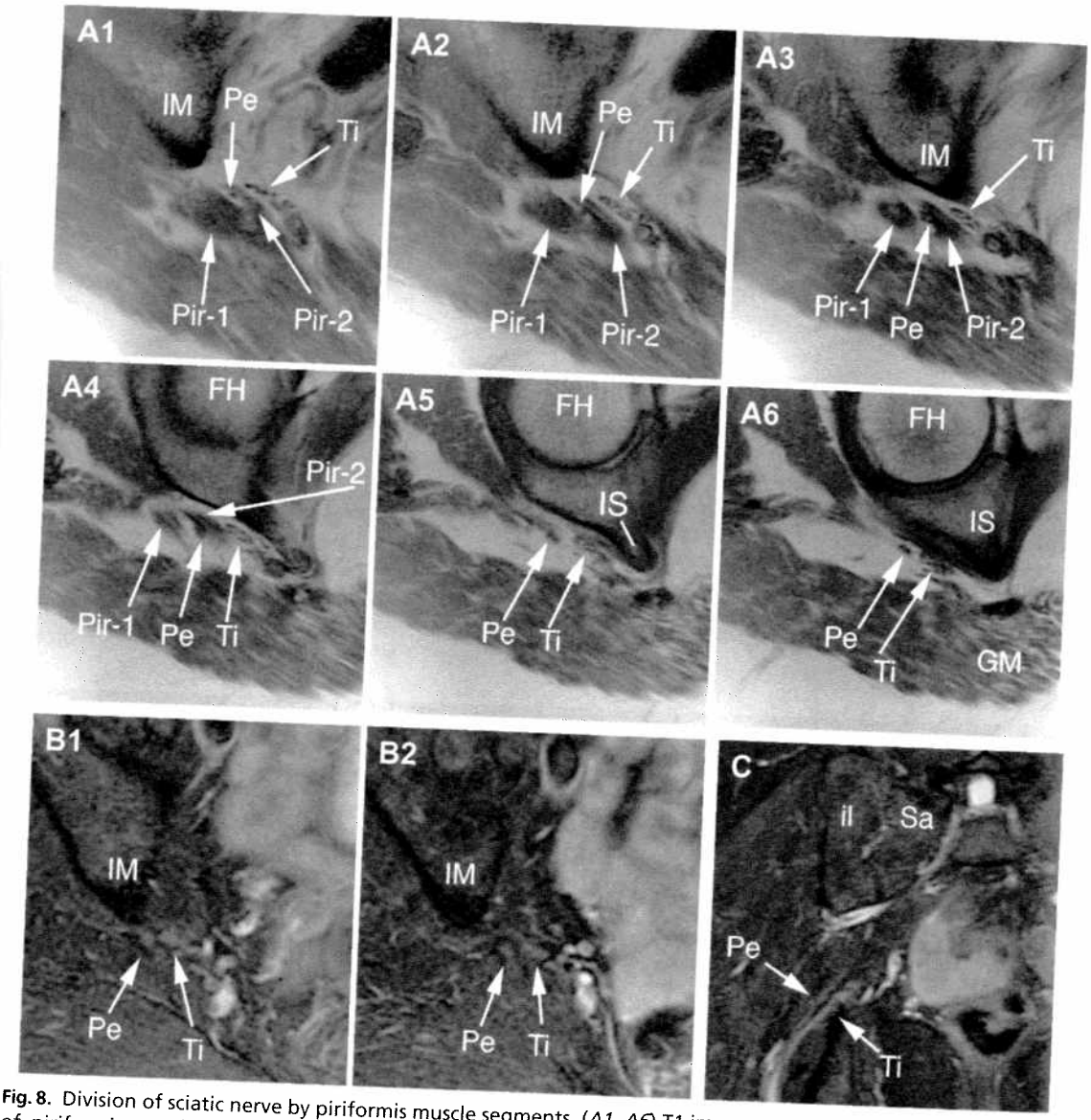

Fig. 8. Division of sciatic nerve by piriformis muscle segments. (*A1–A6*) T1 image sequence showing major portion of piriformis muscle passing between peroneal and tibial components of the proximal sciatic nerve (nerve perpendicular oblique view—T1 sequence). (*B, C*) Separated peroneal and tibial components in patient MF (*B1, B2*—nerve perpendicular oblique view, *C*—modified coronal view neurographic sequence). *Abbreviations:* FH, femoral head; il, ilium; IM, ischial margin; IS, ischial spine; Pe, peroneal component of sciatic nerve; Pir-1 and Pir-2, the two components of the piriformis muscle, Sa, sacrum; Ti, tibial component of sciatic nerve.

assurance that it is actually the piriformis muscle that is being injected. Even when the piriformis muscle is reached, there is no assurance that the entire muscle is injected uniformly. Further, in patients who have significant piriformis pain, EMG stimulation is extremely painful.

Use of open MRI allows for assessment of uniform distribution in multiple image planes (**Fig. 12**). It also makes it convenient to inject other associated structures such as the ischial tunnel, the superior gluteal nerve, the obturator internus, and the pudendal nerve (**Fig. 13**). It additionally makes it convenient to carry out an examination under MRI, which greatly improves the localizing accuracy of the physical examination (**Fig. 14**).

North and colleagues[13] have suggested that injection location is unrelated to the diagnosis. There is no dispute that acupuncture helps some people and that nontargeted injections by physicians can have similar effects. Nerve blocks may be soothing when performed upstream of a pain generator. The formal study of open magnetic resonance-guided injections,[1] however, shows that short-term response to targeted

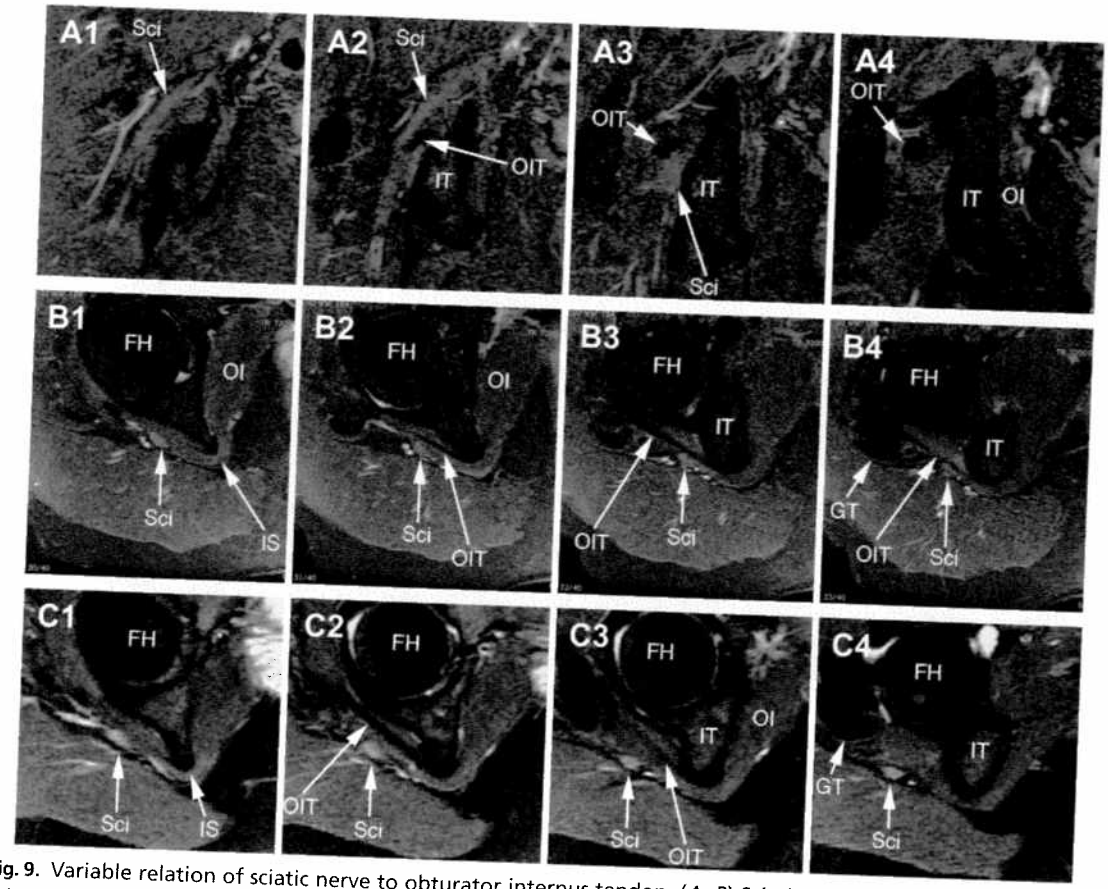

Fig. 9. Variable relation of sciatic nerve to obturator internus tendon. (*A, B*) Sciatic nerve impinged by obturator internus tendon (*A*–coronal, *B*–nerve perpendicular oblique axial). (*C*) Sciatic nerve descending without contacting the obturator internus tendon (nerve perpendicular oblique axial). Note that in individual *C*, the ischial spine is directed more posteriorly, and the greater trochanter (GT) is more anterior. This results in a more anteriorly angled course of the obturator internus tendon (magnetic resonance neurographic acquisition sequence). *Abbreviations:* FH, femoral head; IS, ischial spine; IT, ischial tuberosity; OI, obturator internus muscle; OIT; obturator internus tendon; Sci, sciatic nerve.

injection into the piriformis muscle (not nerve blocks) is correlated very highly with excellent outcome from surgical treatment of the piriformis muscle.

OUTCOME OF TREATMENT

Establishment of diagnostic efficacy by prospective patient-scored outcome reporting on a standardized instrument such as the Oswestry Outcome assessment and the Analog Pain Scale is validated and constitutes class A methodology.[14,15] There is a great deal of confusion, however, about the widely misquoted study on sham knee surgery and placebo outcomes.[16] The reason why there was an ethical basis for randomly assigning patients to sham surgery for knee washouts included the minor nature of the surgery (arthroscopy) and the very small margin of improvement reported for the treatment. That study shows a 10% to 15% placebo improvement for sham operated patients, which was comparable to improvement for actual operations (one point on the analog pain scale). Does this mean that all surgeries in the United States should be halted until a large number of sham operations for every surgical condition can be performed in randomized protocols? Absolutely not!

The only thing that this study proves is that a 10% to 15% improvement on a pain scale assessment should not be scored as a good result; it is not a clinically significant improvement. In the Filler and colleagues' 2005 outcome study, the good-to-excellent improvements were typically 40% to 90% sustained improvement.

Although no sham operations were performed, we had three patients prior to the study who chose sciatic neuroplasty without piriformis resection despite good response to piriformis injection. One had no improvement and two were

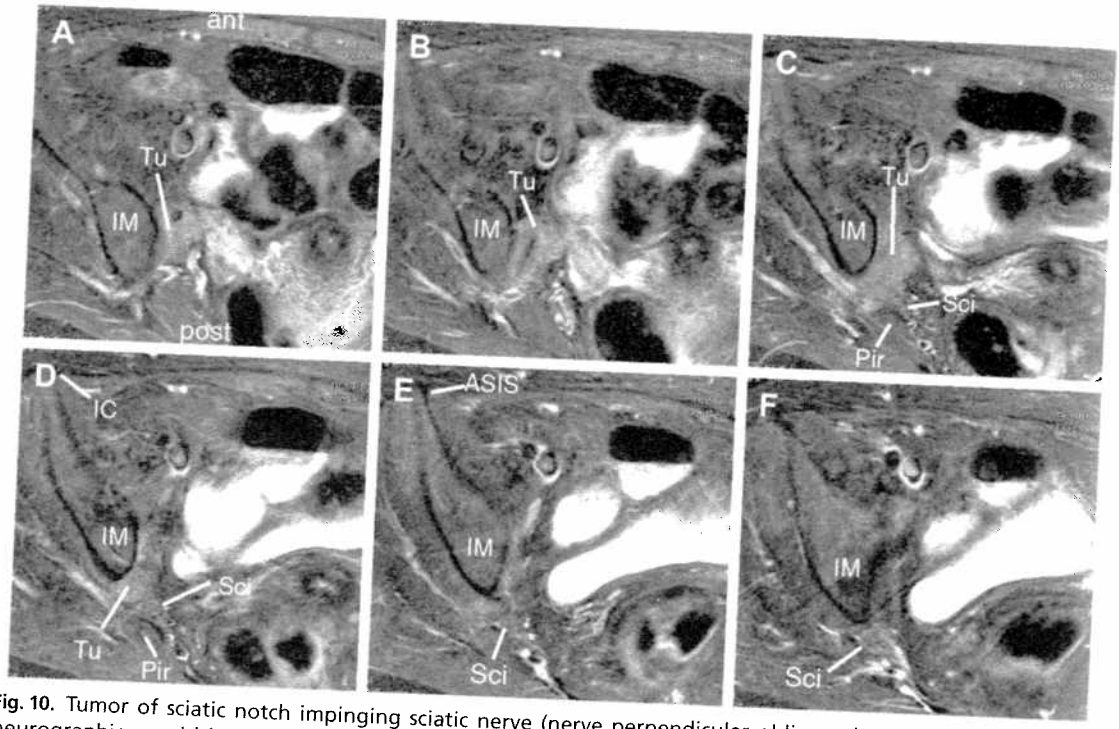

Fig. 10. Tumor of sciatic notch impinging sciatic nerve (nerve perpendicular oblique view, magnetic resonance neurographic acquisition sequence). *Abbreviations:* ASIS, anterior superior iliac spine; IC, iliac crest; IM, ischial margin; Pir, piriformis muscle; Sci, sciatic nerve; Tu, tumor.

worse post-operatively. Each was then reoperated for piriformis resection and obtained excellent long term improvement of 60–80%. This option was not offered to any patients subsequently.

In discussing the placebo issue at debates on piriformis syndrome, the author has pointed out that several patients in the study presented with severe buttock and leg pain, had epidural injections, facet injections, anesthetic disk injections, and nerve root treatment with no benefit. They often then had discectomies with no benefit, and some had artificial disk placement and lumbar fusion with no benefit. They then experienced complete relief (90% improvement going from a 9 to a 0 on the analog pain scale) with piriformis injection or piriformis surgery. The antipiriformis lecturer then insisted it was still placebo effect on the grounds that everyone knows spine surgery does not work but that these patients have been led to believe that piriformis treatment will cure them.

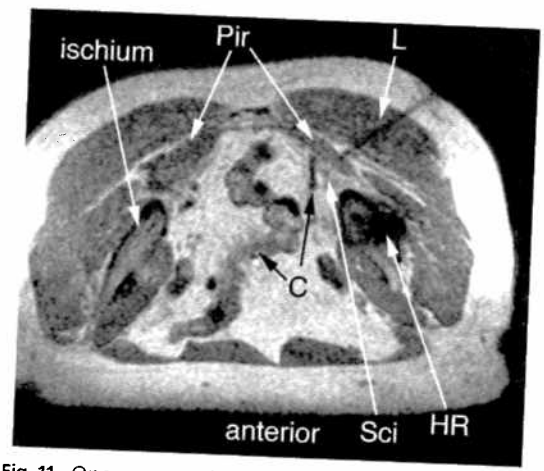

Fig. 11. Open magnetic resonance-guided injection of very thin piriformis muscle adjacent to underlying bowel. Axial T1 weighted acquisition in open MRI. *Abbreviations:* C, colon; HR, hip replacement artifact in ischium; L, Lufkin titanium needle; Pir, piriformis muscle; Sci, sciatic nerve.

The surgical piriformis outcome study reported in 2005[1] and the injection study reported in 2002[2] both conform to class A study methodology and constitute formidable evidence in support of well-documented treatment and paradigms. The surgical study with magnetic resonance neurography diagnostics and image-guided injections was repeated by a second independent group of[17] with the same result. When can one choose to completely dismiss a large-scale prospective class A research study whose results have been reproduced exactly by a second completely independent group using the same methodology? Is it OK to dismiss all this when the only report to the contrary is an open-method retrospective single case report?[18]

Is it not true that traditional orthopedic surgeries for piriformis syndrome can be disabling and ineffective? It is certainly true that

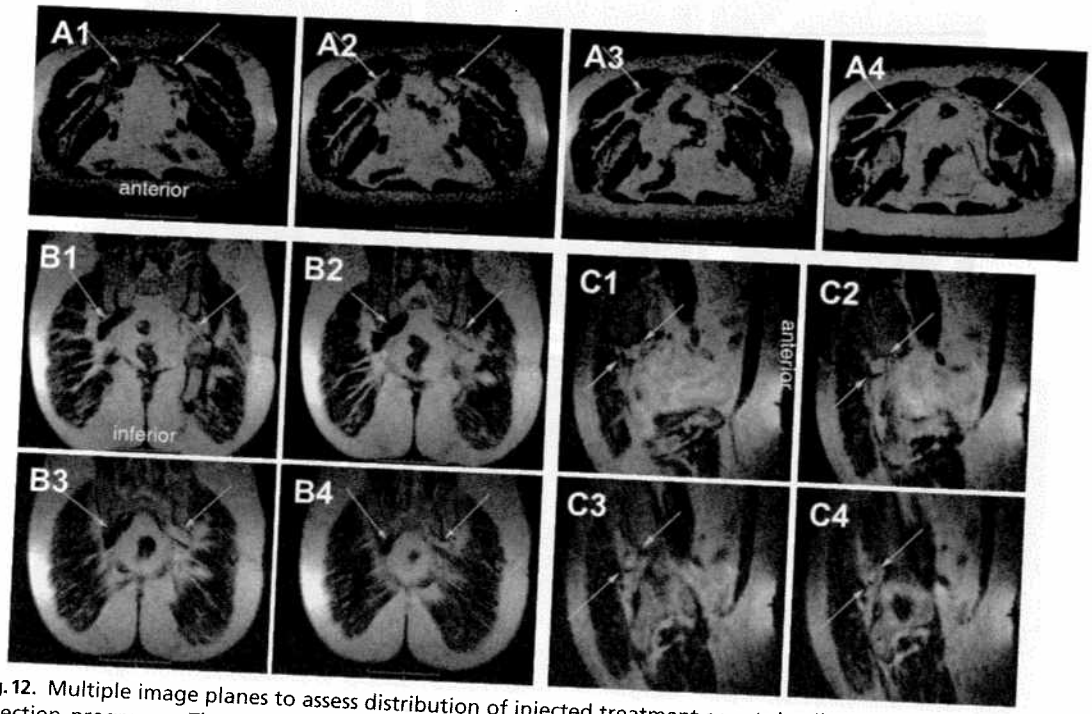

Fig. 12. Multiple image planes to assess distribution of injected treatment agents in all parts of the muscle as the injection progresses. The injected Marcaine appears bright white as it fills the various parts of the piriformis muscle. Axial T2 weighted acquisition in open MRI. (*A*) Axial plane (*arrow* pairs indicate right and left piriformis muscles). (*B*) Coronal plane (*arrow* pairs indicate right and left piriformis muscles). (*C*) Sagittal plane (*arrow* pairs indicate injected piriformis muscle).

a hip replacement-style surgical approach with simple sectioning of the piriformis tendon[19] often will paralyze the leg in a patient who has a split sciatic nerve passing through the muscle (the retracting cut muscle strangulates the nerve). It is also true that a large exposure that involves disconnecting all of the gluteal muscles from the pelvis to evaluate the sciatic nerve[18] could leave the patient unable to walk for months and with a permanent gait deficit when performed by an inexperienced surgeon. The modern minimal access approach with preoperative magnetic resonance neurography imaging published recently,[1] however, has excellent immediate outcomes and excellent ambulation with no reported gait abnormalities because of piriformis resection.

SUMMARY

Entrapments of the sciatic nerve and other nerves in the posterior pelvis may occur at various locations, and the piriformis muscle often is involved. There is a collection of related presentations that also may be called sciatic notch syndromes. These can involve the piriformis muscle alone, the sciatic nerve, the pudendal nerve, the superior gluteal nerve, the nerve to the obturator internus, and any of these in combination. These syndromes can produce severe positional pain that is chronic and debilitating. They share the physical examination finding of sciatic notch tenderness and aggravation by physical examination maneuvers in which the piriformis muscle is activated. They can be documented by specialized electrodiagnostic and imaging tests. The diagnosis can be confirmed by image guided injection studies. Treatment outcomes are good to excellent with very high efficacy rates in several high-quality large-scale outcome studies. There is no viable literature that suggests otherwise. Neglect of appropriate consideration of piriformis syndrome and failure to adequately evaluate and treat when it is suspected no longer should be considered as an appropriate standard of neurosurgical care.

My counterpart in this debate asks the reader to ignore similar results emerging unambiguously from hundreds of patients in three outcome studies by independent groups. Against this, he has only provided a case report on one single patient and a great deal of rhetoric and unsupported opinion yet he suggests that my position warrants Kennedy's epithet about the "great enemy of truth." I think this makes it fair for me to invoke Plato - specifically his "Noble Lie" to lead and protect the people - in fully categorizing my opponent's

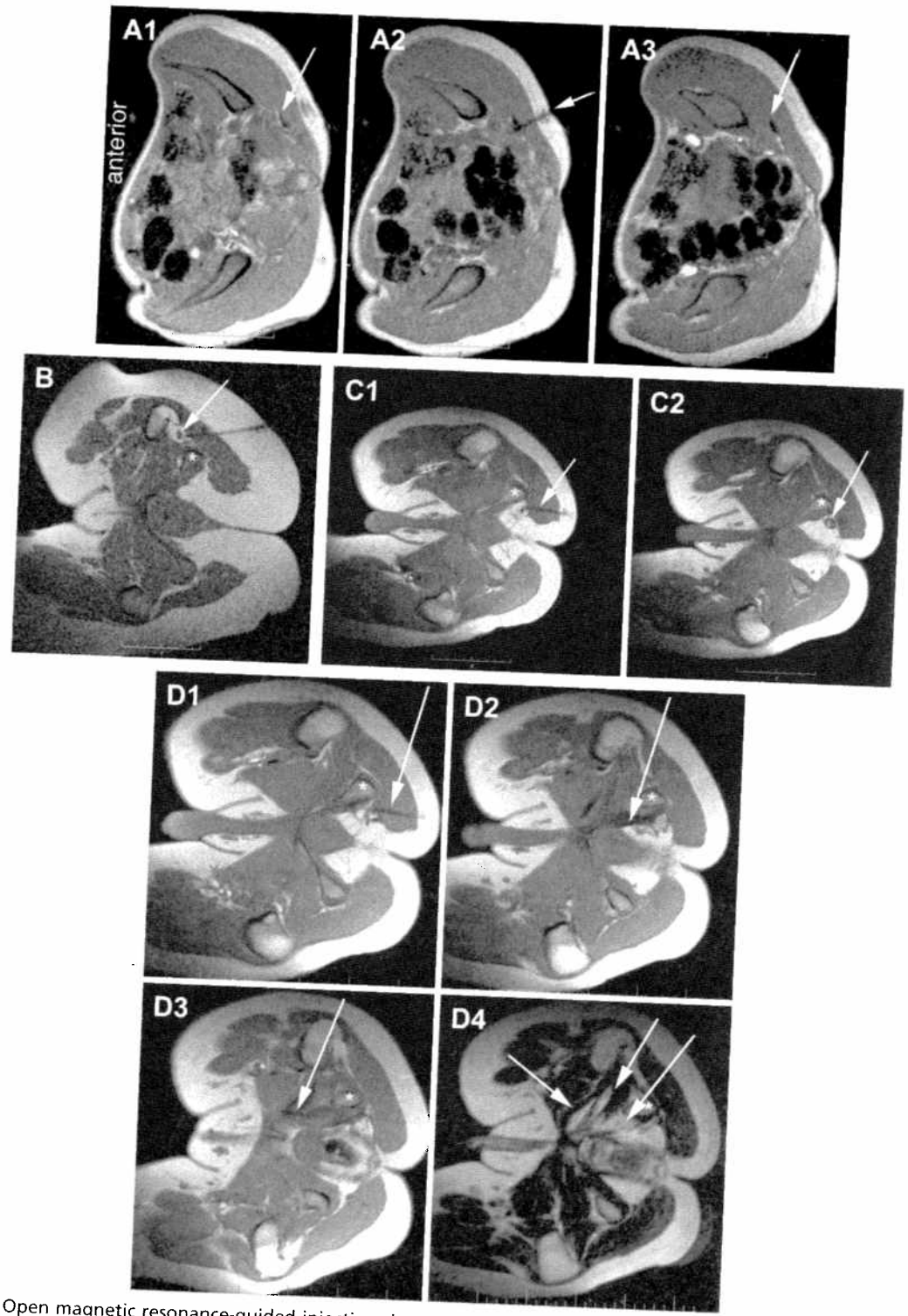

Fig. 13. Open magnetic resonance-guided injections in upper and lower regions of posterior pelvis. (*A*) Superior gluteal nerve—three successive image planes: arrows indicateinjectate along nerve course (*A1, A3*) and the injection needle (*A2*). (*B*) Ischial tunnel—arrow indicates injected medication in ischial tunnel just lateral to sciatic nerve, asterisk on ischial tuberosity. (*C*) Pudendal nerve block at entry to Alcock canal—arrows indicate needle (*C1*) and injected medication just medial to Alcock canal entry opening, asterisk on ischial tuberosity. (*D*) Obturator injections. (*D1*) Arrow needle approaches obturator internus. (*D2*) Arrow-injected medication in obturator internus. (*D3*) Medication in obturator internus and externus, needle passing into pectineus. (*D4*) – Arrows show pectineus, obturator externus, and obturator internus medication in place. Asterisk marks ischial tuberosity (Axial T1 weighted acquisition in open MRI, except *D4* [axial T2 weighted acquisition in open MRI]).

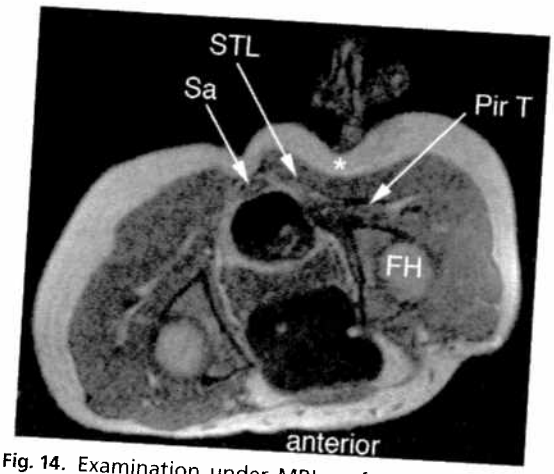

Fig. 14. Examination under MRI performed to distinguish piriformis muscle from sacrotuberous ligament tear as pain source (axial T1 weighted acquisition in open MRI). *Abbreviations:* FH, femoral head; Pir T, piriformis tendon; Sa, sacrum; STL, sacrotuberous ligament.* Examiner's finger.

position. There is a long history to the principle that a doctor can do good by avoiding truth - but in the case of piriformis syndrome, the light of modern science has led to a proof of its existence that can no longer be dodged, diluted, disputed or refuted.

"For if... a lie is really useless to gods and useful to human beings as a sort of remedy, it's plain that anything of the sort must be assigned to doctors while private men must not put their hands to it... Then it's appropriate for the ruler, if for anyone at all, to lie for the benefit of the city in cases involving enemies or citizens, while all the rest must not put their hands to anything of the sort."[20]

"Could we somehow contrive one of those lies that come into being in case of need... some one noble lie to persuade, in the best case, even the rulers, but if not them, the rest of the city?"[20]

"It likely that our rulers will have to use a throng of lies and deceptions for the benefit of the ruled. And, of course, we said everything of this sort is useful as a form of remedy."[20]

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