MR imaging for early complications of transpedicular screw fixation

A. Çolak
M. Kutlay
N. Demircan
H. İ. Seçer
K. Kibici
Ç. Başekim

Received: 2 April 1998
Revised: 10 November 1998
Accepted: 28 November 1998

A. Çolak (✉) · M. Kutlay · N. Demircan
H. İ. Seçer · K. Kibici
Department of Neurosurgery,
GATA Haydarpaşa Training Hospital,
81327 Üsküdar, Istanbul, Turkey
e-mail: colaka@superonline.com
Fax: +216-348 78 80

Ç. Başekim
Department of Radiology,
GATA Haydarpaşa Training Hospital,
Istanbul, Turkey

Abstract This series comprises ten patients treated with transpedicular screw fixation, who suffered early postoperative problems such as radicular pain or motor weakness. Besides plain radiographs, all patients were also evaluated with MR imaging. Three patients were reoperated for either repositioning or removal of the screws. MR images, especially T1-weighted ones, were

very helpful for visualizing the problem and verifying the positions of the screws. In cases of wide areas of signal void around the screws, the neighboring axial MR images at either side, which have fewer artifacts, gave more information about the screws and the vertebrae.

Key words MR imaging · Pedicle screw fixation · Titanium

Introduction

Surgical stabilization for symptomatic lumbar spondylolisthesis and for some traumatic vertebral fractures using a transpedicular screw-rod fixation system is a safe, satisfactory and effective method [19]. Although there are several descriptions for finding the screw entrance points and the direction of the screws intra-operatively, complications of incorrect positioning of screws are still being seen.

In the absence of any sign and/or symptom of spinal pathology and instrumentation, plain radiographs are mostly sufficient to verify the positions of the screws. On the other hand, for patients with radicular pain or muscular weakness, plain radiographs are not very reliable. Plain radiographs may or may not be helpful for visualizing the malpositioned screw or pedicular fracture. In one series, loosening of screws diagnosed with plain radiographs was not confirmed during intra-operative observation in 3 out of 14 cases [10]. If new postoperative problems arise, the patient must also be evaluated with an alternative radiological technique such as CT or MR imaging.

Although interference from metal can produce a blurred image, it is claimed that CT provides the best obtainable information on the position of the transpedicular screw in vivo [4]. If a new postoperative radiculopathy develops despite preventive measures, Dickman et al. suggest CT studies in addition to plain radiographs to evaluate for screw malpositioning [1]. In the evaluation of superior (sagittal) encroachment of screws, CT scans were observed to be inadequate, and lateral radiographs were found to be more informative [5]. MR imaging may give information about all kinds of encroachments of screws, because axial, sagittal and coronal images can be obtained.

The ideal instrumentation should fulfill biomechanical demands and allow imaging of all structures with minimal artifact during postoperative radiological studies. Although titanium implants are said to comply with both requirements, they do create significant artifact [11]. High-quality imaging studies often are required to verify the position of the implants or to evaluate the status of surrounding anatomic structures. Titanium implants generate artifacts on MR imaging, and the use of the appropriate parameters can minimize these effects [17]. The purpose of this study is to determine the efficacy of MR imaging

Table 1 Details of ten patients examined with MR imaging for early complications after transpedicular screw fixation

Patient no.	Age/Sex	Screw levels	Complication	MRI evaluation
<i>Postoperative clinical problems</i>				
1.	33, F	L3–4–5	Left leg pain	Normal
2.	52, F	L3–4–5–S1	Right leg pain	Pedicle fracture
3.	58, F	L3–4–5	Bilateral leg pain	Normal
4.	52, M	L3–4–5	Left leg pain and spasms	Normal
5.	35, M	L4–5–S1	Severe right leg pain	Pedicle fracture
<i>Screw direction and radiological problems</i>				
6.	17, F	L1–3–4	Left L3 screw was placed laterally	Malpositioning
7.	21, M	L2–3–4	Right L3 screw was inserted through fractured pedicle	Normal
8.	23, M	L4–5–S1	Left L5 screw seemed misplaced on plain radiographs	Almost normal
9.	48, F	L4–5–S1	Entry point was not accurate ^a	Normal
10.	70, M	L3–4–5	Screws were not evaluated in plain radiographs ^b	Normal

^aPrevious discectomy and facetectomy^bSevere osteoporosis

in checking the positions of MR-compatible screws in patients with problems in the early postoperative period.

Patients and methods

Between 1993 and 1997, 51 consecutive patients with lumbar spine instability were treated with the Diapason instrumentation system (Stryker Osteonics, Bordeaux) at the Gülhane Military Medical Academy Haydarpaşa Teaching Hospital in Istanbul. The instrumentation system is made of titanium. The operations were performed by the authors N.D., A.Ç. and M.K. under general anesthesia. The patients were positioned prone on a semiflexed operating table permitting lateral fluoroscopy. Entrance sites of the screws were defined using the landmarks described by Krag et al.

[8]. The entry point was at the intersection of a transverse line that bisects the base of the transverse process, and a longitudinal line that just touches the lateral border of the superior articular process. After preparation of the screw insertion site with an awl, the screw canal was drilled into the pedicle and vertebral body with a motor drill. By using a screw-depth gauge, the presence of circumferential bony structures was confirmed before screw insertion. There was always bony contact all around. Screw direction varied according to the level and was determined by the morphometric characteristics described by Zindrick et al. [20]. A C-armed image intensifier was used to guide screw placement. Posterior surfaces of the transverse processes were decorticated with a high-speed drill before constructing the system, and autologous bone grafts from the iliac crest were placed over the decorticated areas to obtain fusion.

This retrospective series includes 10 patients out of 51. These ten patients are the ones who had clinical problems in the early

Fig. 1 **A** Anteroposterior and **B** lateral plain radiographs show asymmetrically placed S1 screws

Fig. 2 T1-weighted axial image of the patient in Fig. 1. The relationship between the S1 root and the malpositioned right S1 screw is shown

postoperative period, such as radicular pain or motor weakness, and the ones with problems of screws positioning (Table 1). There were six women and four men, with a mean age of 39.9 years (17–70 years). The diagnosis was spondylolisthesis in eight cases and spinal fracture in two cases. The instrumentation connected four vertebrae in one case and three vertebrae in all others. The patients had a total of 62 screws inserted. In the early postoperative period, all patients were evaluated with plain radiographs and MR imaging for either their radicular pain or new developing neurological deficits. The MR imaging evaluation was done in the 1st postoperative week.

Results

Three patients continued to suffer back and/or leg pain postoperatively. In the following days, MR evaluation confirmed that the screws were in the right place and direction. The pain of these patients resolved later on.

One patient (no. 5) had a very sharp and intense radicular pain in the 1st postoperative day. Plain radiographs showed slight asymmetry of the S1 screws (Fig. 1 A, B). MR imaging revealed a pedicular fracture and a close relationship with the S1 nerve root (Fig. 2). After removing the right S1 screw and decompressing the S1 root, the pain resolved.

One other patient (no. 2) also had radicular pain. The plain radiographs did not show any major problem related to the pain, but the MR study revealed facet and pedicle fracture (Figs. 3, 4). At reoperation, the right L5 root was decompressed by removing the fractured bone fragments and the screw was left in place.

A screw of one patient was thought to be malpositioned in control plain radiographs, but MR imaging confirmed that the screw was in the right place. In a 70-year-old patient with severe osteoporosis, because of the radiolucency of the vertebrae neither the preoperative nor the

Fig. 3 Anteroposterior plain radiograph did not show any major abnormality

Fig. 4 T1-weighted axial MR image of the patient in Fig. 3. The right L4 pedicle fractured by the screw is clearly seen

postoperative plain radiographs were adequate for evaluating the positions of the screws. MR imaging was very helpful for evaluation of the screw positions in this case.

In one patient with traumatic fracture (no. 7) and in another (no. 9) with a previous lumbar disc herniation operation and wide facetectomy, it was very difficult to find

Fig. 5 T2-weighted axial MR image of the patient. The left-hand screw is malpositioned

the entry points and the directions of the screws. Although no major problem was shown on plain radiographs, the patients suffered some leg pain postoperatively. MR imaging studies revealed that the screws were in normal positions and the pedicles were intact. The pain resolved later on.

In the early period of our experience, one screw was malpositioned laterally in a traumatic vertebral fracture patient. The malpositioned screw was clearly shown on plain radiographs, but to make sure of the positions of other screws, an MR imaging study was done and the patient was then reoperated for repositioning (Fig. 5).

Independent radiographic re-evaluation of MR images was performed by a staff radiologist in addition to the authors' own evaluation. Areas of signal void around screws were smaller in T1-weighted images than in T2-weighted images, and the axial images were especially helpful in confirming the position and the direction of the screws. Signal void areas in the neighboring axial MR images that pass tangentially either side of the screws were smaller than those in the other images, and the relationships of screws to vertebrae were easily verified and evaluated.

Discussion

Transpedicular screw fixation system is a safe procedure [1, 3, 10], but some complications due to the device itself or to the instrumentation technique have been reported. The insertion of pedicle screws has been reported to be associated with a significant complication rate [9, 18]. Even highly experienced spine surgeons have a high rate of screw malpositioning with pedicle screw placement if they rely only on external spinal landmarks [1].

Whether or not the patient has any complaints, it is important to verify the position of the spinal instrumentation radiologically. Technical complications such as inaccurate

screw placement, penetration of the vertebral endplate and pedicle fracture must be excluded. Early postoperative complaints can be differentially diagnosed, and if they correlate to misplacement of the screw, early intervention to revise the internal fixation may be performed [5]. In such cases, screws responsible for symptoms should be removed and redirected and the involved root decompressed [1].

Titanium and titanium alloy pedicular screw systems are nonferromagnetic metals and are considered to be compatible with MR imaging. MR imaging can safely be performed on patients with these pedicular screw systems [7]. As is also true for CT scans, MR scans show blurred images around these screws and the rods, but the local artifacts caused by titanium implants do not interfere with the imaging of the adjacent soft tissues [14]. In one series, the titanium implants of 14 out of 15 patients allowed uncompromised imaging of the spine, with only minimal artifact production, and the titanium implants caused local signal void without the surrounding image deterioration that was characteristic of the stainless steel implants [13]. Ebraheim et al. concluded that the use of the titanium implants permitted high-quality MR imaging of the spinal canal contents [2]. We obtained the same results as Hachiya et al., in that the T1-weighted images had less artifact than T2-weighted images [6]. Despite small signal void areas, T1-weighted images showed the borders of screws and vertebrae sufficiently clearly to evaluate the positioning and the direction of screws. Wang et al. report that it is possible to obtain high-quality MR scans with minimal metal artifact in both the T1- and T2-weighted modes by using appropriate settings [16]. Fast spin echo imaging, in particular, decreases the metallic artifacts [12, 15].

Even the minimal artifacts caused by metallic implants interfere with the nearby anatomic structures. Verifying the continuity of the pedicle walls in the presence of screws may become very important in deciding whether to reoperate or not. We made an interesting observation that, if the screws caused wide signal void areas in axial MR images that compromised the evaluation, the neighboring axial MR images that pass tangentially on either side of the screws were very helpful for evaluation. Because these images all had smaller signal void areas, and both upper and lower surfaces of the screw were visualized clearly, the relationships of screws to the vertebrae were easily confirmed and evaluated.

In cases of wide signal void areas around the screws in axial images, upper and lower images on both sides were very helpful, because the signal void areas were smaller and the margins of screws appeared sharper.

Conclusion

Although the transpedicular screw system is safe, it is still associated with a certain rate of complications. In patients

with a smooth operative and postoperative course, the screws can be checked with plain radiographs, but in cases of probable malpositioning and for complications with MR-compatible devices, we suggest MR imaging to visualize the problem and also to confirm the positions of

the other screws. T1-weighted MR images have less artifact than T2-weighted images. In case of wide signal void areas around the screws, the neighboring axial images at either side seem to have less artifact and give more information about the screws and the vertebrae.

References

- Dickman CA, Fessler RG, MacMillan M, Haid RW (1992) Transpedicular screw-rod fixation of the lumbar spine: operative technique and outcome in 104 cases. *J Neurosurg* 77: S 860–S 870
- Ebraheim NA, Savolaine ER, Stitgen SH, Jackson WT (1992) Magnetic resonance imaging after pedicular screw fixation of the spine. *Clin Orthop* 136: 133–137
- Faraj AA, Webb JK (1997) Early complications of spinal pedicle screw. *Eur Spine J* 6: 324–326
- Gertzbein SD, Robbins ES (1990) Accuracy of pedicular screw placement in vivo. *Spine* 15: 11–15
- Güven O, Yalçın S, Karahan M, Sevinç TT (1994) Postoperative evaluation of transpedicular screws with computed tomography. *Orthop Rev* 23: 511–516
- Hachiya Y, Yoshizawa E, Kobayashi S (1991) Effect of spinal fixators on mri (in Japanese). *J Jpn Spin Res [Soc]* 2: 204
- Iwasaku Y, Yamaguchi Y, Ohi N, Emoto K, Kusabake T (1995) MR imaging evaluation of the spine with titanium alloy pedicular screw fixation. *J Spinal Disord* 8 [Suppl 1]: S 15–S 22
- Krag MH, Beynon BD, Pope MH, Frymoyer JW, Haugh LD, Weaver DL (1986) An internal fixator for posterior application to short segments of the thoracic, lumbar, lumbosacral spine. design and testing. *Clin Orthop* 203: 75–98
- Mulholland RC (1994) Pedicle screw fixation in the spine. *J Bone Joint Surg [Br]* 76: 517–519
- Ohlin A, Karlsson M, Düppe H, Hasserius R, Redlund-Johnell I (1994) Complications after transpedicular stabilization of the spine. A survivorship analysis of 163 cases. *Spine* 19: 2774–2779
- Ortiz O, Pait TG, McAllister P, Sauter K (1996) Postoperative magnetic resonance imaging with titanium implants of the thoracic and lumbar spine. *Neurosurgery* 38: 741–745
- Petersilge CA, Lewin JS, Duerk JL, Ghaneyem AJ (1996) Optimizing imaging parameters for evaluation of the spine with titanium pedicle screws. *AJR* 166: 1213–1218
- Rupp R, Ebraheim NA, Savolaine ER, Jackson WT (1993) Magnetic resonance imaging evaluation of the spine with metal implants. *Spine* 18: 379–385
- Rupp RE, Ebraheim NA, Wong FF (1996) The value of magnetic resonance imaging of the postoperative spine with titanium implants. *J Spinal Disord* 9: 342–346
- Tartaglino LM, Flanders AE, Vinitski S, Friedman DP (1994) Metallic artifacts on MR images of the postoperative spine: reduction with fast spin-echo techniques. *Radiology* 190: 565–569
- Wang JC, Sandhu HS, Yu WD, Minchew JT, Delamarter RB (1997) MR parameters for imaging titanium spinal instrumentation. *J Spinal Disord* 10: 27–32
- Wang JC, Yu WD, Sandhu HS, Tam V, Delamarter RB (1998) A comparison of magnetic resonance and computed tomographic image quality after the implantation of tantalum and titanium spinal instrumentation. *Spine* 23: 1684–1688
- West JL, Oglivie JW, Bradford DW (1991) Complications of the variable plate pedicle screw fixation. *Spine* 16: 576–579
- Yuan HA, Garfin SR, Dickman CA, Mardjetko SM (1994) A historical cohort study of pedicle screw fixation in thoracic, lumbar and sacral spinal fusions. *Spine* 19 [Suppl 20]: 2279–2292
- Zindrick MR, Wiltse LL, Doornik A, Widell EH, Knight GW, Patwardhan AG, Thomas JC, Rothman SL, Fields BT (1987) Analysis of the morphometric characteristics of the thoracic and lumbar pedicles. *Spine* 12: 160–165