

Risk Factors for Pedicle Screw Fracture in the Lumbar Spine

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Learning Objectives: After participating in this CME activity, the neurosurgeon should be better able to:

1. Identify factors that place patients at higher risk for developing pedicle screw fracture in the lumbar spine.
2. Evaluate ways to minimize the risk of hardware failure.

An analysis of trends in spinal surgery by Rajaei et al. over a period of 10 years from 1998 to 2008 revealed that the annual number of spinal fusions has increased 137%. Although spinal fusion rates have increased over this period, in-hospital mortality has decreased. The rate of major and minor complications for spinal fusion is variable, and a focus of part of the literature around this topic has been identification of patient factors that are predictive of a higher rate of postoperative complications.

Literature Review

One type of postoperative complication in lumbar fusion is hardware failure. Although not all hardware failure requires reoperation, for the patient, this complication can be distressing. The rate of pedicle screw fracture in the literature is variable, with one author reporting rates up to 21%.

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Yahiro (1994) performed a review of 101 articles that evaluated patients undergoing lumbar pedicle screw fixation. There were 5756 patients in the literature with pedicle screw fixation devices, and from these patients there were a total of 410 with pedicle screw fracture (7.1%). He reported finding 12 patients (0.2%) with fractured rods. The author did not identify any additional variables associated with fractured screws.

Yuan et al. (1994) obtained information from surgeons about their lumbar fusion cases over a period of 4 months. Data were collected from 2177 patients who underwent lumbar fusion for a preoperative diagnosis of degenerative spondylolisthesis, and the authors report a rate of screw fracture of 2.6%. Data were also collected from 586 patients who underwent lumbar fusion for a diagnosis of fracture. In these patients, the rate of screw fracture was higher at 6.7%. The authors discuss the higher rate of screw fracture in the patients with lumbar fracture, and they attribute this finding to larger mechanical stresses placed on screws that are correcting spinal deformities. They also discuss the importance of anterior column support in reducing screw fractures. Esses et al. (1993) analyzed 617 patients who underwent lumbar pedicle screw fixation through a survey of American Back Society members. The calculated rate of screw fracture was 2.9%. They did not discuss risk factors for instrumentation failure.

Category: Spine

Key Words: Lumbar fusion complications, Pedicle screw fracture

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Matsuzaki et al. (1990) evaluated a group of 57 patients who underwent lumbar pedicle screw plate fixation. In this group, 21% of patients experienced screw breakage postoperatively. They reported that screws in the lumbar spine were more likely to be broken caudally. The location of the fracture on the screw was either outside the pedicle at the junction of the nut or immediately beneath the plate. Three patients with bilateral screw fracture experienced symptoms, but the authors did not give further information about the types of symptoms they experienced. In these 3 cases, the symptoms did not persist beyond 6 months.

Mechanical analysis of screw fracture has revealed the importance of homogenizing stress distribution on the hardware. One author postulates that the position of the interbody graft may help reduce the likelihood of screw fracture. Demir et al. (2012) analyzed the stress concentration at the interface between the rod and the screw. They propose that a small contact area between the rod and the setscrew increases stress concentration, which may predispose to screw failure. They propose a device that increases the contact area, thus decreasing the fracture rate. Rohlmann et al. (1998) analyzed the position of the interbody device in one case of pedicle screw fracture and propose that posteriorly placing the interbody graft may reduce the risk of screw fracture.

Chen et al. (2005) performed analysis of broken lumbar pedicle screws in 16 patients. They found that screws on the caudal end had larger axial stress compared with screws on the cephalic side. Clinically, 75% of the patients with fractured screws had broken the caudal screw, corresponding with the larger axial stress. The broken screws showed striations on the surface, indicating fatigue failure. In this study, the authors documented that 69% of the patients had bone union, indicating that bone fusion did not prevent screw fracture. Lonstein et al. (1999) reported a screw fracture rate of 2.2%, or 20 of 915 patients. Similar to Chen et al., they noted that

7 of the patients had evidence of solid fusion—4 with radiographic evidence and 3 who were determined to have solid fusion during re-exploration.

Dickman et al. (1992) reported a screw failure rate of 4.8% in their analysis. This rate included screws that bent, loosened, or became broken. Two of the incidents developed after a traumatic fall early into recovery. They note that out of the cases in which instrument failure was detected, reoperation occurred in half of them. The revision was performed only if the patient was symptomatic or if a pseudoarthrosis was detected. The authors attribute the screw fractures to narrow-diameter screws, and they note that when they discontinued the use of 4.5- or 5.0-mm screws, there were no more screw fractures detected.

In addition to mechanical factors that have been evaluated, patient factors can be analyzed as possibly placing individuals at a greater risk for screw fracture. Suda et al. (2006) analyzed the risk factors of screw fracture in 101 patients who underwent pedicle screw fixation for isthmic spondylolisthesis. They report a rate of screw fracture of 5.9%. They did not identify a greater risk of screw fracture or pseudoarthrosis from smoking, bone mineral density, number of segments fused, and occupation. They conclude that the lack of identification of patient risk factors was due to the small sample size. They did find that preoperative preserved disc height and kyphosis were correlated to pseudoarthrosis and instrumentation failure.

Patients and Methods

We conducted a study to analyze a population of patients who underwent lumbar pedicle screw fixation by a single neurosurgeon and determine the rate of screw fracture. In addition, characteristics of patients with screw fracture are compared with the cohort to determine any common variables within the fracture group and ways to minimize the risk of hardware failure are discussed.

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Data were obtained from all patients who underwent lumbar pedicle screw fixation during the period of 2008 through 2010. Corticocancellous allograft was used; no iliac crest was harvested in any of the patients. Obesity was defined as body mass index of at least 30 kg/m². Smoking and alcohol history were self-reported by patients, and alcohol use was defined as consumption of 6 or more alcoholic beverages on a weekly basis. Preoperative diagnosis was made by the surgeon before the procedure and obtained directly from the operative record. All screw fractures were diagnosed by radiographic means. Charts of the patients with screw fractured were individually reviewed for clinical presentation and time to fracture. For each factor that was analyzed, the total number of patients was counted in the population group and in the screw fracture group. Percentages were calculated to compare differences in the representation of each factor within the groups.

A total of 1036 patients was included in this study. The age range of patients was 20 to 89 years. There were 631 women and 405 men. From these 1036 patients, there were a total of 13 screw fractures (1.3%) identified postoperatively. All 13 of the patients with screw fractures underwent reoperation.

Among a total of 1036 patients, 631 (60.9%) were women compared with 9 (69.2%) of the 13 who developed a screw fracture. Of the total of 1036 patients, 405 (39.1%) were men compared with 4 (30.2%) of the 13 who developed a screw fracture. Among 1035 patients, 450 (43.5%) were classified as obese compared with 7 (53.8%) of the 13 who developed a screw fracture. Of 1031 patients, 460 (44.6%) listed a smoking history compared with 7 (53.8%) of the 13 with screw fracture. Of 1027 patients with data, 132 (12.9%) listed an alcohol history compared with only 1 (7.7%) of the 13 with screw fracture. Of the 1031 patients with data, 35 (3.4%) listed a medical

history significant for osteoporosis compared with 0 (0%) with screw fracture. Figure 1 provides a graphic representation of the patient factors seen in each group of patients. Note that female sex, obesity, and smoking were seen at a higher percentage in the group that sustained screw fractures.

Of 1032 patients, 202 (19.6%) had a preoperative diagnosis of scoliosis compared with 2 (15.4%) of the 13 with screw fracture. Of 1033 patients, 257 (24.9%) had a diagnosis of a pars defect compared with 5 (38.5%) of the 13 with screw fracture. Of 1034 patients, 671 (64.9%) had a diagnosis of anterolisthesis compared with 7 (53.8%) of the 13 patients who developed a screw fracture. Of 1027 patients with data, 66 (6.4%) had a diagnosis of posterolisthesis compared with 1 patient (7.7%) who developed a screw fracture. Of 1029 patients with available data, 288 (28%) had preoperative evidence of movement or significant instability compared with 4 (30.8%) of the 13 who developed a screw fracture. Of 1036 patients, 322 (31.1%) had mechanical lower back pain and collapse of the disc space of 1 or more levels compared with 1 (7.7%) of the 13 with screw fracture. Of 1031 patients, 23 (2.2%) had a diagnosis of pseudoarthrosis compared with 3 (23.1%) of the 13 with screw fracture. Figure 2 shows preoperative diagnosis as it relates to screw fracture in the lumbar spine

Of 1036 patients, 371 (35.8%) were classified as having redo surgery compared with 5 (38.5%) of the 13 with screw fracture. Patients in this cohort who had redo surgery had previous laminectomy and developed either instability or facet incompetency with disc collapse, lateral recess stenosis, and/or disc herniation. Of 1027 patients with available data, 309 (30.1%) had undergone previous laminectomy compared with 3 (23.1%) of the 13 who developed a screw fracture. Of 1024 patients, 7 (0.7%) were classified as having an extension

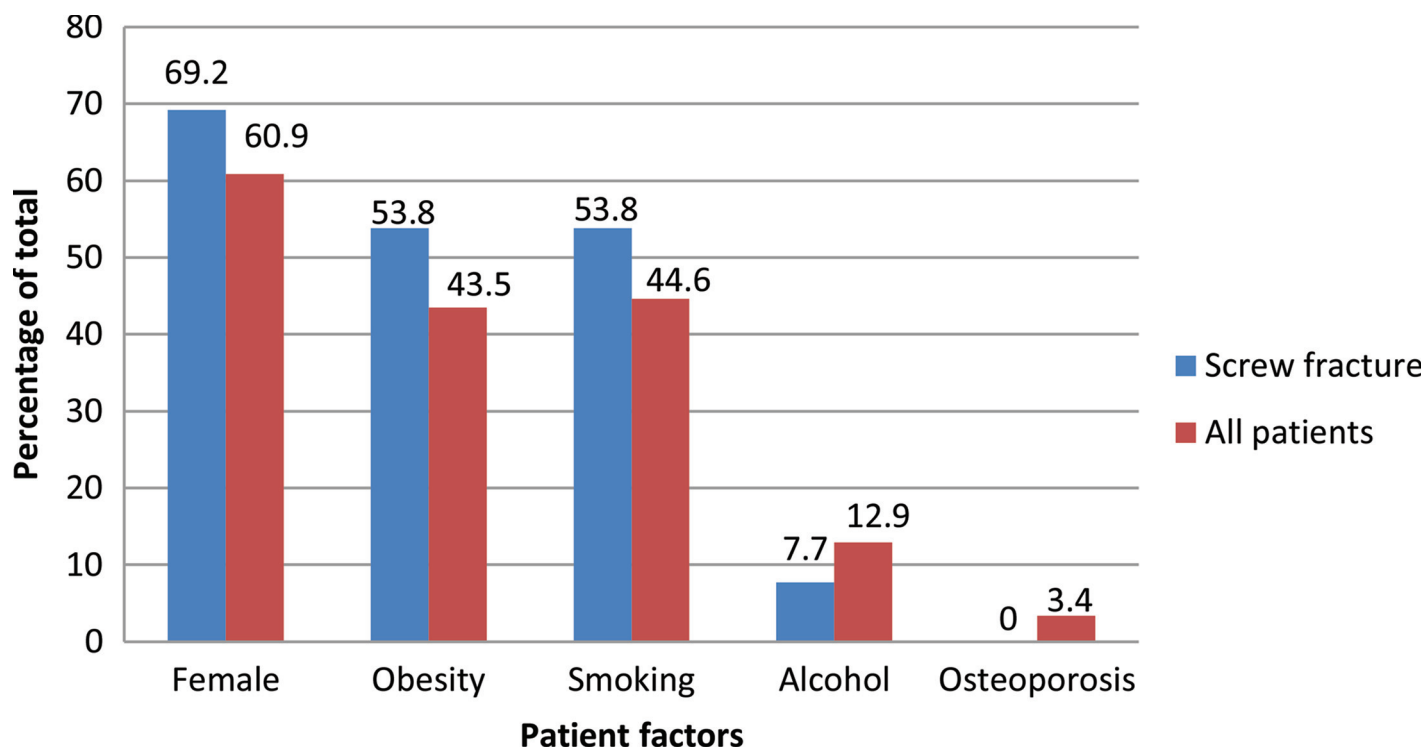


Figure 1. Patient factors in lumbar pedicle screw fixation with screw fracture.

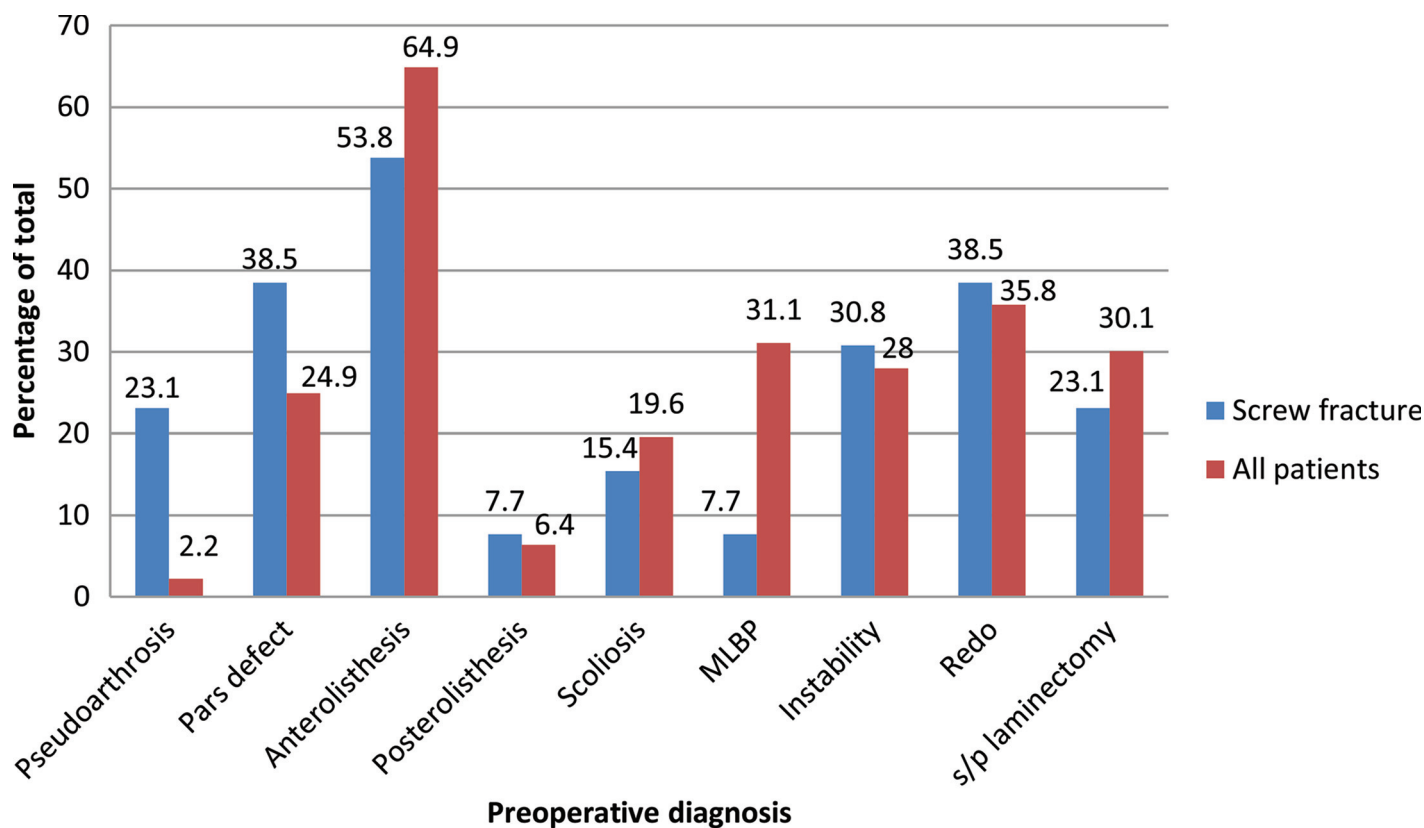


Figure 2. Preoperative diagnosis as it relates to screw fracture in the lumbar spine. MLBP, mechanical lower back pain.

procedure onto a previous instrumented fusion whereas none of the patients with screw fracture were placed into this category. Of 1021 patients with available data, 578 (56.6%) had interbody fusion placed compared with 3 (23.1%) of the 13 with screw fracture. Of these 1021 patients, 443 (43.4%) did not have interbody fusion placed compared with 10 (76.9%) with screw fracture. Postoperatively, of 1024 patients, 324 (31.6%) used a bone stimulator compared with 6 (46.2%) of the 13 with screw fracture. Of 1024 patients, 700 (68.4%) did not use a bone stimulator compared with 7 (53.8%) of the 13 with screw fracture.

Of the 631 women, 9 (1.4%) developed a screw fracture compared with 4 (1%) of the 405 men. Of the 450 obese patients, 7 (1.6%) developed a screw fracture compared with 6 (1%) of the 585 who were not classified as obese. Of the 460 patients with documented smoking history, 7 (1.5%) developed a screw fracture compared with 6 (1.1%) of the 571 who did not report a smoking history.

The time from surgery to when the fracture was radiologically identified varied. In 6 patients, fracture was identified in less than 1 year from the original surgery. The range was 2 months to 3 years, 9 months.

Discussion

The rate of screw fracture in this study was found to be 1.3%, which is in the lower range of the average reported in the literature. Out of each individual subgroup, there were some characteristics that were found in a higher percentage in the screw fracture group than the overall percentage for

screw fracture in the population group. Of the 460 patients with a history of smoking, 7 (1.5%) developed a screw fracture. Of the 450 obese patients, 7 (1.6%) had a screw fracture. Of the 443 patients who did not have interbody fusion placed, 10 (2.3%) developed a screw fracture. Of the 257 patients with a pars defect, 5 (1.9%) developed a screw fracture. Of the 324 patients who used a bone stimulator, 6 (1.9%) developed a screw fracture, which was contrary to what was expected.

Conclusions

The goal of this study was to evaluate risk factors for pedicle screw fracture in the lumbar spine. The rate of screw fracture in this group of 1036 patients was 1.3%, which was lower than many reported studies. Because of the small number of fractured screws, it is difficult to draw any solid conclusions about risk factors for screw fracture. However, on the basis of these numbers, it seems that obesity, female sex, smoking, and pars defect with listhesis place patients at a somewhat greater risk of a fractured pedicle screw. Long-segment fusion of 4 or more levels with scoliotic deformity tends to have a high risk of screw fracture, although in this study the number of patients with scoliosis and screw fracture was comparatively low. In addition, the placement of interbody fusion intraoperatively seems to lower the risk of screw fracture but does not eliminate it.

Preparation and shaving of the endplate of the disc space at the interbody fusion level, good decortication of transverse processes and lateral aspect of facet joints, and

increased stress and compaction at the surface area around the allograft and interbody fusion tend to enhance fusion and decrease the risk of screw fracture. The use of an external bone stimulator did not seem to decrease the risk of screw fracture.

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1. Patients with a pars defect preoperatively had a higher rate of screw fracture.
True or False?
2. Patients with anterolisthesis preoperatively had a higher rate of screw fracture.
True or False?
3. Pseudoarthrosis occurred at a higher rate in patients with screw fracture.
True or False?
4. The rate of screw fracture in the lumbar spine is variable in the current literature.
True or False?
5. According to the current study, interbody fusion eliminates the risk of pedicle screw fracture.
True or False?
6. The use of an external bone stimulator eliminated the risk of screw fracture in this evaluation.
True or False?
7. Obesity was more prevalent among patients who developed a screw fracture than the general population of patients.
True or False?
8. Men were more likely to develop a screw fracture than women.
True or False?
9. Preparation and shaving of the endplate of the disc space at the interbody fusion level, good decortication of transverse processes and lateral aspect of facet joints, and increased stress and compaction at the surface area around the allograft and interbody fusion tend to enhance fusion and decrease the risk of screw fracture.
True or False?
10. Smoking may place patients at a higher risk for developing lumbar pedicle screw fracture.
True or False?