Surgical complications of posterior lumbar interbody fusion with total facetectomy in 251 patients

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OBJECT. Previous studies of surgical complications associated with posterior lumbar interbody fusion (PLIF) are of limited value due to intrastudy variation in instrumentation and fusion techniques. The purpose of the present study was to examine rates of intraoperative and postoperative complications of PLIF using a large number of cases with uniform instrumentation and a uniform fusion technique.

METHODS. The authors reviewed the hospital records of 251 patients who underwent PLIF for degenerative lumbar disorders between 1996 and 2002 and who could be followed for at least 2 years. Intraoperative, early postoperative, and late postoperative complications were investigated. Intraoperative complications occurred in 26 patients: dural tearing in 19 patients and pedicle screw malposition in seven patients. Intraoperative complications did not affect the postoperative clinical results. Early postoperative complications occurred in 19 patients: brain infarction occurred in one, infection in one, and neurological complications in 17. Of the 17 patients with neurological complications, nine showed severe motor loss such as foot drop; the remaining eight patients showed slight motor loss or radicular pain alone, and their symptoms improved within 6 weeks. Late postoperative complications occurred in 17 patients: hardware failure in three, nonunion in three, and adjacent-segment degeneration in 11. Postoperative progression of symptomatic adjacent-segment degeneration was defined as a condition that required additional surgery to treat neurological deterioration.

CONCLUSIONS. The most serious complications of PLIF were postoperative severe neurological deficits and adjacent-segment degeneration. Prevention and management of such complications are necessary to attain good long-term clinical results.

KEY WORDS • lumbar spine • spinal fusion • facetectomy • complication

Clinical Material and Methods

Two hundred fifty-one patients (121 men and 130 women) underwent PLIF for degenerative lumbar disorders between 1996 and 2002 and were followed up for at least 2 years. The follow-up rate was 88%. The mean age at surgery was 61 years (range 15–87 years), and the mean follow-up period was 50 months (range 24–90 months). Most (154) of the patients had a diagnosis of degenerative spondylolisthesis, 53 ischemic spondylolisthesis, 23 lumbar canal stenosis, and 21 disc herniation. We excluded patients who suffered from infection, fracture–dislocation, rheumatoid arthritis, or destructive spinal arthropathy. The vertebral levels of the PLIF segments were as follows: L1–2 in two cases, L2–3 in five, L3–4 in 18, L4–5 in 162, L5–6 in 12, and L5–S1 in 39 cases. In 13 patients, two levels were fused: L2–4 in two patients, L3–5 in 10, and L4–S1 in one patient.

Abbreviations used in this paper: CT = computerized tomography; JOA = Japanese Orthopaedic Association; MMT = manual muscle test; PLIF = posterior lumbar interbody fusion.
Surgical complications of PLIF

All patients considered for surgery had severe, disabling low-back pain and lower-extremity pain that were unresponsive to conservative treatment such as medication and epidural steroid injection. The indications for PLIF were as follows: spondylolisthesis with slippage greater than 3 mm and a posterior opening greater than 5° on flexion–extension lateral radiographs, lumbar canal stenosis, or disc herniation requiring wide decompression and discectomy. All PLIF procedures were performed using the same technique, which has been described elsewhere. All procedures were performed by five surgeons, each of whom had more than 10 years of experience in orthopedic surgery and had performed PLIF at least 30 times. Briefly, PLIF was performed using the Steffee variable screw placement system and local bone grafting with Brantigan interbody fusion cages. Total facetectomy was performed to prevent excessive retraction of neural elements during discectomy and bone grafting. In all cases, autografting was performed using local lamina bone. Neither fluoroscopic guidance nor computer navigation was used during the pedicle screw insertion. Posterolateral fusion was not added at any level.

Complete hospital and attending physician records of all patients were available for review. These records were reviewed to determine demographic data, primary diagnosis, clinical results, and intra- and postoperative complications. Lumbar lesions were assessed using the scoring system proposed by the JOA. Briefly, the JOA score consists of ratings of subjective symptoms (low-back pain, 3 points; leg pain, 3 points; gait abnormality, 3 points), clinical symptoms (straight leg–raising test, 2 points; sensory abnormality, 2 points; motor disturbance, 2 points), restriction of activities of daily living (14 points), and urinary bladder function (−6 points). A normal total JOA score is 29 points (Table 1). Clinical and radiological assessments were performed for all patients before surgery and at 1, 3, 6, 12, 15, 18, and 24 months after surgery. Complications of PLIF were classified into three categories: intraoperative, early postoperative, and late postoperative. Early and late postoperative complications were respectively defined as complications occurring less than or equal to 1 month, and greater than 1 month postoperatively. Complications that were not specific for spine surgery and did not affect recovery (for example, urinary tract infection, anemia, and confusion) were considered minor complications and were excluded. Spine-specific complications such as pedicle screw malpositions were included, even if they did not affect postoperative clinical results.

The intraoperative complications we investigated were dural tearing, nerve injury (for example, cauda equina and/or nerve root damage), and pedicle screw malposition. A pedicle screw malposition was defined as penetration of the medial or lateral pedicle cortex by more than half the diameter of the pedicle screw or penetration of the anterior vertebral cortex by more than 5 mm of the pedicle screw tip, as assessed using postoperative CT studies.

The early postoperative complications we investigated were major complications such as pulmonary, cardiac, and cerebrovascular morbidity; infection; hardware failure; and neurological complications. Postoperative wound infection was defined as a deep infection requiring additional surgery such as debridement. Postoperative neurological complications were classified into three categories: increased leg pain without motor loss; slight motor loss, with an MMT score of 3 to 4, with or without increased leg pain; and severe motor loss, with an MMT score of less than 3, with or without increased leg pain.

The late postoperative complications we investigated were late infection, hardware failure, nonunion, and adjacent-segment degeneration. All patients underwent postoperative CT scanning. Solid fusion was defined as a condition in which bone continuity between graft bone and vertebra was detected on conventional and reconstruction CT scans, with neither loosening of pedicle screws nor motion at the fused segment demonstrated on flexion–extension lateral radiographs. If solid fusion was not detected 6 months after surgery, a conventional and reconstruction CT study was performed every 3 months to confirm bone continuity between graft bone and vertebra. Postoperative progression of adjacent-segment degeneration was defined as a condition in which additional surgery was required to treat neurological deterioration due to adjacent-segment degeneration.

Results

Clinical Results

The clinical results obtained in patients who did not undergo revision surgery were assessed at the final follow-up examination. The clinical results of the patients who underwent revision surgery were assessed immediately before the second operation. The average pre- and postoperative JOA scores for all patients were 13 and 24 points, respectively.

Intraoperative Complications

Intraoperative complications occurred in 26 patients. Nineteen patients (7.6%) experienced dural tearing, and seven (2.8%) had pedicle screw malposition (one pedicle screw malposition per patient; Table 2). No major intraoperative complications, such as neurovascular injury, were observed. Cauda equina injury was not observed in any case of dural tearing. All patients underwent primary sutur-
ing, which did not affect the clinical results. Neither persistent cerebrospinal fluid leakage nor meningitis was observed in any patient.

Pedicle screw malpositions were not detectable during the surgery but were detected on postoperative CT studies. None of the patients had pedicle screw malpositions on both sides. One patient with irritation of the nerve root due to medial penetration of the pedicle screw underwent revision surgery for decompression and replacement of the pedicle screw; this patient’s symptoms improved after revision surgery. No other patient had symptoms due to pedicle screw malposition.

**Early Postoperative Complications**

Early postoperative complications occurred in 19 patients: brain infarction in one, infection in one, and neurological complications in 17 patients (6.8%; Table 2). In one patient, brain infarction was observed 2 days after surgery, and was successfully treated with conservative therapy.

In one case, chronic renal failure due to diabetes mellitus was treated with hemodialysis, and deep wound infection was observed 1 week after the primary surgery. This infection was treated with debridement three times, and it improved without hardware removal.

No, slight, and severe motor loss were observed in two (0.8%), six (2.4%), and nine cases (3.6%), respectively. One patient with irritation of the nerve root due to medial penetration of the pedicle screw was excluded from this category of neurological complication. All but one of these patients had single nerve root palsy. In 15 cases, the palsy involved the L-5 root; in one, the L-4 root; and in one, global weakness. All patients with no motor loss or slight motor loss exhibited improvement in their symptoms within an average of 6 weeks (range 2–18 weeks). In all patients with severe motor loss, neurological deficits were observed for several days after surgery, but compression of neural elements was not detected on magnetic resonance imaging studies, plain myelography, or CT myelography. We proposed revision surgery for all patients with severe motor loss, to reconfirm the condition and/or to accomplish decompression of the neural elements. Five patients agreed to undergo revision surgery and underwent a second operation. The average period between the first and second operation was 9 days (range 3–14 days). Of these five patients, two experienced compression of the nerve root due to expansion of hemostatic agents; one, an epidural hematoma; and one, inadequate decompression around the nerve root. In the remaining patient, no apparent cause of the neurological deficit was observed. With the exception of the latter case, all causes of neurological deficits were identified, and all patients recovered fully after the second operation. In the four patients with severe motor loss in which revision surgery could not be performed, neurological deficits persisted permanently. Among patients who underwent revision surgery, the average JOA scores before the first operation and after the second operation were 10 and 21 points, respectively. Among patients who did not undergo revision surgery, the average pre- and postoperative JOA scores were 10 and 12 points, respectively.

**Late Postoperative Complications**

Late postoperative complications occurred in 17 patients: hardware failure in three (1.2%), nonunion in three (1.2%), and adjacent-segment degeneration in 11 (4.4%; Table 2). No cases of late-phase deep wound infection were observed. All three patients with hardware failure exhibited pedicle screw breakage, but none of them had complaints such as back pain or radicular pain due to the hardware failure, and bone fusion was detected at the final follow-up examination.

None of the three patients with nonunion experienced pedicle screw breakage, but pedicle screw loosening was detected on radiographic and CT studies. Of these three patients, one had no complaints, but the remaining two had severe low-back pain that was unresponsive to conservative treatment for more than 1 year and was treated with a second operation. One of the latter two patients underwent replacement of both pedicle screws, interbody cages, and the bone graft. The other patient underwent replacement of pedicle screws and the addition of posterolateral fusion without replacement of the interbody cages or bone graft. These two patients exhibited improvement of symptoms and osseous fusion after the second operation. The average period between the first and second operations was 17 months (range 13–20 months).

Postoperative progression of adjacent-segment degeneration was observed in 11 patients (4.4%; seven men and four women). A summary of clinical data for these patients is shown in Table 3. The patients’ mean age at the first operation was 65 years (range 57–73 years). The vertebral levels of the PLIF segments in the first operation were as follows: in one case at L3–4, in nine at L4–5, and in one at L5–S1. The progression of adjacent-segment degeneration was observed at the cranial segment in nine cases and at the caudal segment in two cases. All patients with adjacent-segment degeneration exhibited initial improvement of symptoms after the first operation, but they then exhibited gradual deterioration of neurological symptoms, which consisted of radicular pain, sensory disturbance, and motor weakness. Magnetic resonance imaging studies and myel-
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graphy performed immediately before the second operation showed compression of the dural sac and/or nerve root at the adjacent fusion segment, although no significant compression was detected before the first operation. For these patients the average JOA score before the first operation, the maximum JOA score after the second operation, and the average JOA score immediately before the second operation were 13.25, and 14 points, respectively. The second operation was indicated when conservative treatment such as medication and epidural steroid injection was not effective. In the seven patients who exhibited degenerative spondylolisthesis at the first operation, the following conditions were observed at the second operation: degenerative spondylolisthesis in four patients, spinal canal stenosis in two, and disc herniation in one. Of the three patients who exhibited spinal canal stenosis at the first operation, two underwent the second operation due to adjacent-segment canal stenosis and one underwent reoperation due to disc herniation. Similarly, in the one patient in whom disc herniation was observed during the first operation, the second operation was performed due to adjacent disc herniation. Of the 11 patients who underwent a second operation, six patients underwent laminotomy, four underwent PLIF, and one underwent discectomy. The surgical procedure was selected according to the following criteria. A PLIF was selected if there was segment instability such as progression of slippage greater than 3 mm with posterior opening greater than 5°. If there was no instability, decompression alone (laminotomy or discectomy) was selected. After the second operation, all 11 patients exhibited improvement of neurological symptoms. The average period between the first and second operations was 24 months (range 8–54 months).

Discussion

Intraoperative Complications

Dural tearing was observed in 19 cases (7.6%), which is similar to the results of previous reports, in which the incidence of dural tearing for PLIF has ranged from 5.5 to 10.1%4,6,8,10,12,13,16,24,28,29. Dural-related complications are often considered of little consequence to the final outcome, as was the case in the present series.

In seven (2.8%) of the patients in the present series, pedicle screw malposition was observed (one pedicle screw malposition per patient), and pedicle screw replacement was performed in one. In previous reports, the incidence of pedicle screw malposition has ranged from 1 to 11%4,6,8,10,12,13,16,24. The incidence of pedicle screw malposition should be reduced by development of computer navigation systems.

Early Postoperative Complications

In the present series, major complications such as brain infarction were rare. In previous reports, the incidence of major complications has ranged from 1 to 6.7%4,6,8,12,24. Deep wound infection was observed in one patient who had chronic renal failure due to diabetes mellitus. In previous reports, the incidence of deep wound infection has ranged from 1 to 4%4,6,8,10,12,13,16,24,25. In one earlier study, diabetes mellitus was found to be a major risk factor for infection.14

Postoperative neurological complications are generally considered serious complications of PLIF. In previous reports, the incidence of neurological complications has ranged from 2 to 8%, and the incidence of permanent neurological deficits has ranged from 1.7 to 6.5%,4,6,8,10,12,13,16,24,28,29. Several techniques have been developed to prevent nerve injury24,33. Total facetectomy can provide more space for PLIF maneuvering and can facilitate retraction of nerve roots. The current incidence of neurological complications is substantially lower than that reported in the 1980s and early 1990s4,6,8,10,12,13,16,24,28,29,31. Despite such advances, however, 17 patients (6.8%) in the present series exhibited neurological complications after the first operation, and permanent motor loss was observed in four patients (1.6%). We concluded that the low rate of permanent motor loss in the current series, compared with previous reports, was due to surgical innovations such as total facetectomy. All of the patients with no or slight motor loss exhibited improvement of their symptoms within an average of 6 weeks. In four of the five patients with severe motor loss who had undergone revision surgery, the causes of neurological deficits were identified, and the patients recovered fully after the second operation. All four patients with severe motor loss who refused revision surgery exhibited permanent motor loss. Among the patients with severe motor loss, there were clear differences in clinical results between those who underwent revision surgery and those who did not. In the current series, all patients with severe motor loss exhibited neurological deficits for a few days after surgery. Therefore, we conclude that intraoperative nerve injury was not the cause of these neurological deficits. Previous reports have described the incidence of postoperative neurological complications, but there have been no reports describing management of postoperative neurological complications after PLIF. Based on the present results, we recommend that in cases in which severe motor loss occurs a few days after PLIF, surgical intervention should be performed to confirm decompression of the nerve roots, even if compression of neural elements is not detected on postoperative neuroimages.

Late Postoperative Complications

In the present series, hardware failure was observed in three patients (1.2%), each of whom exhibited pedicle

**Table 3**

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<th>Case (yrs), Vertebral Vertebral Level</th>
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<th>2nd Op</th>
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<td>Diagnosis</td>
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<td>Pedicle screw malposition</td>
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<td>Pedicle screw replacement</td>
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<td>1 57, F     LCS L4–5 LCS L3–4</td>
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<td>2 65, M     LCS L4–5 LCS L3–4</td>
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<td>3 68, F     LCS L4–5 LCS L3–4</td>
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<td>4 64, M     LCS L4–5 LCS L3–4</td>
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<td>5 64, M     LCS L4–5 LCS L3–4</td>
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<td>6 65, M     LCS L4–5 LCS L3–4</td>
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<td>11 63, M    LCS L4–5 LCS L3–4</td>
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\* DH = disc herniation; DS = degenerative spondylolisthesis; LCS = lumbar canal stenosis.
screw breakage. In previous reports, the incidence of hardware failure has ranged from 2 to 12.1%. The authors of those reports have stated that hardware failure was likely to increase in cases in which more fusion levels were involved, but they have concluded that it did not affect clinical results. In three of the present cases with hardware failure, the patient underwent PLIF for two segments, although none of the present patients had complaints due to hardware failure.

In the present series, nonunion was observed in three cases (1.2%). The causes of these nonunions were not indicated by the patient’s history or laboratory data. In previous reports, the fusion rate has ranged from 65 to 100%. We managed to achieve an extensive bone graft area in the disc space by total facetectomy and extensive disectomy at the lateral border. Such techniques increased the fusion rate to 99% in the present series.

Adjacent-segment degeneration after PLIF was one of the most important sequelae affecting long-term results. In the present series, 11 patients (4.4%) exhibited adjacent-segment degeneration requiring surgical intervention. Adjacent-segment degeneration tended to occur at the cranial segment, producing the same conditions seen in the patients at primary surgery; seven of the 11 patients with adjacent-segment degeneration had the same diagnosis at the first and second operations. All adjacent-segment degenerations were detected within a distance of one level from the fusion segment. In previous reports, the reoperation rate for adjacent-segment degeneration has ranged from 1.4 to 16.8%.

Although progression of adjacent-segment degeneration can be considered part of the normal aging and deterioration process, this phenomenon appears to be at least partly influenced by the alteration of stresses that occurs as a consequence of lumbar fusion. In the present series, the average period between the first and second operations was 24 months. This time period is a serious problem for comparison of the clinical results with those of other standard surgical techniques for orthopedic degenerative disorders, such as total hip arthroplasty. In addition to the aging factor, certain mechanical factors may affect progression of adjacent-segment degeneration after PLIF. Park, et al., have reviewed previous reports and have concluded that it did not affect clinical results.

In the present study, the most serious complications of PLIF were postoperative severe neurological complications and adjacent-segment degeneration. We recommend that in cases in which severe motor loss occurs a few days after PLIF, revision surgery should be performed to confirm decompression of the nerve roots. In the present cases, adjacent-segment degeneration tended to occur at the cranial segment, producing the same conditions as those seen at the first operation. Prevention and management of such complications are necessary for obtaining good long-term clinical results.

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