Facet Fusion in the Lumbosacral Spine: A 2-year Follow-up Study

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OBJECTIVE: A clinical and radiological follow-up study was undertaken to assess the safety, efficacy, and complication rate associated with instrumented facet fusion of the lumbar and lumbosacral spine.

METHODS: This study involved 99 patients with degenerative lumbar disorders who were treated surgically at the authors' neurosurgical department and followed for more than 2 years. Eighty-two patients underwent one-level fusion for the treatment of Grade I or II degenerative spondylolisthesis and accompanying spinal canal stenosis (44 patients) or recurrent disc herniation (38 patients). Seventeen patients underwent two-level fusion for the treatment of either double instances of the above indications (seven patients) or concurrent stenosis at the adjacent level (10 patients).

RESULTS: There were no technique-related complications. The overall 2-year success rate of fusion was 96%; the success rates by fusion type were 99% in one-level fusions and 88% in two-level fusions. Degenerative spondylolisthesis had the highest success rate at 100%, whereas the success rate in patients who had not responded to previous discectomy was 93%. Patients with concurrent stenosis experienced the lowest success rate: 80%. Excellent or good clinical results were obtained for 85% of patients with one-level fusions and for 65% of patients with two-level fusions.

CONCLUSION: Instrumented facet fusion alone is a simple, safe, and effective surgical option for the treatment of patients with single-level disorders, especially patients with degenerative spondylolisthesis.

KEY WORDS: Degenerative disorder, Facet joint, Fusion, Instrument, Lumbar spine

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Surgery in patients with degenerative lumbar spinal disorders is performed mostly to treat neural compression. However, additional bone fusion may sometimes be required. The most widely used options are intertransverse process fusion (ITF) and posterior interbody fusion (PIF) (4, 5, 12, 17, 25, 29). Although these two fusion techniques are reliable and have a long history, they prolong operating time and result in operative risks, including muscle wasting, blood loss, infection, and neural injuries. For example, ITF requires wide bilateral muscle dissection to expose the upper and lower transverse processes. PIF also requires a wide passage for endplate preparation and graft insertion. Providing a wide area of decortication and an adequate amount of bone graft is considered the key to successful fusion and is still the most important part of the procedure, although the success rate improves with the introduction of internal fixation (6, 18, 23). A simple and less morbid fusion procedure may prove to be a better option, however, if it results in a successful outcome. In this context, facet joints are excellent candidates because of their close proximity to adjacent segments and because of the ease of access to them.

Facet fusion alone in the lumbar spine was abandoned after McBride's initial report in 1949 (14). However, some surgeons have used it as part of a posterolateral fusion procedure (8, 13, 28) since Watkins (27) added it to the regular fusion base that includes the pars interarticularis and transverse processes. Nevertheless, many surgeons perform only ITFs (22, 26) because no solid evaluations of the role of facet fusion as a fusion base have been conducted and because of concerns regarding instability resulting from facet destruction (2).

Since 1993, we have used the pedicle screw fixation system to compensate for the instability that follows bilateral facet destruction, and we previously reported the technique and our preliminary data based on our initial experience (15). The purpose of this retrospective study is to define the long-term safety and efficacy of instrumented facet fusion performed to treat patients with degenerative lumbar spinal disorders.

PATIENTS AND METHODS

Our study comprised 116 spinal levels in 99 patients who were treated by decompression and instrumented facet fusion via pedicle screw fixation (Diapason instrumentation system; Stryker, Inc., Bordeaux, France) at the authors' institution from November 1993 to March 1999. We followed the patients for more than 2 years after surgery. One-level fusion was performed in 82 patients. Forty-four patients underwent surgery for the treatment of single-level Grade I or II degenerative spondylolisthesis and accompanying spinal canal stenosis. Of 38 patients with single-level recurrent disc herniation, 29 had undergone two previous surgical treatments of the same disc segment on which we operated, and 9 had a large central disc herniation at the same level. Two-level fusions were performed in 10 patients with two-level stenosis and spondylolisthesis at one level, in 4 patients with two-level spondylolisthesis, and in 3 patients with recurrent disc herniation at one or both of the two segments on which we operated. All patients experienced incapacitating back pain, associated leg pain, and radiological evidence of compression of the cauda equina or the exiting nerve roots.

Surgical Technique

All patients were treated with decompression, autogenous iliac crest bone grafting, facet joint fusion, and segmental instrumentation. All operations were performed by the same surgeon (YKP), who used the protocol we described previously (15). Briefly, the spine is exposed through a posterior midline incision, and subperiosteal muscle dissection is performed laterally to the dorsal aspect of the facet joint. First, the exposed capsule of the joint is incised, then drilling between the articular surfaces is performed carefully to a depth of approximately 1.0 to 1.5 cm with a 4-mm cutting burr (*Fig. 1*). The removal of both cartilaginous plates and underlying cortical bone on the articular process is important. Because the interface of degenerative facet joints is irregular, surgeons are apt to misplace the cutting burr, especially in patients with degenerative spondylolisthesis. Lifting up the spinous process of the caudal segment with a towel clip is helpful in finding the interface. Once the cutting burr is placed correctly inside the joint, there is no chance of incorrect positioning.

Regarding the extent of decortication, we recommend less rather than more with regard to both width and depth. Decortication extending from approximately one-half to two-thirds the depth of the facet interface usually was sufficient in our patients. After preparing the interface, the central canal and the lateral recesses are decompressed by laminectomy and

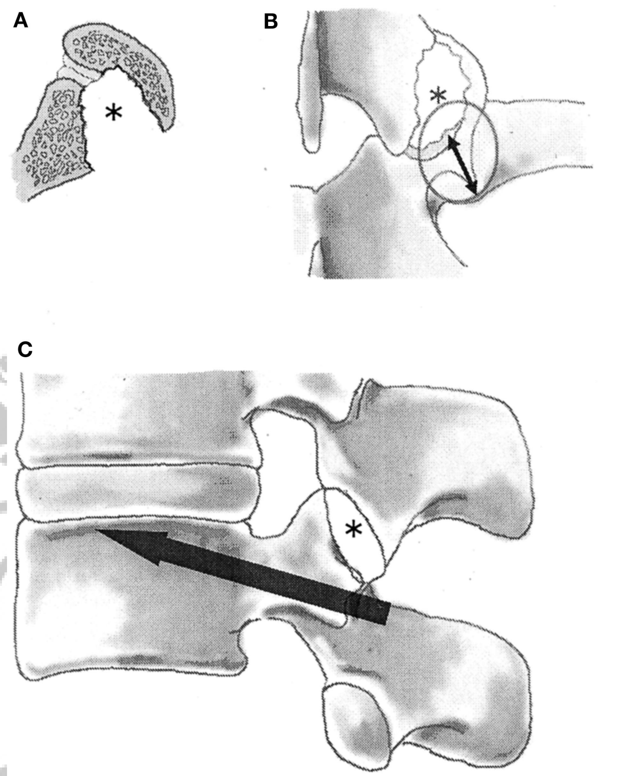

FIGURE 1. *Drawing illustrating surgical techniques for lumbar facet fusion. Axial (A), posterior (B), and lateral (C) views of the lumbar facet and its adjacent structures.* *, *area of decortication for facet fusion;* oval, *cortical outline of the pedicle;* small bidirectional arrow, *safe margin of entry;* large arrow, *trajectory of pedicle screw.*

bilateral undercutting of the medial part of the facet joint. With the addition of longitudinal extension, sufficient decompression of the segment can be achieved. We always preserve the pars interarticularis and some of the proximal arch of the cranial segment. Using the "up and in" approach guided by biplanar fluoroscopy, pedicle screws are placed segmentally, with care taken not to violate the facet joint. Cancellous chips from the posterior iliac crest are pushed into the drilled joint space, and the rods are assembled. Postoperative walking was encouraged on the third or fourth day after the operation. Patients wore a corset for 3 months after the operation.

Radiological Investigations

All patients were assessed at 4, 12, and 24 months after surgery and at least annually thereafter. Dynamic x-rays of the lumbosacral spine as well as spinal computed tomographic (CT) scans of the operated level were obtained at 4, 12, and 24 months. Once a successful fusion was confirmed, CT scans were excluded from the follow-up examinations. CT scans were made contiguously with 3-mm collimation and 3-mm scan spacing, all of which were oriented in a plane parallel to the intervertebral space. The fusion status was classified into fusion or nonunion on the basis of the CT scans by an independent reviewer. The criterion for the fusion of the facet joint was defined as a continuous, uninterrupted area of cancellous bone bridging the facet joint space on at least one of the two sides observed on CT scans (*Fig. 2*). The presence of a noticeable space was considered to be nonunion, even in patients without movement visualized on dynamic x-rays.

Clinical Evaluation

Clinical outcome data were recorded by questionnaires, which included pre- and postoperative visual analog pain scales, rate of improvement in pain, and patient satisfaction scores at 24 months (21). The postoperative index was expressed as a percentage calculated by dividing the final pain score by the initial pain score. Pain-free patients were considered to have an excellent result. An index of more than 50% was deemed good, more than 20% was considered improved, and less than 20% was recorded as poor (11).

RESULTS

Our patients' profiles are listed in *Table 1*. The mean age at the time of the operation was 52 years (range, 21–76 yr). The average follow-up period was 41 months (range, 25–89 mo). The study group comprised 42 men and 57 women. The mean duration of surgery for one-level fusions was 118 minutes (range, 90–190 min), and for two-level fusions, it was 195 minutes (range, 150–270 min). The mean blood loss in single- and two-level fusions was 144 and 192 ml, respectively. No patient required a blood transfusion. No new neurological deficits were noted after the operation. No patient required early hardware removal as a result of postoperative persistent radicular pain.

TABLE 1. Characteristics of patients who received instrumented facet fusion of the lumbar and lumbosacral spine

Characteristic	Value
No. of patients	99
Sex (M/F)	42/57
Fusion	
One-level	82
Two-level	17
Age (yr)	
Mean ± standard deviation	52 ± 12
Range	21–76
Diagnosis of operated level (n)	
Total operated level	116
Degenerative spondylolisthesis	63
Recurrent disc disease	43
Concurrent stenosis	10
Operated level (n)	
L3–L4	23
L4–L5	76
L5–S1	17
Location and average duration of pain (yr)	
Back	5
Leg	3
History of smoking (no. of patients, %)	33 (33%)
Previous lumbar surgery[a]	
No. of patients with previous lumbar surgery	70
No. of patients with spondylolisthesis with no previous surgery	58

[a] There were 70 previous simple discectomies in 41 patients, or 1.7 previous lumbar operations per patient.

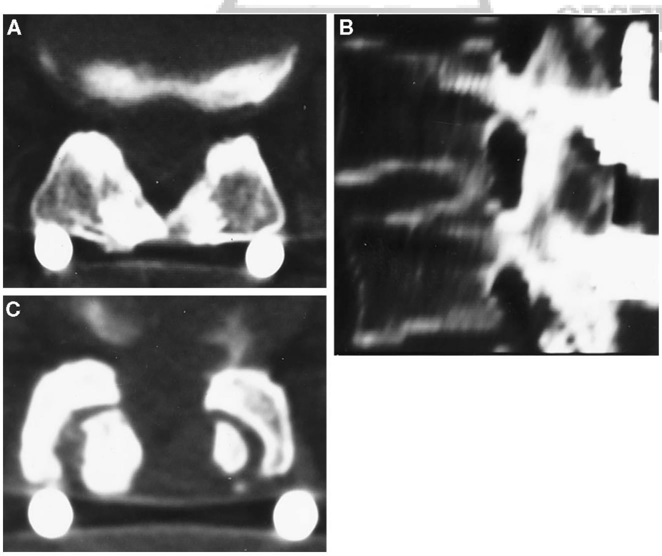

FIGURE 2. *Postoperative CT scans obtained to evaluate fusion status. Successful fusion is displayed on both sides of the facet joints in an axial scan (A) and confirmed in a sagittal reconstruction of a CT scan (B). An axial CT scan (C) shows a case of failed union as a result of radiolucency in the facet joint.*

The fusion rates, based on the authors' method of evaluation, are listed in *Table 2*. Five of 99 patients experienced nonunion with or without hardware failure. At 24 months after surgery, the rate of successful fusion was 99% in patients with one-level surgery. In patients with two-level surgery, 88% displayed successful fusion. The difference between fusion rates according to the number of operated levels was statistically significant ($P = 0.041$, χ^2 test). Although the difference in fusion rates according to the preoperative diagnosis was not significant in one-level surgery ($P = 0.463$, Fisher's exact test), the difference observed after two-level surgery was significant ($P = 0.03$, χ^2 test). The highest rate of nonunion was observed in the patients whose previous two-level operations had failed, which was significantly different from that of patients with degenerative spondylolisthesis ($P = 0.0362$, Fisher's exact test). No patients with degenerative spondylolisthesis experienced pseudoarthrosis.

The clinical data of patients who experienced nonunion are summarized in *Table 3*. All four patients who experienced

TABLE 2. Rate of nonunion according to cause

No. of levels operated	Rate of nonunion % (nonunion/levels operated)			
	Degenerative spondylolisthesis	Previous failed discectomy	Concurrent stenosis	Total
1	0% (0/44)	2.6% (1/38)	—	1.2% (1/82)
2	0% (0/19)	40% (2/5)	20% (2/10)	11.8% (4/34)
Total	0% (0/63)	7% (3/43)	20% (2/10)	4.3% (5/116)

TABLE 3. Clinical data in five patients who experienced nonunion after undergoing instrumented facet fusion[a]

Patient no.	Sex/age (yr)	Surgical indication			Follow-up (mo)	Sagittal plane ROM of failed segment (extension/flexion)			Radiological finding	Clinical outcome
		L3–L4	L4–L5	L5–S1		Before surgery	1 year after surgery	2 years after surgery		
1	F/54	DS	RD[b]		26	15 (8/−7)	8 (6/−2)	7 (7/0)	Erosion around the screw in L5	Improved
2	M/62	DS	CS[b]		32	9 (9/0)	7 (7/0)	3 (7/4)	Erosion around the screw in L5	Good
3	F/61		DS	CS[b]	30	6 (10/4)	3 (8/5)	1 (8/7)	Articular process fracture of S1	Excellent
4	M/54		RD	RD[b]	35	13 (23/10)	19 (18/9)	7 (16/9)	Erosion around the screw in S1	Poor
5	M/30		RD[b]		48	10 (12/2)	7 (10/3)	3 (9/6)	Erosion around the screw in L5	Good

[a] ROM, range of motion; DS, degenerative spondylolisthesis; RD, recurrent disc herniations; CS, concurrent stenosis.
[b] Segment of nonunion.

nonunion who previously had undergone two-level surgery developed pseudoarthrosis in the distal segment. A 61-year-old woman with osteoporosis experienced segmental fusion failure that was the result of fractures on the junction between the superior articular process and the pedicle of segment S1. Bone erosion around the screw was found in four patients. No patient with pseudoarthrosis indicated any increase in the range of motion during the 2-year follow-up period. Before surgery, these patients averaged 10.6 degrees of angular motion in the flexion-extension x-rays (range, 6–15 degrees). Range of motion decreased to 4.2 degrees by 2 years after the operation. There was no need for patients to undergo further surgery to achieve stability in the segment, even though a successful fusion had not been achieved completely. The patient with an improved outcome was able to tolerate the residual intermittent lower-back pain with low doses of orally administered narcotics, which were provided frequently. Therefore, we decided to follow this patient's progress conservatively. Of the five patients with pseudoarthrosis, one patient (Patient 4 in *Table 3*) underwent further decompressive lumbar surgery with ITF because of radicular pain arising from the nonunited caudal segment 2 years after the facet fusion.

There were no postoperative changes in curvature or in disc space narrowing in the operated lumbar segment during the follow-up period. Long-term radiological changes included sclerosis of the involved facet joint and osteoporosis in the vertebral body and lamina.

Table 4 lists the clinical outcomes of the patients in this study. The questionnaire, which used the 10-point visual analog scale, indicated that 70 (85%) of the 82 patients who had one-level surgery and 11 (65%) of the 17 patients who underwent two-level surgery reported a visual analog pain index of more than 50% (good or excellent result). It also revealed that 67 patients (82%) who had one-level surgery and 10 patients (59%) who underwent two-level surgery were satisfied with the operative treatment. Preoperative lower-back pain scores did not differ between groups, but postoperative scores differed significantly between the single- and two-level fusion

TABLE 4. Percentage of patients who responded to postoperative questionnaire[a]

Question	One-level fusion (n = 82)	Two-level fusion (n = 17)
VAS scores (mean ± SD)		
Overall pain		
Before surgery	8.8 ± 1.9	9.1 ± 1.3
2 yr after surgery	3.2 ± 2.1	4.4 ± 3.2
Back or buttock pain		
Before surgery	8.5 ± 1.8	9.0 ± 1.6
2 yr after surgery	3.5 ± 2.4	5.2 ± 2.8
Pain in legs or feet		
Before surgery	9.0 ± 1.4	9.1 ± 1.5
2 yr after surgery	3.0 ± 2.0	3.8 ± 2.8
Clinical outcome (n, %)		
Excellent	24 (29.3)	2 (11.8)
Good	46 (56)	9 (52.9)
Improved	9 (11)	3 (17.6)
Poor	3 (3.7)	3 (17.3)
How satisfied are you with the overall results of the surgery? (n, %)		
Very satisfied	27 (32.9)	3 (17.6)
Somewhat satisfied	40 (48.8)	7 (41.2)
Somewhat dissatisfied	12 (14.6)	4 (23.5)
Very dissatisfied	3 (3.7)	3 (17.6)

[a] VAS, visual analog pain scale; SD, standard deviation.

groups ($P = 0.011$, unpaired t test). The clinical outcomes were not affected by age, sex, or smoking.

DISCUSSION

Advantages of Facet Fusion

Simple and Less Morbid Technique

In terms of dissection range, decompressive laminectomy is sufficient, and additional dissection is not needed. Therefore, the facet fusion procedure causes minimal muscle division, less bleeding, and fewer operative complications.

Closest Structure between Two Segments

Although the intertransverse process distance is approximately 30 mm in most lumbar segments and the intervertebral disc space is approximately 10 to 15 mm, the distance between facet joints is 3 to 5 mm in the articular interspace. Therefore, facet fusion needs a minimum amount of cancellous bones, and a rapid incorporation of the bone graft is expected.

Facet Joint and Weight Bearing

When holding an erect posture for a long period in the normal lumbar spine, one-sixth of the compressive force is borne by the facet joint (16). This load increases when the spine is in extension and torsion. In addition, the load on the facet joint increases by 70% in patients in whom degenerative changes result in disc narrowing (7, 19, 20). The load-sharing or stress-shielding effects of the pedicle screw construct apparently reduce the weight-bearing potential of the intervertebral disc as well as that of the facet joints. Actually, load sharing through the interbody space is mechanically more advantageous for successful fusion than load sharing through the posterior part. However, anterior load sharing through a disc and a pair of grafted facet joints that are located anterior to the rod or plate system also significantly reduces the mechanical fatigue and improves the durability of pedicle fixation.

A fusion area more than 30% of the total endplate area of the vertebral body is known to provide a margin of safety for successful interbody fusion (3). In our unpublished morphological study of a normal spine, the sum of the cross sectional areas of each facet joint was 25 to 31% of that of the lumbar vertebral body. Moreover, the dimensions usually increased by 30 to 40% in patients with degenerative disorders and enlarged further after instrumented facet fusion (*Figs. 3* and *4*). Although the coronal dimension in the facet joint is reduced by later decompressive undercutting facetectomy, this decrease is less than the 22.7% reduction in the dimension known to occur with pedicle-to-pedicle decompression (9). The postoperative increase in fusion mass is thought to be partly the result of spontaneous closure of the laminectomy defect, as observed in patients after laminectomy, and partly the result of progressive osseous transformation of the remain-

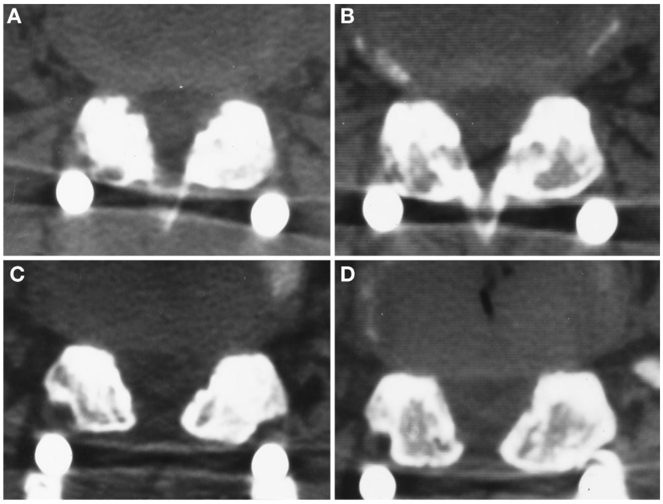

FIGURE 3. *Follow-up axial CT scans obtained 4 months (*A, C*) and 2 years (*B, D*) after surgery in a patient who underwent two-level surgery (*A*, L3–L4;* B*, L4–L5;* C*, L3–L4;* D*, L4–L5). Note the changes in the size and shape of the fusion mass.*

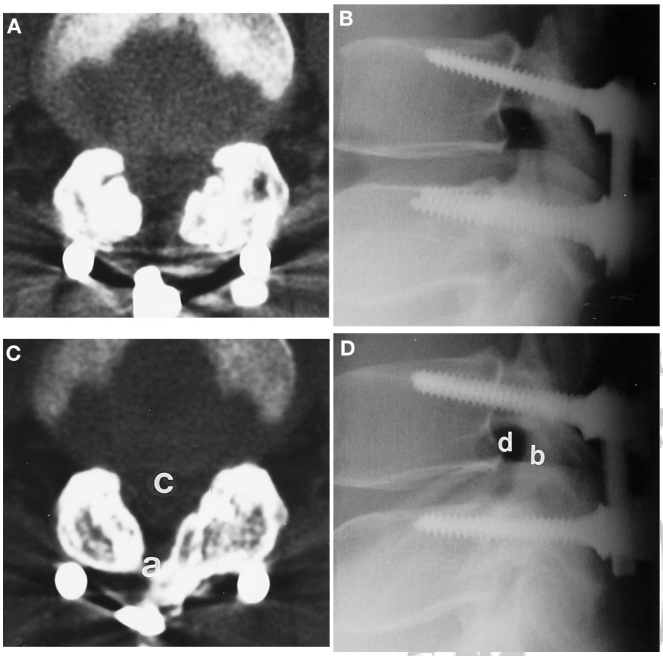

FIGURE 4. *Follow-up axial CT scans (A, C) and lateral x-rays (B, D) obtained 4 months (A, B) and 4 years (C, D) after surgery. The fusion mass grows larger secondary to spontaneous closure of the laminectomy defect (a) and osseous transformation of the remaining ligamentous structure around the facet joint (b). However, the mass does not compromise the central canal (c) and the neural foramen (d).*

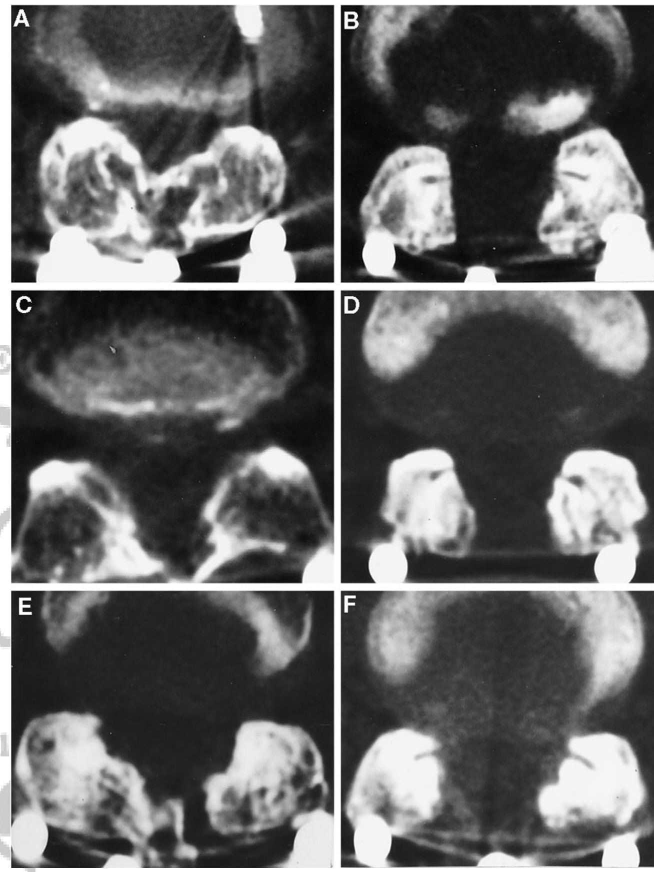

FIGURE 5. *Second-year postoperative CT scans of representative patients with different surgical indications. The fusion mass of the patients with degenerative spondylolisthesis (A, C, E) is larger than that of the patients whose previous discectomies had failed (B, D, F). The cross sectional areas of fusion mass in proportion to the vertebral body range from 46 to 51% and from 39 to 42%, respectively, for the two groups.*

ing ligamentous structure around the facet joint. The central canal and neural foramen have remained intact, as indicated by long-term x-ray, however, and during the follow-up period, no patient complained of delayed neurological impairments originating from compromised roots above or beneath the facet fusion.

Reactive Bone Formation

Marginal spur formation and facet joint hypertrophy, which are involved in aging and degeneration, gradually occur in structures to which a stress is applied. In the case of degenerative spondylolisthesis, in which sagittal plane stability is impaired, hypertrophy of articular processes and ligaments usually occurs. A hypertrophied joint demonstrates irregular articular surfaces and poor demarcation of its cancellous portion because of hardening of the cortical bone. Hence, despite active and sufficient drilling, cancellous bone exposure is difficult to achieve, and the preparation for fusion in a patient with degenerative spondylolisthesis would not be better than that for a patient with the other operative indications for fusion. Nonetheless, because the postoperative fusion mass is larger in patients with degenerative spondylolisthesis than in patients with other indications for fusion (*Fig. 5*), and because the fusion success rate is as high as 100%, reactive changes and hypertrophy of facet joints are interpreted as being more positive postoperative signs of successful fusion. Spontaneous fusion of the facet joint, which was investigated in most ITF cases in the study by Kim et al. (10), also implies that postoperative reactive change is active in the joint.

Other Surgical Options

ITF, PIF, and circumferential fusion are possible revision surgery options after failed facet fusion because the fusion bases, including intervertebral disc space and transverse processes, are intact. Although fastening the previous screw may be difficult as a result of breakage or loosening associated with nonunion, screw fixation can be tried again. In one patient who had two-level surgery, the revision was performed for radiculopathy that resulted from disc fragments in the nonfused segment, which occurred 2 years after the initial surgery. Decompression and ITF led to immediate pain relief and successful bone fusion, which were confirmed radiologically 1 year after the revision.

Limitations of the Current Technique

Limitation in Indications

The facet fusion procedure can be performed on an intact posterior arch. Therefore, patients who have preoperative defects on pars interarticularis or need removal of a part of pars interarticularis should not undergo surgery that uses this technique.

Limitation in Facet Removal

The facet joint area is relatively small (1.5×1.5 cm) and is limited in size and thickness. Therefore, surgeons must not perform excessive decortication of the articular surface or extensive facetectomy. To avoid this problem, facet joint drilling would be better performed before the spinal canal decompression. Undercutting the lamina through the contralateral side usually provides appropriate neural decompression with minimum facet removal. Patients with recurrent disc herniation may have fewer inferior articular processes remaining, which reflected simply a high rate of nonunion in 3 (7%) of 43 levels in our patients. All of the cases of pedicle screw loosening and fractures in our patients occurred in the pedicles of distal vertebrae, where weight bearing increases and where the moment arm length—that is, the distance from the disc center space—is shorter than that of the proximal screw. Therefore, excessive drilling of the facet joint to weaken the pedicle and the adjacent parts of the distal segment should be avoided.

Limitation of Internal Fixation

Although auxiliary internal fixation with a pedicle screw contributes to a higher success rate, either ITF or PIF can be used for fusion alone, and fixation is optional. It seems to be mandatory for facet fusion alone to be combined with instrument fixation, however, probably because of the lack of data in the literature concerning its safety. The success rate for percutaneous facet fusion alone in a canine model was low (42%) (24). In the normal spinal motion of flexion-extension, motion is greater in the articular processes than in the vertebral bodies or the transverse processes. In full flexion, as assessed by the elastic limit of the supraspinous and interspinous ligaments, the capsular ligaments provide approximately 40% of the segmental resistance, and other posterior ligamentous structures, which are removed in the process of facet fusion, are responsible for 30% (1). Therefore, the removal of ligamentous structures is expected to bring a loss of segmental resistance of 70%. This procedure increases mobility and reduces the possibility of a successful fusion, according to findings regarding the increments of sagittal and axial ranges of motion and segmental instability in a cadaveric study (2).

CONCLUSIONS

Instrumented facet fusion is a simple, safe, and effective surgical option for the treatment of patients with single-level disorders of lumbosacral spine. It is especially beneficial for patients with degenerative spondylolisthesis. However, in our patients, the success rate was somewhat low with regard to the distal segment in multilevel fusion procedures. Consequently, facet joint fusion should be included when possible in any posterior spinal fusion operation, and the surgeon needs to develop the proper technique for achieving successful fusion.

REFERENCES

1. Adams MA, Hutton WC, Stott JR: The resistance to flexion of the lumbar intervertebral joint. **Spine** 5:245–253, 1980.
2. Boden SD, Martin C, Rudolph R, Kirkpatrick JS, Moeini SM, Hutton WC: Increase of motion between lumbar vertebrae after excision of the capsule and cartilage of the facets: A cadaver study. **J Bone Joint Surg Am** 76A: 1847–1853, 1994.
3. Closkey RF, Parsons JR, Lee CK, Blacksin MF, Zimmerman MC: Mechanics of interbody spinal fusion: Analysis of critical bone graft area. **Spine** 18: 1011–1015, 1993.
4. de Loubresse CG, Bon T, Deburge A, Lassale B, Benoit M: Posterolateral fusion for radicular pain in isthmic spondylolisthesis. **Clin Orthop** 323:194–201, 1996.
5. Enker P, Steffee AD: Interbody fusion and instrumentation. **Clin Orthop** 300:90–101, 1994.
6. Fischgrund JS, Mackay M, Herkowitz HN, Brower R, Montgomery DM, Kurz LT: Volvo Award winner in clinical studies: Degenerative lumbar spondylolisthesis with spinal stenosis—A prospective, randomized study comparing decompressive laminectomy and arthrodesis with and without spinal instrumentation. **Spine** 22:2807–2812, 1997.
7. Goel VK, Kong W, Han JS, Weinstein JN, Gilbertson LG: A combined finite element and optimization investigation of lumbar spine mechanics with and without muscles. **Spine** 18:1531–1541, 1993.
8. Greenough CG, Peterson MD, Hadlow S, Fraser RD: Instrumented posterolateral lumbar fusion: Results and comparison with anterior interbody fusion. **Spine** 23:479–486, 1998.
9. Grobler LJ, Robertson PA, Novotny JE, Ahern JW: Decompression for degenerative spondylolisthesis and spinal stenosis at L4–5: The effects on facet joint morphology. **Spine** 18:1475–1482, 1993.
10. Kim KW, Ha KY, Moon MS, Kim YS, Kwon SY, Woo YK: Fate of the facet joints after instrumented intertransverse process fusion. **Clin Orthop** 366: 110–119, 1999.
11. Knight MT, Goswami A, Patko JT, Buxton N: Endoscopic foraminoplasty: A prospective study on 250 consecutive patients with independent evaluation. **J Clin Laser Med Surg** 19:73–81, 2001.
12. Lerat JL, Rubini J, Vincent P, Besse JL, Moyen B: Results of posterior lumbar intersomatic fusion in the treatment of isthmic spondylolisthesis: Apropos of 27 cases followed over more than 10 years [in French]. **Rev Chir Orthop Reparatrice Appar Mot** 82:475–489, 1996.
13. Macnab I, Dall D: The blood supply of the lumbar spine and its application to the technique of intertransverse lumbar fusion**. J Bone Joint Surg Br** 53B:628–638, 1971.
14. McBride ED: A mortised transfacet bone block for lumbo-sacral fusion. **J Bone Joint Surg** 31:385–393, 1949.
15. Park YK, Chung HS: Instrumented facet fusion for the degenerative lumbar disorders. **Acta Neurochir (Wien)** 141:915–920, 1999.
16. Schendel MJ, Wood KB, Buttermann GR, Lewis JL, Ogilvie JW: Experimental measurement of ligament force, facet force, and segment motion in the human lumbar spine. **J Biomech** 26:427–438, 1993.
17. Schnee CL, Freese A, Ansell LV: Outcome analysis for adults with spondylolisthesis treated with posterolateral fusion and transpedicular screw fixation. **J Neurosurg** 86:56–63, 1997.
18. Schwab FJ, Nazarian DG, Mahmud F, Michelsen CB: Effects of spinal instrumentation on fusion of the lumbosacral spine. **Spine** 20:2023–2028, 1995.
19. Sharma M, Langrana NA, Rodriguez J: Modeling of facet articulation as a nonlinear moving contact problem: Sensitivity study on lumbar facet response. **J Biomech Eng** 120:118–125, 1998.
20. Shirazi-Adl A: Nonlinear stress analysis of the whole lumbar spine in torsion: Mechanics of facet articulation. **J Biomech** 27:289–299, 1994.

21. Simotas AC, Dorey FJ, Hansraj KK, Cammisa F Jr: Nonoperative treatment for lumbar spinal stenosis: Clinical and outcome results and a 3-year survivorship analysis. **Spine** 25:197–203, 2000.
22. Slappey G, Toribatake Y, Ganey TM, Ogden JA, Hutton WC: Guidelines to decortication in posterolateral spine fusion. **J Spinal Disord** 11:102–109, 1998.
23. Soini J, Laine T, Pohjolainen T, Hurri H, Alaranta H: Spondylodesis augmented by transpedicular fixation in the treatment of olisthetic and degenerative conditions of the lumbar spine. **Clin Orthop** 297:111–116, 1993.
24. Stein M, Elliott D, Glen J, Morava-Protzner I: Young Investigator Award: Percutaneous facet joint fusion—Preliminary experience. **J Vasc Interv Radiol** 4:69–74, 1993.
25. Thalgott JS, Sasso RC, Cotler HB, Aebi M, LaRocca SH: Adult spondylolisthesis treated with posterolateral lumbar fusion and pedicular instrumentation with AO DC plates. **J Spinal Disord** 10:204–208, 1997.
26. Truchly G, Thomson WA: Posterolateral fusion of the lumbosacral spine. **J Bone Joint Surg Am** 44A:505–512, 1962.
27. Watkins MB: Posterolateral fusion of the lumbar and lumbosacral spine. **J Bone Joint Surg Am** 35A:1014–1018, 1953.
28. Wiltse LL: The paraspinal sacrospinalis-splitting approach to the lumbar spine. **Clin Orthop** 91:48–57, 1973.
29. Yuan HA, Garfin SR, Dickman CA, Mardjetko SM: A historical cohort study of pedicle screw fixation in thoracic, lumbar, and sacral spinal fusions. **Spine** 19[20 Suppl]:2279S–2296S, 1994.

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COMMENTS

The majority of older adult patients with degenerative lumbar stenosis also have spondylolisthesis, and lumbar fusion at the time of decompressive surgery is generally indicated to prevent progression of their slip and the development of back pain. The use of lumbar fusion in the management of recurrent disc herniations is more controversial, and most spinal surgeons reserve it for patients who recur a second time.

The most commonly used technique for producing stability in the lumbar spine is pedicle screw fixation with intertransverse process bone grafting. Selected patients may show an improved fusion rate with supplementary interbody fusion from an anterior or posterior approach. However, intertransverse fusion requires extensive paraspinous muscle dissection and relatively large amounts of bone graft. The procedure is painful, can be associated with significant blood loss when multiple levels are fused, and is likely to denervate the paraspinous muscles.

The results of facet fusion described by these authors are comparable or superior to more commonly used fusion techniques. Importantly, the authors' technique requires less bone for grafting, minimizes blood loss, and is less traumatic to the paraspinous musculature. Nevertheless, it cannot be used in patients with spondylolysis or in patients who require extensive facet removal. The authors performed spinal fusion only at one or two motion segments, and, as expected, there was a higher rate of nonfusion after two-level fusion procedures. One does not know whether the technique would be appropriate in patients with fusions of three or more motion segments or in younger patients with preserved disc height. Although the authors performed excellent facet fusions, whether their patients' outcomes in terms of pain and patient satisfaction were as good as those obtained with currently used fusion techniques is unclear. To resolve the issue, a larger number of patients with comparable clinical conditions who are treated with this technique need to be compared with patients who are treated with intertransverse fusion.

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Park et al. present a relatively large series of patients who were treated surgically with facet fusion and accompanying pedicle screw fixation. They make analogies between cervical facet fixation and lumbar facet fixation and infer that performing facet fusion rather than intertransverse process fusion is supported by a rationale that is appropriate to lumbar fixation and fusion. Their technique, although applied by many surgeons, has not been discussed widely or reported in the literature. This contribution to the literature therefore is meaningful and timely. By using a meticulous technique, a less invasive, highly successful strategy in the spine surgeon's armamentarium may find increased use.

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It is common, accepted knowledge that fusion of the facet joint is critical to the success of any operation that is performed to treat spinal deformity. The idea is that performing the fusion to the tips of the transverse processes provides theoretical increased bulk for the resulting fusion mass, leading to a more stable fusion. In reality, the bone grafts on the tips of the transverse processes often are resorbed and cannot span the gap between the two transverse processes. Critical motion occurs between the articular processes of the facet joint in the posterior column. Pseudoarthroses typically include the residual of the facet joint. The authors point out that by performing the facet fusion and combining it with pedicle screw internal fixation, a high fusion rate can be achieved. The resultant information of importance in the article, in my opinion, is that a facet joint fusion should be performed with pedicle screw fixation and posterior instrumentation. This statement by no means implies that supplemental anterior interbody fusion or posterior lumbar interbody fusion is either needed or not needed in any particular case. Interbody fusion techniques are necessary to correct deformity and to improve the surface area for healing. Under certain circumstances, only interbody fusion is necessary to fuse a segment successfully. The article addresses one specific question—is fusion of the facet joint necessary with posterior instrumentation? The answer is "yes."

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Park et al. present a review of 99 patients who underwent instrumented facet fusion for a variety of degenerative lumbar diseases, with a minimum of 2 years of follow-up.

Fusion status was determined by an independent reviewer and was considered successful if computed tomographic (CT) imaging demonstrated contiguous bone across at least one facet joint. Clinical outcomes regarding pain reduction and patients' satisfaction with treatment were determined on the basis of patient questionnaires. The results demonstrate that, in the authors' hands, this technique is safe, with fusion rates and patient outcomes comparable to those achieved with the use of other, standard techniques. Generalizations should be avoided, because the observed results are unique to the authors' selection criteria, technical performance, and outcome assessment.

The lack of an adequate control group and validated outcomes assessment prohibits any meaningful comparisons with results observed with the use of alternative techniques. The use of an arbitrary scale to monitor pain reduction makes it difficult if not impossible to interpret the data in an objective manner. How, for example, did the authors determine that a 20% reduction in preoperative pain constitutes a clinical improvement? Such arbitrary measures make it difficult to assess or compare treatment effects objectively.

Another point of contention exists regarding the authors' assessment of fusion status. In most practices, the use of dynamic imaging is important to diagnosis pseudoarthrosis. Static CT images spaced 3 mm apart leave a considerable margin of error. The authors' assessment of pseudoarthrosis in *Figure 2* is also questionable. On the basis of the images displayed and the criteria set forth by the authors, it appears that the patient identified as having pseudoarthrosis may be inaccurate.

The retrospective design and lack of appropriate controls makes it impossible to determine the overall efficacy of this technique. The authors claim that isolated facet fusion is associated with fewer operative complications and that alternative techniques such as interbody or intertransverse fusions should be considered second-tier procedures. These statements are purely the opinion of the authors, because objective data in support of such claims are completely lacking. Any further conclusions drawn from the data presented would be speculative at best.

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This article by Park et al. describes a retrospective series of instrumented lumbosacral fusions where the bone graft was applied only to the facet joint. The current series describes 99 patients with single-level (n = 82) or two-level (n = 17) lumbar fusion for one of two degenerative conditions: degenerative spondylolisthesis or recurrent disc herniation. Fusion was assessed at 4, 12, or 24 months by plain radiography and computed tomography. The primary measure of fusion was described as a solid mass of bone through the facet joint on axial CT scans, with a success rate of 99% in one-level fusions and 88% in the two-level fusions. Correlation with clinical outcome was then calculated by comparing the change in pre- and postoperative visual analog pain scale (VAS) scores. In addition, a patient satisfaction survey was conducted to determine the benefit of the surgical procedure.

This study is useful in that it provides some evidence of the efficacy of a procedure that carries with it less morbidity than either traditional posterolateral fusion or posterior lumbar interbody fusion, especially in single-level fusions. Patients whose VAS score improves by more than 50% were deemed to have good or excellent results; 85% of patients who underwent single-level surgery and 65% of patients who had two-level surgery achieved good or excellent results at 24-month follow-up. These results correlated well with the patient satisfaction index, with which the authors found that 82% of the single-level fusion group were very or somewhat satisfied with the results of surgery and that 59% of patients in the two-level group were very or somewhat satisfied.

The authors did not differentiate between leg and back pain on the VAS. We assume that after the decompression, most patients in both groups had major or total lower-extremity pain relief and that the residual pain reported is back pain. If that is not the case, the option to preserve more of the facet for fusion may have led to inadequate decompression. In addition, another measure of functional outcome besides the VAS would be useful in determining postoperative clinical improvement.

The authors neglect to mention another alternative that includes facet fusion with the addition of translaminar facet screws. Initially described by Magerl et al. as an adjunct to fusion in the degenerative lumbar spine, currently it is often used in conjunction with anterior lumbar interbody fusion. Several reports suggest that this combination of techniques can lead to up to a 94% fusion rate in patients with single- or two-level degenerative disease, however, even without interbody support (2). In addition, this combined procedure provides stabilization that is comparable to pedicle fixation in extension and axial rotation (1, 2). Although the need to preserve the lamina does limit the extent of decompression, the technique has been used with foraminotomy in the setting of recurrent disc herniation and stenosis.

Clearly, this article contains interesting information that expands on the authors' previously published results (3). However, a direct comparison with other methods of lumbar fusion would be desirable before surgeons adopt this approach as a first-line treatment in patients with degenerative disease of the lumbar spine.

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1. Deguchi M, Cheng BC, Sato K, Matsuyama Y, Zdeblick TA: Biomechanical evaluation of translaminar facet joint fixation: A comparative study of poly-L-lactide pins, screws, and pedicle fixation. **Spine** 23:1307–1313, 1998.
2. Humke T, Grob D, Dvorak J, Messikommer A: Translaminar screw fixation of the lumbar and lumbosacral spine: A 5-year follow-up. **Spine** 23:1180–1184, 1998.
3. Park YK, Chung HS: Instrumented facet fusion for the degenerative lumbar disorders. **Acta Neurochir (Wien)** 141:915–920, 1999.