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ORIGINAL ARTICLE

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Direct repair of defect in lumbar spondylolysis and mild isthmic spondylolisthesis by bone grafting, with or without facet joint fusion

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Abstract Forty-six patients with lumbar spondylolysis and mild isthmic spondylolisthesis were managed with direct repair of the defect with or without facet joint fusion in the affected segment. There were 24 males and 22 females, ranging in age from 15 to 56 years (average, 38.2 years). These patients had experienced clinical symptoms due to spondylolysis for between 4 months and 20 years (average, 5.3 years). Of 46 patients, 28 had no spondylolisthesis, 11 had Meyerding grade I vertebral slippage and 7 had grade II. Direct repair of 98 defects was performed on these patients. Twenty-six patients, in whom the disc adjacent to the defect was determined as degenerative by magnetic resonance imaging (MRI), simultaneously underwent facet joint fusion; 17 in one segment and 9 in two segments. The average period of follow-up was 50 months (24–92 months). Ninety-four defects achieved bony healing. As a result, 28 patients were graded as having an excellent outcome, 15 good, and 3 fair. Bone grafting in the defects achieves union between the loose lamina and the anterior element of lumbar vertebrae, and reconstructs the anatomic structure and physiologic functions of the lumbar vertebrae. There was no significant difference in outcome between the spondylolytic/spondylolisthetic patients with non-degenerative disc, who were treated with direct repair of defect only, and those with degenerative disc, who additionally underwent a fusion procedure ($P>0.05$). The present series demonstrates a satisfactory result and a high rate of bony healing of the pars defect by this operative procedure in patients with lumbar spondylolysis and mild isthmic spondylolisthesis. Preoperative assessment of the disc degeneration with MRI is of great assistance in making the protocol choice of whether to opt for fusion.

Keywords Lumbar vertebrae · Spondylolysis · Spondylolisthesis · Spinal fusion · Intervertebral disc · MRI

Introduction

Being responsive to conservative treatment, most patients with lumbar spondylolysis and mild spondylolisthesis do not require surgical intervention [25,26]. However, some patients do eventually undergo surgery. If persistent back pain and/or radicular pain is resistant to conservative treatment or the slippage of the vertebra is increasing, surgical treatment is usually indicated. A variety of fusion techniques have been proposed. Among these procedures, direct repair of the defect has the advantage over others in preserving anatomic integrity and mobility of the affected segment. Since it was introduced by Kimura [15] in 1968 and Buck [4] in 1970, this technique has been not only widely applied but also modified with internal fixation. The direct repair of the pars interarticularis defect seems to be the most appropriate treatment for spondylolysis and

mild isthmic spondylolithesis, but a negative effect of disc pathology on the results has been documented [3, 10,13]. This paper reviews the outcome of 46 patients who underwent direct repair with or without facet fusion at our hospital, and discusses the indications for this procedure.

Materials and methods

Between 1987 and 1995, direct repair of pars interarticularis defect was performed in 46 patients at our hospital. There were 24 males and 22 females. Age at the time of surgery ranged from 15 to 56 years, with an average of 38.2 years. The mean duration of symptoms was 5.3 years, ranging from 4 months to 20 years. All patients complained of low back pain, which characteristically started or increased at times of strenuous work or during athletic activities and decreased at times of rest or a reduction of workload. Of the 46 patients, ten reported combined intermittent claudication and four had associated sciatica. The pars defect was bilateral in all patients, with the affected vertebrae being L5 in 24 patients, L4 in 18 patients and L3 in one. Three patients showed double-level involvement, including two L4-L5 and one L3-L4. Thus, a total of 98 pars defects were identified. Meyerding's method [17], for which the end plate of S1 is divided into four quarters, was used to measure the degree of tangential slip of the vertebral body over the one below. Grades I, II, III and IV are assigned to slippages over one, two, three and four quarters, respectively. Grade V represents spondyloptosis. Eighteen patients had spondylolisthesis: 11 grade I and 7 grade II.

Magnetic resonance imaging (MRI) of the lumbar spine was performed in all patients, using an MT/S 0.35-T superconductive unit (Diasonics). Five-millimeter-thick multislice midsagittal images were obtained with a T2-weighted spin echo sequence (TR 1500/TE 80 ms) to evaluate the degree of disc degeneration below and above the defect. The images were graded according to signal intensity using the five-point scale of Gibson et al. [7]: grade 0, very intense; grade 2, moderate; grade 3, slight; grade 4, none. We then defined grade 0 intensity as indicating a normal disc, grades 1 and 2 as mild and moderate disc degeneration, and grades 3 and 4

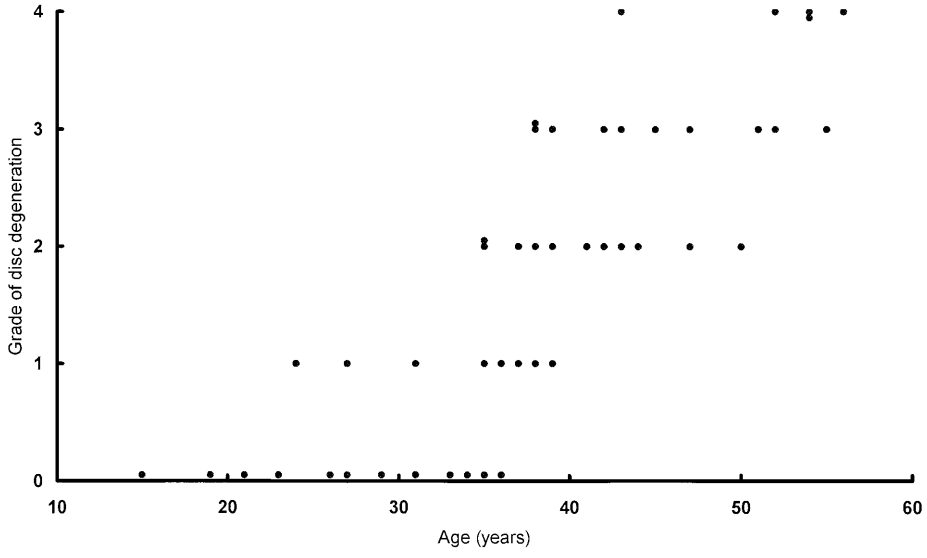

Fig. 1 Correlation of the grade of disc degeneration, defined by magnetic resonance imaging (MRI) according to Gibson et al. [7], with age

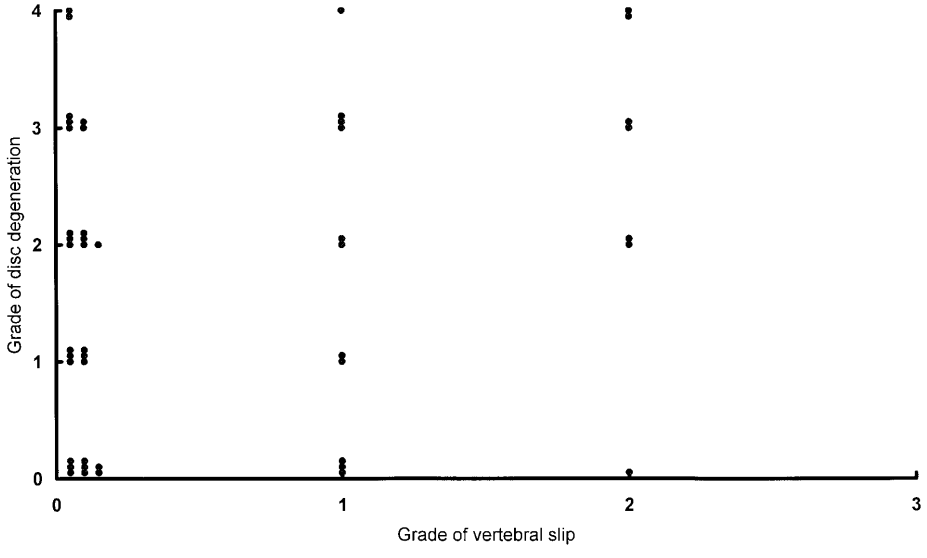

Fig. 2 Correlation of the grade of disc degeneration, defined by MRI according to Gibson et al. [7], with grade of vertebral slip

as severe disc degeneration. In this series, there was a grade 0 disc in 12 patients, a grade 1 disc in eight patients, a grade 2 disc in 11 patients, a grade 3 disc in ten patients and a grade 4 disc in five patients. The grade of disc degeneration was significantly correlated with age (χ=0.825, P<0.01) (Fig. 1), but not associated with the grade of vertebral slip (χ=0.197, P>0.05) (Fig. 2).

The indications for operation included persistent low back pain with or without sciatica, refractory to conservative treatment for a period longer than 3 months. The operation was carried out through a midline longitudinal incision over the appropriate lumbar vertebra to subperiosteally expose the spinous process, lamina and base of the transverse processes of the affected vertebra. The defect of the pars interarticularis was identified by demonstrating abnormal mobility of the segment. If the defect was covered by the lower end of the inferior apophyseal process of the upper vertebra, the apex was removed. The defect was then cleared of fibrous, cartilaginous and sclerotic tissue until healthy bone was exposed. After freshening of the bony stumps, cancellous bone autograft harvested from the iliac crest was carefully inserted in the defect. In one patient with disc herniation, discectomy through laminotomy was performed. Six patients with lateral recess stenosis identified by computed tomography (CT) underwent fenestration: the inferior margin of the lamina and the medial inferior facet were first removed, then the ligamentum flavum was excised. Fusion of facet joint below and above the defect was supplemented with bone grafting if moderate or severe disc degeneration was demonstrated on MRI examination. The procedures included decorticating the articular surfaces of the facet joints and packing the bone graft over the decorticated facet joints. Seventeen patients underwent facet fusion in one segment and nine in two segments. The preoperative data of all 46 patients are shown in Table 1.

The patients were allowed out of bed from the 10th postoperative day, wearing a plaster cast without inclusion of the thigh for 3–4 months. The mean hospital stay time was 15 days. Unrestricted activities were not recommended until after 6 months.

For evaluating the clinical results, the criteria of Henderson [11] (Table 2) were followed. In reviewing radiographic results, oblique projections of the pars interarticularis were obtained postoperatively and at regular intervals until bony healing was demonstrated. Bony healing was defined strictly as the presence of bilateral continuous trabecular bone across the defect or dorsal to the defect.

Table 1 Preoperative data of 46 patients with spondylolysis

	Direct repair	Direct repair combined with facet fusion
Age (years)	35.3	40.4
Sex (male/female)	9/11	15/11
Duration of symptoms (years)	3.6	6.6
Symptoms		
Low back pain (*n*)	20	26
Intermittent claudication (*n*)	2	8
Sciatica (*n*)	1	3
Level of defect		
L3	1	0
L4	7	11
L5	11	13
L4,L5	1	1
L3,L4	0	1
Spondylolisthesis		
Grade I	5	6
Grade II	1	6
Disc degeneration		
Grade 0	12	0
Grade 1	8	0
Grade 2	0	11
Grade 3	0	10
Grade 4	0	5

Table 2 Assessment criteria of functional capacity (according to Henderson [11])

Grade	Functional capacity
Excellent	No pain Able to return to former occupation with no restrictions Sports or recreational activities are unrestricted
Good	Occasional pain, no more than 12 h after unusually strenuous activity Able to resume occupation Not restricted from engaging in less strenuous sports
Fair	Less pain than preoperatively, but it is still a problem Must either wear an external support at work or be restricted to lighter work than before Sports and recreation are restricted
Poor	No better than preoperatively Unable to work Continues to seek medical help for pain

Results

No patient needed a transfusion during surgery nor did any complications developed afterwards. Results, with a follow-up period of more than 2 years, were available for all patients (range, 24–92 months). The mean follow-up period was 50 months. No obvious reduction of vertebral slip was demonstrated in any patient in this series. Twenty-eight patients experienced complete relief of their preoperative complaints after surgery, with excellent results. In 15 patients, the results were rated as good. In the 43 patients rated excellent or good, all pars repairs were healed and all but two showed no significant progression (Fig. 3). The two exceptions had a progression of vertebral slip from grade 0 to grade I and from grade I to grade II, respectively, but were graded as a good outcome on the grounds that, participating in less strenuous activity, they noted a definite improvement, experiencing only occasional minor back pain. Failed bony healing of the defect was noted in four defects in three patients: one patient had a bilateral pseudoarthrosis following direct pars repair of the defect and reported less back pain and sciatica than preoperatively, two showed non-union on one side after pars repair combined with facet fusion and complained of moderate back pain. No postoperative increase in the amount of vertebral slip was found in any of these three

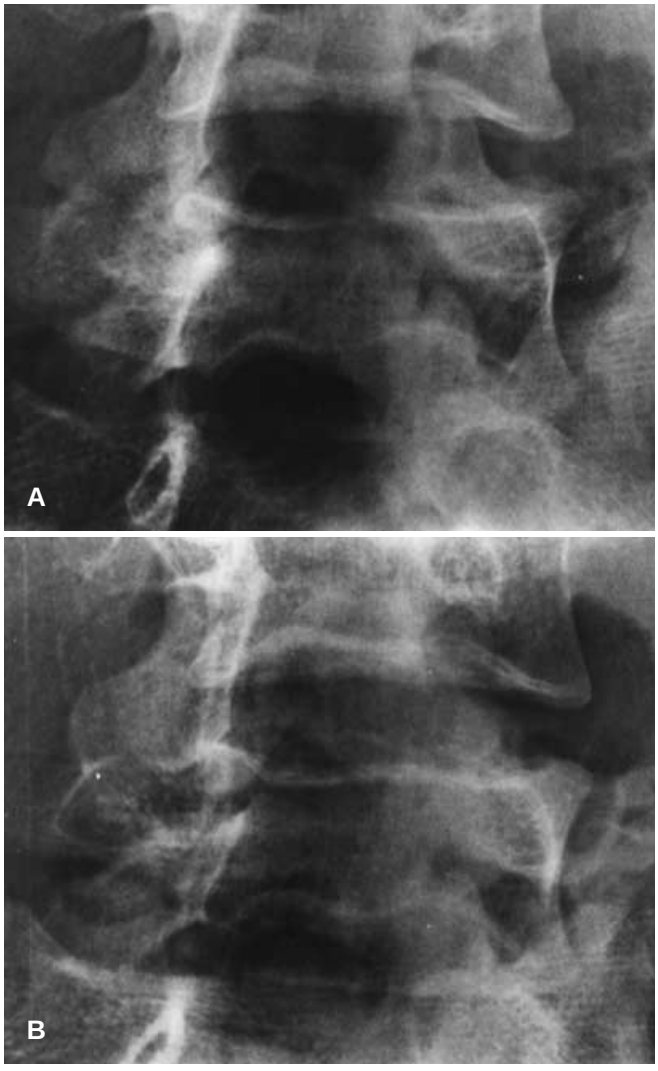

Fig. 3 **A** Preoperative oblique radiograph showing a defect of pars interarticularis. **B** Oblique radiograph 6 years after direct repair of defect showing a normal appearance of the pars interarticularis

Table 3 Clinical results by treatment groups (n=46)

Treatment	Clinical results		
	Excellent	Good	Fair
Direct repair	10[a]	9	1
Direct repair combined with facet fusion	18[a]	6[a]	2

[a]Including one case with fusion of two-level defect

patients. These patients with failed bony healing achieved fair results and were not being considered for reoperation at the time of last follow-up examination. The clinical results of patients treated with direct repair of the defect only were compared with the results of those treated with direct repair of defect combined with facet fusion (Table 3), and no significant difference was found (χ^2= 2.478, P>0.05).

Discussion

Direct repair of pars interarticularis defect has been reported to give satisfactory results. Kimura [15] used bone graft without internal fixation, confining the patients to bed for 2 months and then asking them to wear a plaster cast until union of the lysis. This technique aims at restoring the normal anatomy and motion of the involved vertebra by carrying out direct repair between the loose arch and the anterior part of the vertebra; it involves less surgical dissection and runs less of a neurological risk. This seems a more logical treatment for younger patients with either no or mild spondylolisthesis, especially for those with multilevel defects. However, patients with high-grade spondylolisthesis are not candidates for direct repair. Following Kimura's initial introduction of the direct repair technique, screw [2, 11, 12, 21, 23, 25, 30,31], wire [3, 9, 13,20], hook-screw [1, 10,18], rod-screw [8], and plate [16] fixation and some variations [14] were used to stabilize the repaired defects. These techniques allow the patients up as soon as possible postoperatively, but reoperation is required to remove the internal fixation device. In this series, 93.4% of excellent and good results and 95.9% of bony healing without internal fixation were found – rates that are comparable to those achieved with internal fixation reported in the literature. The operation is simple and no complications occurred. In our opinion, a plaster cast is safe, effective, and sufficient for postoperative immobilization. In fact, some of patients in this series preferred to stay in bed until bony union had been established. This might account, in part, for the high bony union rate in patients with uninstrumented grafting procedure. The disadvantage of wearing a plaster cast may be the discomfort suffered by the patient.

The results of direct defect repair depend, to a considerable degree, upon the degree of degeneration of the intervertebral disc involved. Although some authors [2,9] have reported satisfactory results with direct repair even in older patients, most experiences have shown that younger patients have a better clinical outcome than older patients [1, 10, 13, 20, 23,31]. These latter studies found that adult patients require a segmental fusion rather than direct repair, which was deemed to be a suitable method only in juvenile patients. Hefti et al. believed that there might be other sources of pain in spondylolysis than the spondylolysis defect, and that disc degeneration and subsequent segmental instability might be a cause of symptoms persistent after defect healing [10]. Spondylolysis means the discontinuation of the posterior element in lumbar vertebrae. This will exert a greater load on the anterior element, in which intervertebral disc is included, and, therefore, accelerate the process of disc degeneration.

Thus, spondylolytic segments will be predisposed to instability, and defect healing will consequently be interrupted. In addition, disc herniation may be complicated, thereby leading to nerve root compression [6,24]. In consequence, direct repair has been suggested for symptomatic patients under 25–35 years of age [3, 13, 16,20], whose disc is healthy. Szypryt et al. [28] assessed the morphology of the intervertebral discs in 40 patients with spondylolytic and mild (Meyerding grades I and II) spondylolisthetic defects of the lumbar spine using MRI. The results suggested that the pars defect is associated with an increased prevalence of disc degeneration compared with the age- and sex-matched asymptomatic controls, especially in the groups over 25 years of age. Szypryt et al. insisted on segmental fusion in management of the patients over 25 years of age. Nachemson [19] even extended the indications of defect repair combined with intertransverse fusion to young patients, obtaining a fusion rate of 92%. In a retrospective review [29], however, degenerative changes or narrowing of the operated level was identified in only 1 of 12 patients aged between 16 and 39 years after an average period of 10 years. This result indicates that there is no reason to set an upper age limit for direct repair of spondylolysis if disc degeneration is excluded. Schlenzka et al. [26] asserted that the direct repair procedure did not protect the disc of the lytic/olisthetic segment from further degeneration, but they did not provide any preoperative MRI data. In fact, preoperative assessment of degeneration of the discs adjacent to the defect is of great importance. MRI has proved an effective and accurate method for diagnosis of disc degeneration [5, 7,22]. In this series, facet joint fusion in the affected segment was supplemented with direct repair in patients with moderate or severe degeneration of discs above and/or below the defects. The results were satisfactory after more than 2 years, irrespective of preoperative disc pathology.

We conclude that direct repair of the pars interarticularis defect is a valuable and suitable procedure in patients with lumbar spondylolysis and mild isthmic spondylolisthesis. When the discs adjacent to the defect are degenerative, facet joint fusion in the affected segment should be added. MRI is useful in preoperative assessment of disc degeneration.

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