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Assessment of bony union following surgical stabilisation for lumbar spondylolysis: a comparative study between radiography and computed tomography

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ABSTRACT

Purpose. To compare the status of bony union seen on plain radiography versus computed tomography (CT) following tension band repair for refractory spondylolysis.
Methods. 14 patients (12 men and 2 women; mean age, 23 years; age range, 16–56 years) with a mean follow-up period of 6.35 years were included. All patients were operated on by one senior surgeon using either a Scott procedure (n=2) or van Dam modification of the Scott procedure (n=12). Bony union of the pars was assessed using both plain radiography (anteroposterior, lateral, and oblique views) and reverse gantry CT. The presence of bony union was determined if a bridging bone was shown in the images. The Oswestry Disability Index was measured at 6-year follow-up.
Results. 13 (93%) of 14 patients showed bony union on plain/oblique radiographs versus 7 (50%) on CT scan. The mean Oswestry Disability Index was 28 (good to excellent). The high incidence of nonunion shown on CT scanning did not correlate well with clinical results.
Conclusion. Bony nonunion is more difficult to visualise on plain radiographs than reverse gantry CT. CT demonstrates more clearly the presence or absence of the bridging bone. Clinical results do not correlate with bony union, indicating that bony union is not required to achieve good results.

Key words: *radiography; spinal fusion; spondylolysis; tomography, X-ray computed*

INTRODUCTION

Spondylolytic pars defects are seen in 6% of the general population, and most commonly affect the L5 vertebra.[1] Spondylolysis is a fracture caused by mechanical stress, and the mode of failure is fatigue. The likelihood of fatigue failure is greater in activities that require alternating flexion and extension of the lumbar spine.

Repair of the pars defect is an appealing option

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Table 1
Preoperative radiological findings

Preoperative radiological findings	No. of patients, n=14
Level involved	
Single	12
Double	2
Level of lesion	
L3	2
L4	2
L5	12
Type of lesion	
Unilateral lysis	0
Bilateral lysis	12
Lysis and sclerosis in each side	4

Table 2
Clinical assessment using Oswestry Disability Index[14]

	Score (%)	No. of patients, n=14
Excellent (minimal disability)	0–20	9
Good (moderate disability)	21–40	4
Fair (severe disability)	41–60	1
Poor (completely disabled)	61–80	0
Very poor (bed-bound)	81–100	0

for symptomatic patients (especially athletes) in whom conservative treatment has failed. Several techniques[1–7] have been described with variable success rates of 80% to 100%.[8] In all these series, bony union was determined based on clinical and radiological findings of plain radiographs.

Although plain radiography is the most common means to evaluate the status of bony union, it does not reliably detect nonunion.[9–13] There is no accurate radiological assessment to determine union, and the definitive criteria for a successful repair of spondylolysis remain controversial.

We demonstrate the disparity of radiological union seen on plain radiography versus computed tomography (CT) in 14 patients with lumbar spondylolysis who underwent surgical stabilisation by a senior surgeon using a pedicle screw and Songer cable.

MATERIALS AND METHODS

Between 1994 and 1998, 20 patients with spondylolysis or grade-1 listhesis with pars defect were operated on by a senior surgeon. 14 patients (12 men and 2 women; mean age, 23 years; age range, 16–56 years) with both plain radiographs and CT scans taken at 6-year follow-up were included.

The mean duration of symptoms before surgery was 9 months. In all patients, nonoperative treatment consisted of abstinence from sports, wearing of a brace, training, and/or administering non-steroidal anti-inflammatory drugs for a minimum period of 6 months.

Preoperative assessment included plain radiography (anteroposterior, lateral, and oblique views), with or without bone scan, reverse gantry CT scan, and magnetic resonance imaging (MRI) and discogram (in selected cases). Three patients had mild (grade 1) slip in addition to pars defect. The sites for the pars defect were L5 (n=12), L4 (n=2), and L3 (n=2); 2 patients had multilevel involvement. All lesions were classified as unilateral or bilateral, sclerotic or lytic (Table 1).

All patients were operated on by one senior surgeon using either a Scott procedure[5] (n=2) or the van Dam modification[7] of the Scott procedure (n=12). These involved bone grafting of the defect, insertion of a pedicle screw, and a tension band connecting the pedicle screw and spinous process using Songer cables. One patient underwent a van Dam procedure for an L4 pars defect in addition to L5-S1 fusion.

Bony union of the pars was assessed using plain radiographs (anteroposterior, lateral, and oblique views) at 3 months and 12 months. A reverse gantry CT scan (slice thickness, 5 mm; voltage, 135 kV; amperage, 250 mA; and rotation time, 1.5 seconds) was performed on the affected vertebrae. Images were examined by a single radiologist who was blinded to the clinical history and plain radiographic findings. Images were further confirmed by an independent assessor. The presence of bony union was determined if a bridging bone was shown on the images.

The Oswestry Disability Index[14] was measured at 6-year follow-up by an independent assessor.

RESULTS

The mean follow-up period was 6.35 years (range, 4–10 years). The mean Oswestry Disability Index was 28 (good to excellent). In June 2004, 13 patients showed an excellent to good result and one showed a fair result (Table 2).

In 13 (93%) of 14 patients, bony union was evident on plain/oblique radiographs. One patient made an excellent clinical recovery and resumed competitive rugby and had an excellent Oswestry score, despite showing radiographic nonunion following the Scott's procedure. Reverse gantry CT scans were performed

Table 3
Evidence of bony union shown on plain radiography and computed tomography (CT)

	Plain radiography, n=14	CT, n=14
Union	13 (93%)	7 (50%)
Nonunion	1 (7%)	7 (50%)
Scott procedure, n=2	1 (50%)	1 (50%)
van Dam modification, n=12	0 (0%)	6 (50%)

Table 4
Evidence of bony union shown on plain radiography and computed tomography (CT) based on Oswestry results

	Excellent	Good	Fair
Radiographic union + CT union	4	3	0
Radiographic union + CT nonunion	4	1	1
Radiographic nonunion + CT nonunion	1	0	0

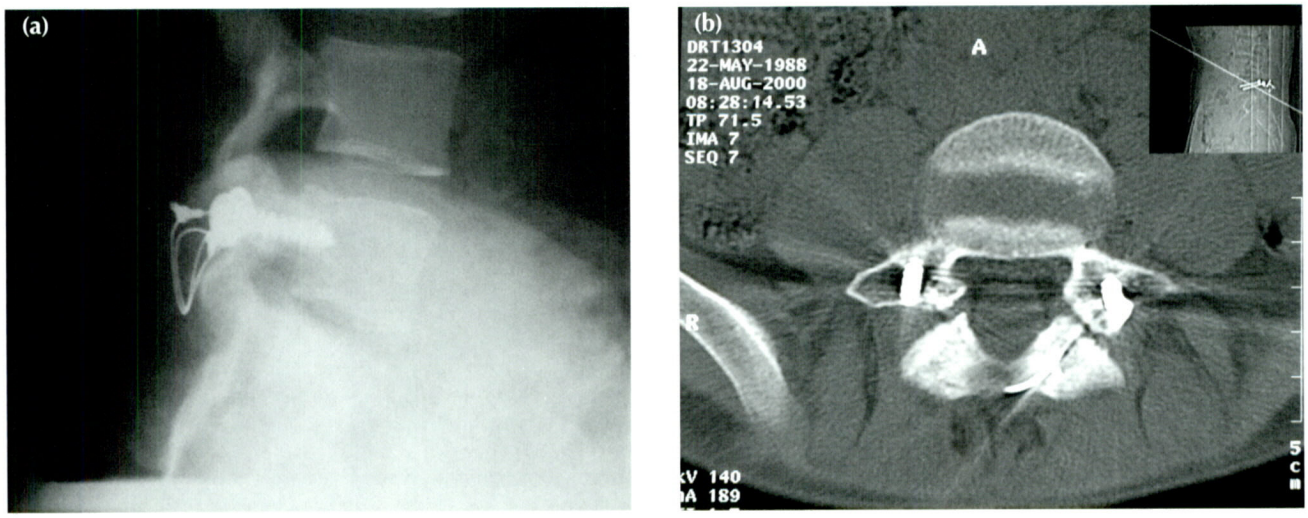

Figure The pars interarticularis of the same patient showing **(a)** bony union on radiography and **(b)** nonunion on computed tomography.

in all 14 patients after a mean period of 13 months. Complete bony union was shown in 7 (50%) patients and frank nonunion in 7. This indicates that bony union shown on plain radiographs may not accurately reflect the actual bony union (Table 3). This occurred more commonly in patients in the van Dam group than the Scott group. It is possible that the presence of the pedicle screw may obscure the evidence of nonunion on plain radiographs (Fig.).

The high incidence of CT nonunion correlated poorly with clinical results (Table 4). Six of the 7 patients with nonunion had excellent to good clinical results. There were no differences in clinical outcome with regard to sports or job resumption between the 2 procedures, according to CT.

DISCUSSION

Tension band wiring is required for patients with symptomatic spondylolysis in whom nonoperative treatment has failed. Results are excellent in young patients (under 30 years) in the absence of spondylolisthesis or disc degeneration on MRI.

Repair of spondylolysis using a Scott procedure or van Dam modification in active young adults results in a significant improvement in Oswestry scores.[8,15] A successful outcome of 88% has been reported in patients younger than 20 years and of 71% in patients older than 20 years with significantly improved physical function and reduced pain 2 years postoperatively.[16]

Objective assessment of bony union following surgical repair of spondylolysis has not been clearly defined in the literature. Plain radiography has been widely used in the assessment of union status, largely because of its low cost and wide availability.[1,2,8,15] Nonetheless, the reliability of this assessment is questionable. The accuracy of plain radiographs to predict the status of a surgical union has been correct

in 69% of cases.[9,17] Our findings showed a much higher union rate (90% versus 50%) using plain radiography than reverse gantry CT. These findings reflect the inability of plain radiography to detect nonunions and lead to overestimation of union. Plain radiography only projects 2-dimensional images and cannot accurately detect union that is 3-dimensional.[17] Assessment of union becomes more difficult in the presence of a pedicle screw.

Clinically good results did not always correlate with union of the fracture on CT during a mean follow-up of 6 years. Nevertheless, CT nonunion did not appear to deter clinical results indicating that bony union is not required to achieve good results. In 34 competitive athletes treated with a brace for a mean period of 16 weeks, good to excellent results were achieved in 32 patients, but only 16 demonstrated osseous union on CT scan.[18] Osseous union is more likely to occur in unilateral spondylolysis than bilateral spondylolysis although this study did not confirm this finding.[18]

The exact cause for nonunion after rigid fixation with a cable and pedicle is unknown. The screw interference at the pars articularis is negligible with our modified fixation compared with the Buck screw fixation. This fixation nonetheless allows some movement at the pars on extension and may be responsible for the nonunion.

Irrespective of CT findings, clinical outcome following this van Dam modification is excellent. Nonunion does not appear to compromise overall outcome or sports resumption in the short term. Patients in whom a CT scan suggests nonunion and who remain asymptomatic do not require further diagnostic workup, but closer clinical follow-up is required to identify the development of mechanical symptoms as the long-term consequences have not been established. The present study nonetheless showed that the results did not change after 6-year follow-up.

REFERENCES

1. Buck JE. Direct repair of the defect in spondylolisthesis. Preliminary report. J Bone Joint Surg Br 1970;52:432–7.
2. Morscher E, Gerber B, Fasel J. Surgical treatment of spondylolisthesis by bone grating and direct stabilization of spondylolysis by means of a hook screw. Arch Orthop Trauma Surg 1984;103:175–8.
3. Kakiuchi M. Repair of the defect in spondylolysis. Durable fixation with pedicle screw and laminar hooks. J Bone Joint Surg Am 1997;79:818–25.
4. Salib RM, Pettine KA. Modified repair of a defect in spondylolysis or minimal spondylolisthesis by pedicle screw, segmental wire fixation, and bone grafting. Spine 1993;18:440–3.
5. McQueen MM, Court-Brown C, Scott JH. Stabilisation of spondylolisthesis using Dwyer instrumentation. J Bone Joint Surg Br 1986;68:185–8.
6. Songer MN, Rovin R. Repair of the pars interarticularis defect with a cable-screw construct. A preliminary report. Spine 1998;23:263–9.
7. van Dam BE. Modified Scott technique. In: Bridwell KH, DeWald RL, editors. The textbook of spinal surgery, 2nd ed. Philadelphia: Lippincott-Raven; 1997:124.
8. Debnath UK, Freeman BJ, Gregory P, de la Harpe D, Kerslake RW, Webb JK. Clinical outcome and return to sport after the surgical treatment of spondylolysis in young athletes. J Bone Joint Surg Br 2003;85:244–9.
9. Blumenthal SL, Gill K. Can lumbar spine radiographs accurately determine fusion in postoperative patients? Correlation of routine radiographs with a second surgical look at lumbar fusions. Spine 1993;18:1186–9.
10. Brodsky AE, Kovalsky ES, Khalil MA. Correlation of radiologic assessment of lumbar spine fusions with surgical exploration. Spine 1991;16(6 Suppl):S261–5.
11. Cizek GR, Boyd LM. Imaging pitfalls of interbody spinal implants. Spine 2000;25:2633–6.
12. Pearcy M, Burrough S. Assessment of bony union after interbody fusion of the lumbar spine using a biplanar radiographic technique. J Bone Joint Surg Br 1982;64:228–32.
13. Santos ER, Goss DG, Morcom RK, Fraser RD. Radiologic assessment of interbody fusion using carbon fiber cages. Spine 2003;28:997–1001.
14. Fairbank JC, Couper J, Davies JB, O'Brien JP. The Oswestry low back pain questionnaire. Physiotherapy 1980;66:271–3.
15. Ivanic GM, Pink TP, Achatz W, Ward JC, Homann NC, May M. Direct stabilization of lumbar spondylolysis with a hook screw: mean 11-year follow-up period for 113 patients. Spine 2003;28:255–9.
16. Hefti F. Direct screw repair spondylolysis with the hooked screw [in German]. Orthopade 1997;26:769–73.
17. Kant AP, Daum WJ, Dean SM, Uchida T. Evaluation of lumbar spine fusion. Plain radiographs versus direct surgical exploration and observation. Spine 1995;20:2313–7.
18. Sys J, Michielsen J, Bracke P, Martens M, Verstreken J. Nonoperative treatment of active spondylolysis in elite athletes with normal X-ray findings: literature review and results of conservative treatment. Eur Spine J 2001;10:498–504.