ORIGINAL STUDY

Pedicle Screw/Sublaminar Hook Fixation Versus Pedicle Screw/Infraspinous Wire Fixation for Spondylolysis Repair: A Retrospective Comparative Study With Multislice Computed Tomography Assessment

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Abstract

Background data: Spondylolysis is a stress fracture of the pars interarticularis that occurs in 2–5% of the population. Surgical techniques of spondylolysis repair have been challenging in the last decades.

Purpose: To compare pedicle screw-hook and pedicle screw-infraspinous wire fixation in pars repair clinically and radiologically.

Study design: Retrospective comparative clinical case study.

Patients and methods: Twenty-four patients with pars repair using pedicle screw-hook fixation (group I) compared with 21 patients using pedicle screw-infraspinous wire fixation (group II) were reported. Autogenous iliac bone grafting was performed in both groups. Two cases in group I had concomitant unilateral laminolysis with hypertrophied nonunion. All patients were assessed for back pain visual analog score (VAS) and Oswestry disability index (ODI) preoperatively. Clinical follow-up was conducted at 3, 6, 9, and 12 months using VAS and ODI. Union was assessed using multislice CT.

Results: At the final follow-up, back pain VAS and ODI improved significantly in both groups (P < 0.001, P < 0.0001), respectively. There were insignificant statistical differences between the two groups regarding ODI improvement, VAS improvement, and time to return to work. At the 9-month follow-up, the complete bilateral union was achieved in 95.8% in group I and 90.5% in group II, with insignificant difference between the two groups.

Conclusion: Both pedicle screw-sublaminar hook and pedicle screw-infraspinous wire fixation plus autogenous bone graft have satisfactory outcomes in spondylolysis repair. Using screw-hook construct was associated with significant earlier union, and could be considered a good choice for combined spondylolysis and laminolysis.

Keywords: Infraspinous wire, Laminolysis, Pars fracture, Pars repair, Pedicle screw, Spondylolysis, Sublaminar hook

The article does not contain information about medical device(s)/drug(s).
Introduction

Spondylolysis is defined as a stress fracture of the pars interarticularis in the lumbar spine. It could happen after repeated minor trauma or after a single trauma that frequently occurs in adolescent sports players. Due to genetic predisposition, a high prevalence of spondylolysis occurs in some families and some populations [1,2]. The incidence of spondylolysis ranges between 2% and 5% in the general population, and the majority are asymptomatic cases [3].

Surgical techniques of spondylolysis repair were challenging, with low union rates that led some surgeons to recommend posterolateral segmental fusion [4]. In the last decades, good results with pars interarticularis repair are now more achievable and demonstrated an excellent union rate reaching more than 90% with the advantage of preserving intersegmental motion [5,6]. Many implants have been used for pars repairs, such as compression screw fixation, Morscher’s hook screw fixation, cerclage wire fixation, pedicle screw cable fixation, pedicle screw-hook fixation, and pedicle screw rod fixation with wide ranges of union rates [6–9]. Until now, no consensus has been reached regarding the better tool to treat pars defect.

This study compares pedicle screw-sublaminar hook fixation and pedicle screw-infraspinous wire fixation for pars repair reporting feasibility, results, and possible complications.

Patients and methods

After being approved by the institutional research ethics committee, 24 consecutive pars repair surgeries were performed using pedicle screws-sublaminar hooks construct fixation between January 2015 to December 2019 (Group I). The data of this group were compared retrospectively to the data of 21 consecutive patients performed from January 2010 and December 2014 using pedicle screw-infraspinous wire fixation (group II).

All patients had signed written informed consent for surgery, including iliac autografting, and for participation in the study. The age of the patients was between skeletal maturity and 40 years old in both groups.

All patients had failed adequate conservative treatment courses in the form of rest, bracing, physical therapy, temporary restriction of activity, and NSAIDs for at least 24 weeks.

Any case with the following findings was excluded: sciatica, obesity with BMI more than 30, comorbidities like diabetes mellitus and any systemic diseases, smoking, narrowing of disc space, black disc in the level just below the lysis in MRI, MRI findings of nerve root compression, degenerative arthritis of a facet joint, physical signs of nerve root compression, or presence of a spondylolisthesis.

All patients were assessed clinically (locally and neurologically), as well as radiographically (full study X-ray, multislice computed tomography (MSCT) scan, and MRI lumbosacral spine). The preoperative back pain VAS and ODI scores were reported.

In group I, the affected pars was L5 in 14 patients and L4 in 10 patients, while in group II, the affected pars was L5 in 12 patients and L4 in 9 patients, with no difference among both groups (P = 0.94).

All patients in both groups had bilateral pars defects. Two cases in group I had a concomitant unilateral laminolysis on the right side with no history of trauma.

A confirmatory diagnostic test was done for all patients by local injection of lidocaine bilaterally in the pars defect under fluoroscopic guidance, where temporary relief of pain indicated that the lysis was the only source of pain.

Surgical technique

Under general anesthesia, patients were placed in the prone position on a Wilson Frame. The involved laminae, including the pars defect on both sides, were exposed through a midline posterior incision. Subperiosteal dissection was performed without interfering with the facet capsule. The fibrous tissues of the pseudoarthrosis in the defects were removed with rongeurs and curettes. The sclerotic margins on both sides of the pars defect were removed using bone curettes and a high-speed burr. The pars defect was measured, and a tricortical bone graft was harvested from the iliac bone through a separate incision, shaped with the accurate size and impacted within the defect.

Pedicle screw insertion: in group I, 6.2 mm polyaxial titanium screws were used, while in group II, 4.5 mm conventional stainless steel cortical screws were used.

In group I, preparation of laminae for hook insertion by flavectomy was done using micro curettes and Kerrison rongeurs. The rods were cut to the appropriate length, bent to about 80°, and attached to the heads of the polyaxial screws. The rods were attached to the laminar hooks after the engagement of these hooks to the inferior edge of the lamina. The authors have applied mild compression between the hook and the screw head with a...
compressor before tightening the nut. However, after a medial pedicle breach had happened in one case, the authors replaced this step with the application of push force on the hook after tightening the nut of the screw and before tightening the nut of the hook (Fig. 1).

In group II, two pieces of 1.2 mm stainless steel wire were encircled around the screw head, braided, then passed under the spinous process of the same level, and tightened (Fig. 2).

Two cases in group I had concomitant bilateral spondylolysis and unilateral lamina fracture (laminolysis) in which the hypertrophied nonunited lamina fracture site was curetted and the sublaminar hook was inserted as mentioned without need for grafting of the lamina and the lamina fracture was found to be stable after tightening the nuts (Fig. 1).

Postoperative care and follow-up

Postoperatively, all patients were allowed to walk on the second day, instructed to wear rigid lumbosacral orthosis 24 h/day for 6 weeks, and avoid prone position, bending, twisting, lifting, and all athletic activities for 3 months. Patients were followed up for at least one year of clinical examinations including ODI, and VAS scores were recorded at 3, 6, 9, and 12 months. Time to return to work was recorded in both groups. Plain radiographs in AP and lateral views were requested at 3-, 6-, 9-, and 12-month follow-ups.

Pars union was assessed using MSCT examination with 0.3 mm slice thickness and sagittal reconstructions. The MSCT examinations were assessed for union blindly by two readers; one musculoskeletal radiologist, MFAA, with 12-year experience in musculoskeletal cross-sectional imaging and one orthopedic surgeon, AFAA. MSCT was done at 3 months postoperatively; if an early union was noted, MSCT examination was not repeated in the next follow-up periods and gentle exercises were allowed, with no vigorous/athletic activities until 6 months. If no union was seen at 3 months, then the MSCT study was repeated every 3 months until union was achieved or until 1 year of follow-up.
Statistical analysis

All collected data were analyzed and compared retrospectively using SPSS software 20 (SPSS Inc., Chicago, IL, USA) and Megastat software version 10.1 (McGraw-Hill). P values less than 0.05 were considered statistically significant.

Results

The mean age at operation was 25.2 ± 3.4 (range, 21–34) years in group I; 18 patients were males and 6 were females. In group II, the mean age at operation was 23.6 ± 3.7 (range, 18–32) years; 16 patients were males and 5 were females. The mean duration of symptoms was 12.7 ± 4.9 (range, 6–24 months) in group I and 11.2 ± 4.4 (range, 5–21 months) in group II. The differences between both groups regarding epidemiological data were insignificant (Table 1). No patient was lost to follow-up, and the mean follow-up period was comparable in both groups without significant differences (Table 2).

Operative Notes: The mean operative time was 123.6 ± 15.6 (110–180) minutes in group I and 100.4 ± 25.63 (90–150) minutes in group II (P = 0.079). The mean hospital stay in group I was 1.7 ± 0.62 (range, 1–3) days, while in group II, it was 1.8 ± 0.68 (range, 1–3) days (P = 0.81). Blood loss was comparable in both groups with no significant differences (Table 2).

Clinical evaluation

VAS Score: In both groups, pain scores improved significantly for back pain VAS score preoperatively of 5.6 ± 1 to 1.4 ± 0.5 postoperatively in group I (P < 0.001) and from preoperatively 5.3 ± 1.04 to 1.12 ± 0.4 postoperatively in group II (P < 0.0001), with no significant difference between both groups (P = 0.62).

ODI Score: Patients in both groups showed significant postoperative improvement in ODI scores compared to preoperative values (P < 0.0001). ODI improvement was formulated by deduction of the postoperative ODI from the preoperative ODI as follows: [pre ODI – post ODI]. Comparing the ODI improvement of the two groups showed insignificant statistical differences (P = 0.31) (Table 3).

Return to Work: At a 3-month follow-up, all patients in both groups were able to return to their presymptomatic level of activity other than vigorous/athletic activity, which was postponed until the complete radiological union was achieved. The mean time to return to their presymptomatic activity was 2.3 ± 0.49 months in group I and 2.5 ± 0.51 months in group II, with no significant difference between both groups (P = 0.19).

Radiological evaluation

Radiographic union was considered complete when total obliteration of pars defect was observed on the MDCT without any lucency in both sagittal and axial cuts.

By the end of the 9-month follow-up, 23 patients out of 24 (95.8%) in group I vs. 19 patients out of 21 (90.4%) in group II showed complete bilateral union; in other words, one patient in group I and two patients in group II have been reported having nonunion even at the 12-month follow-up with no

Table 1. Summary of epidemiological data.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I (n = 24)</th>
<th>Group II (n = 21)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age/years</td>
<td>25.2 ± 3.4 (21–34)</td>
<td>23.6 ± 3.7 (18–32)</td>
<td>028</td>
</tr>
<tr>
<td>Male/Female</td>
<td>18/6</td>
<td>16/5</td>
<td>0.21</td>
</tr>
<tr>
<td>Duration of symptoms/months</td>
<td>12.7 ± 4.9 (6–24)</td>
<td>11.2 ± 4.4 (5–21)</td>
<td>0.31</td>
</tr>
</tbody>
</table>

Table 2. Summary of perioperative data in both groups.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I (n = 24)</th>
<th>Group II (n = 21)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operative time/minutes</td>
<td>123.6 ± 15.6 (110–180)</td>
<td>100.4 ± 25.63 (90–150)</td>
<td>0.079</td>
</tr>
<tr>
<td>BI loss/ml</td>
<td>146.4 ± 34</td>
<td>143 ± 41</td>
<td>0.73</td>
</tr>
<tr>
<td>Hospital stay/days</td>
<td>1.7 ± 0.62 (1–3)</td>
<td>1.8 ± 0.68 (1–3)</td>
<td>0.81</td>
</tr>
<tr>
<td>Return to work/months</td>
<td>2.3 ± 0.49</td>
<td>2.5 ± 0.51</td>
<td>0.19</td>
</tr>
<tr>
<td>Op complication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screw malposition</td>
<td>1</td>
<td>0</td>
<td>0.37</td>
</tr>
<tr>
<td>Donor site pain</td>
<td>2</td>
<td>1</td>
<td>0.65</td>
</tr>
<tr>
<td>Nonunion</td>
<td>1</td>
<td>2</td>
<td>0.24</td>
</tr>
<tr>
<td>Revision</td>
<td>1</td>
<td>0</td>
<td>0.37</td>
</tr>
<tr>
<td>Follow-up/months</td>
<td>13 ± 1.53 (12–18)</td>
<td>12.3 ± 0.86 (12–15)</td>
<td>0.056</td>
</tr>
</tbody>
</table>

Mann–Whitney U test: for nonparametric quantitative data, significant if P value < 0.05.
significant difference ($P = 0.42$). There was an insignificant difference between the two groups regarding the time of complete bilateral union: 12.5% in group I vs. 4.7% in group II at 3 months ($P = 0.38$); 83.3% in group I vs. 66.6% in group II at 6 months ($P = 0.58$); 95.8% in group I vs. 90.4% in group II at 9 months ($P = 0.42$) (Table 4).

In group I, the laminolysis had achieved union at the same time as pars union in the two cases of combined spondylolysis and laminolysis: one case at 3 months and the other at 6 months.

Complications

One case in group I with L5 pars repair had a left-sided pedicle screw medial breach causing left sciatica without motor deficit; medial encroachment was 4 mm when measured on MSCT axial cut where a revision surgery was decided for revision of the screw after two weeks with complete resolution of sciatica within 1 week. No case in group II had such a complication ($P = 0.37$).

Two cases in group I and one case in group II experienced chronic donor site pain, all resolved after three weeks of conservative treatment with NSAIDs, hot packs, and physical therapy ($P = 0.65$).

One case in group I had nonunion: patient was 22 years old and a smoker, and his final MSCT at 12 months showed unilateral incomplete union in the Rt pars and nonunion in the Lt pars and the dynamic lateral radiograph showed no instability. Two cases in group II had nonunion: both were nonsmokers, their ages were 30 and 32 years, and their final MSCT at 12 months showed bilateral nonunion in both cases, with no instability on the dynamic lateral radiograph. Patients refused further surgery and revision was not decided for any of them. Nonunited cases in both groups showed good clinical outcomes despite nonunion, with an improvement of VAS and ODI scores and a return to normal presymptomatic activity other than sports. No recorded case of infection, loosening, or hardware failure was seen in either group. There were no postoperative neurologic deficits in either group.

Discussion

This study was performed to compare two methods of pars repair retrospectively; pedicle screws/sublaminar hooks construct fixation (24 patients mean age 25.2 ± 3.4 (Group I)) and pedicle screw/infraspinous wire fixation (21 patients mean age 23.6 ± 3.7 (Group II)).

Pars interarticularis repair by bone grafting without instrumentation for the treatment of spondylolysis was first described by Kimura in 1968 as an alternative to segmental fusion [10]. Since then, many techniques for pars interarticularis repair have been described, such as direct internal fixation by screw, fixation by modified hook screw, and the Scott technique of cerclage wiring, for which variable union rates were reported from 73% to 88% [11–14].

After the development of Cotrel–Dubousset instrumentation and the progress made in subsequent generations of spinal implants, the use of pedicle screw and laminar hook fixation was widely described, with excellent clinical and radiographic results [5]. Pedicle screw and laminar hook fixation was first reported as a method for spondylolysis repair in Bridwell and DeWald’s textbook of spinal

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group I ($n = 24$)</th>
<th>Group II ($n = 21$)</th>
<th>$P$</th>
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<tbody>
<tr>
<td>ODI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>30 ± 6.3 (16–40)</td>
<td>28.6 ± 7.2 (16–43)</td>
<td>0.55</td>
</tr>
<tr>
<td>Postoperative</td>
<td>9.4 ± 4.6 (2–21)</td>
<td>7.7 ± 3.9 (2–16)</td>
<td>0.27</td>
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<tr>
<td>Improvement</td>
<td>20.5 ± 7.1 (2–34)</td>
<td>20.9 ± 6.8 (6–35)</td>
<td>0.72</td>
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<tr>
<td>VAS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative</td>
<td>5.6 ± 1</td>
<td>5.3 ± 1.04</td>
<td>0.17</td>
</tr>
<tr>
<td>Postoperative</td>
<td>1.4 ± 0.5</td>
<td>1.12 ± 0.4</td>
<td>0.22</td>
</tr>
<tr>
<td>Improvement</td>
<td>4.75 ± 1.59</td>
<td>5.43 ± 1.86</td>
<td>0.064</td>
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</tbody>
</table>

Mann–Whitney $U$ test: for nonparametric quantitative data, significant if $P$ value $< 0.05$.

<table>
<thead>
<tr>
<th>Pars union</th>
<th>United at 3 months</th>
<th>United at 6 months</th>
<th>United at 9 months</th>
<th>United at 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>GI</td>
<td>3 (12.5%)</td>
<td>20 (83.3%)</td>
<td>23 (95.8%)</td>
<td>23 (95.8%)</td>
</tr>
<tr>
<td>GII</td>
<td>1 (4.7%)</td>
<td>14 (66.6%)</td>
<td>19 (90.4%)</td>
<td>19 (90.4%)</td>
</tr>
</tbody>
</table>

$P$ value: 0.38* 0.58* 0.42* 0.42*

Chi-square test for categorical data, significant if $P$ value $< 0.05$. 

Table 3. Comparison between the two groups regarding the ODI and VAS scores.

Table 4. Comparison between the two groups regarding the union rates at different follow-up periods.
surgery 1991; this method placed compression force at the pars defect graft interface, the compressing points were the pedicle and the inferior edge of the lamina [11].

Gupta and Gupta treated 10 adolescent spondylolysis patients with pedicle screw and laminar hook fixation and autogenous iliac bone grafting augmented by a demineralized bone matrix in three patients and rhBMP-2 in seven patients; the solid union was demonstrated in nine patients (90%) at 3 months postoperatively, and the union was achieved in the last patient at the subsequent follow-up [5]. In a similar study, the six-month union rate was 91% (21 out of 23 patients) after using a specialized rod–laminar hook complex attached to a standard or polyaxial pedicle screw [15].

In this study, the union rate was 95.8% at 9 months of follow-up in group 1 with the use of pedicle screw-sublaminar hook fixation. We used an autogenous iliac bone graft without any other material augmentation; the union rate was 12.5% at 3 months, increasing to 83.3% at 6 months, then 95.8% at 9 months.

In a comparative study between pedicle screw-hook fixation and pedicle screw claw-hook fixation using the latter two hooks from above and below the lamina, Ishida et al. [16] 2018 reported a much lower fusion rate in the hook group than the claw-hook group (40% in the hook group and 71% in the claw-hook group at 12 months). However, with careful examination of their published postoperative radiographs, we observed that the connecting rod was put straight between the pedicle screw and the hook making the hook tilted toward the pedicle screw; thus, it was not engaged well to the laminar edge.

Returning to Gupta and Gupta’s work, they preferred to make acute bending in the rod that could be seen reaching 70–80° in their illustrated model. This bending was to maintain the alignment of the hook with the laminar contour and to avoid injury to the suprajacent facet joint [5]. In the current study, the surgical technique in group I was similar to what was published by Gupta and Gupta, as rods were bent to about 80° and the union rate was 95.8% at the 9-month follow-up.

The wiring technique was described first by Scott in 1986 as passing wires around the transverse processes and caudal to the spinous process with reported excellent results [17]. Nozawa et al. [18] used the same wiring technique on 20 athletes and recorded bony union in all cases with a return to sports activities.

This method’s compressing points were the transverse and spinous processes. Tensioning applied puts stress on the transverse processes, which is the weakest part of the vertebra. Moreover, this technique required extensive dissection for transverse process exposure, and the wire path could be close to the nerve roots [19].

Another method used was a V-shaped rod connecting the pedicle screws within the affected vertebra and passing caudal to the spinous process. The compressing points were the pedicles and the inferior edge of the spinous process. Gillet et al. [20] described this procedure in 1999 and performed it on 10 patients; excellent results were recorded in 6 patients with a return to normal activities.

In a recent clinical study in 2019 on the same procedure with a 10-year follow-up of 22 patients with spondylolysis, 50% had grade I spondylolisthesis, and only three patients needed revision surgery, all of whom had preoperative grade I spondylolisthesis. This study concluded significant improvement in ODI and VAS and radiologic stability with a survival rate of 81.8% for Gillet instrumentation [21].

In group II of our study, the authors used a modified wiring technique in which the wire was connected between pedicle screws within the affected vertebra and passed caudal to the spinous process. Like the Gillet method, the compressing points were the pedicles and the inferior edge of the spinous process. The union rate in the wiring group was 66.6% at 6 months, which increased to 90.4% at 9 months. All previously mentioned studies reported excellent outcomes regarding VAS, functional score improvement, and return to work and sports.

In the current study, there was a statistically significant improvement in VAS and ODI scores postoperatively in both groups with a return to presymptomatic activity in all patients at 3 months of follow-up period with the exclusion of vigorous/athletic activities, which were postponed until complete radiological union.

Many studies have compared different methods of pars repair, and all were retrospective ones. Kakiuchi [22], in 1997, retrospectively compared between laminar compression screw versus pedicle screw-sublaminar hook construct in pars repair. The six-month healing rate was 100% similar in both groups; patients with pedicle screw-laminar hook construct were more likely to return to sports earlier relative to patients with compression screw (5.9 vs. 7.7 months, respectively). In another comparative study, Karatas et al. [23] (2016) compared compression screw versus pedicle screw-sublaminar hook for spondylolysis repair in pediatric and adolescent patients; the healing rate was 100% after 6 months and the healing time was similar in both the groups.
In a meta-analysis comparing different techniques of pars repairs, Mohamed et al. [6] reported that pedicle screw-based repairs are the best choice of procedure, with the highest fusion and lowest complication rates, followed by the Buck repair. They also stated that Morscher repair and Scott repair had high rates of complications and lower fusion rates.

The wiring technique in the current study was based and tensioned between two pedicle 4.5 mm screws and was different from that of Scott repair; 90.4% of patients showed bilateral complete union at the end of the 9-month follow-up, with an insignificant difference when compared to pedicle screw-sublaminar hook fixation group (95.8%, $P = 0.47$).

To the best of our knowledge, no study compared pedicle screw-sublaminar hook fixation and pedicle screw-infraspinous wire fixation in pars repair. Wick et al. [24], in 2000, used the term laminolysis to describe the retroisthmic cleft by analogy with the nomenclature of the applied spondylolysis. Two types of laminolysis were described in the literature; hemilaminar type and intralaminar type. The hemilaminar type was reported as an associated finding with unilateral pars fracture [25].

To our knowledge, there are no reported cases of concomitant bilateral pars fracture and lamina fracture; the authors recorded two cases of combined bilateral pars fracture and lamina fracture in group I with a complete union of the three fractures in both cases using pedicle screw/sublaminar hook construct. In the current study in group I, the laminolysis cases achieved union at the same time as pars union in the two cases of combined spondylolysis and laminolysis both at 6 months.

Limitations of this study include its retrospective nature and the small population number without a priori power analysis. A prospective study with a larger population and a priori power analysis is recommended. The authors recommend not using a compressor to apply compression between the pedicle screw and the laminar hook; just push on the hook after tightening the screw nut, then tighten the hook nut. Both methods used in this study were simple and easily applied; using wire was cheaper than using hooks. However, the pedicle screw-sublaminar hook construct is thought to be more rigid as associated with the significant earlier union. Moreover, we consider it a very good choice for combined spondylolysis and laminolysis.

**Conclusion**

Pedicle screw-sublaminar hook fixation and pedicle screw-infraspinous wire fixation plus autogenous bone graft for spondylolysis repair have satisfactory clinical outcomes with no statistically significant differences.

**Conflict of Interest**

There are no conflicts of interest.

**Author declaration of funding statement**

No funds were received in support of this work.

**Abbreviation list**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>MDCT</td>
<td>Multidetector computed tomography</td>
</tr>
<tr>
<td>CT</td>
<td>Computed tomography</td>
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<tr>
<td>MRI</td>
<td>Magnetic resonance imaging</td>
</tr>
<tr>
<td>NSAIDs</td>
<td>Non-steroidal anti-inflammatory drugs</td>
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<tr>
<td>ODI</td>
<td>Oswestry disability index</td>
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<tr>
<td>VAS</td>
<td>Visual analog scale</td>
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**References**


