Evaluation of Efficacy and Safety of All Pedicle Screw Posterior-Only Surgery in Patients with Dystrophic Neurofibromatosis Scoliosis

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ABSTRACT

Background Data: Neurofibromatosis type 1 (NF-1) patients with dystrophic changes of the spine develop severe spinal deformity and/or instability and always need early surgical treatment. Combined anterior-posterior fusion was the treatment of choice of such curves because of the risk of progression and pseudoarthrosis even in the presence of solid posterior fusion mass. Recent 3rd-generation posterior stabilization systems using pedicle screw fixation allow better 3-column purchase and 3D control and correction of deformity and stable posterior fixation of the spine preventing progression of the curves. Posterior-only surgery has been recently used in dystrophic NF-1 scoliosis due to use of pedicle screws fixation and development of different types of posterior release/osteotomies which lead to successful and sustained correction of these curves.

Study Design: A retrospective clinical cohort study.

Purpose: To study the results of posterior stabilization alone using all pedicle screws fixation in NF-1 patients with dystrophic scoliosis.

Patients and Methods: 16 patients with NF-1 having dystrophic scoliosis were treated by posterior instrumentation using all pedicle screws. There were 5 female and 11 male patients and the average age was 13 years (range, 9–16 years). The study was done in the period between 2009 and 2016. Preoperative clinical examination included examination for neurofibromatosis, assessment of curve flexibility, and thorough neurological examination. Radiological examination included standard plain X-rays, anterior-posterior (A-P) and lateral and flexibility views, and MRI. Screw density of the whole construct and of the apical region (two vertebrae above and below the apex) was calculated. Functional outcomes were assessed by the ODI and SRS-30 scores at the last follow-up.

Results: The mean follow-up was 5.15±1.78 years (range, 3–8). The mean Cobb angle improved in the coronal plane from 67.13±11.88 (range, 45–90°) to 20±8.9 (range, 6–30°) showing 70.1±11.2%. The mean preoperative sagittal plane deformity significantly improved from 61.82±20.28 (range, 35–90°) to 25.91±7.68 (range, 10–35°) postoperatively yielding 53.15±21.43 (range, 25–83.33%) mean correction with insignificant loss of correction at last follow-up. Loss of correction was 2±1.8% and 1.8±2.1% in the coronal and sagittal planes, respectively. At last follow-up the average SRS-30 score was 121±17.7 and the
average ODI score was 8.46±3.26 without disability. Perioperative complications were minimal with no neurologic deficits, dural tears, or deep infection. Implant failure occurred in one patient. **Conclusion:** Our data suggest that posterior-only all pedicle screw based posterior instrumentation in NF-1 dystrophic scoliosis has been associated with good clinical outcome. It can be used safely in the presence of sufficient apical screw density (2018ESJ172). **Keywords:** NF-1; dystrophic scoliosis; posterior only surgery; all pedicle screw; deformity

**INTRODUCTION**

Neurofibromatosis type 1 (NF-1) is the most common type of neurofibromatosis (NF). It is an autosomal dominant disorder and the most commonly encountered by the orthopedist. Its prevalence is 1/3500. Scoliosis is the most common osseous presentation of NF-1 occurring in 10-30% of NF-1 patients. Two distinct types of scoliosis curves occur in NF-1: the nondystrophic type which is similar to the idiopathic scoliosis in its natural history and treatment and the dystrophic type which is characterized by being sharp, angular, short segment curve and usually accompanied by kyphosis and associated with dystrophic changes of the spine. The dystrophic type is the most likely to progress into severe deformity and instability even in the presence of solid bony fusion. Posterior instrumentation and fusion have been recommended in simple patients of dystrophic scoliosis of 20–40 and kyphosis angle less than 50°.

Anterior-posterior fusion was the traditional treatment of dystrophic scoliosis of larger curve magnitude >40° and kyphosis >50° because of the increased incidence of pseudoarthrosis and difficulty in correction and maintenance of correction of severe angular and kyphotic deformity. Posterior-only surgeries have been used recently in dystrophic NF-1 scoliosis after the introduction of pedicle screw instrumentation with its biomechanical superiority and the development of different types of posterior release/osteotomies that produce successful and sustained correction of these severe curves. Few studies report on using posterior-only surgery in dystrophic NF-1 scoliosis.

The aim of this study was to review the clinical and radiological results of using posterior-only all pedicle screw surgery in dystrophic NF-1 scoliosis curves analysing its efficiency, safety, and limitation in correction and maintenance of correction and any possible complications.

**PATIENTS AND METHODS**

After approval of the institutional review board, a retrospective study was conducted on dystrophic NF-1 patients who were surgically treated posteriorly only using all pedicle screw based posterior instrumentation between January 2011 and January 2016 at Mansoura insurance hospitals. The diagnosis of NF-1 was made according to the criteria of the National Institute of Health on NF-1. The inclusion criteria included dystrophic curves with the presence of at least 3 of 5 dystrophic changes, including vertebral scalloping, severe apical vertebral rotation, rib pencilling, spindled transverse processes and neuroforamenal enlargement, curve magnitude over 40°, and all pedicle screw based posterior instrumentation procedure. The study included 19 patients with dystrophic NF-1 scoliosis: 3 patients were lost during the follow-up and the remaining 16 patients were followed up for a minimum of 3 years. There were 11 males and 5 females whose mean ages were 13.18±3.21 years (range, 9–19). Positive family history was present in 3 patients (Table 1). Patients were subjected to clinical and radiological examination. Clinical examination included examination for NF-1, assessment of curve flexibility, and neurological examination. All patients were neurologically free. Radiological examination included standard plain X-rays, anterior-posterior (A-P) and lateral and flexibility views, and MRI. Cobb’s method was used for coronal and sagittal curves measurements and the Nash-Moe method was used for measurement of...
The curve patterns were single thoracic in 9 patients (56.25%), double thoracic in 3 patients (18.75%), and thoracolumbar in 4 patients (25%) (Table 1). Screw density of the whole construct and of the apical region (two vertebrae above and below the apex) was determined by calculating the number of inserted screws in relation to the number of available pedicles. Pseudoarthrosis was diagnosed clinically by presence of localized pain and radiologically by presence of a defect in the fusion mass, persistence of the facet joint line, and loss of correction on plain X-ray. In doubtful cases, tomography confirms the diagnosis. Implant failure after the first year was considered as pseudoarthrosis. Functional outcomes were assessed by the ODI and SRS-30 scores at the last follow-up.

All patients had posterior-only surgery using all pedicle screw based posterior instrumentation, posterior release with or without osteotomies according to the flexibility of the curve, and posterior fusion using local bone graft. The levels of fusion included the neutral and stable vertebrae in the coronal and sagittal planes and every effort was made to insert pedicle screws at the apical region. Screws were inserted using different techniques including free hand technique, under C-arm guidance, and the open technique under direct vision of the pedicle after doing laminotomy in difficult cases. Correction was achieved using combination of corrective forces including mainly translational and derotational (rod and apical vertebral derotation) forces. Further correction was achieved by convex side compression. Wake-up test was done before closure of the wound and all patients had a positive test. Postoperatively, patients were mobilized in the first postoperative day in a thoracolumbar support which was continued for 3 months.

**Statistical Analysis:**

Data was analyzed using SPSS (Statistical Package for Social Sciences) version 15. Qualitative data was presented as number and percent. Qualitative data was presented as mean ±SD and range (min-max). Paired t-test was used for comparison within groups. Pearson’s Correlation Coefficient was used to test correlation between variables. P<0.05 was considered to be statistically significant.

**RESULTS**

The mean follow-up period was 5.15±1.78 years (range, 3–8). The mean operative time was 195±20.12 minutes (range, 160–240) and the mean amount of blood loss was 895.45±182.28 ml (range, 600–1200). The mean preoperative coronal Cobb angle was 67.13±11.88° (range, 45–90°). The flexibility index of scoliotic curves was 34.20±3.26% (range, 25–42%). Scoliotic deformity was corrected postoperatively to 20±8.9° (range, 6–30°) showing 70.1±11.2 significant correction (P=0.000) with minimal change ≥1.8 (range, 0.6–3.5%) at last follow-up. The mean preoperative sagittal plane deformity significantly improved from 61.82±20.2° (range, 35–90°) to 25.91±7.68° (range, 10–35°) postoperatively yielding 53.15±21.43% (range, 25–83.33 %) mean correction (P=0.001) (Table 2). At final follow-up, loss of correction was 1.8%±2.1 (P=0.341). Preoperatively, apical vertebral rotation was grade (G) 2 in 4 patients, G3 in 8 patients, and G4 in 4 patients. Postoperatively, apical vertebral rotation becomes G1 in 8, G2 in 6, and G3 in 2 patients. All patients showed at least one grade of rotation correction. The average preoperative rotation was 3.15±0.69 grades (range, 3–5) and the average postoperative rotation was 1.54±0.66 grades (range, 1–3) showing an average correction of 51.92%±14.50% (range, 25–66.67%). Screw density was 74% (range, 63–88%). The mean apical region screw density was 52.14 (range, 30–70%). Only one patient had screw density of 0% at the apical region with scalloping of the vertebral bodies and had failure of the instrumentation within six months postoperatively. An average of 12 (range, 9–15 levels) were included in the fusion area. No patient had pseudoarthrosis at the end of follow-up. At last follow-up the average SRS-30 score was 121±17.7 (range, 88–140) and the average ODI score was 8.46±3.26 (range, 5–15) without disability.
Complications encountered included superficial infection in one patient who was successfully treated by antibiotics and repeated dressings. Implant failure in the form of broken rod at the apical region level occurred in one patient who was 9 years old with small scalloped vertebral bodies and destruction of the posterior elements after open biopsy for the paraspinal mass with absence of pedicle screws in the apical region. The patient was treated by revision surgery in the form of anterior rib grafting of the scalloped vertebral bodies and change of the broken rod posteriorly. There were no dural tears, neurologic deterioration, deep late infection, pseudoarthrosis, or progression of deformity.

**Table.** Clinical and radiological outcome parameters.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PreOp</th>
<th>PostOp</th>
<th>Correction rate (%)</th>
<th>Last follow-up</th>
<th>Loss of correction (%)</th>
<th>PreOp versus postOp</th>
<th>PostOp versus last</th>
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<tr>
<td>Scoliosis angle</td>
<td>67.15±11.88</td>
<td>20.00±8.89</td>
<td>70.1±11.2</td>
<td>21.348.76</td>
<td>2.0±1.8</td>
<td>&lt;0.001*</td>
<td>&gt;0.05</td>
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<tr>
<td>Kyphosis angle</td>
<td>61.82±20.28</td>
<td>25.91±7.68</td>
<td>53.15±21.44</td>
<td>27±7.74</td>
<td>1.8±2.1</td>
<td>&lt;0.001*</td>
<td>&gt;0.05</td>
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<tr>
<td>ODI score</td>
<td></td>
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<td></td>
<td>8.46±3.26</td>
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<td>SRS-30 score</td>
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<td>121.18±17.7</td>
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Figure 1. 14-year-old boy with NF-1 dystrophic kyphoscoliosis. (A) Preoperative photo of the patient showing the typical café au lait patches and left thoracic kyphoscoliotic deformity. (B,C) Preoperative X-rays showing left thoracic scoliosis measuring 80° and kyphosis of 85. (D,E) Right and left side bending flexibility views showing rigid deformity with 20% flexibility index. The patient was treated by posterior-only all pedicle screw instrumentation together with posterior release and Ponte osteotomies with adequate correction to 25° in the coronal and 30° in the sagittal planes showing 68.75% correction rate in both planes (F). Whole screw density was 71.4 % and periapical screw density was 60%. (G) Immediate postoperative photo of the patient showing a clinically well-balanced spine with leveled shoulders and pelvis. (H) Last follow-up X-rays 6 years after operation, showing maintenance of correction in both planes without failure and good bony fusion. (I) Last follow-up photo of the patient showing no change; the patient returned to full activity without any disability.
Figure 2. Nine-year-old boy with dystrophic NF-1 kyphoscoliosis at the thoracolumbar junctional area. (A) Preoperative photo of the patient showing typical café au lait patches and severe kyphotic deformity with previous longitudinal and transverse scars on the back for 2 open biopsies that was taken before attendance for a paraspinal soft tissue mass on the right side which was wrongly diagnosed as abscess or tumour. (B,C) AP and lat. X-rays showing Cobb angles of 65° and 90° in the coronal and sagittal planes, respectively, with small scalloped, spindled, and malaligned vertebral bodies at the apical region. (D,E) MRI sagittal and axial cuts showing paraspinal soft tissue mass. The patient was operated on posteriorly only using all pedicle screws and the deformity was corrected to 20° in the coronal and sagittal planes achieving 69.23 % and 77.7 % correction rate in the coronal and sagittal planes, respectively (F,G). Unfortunately, the screw density in the apical region was 0% because of difficulty in inserting screws into the small scalloped deficient apical vertebral bodies and the poor bone stock from 2 previous surgeries for open biopsy. This ended by implant failure during the first 6 months postoperatively in the form of broken rod (H,I). The patient was revised by one-stage anterior-posterior operation changing the rod posteriorly and reconstructing the apical vertebral bodies anteriorly through thoracoabdominal transdiaphragmatic approach using rib interbody grafts because there was difficulty in putting structural graft on the concavity of the curve because of malalignment of the spine. (J) Last follow-up X-rays, 3 years postoperatively, showing maintenance of correction and good interbody bony fusion without failure or any complications. (K) Last follow-up photo of the patient with maintained correction and a well-balanced spine in the coronal and sagittal planes.
Dystrophic scoliosis in NF-1 is characterized by being progressive, sharp, angular, short segmented curve with severe wedging, rotation, and scalloping of the apical vertebral bodies due to some form of bone dysplasia and soft tissue tumours affecting the spinal canal. Surgical treatment of dystrophic curves is a major challenge because of the increased incidence of pseudoarthrosis, implant failure, and progression of deformity even after obtaining solid bony fusion because it is a disease process that tends to worsen over time. The presence of osteopenia and poor bone stock, soft tissue tumours, and dural ectasia causing widening of the spinal canal especially in the apical region makes the posterior fixation via hooks weak and insecure with increased incidence of loosening and failure. The aim of surgical treatment of these dystrophic curves is to decrease curve magnitude and have a stable spinal fixation to achieve solid bony fusion in a balanced position and prevent progression of deformity and to do these safely rather than doing a heroic unsafe surgery.8

Anterior-posterior surgery was the traditional treatment of dystrophic NF-1 scoliosis because posterior fixation alone has been associated with increased incidence of failure and loss of correction by many studies.15,18,19,23,24 But these studies were using either the Harrington distraction rod, hooks system, or hybrid instrumentation. These instrumentation systems rely on fixing only the posterior column and cannot withstand the applied stresses during correction of deformity and during the follow-up period. Pedicle screw fixation allows better and more stable fixation because of allowing three-column fixation of the vertebrae and a superior moment arm because of its anatomic location compared with hooks. Posterior-only surgery using pedicle screws has been recently used in NF-1 scoliosis with encouraging results. Li et al. 20 report on 19 NF-1 scoliosis patients treated by long posterior instrumented fusion using hybrid instrumentation.

Sixteen patients had dystrophic scoliosis in which the Cobb angles in the coronal and sagittal planes before and after surgery and at final follow-up were 68°, 31°, and 27° and 28°, 33°, and 30°, respectively. There was no patient with neurologic complications, coronal or sagittal decompensation, or infection. Pseudoarthrosis and implant failure (5.2%) occurred in one patient. This was revised posteriorly only by removal of the implant and refixation by hybrid instrumentation and repair of the pseudoarthrosis defect by large amount of autologous bone graft. Two patients had curve deterioration of more than 10° without

Figure 3. 12-year-old boy having dystrophic NF-1 scoliosis. (A,B) AP and lat. X-rays showing short segment sharp angular left high thoracic dystrophic kyphoscoliosis curve measuring 75° and 70° in the coronal and sagittal planes, respectively. (C) Sagittal MRI image showing angular kyphosis with absence of soft tissue abnormality. The patient was treated by posterior-only surgical correction using all pedicle screw instrumentation, posterior Ponte osteotomies, and posterior fusion. (D,E) Immediate postoperative X-rays showing correction of the deformity into 30° in the coronal and sagittal planes yielding 60% and 57% correction rate in the coronal and sagittal planes, respectively. (F) Last follow-up X-rays 4 years postoperatively showing maintenance of correction in both coronal and sagittal planes.
failure or revision surgery and another patient had distal hook dislodgement and did not require surgery. One patient developed asymptomatic cervicothoracic kyphosis and three patients had dural tears intraoperatively and healed well. Xiong ZX et al.\textsuperscript{30} in their retrospective study including 26 patients of dystrophic scoliosis treated by posterior-only instrumented fusion using hybrid instrumentation of screws and hooks had similar results. The average preoperative and postoperative scoliosis Cobb angles were 47 (range, 35–96°) and 21 (range, 10–37°), respectively, yielding 55% correction and 6.6% loss of correction at final follow-up. The average preoperative kyphosis angle was 43° (range, 15–86°) and the average postoperative kyphosis angle was 20° (range, 10–39°) yielding 53% correction and 4.6% loss of correction at final follow-up. Two patients had hook dislodgement and pseudoarthrosis treated by exploration for replacing the hook and repair of the pseudoarthrosis by regrafting. In this study, the average postoperative curve correction in the coronal and sagittal planes was 78% and 53%, respectively, and loss of correction was 1.5% and 2%, respectively, which are better. This can be explained by using posterior release/osteotomies and all pedicle screws without hooks in our study which are mechanically more efficient giving better and safe correction and maintenance of correction.

There were no neurologic complications or dural tears because the screws can better manipulate and control the vertebrae and withstand different corrective forces during correction and they do not violate the spinal canal like the hooks or sublaminar wires. Implant failure occurred in one skeletally immature patient whose age was 9 years with severe vertebral scalloping and small vertebrae in the apical region with previous surgery for open biopsy that ended by destruction of the posterior elements of the spine. This led to destabilization of the spine and progression of deformity and made screw fixation into the apical region very difficult and ended by failure of the implant with broken rod. The patient was revised by changing the rod posteriorly and reconstructing and fusing the vertebral bodies anteriorly without failure.

We agree with previous studies\textsuperscript{14,15,23} that less than 30% screw density in the apical region in dystrophic NF-1 associated scoliosis leads to higher incidence of pseudoarthrosis and rod fracture and anterior reconstruction and fusion of the small deficient vertebral bodies are recommended in such patients. Studies\textsuperscript{4,26} have shown that increasing the screw density was correlated with increasing the correction rate of scoliosis and less screw pull-outs and pedicle fracture during rod rotation manoeuvre. Also extremely low implant density in the apical region has a tendency for progression of deformity\textsuperscript{2,3} because lower implant density increases the stress concentrated on the screws with greater possibility of implant failure\textsuperscript{16} and because the apical region is the most deforming part of the curve. Hsu et al.\textsuperscript{15} reported 15% correction loss in dystrophic NF-1 patients in whom the apical region was devoid of implants. However, insertion of pedicle screws in the apical region of NF-1 associated dystrophic scoliosis may be challenging because of the innate weakness of bone especially in the apical region,\textsuperscript{20} severely rotated or sublaxated apical vertebral bodies into a bayonet apposition, and the distorted and small diameter of the pedicles due to the dystrophic changes. Accuracy of the apical screw insertion can be improved by using different techniques including the C-arm guidance, the open technique under direct vision, or more recently the assistance of the O-arm navigation showing higher accuracy rate of 79% compared to 67% in the free hand group and lower perforation rate.\textsuperscript{16}

The anterior surgery in dystrophic scoliosis curves was recommended to decrease the incidence of pseudoarthrosis and progression of deformity and to increase the correction rate in rigid and severe deformity by doing anterior release and to do anterior growth arrest to avoid the development of crankshaft phenomenon.\textsuperscript{5,10,22} It was recommended in kyphoscoliosis, severe rigid deformity, and children less than 10 years with open triradiate cartilage. Severe scoliosis according to the definition of Lenke et al.\textsuperscript{19} is ≥70° curve and according to the definition of Greiner
et al.\textsuperscript{13} in AIS is the curve that leads to respiratory symptoms which is 60\degree–100. Li et al.\textsuperscript{20} used 90\degree as the limit of severe deformity as previous studies have shown that scoliosis over 90\degree is associated with poor outcome\textsuperscript{12,27} and so they believed that this level is the limit of posterior surgery.

Anterior surgery was recommended in severe rigid and kyphoscoliotic deformity because of the weak osteoprotic bone and spinal instability leading to high stresses on the hooks during and after correction\textsuperscript{18} and also because the posterior surgery combines compression and the anterior surgery combines distraction of the vertebrae making the correction of deformity more complete.\textsuperscript{20} However, with the use of the third-generation all pedicle screws instrumentation and using posterior release/osteotomies, safe and good correction of the deformity can be achieved.\textsuperscript{18,20} In this study, scoliotic curves up to 90\degree with flexibility index up to 25% and kyphosis up to 90\degree were corrected posteriorly only. Li et al.\textsuperscript{20} and Deng et al.\textsuperscript{8} reported similar good results using posterior-only surgery. We think that posterior-only surgery may not be sufficient in dystrophic NF-1 scoliosis curves in the presence of small scalloped deficient apical vertebral bodies that cannot share load and that lead to insufficient apical screw density less than 30%. However, Deng et al.\textsuperscript{8} recently reported on using Multiple Anchor Point Method (MAPM) by successfully using shorter (10–25 mm) pedicle screws at the apex with good results.

The incidence of crankshaft phenomenon in dystrophic NF-1 scoliosis is lower because the growth of the apical vertebral bodies is usually affected\textsuperscript{6,11,28} and the pedicle screws allow three-column fixation of the vertebra like anterior epiphysiodesis preventing the anterior growth. Anterior/posterior surgery in addition to being a two-operation surgery carries a higher risk of complications including decreased pulmonary function, difficulty in some areas as the high thoracic area, and complications related to the dystrophic nature of the vertebrae in these NF-1 curves. The anterior approach may be difficult or impossible to be done in some patients and can be postponed even after doing it bilaterally due to the presence of complex paraspinal tumours and the presence of plexiform venous channels.\textsuperscript{8,20} Also the apical vertebrae may be subluxated, severely rotated, and malaligned with the rest of the spine making insertion of a structural graft on the concavity of the curve impossible and mechanically ineffective.\textsuperscript{8}

Limitation of this study was the retrospective nature of the study, the small number of patients, and the small number of patients with instrumentation failure for analysis. Our average follow-up period was 5 years; this may not be sufficient to know the long-term outcomes as the true incidence of pseudoarthrosis and implant failure especially in skeletally immature patients who require longer follow-up.

**CONCLUSION**

Our data suggest that posterior-only all pedicle screw based posterior instrumentation in NF-1 dystrophic scoliosis has been associated with good clinical outcome. It can be used safely in the presence of sufficient apical screw density.

**REFERENCES**


الملخص العربي


الملخص العربي

تجميع الجنف التصنعى لمرضى الورم العصبي الليفى بواسطة الجراحة من الخلف فقط

البيانات التابعة: يؤدي مرض الورم العصبي الليفى من النوع الأول (NF-1) مع وجود التغيرات التصنيعية للعمود الفقري إلى تشوه العمود الفقري أو / و عدم استقرار بالاقزام وقوائم الأطفال دائماً يحتاجون للعلاج الجراحي المبكر. وقد كان العالم الجراحي عن طريق دمج الاقزام من الأمام والخلف هو الخيار الأفضل لمثل هذه الحالات بسبب افتراض نسبة عدم احتصال الاقزام وزيادة التقوس حتى في وجود النجاح كاملاً للاقزام. ولكن مع وجود الجيل الثالث من وسائل تثبيت العمود الفقري من الخلف بواسطة إستعمال مسامير عنق الاقزام أصبحت النتائج الجراحية الواحدة من الخلف جيدة.

تصميم الدراسة: تقسيم استعداد

المرض: تقييم نتائج التثبيت الخلفي للعمود الفقري بواسطة مسامير عنق الاقزام في تشوهات العمود الفقري

المصاصة لمرض الورم العصبي الليفى 1 (NF-1) مع وجود التغيرات التصنيعية.


النتائج: كان متوسط فترة متابعة الحالات 5.15 عاماً (3-8 سنوات) وحد الحساسة تم دراسة زاوية اللوغج للأسلوب من 67.13% بعد الجراحة بنسبة 70% نسبة إصلاح كما إصلاح النتائج للأمام (المحدب) بنسبة 61.82% قبل العملية إلى 25.91 ° بعد الجراحة. نسبة فقدان الإصلاح في نهاية فترة المتابعة 2% و1.8% للقوس لللجن واللالم بالثبات. وقد حدد تحسن في الحالة الوظيفية والكلينيكية لليفرتين بعد الجراحة في نهاية فترة المتابعة ظاهر ذلك في حصول تحسن في تقييم الدرجة 1.86% في مقياس ODI 30-30 , ODI 121 بالثبات مع عدم وجود إعاقة بعد الجراحة. حدد فشل في التثبيت ظاهر في فترة كسر عمود التثبيت في طول 9 سنوات.

الاستنتاج: الجراحة من الخلف مع تثبيت الاقزام بواسطة مسامير عنق الاقزام مع زيادة كثافة المسامير ووجود كثافة معقولة لا تقل عن 30% في منطقة قمة التقوس يؤدي إلى نتائج جيدة وأمنة في حالات التقصم التصنعى للعمود الفقري المصاحبة لمرض الورم العصبي الليفى من النوع الأول.