Journal of Orthopaedics, Trauma and Rehabilitation 18 (2014) 30–34

Contents lists available at ScienceDirect

Journal of Orthopaedics, Trauma and Rehabilitation

Journal homepages: www.e-jotr.com & www.ejotr.org

Original Article

Clinical Outcome and Complications of Transpedicular Closing-wedge Osteotomy for Correction of Deformity in Ankylosing Spondylitis in a Regional Hospital

椎弓根閉合式截骨矯正術矯正強直性脊柱炎駝背畸形的手術結果和並發症

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ARTICLE INFO

Article history:
Accepted August 2013

Keywords:
ankylosing spondylitis
clinical outcome
complications
kyphotic deformity
transpedicular closing-wedge osteotomy

ABSTRACT

Study design: Prospective study of surgical correction of thoracolumbar kyphotic deformity caused by ankylosing spondylitis.
Objectives: To assess surgical outcomes and complications of thoracolumbar kyphotic deformity corrected with transpedicular closing-wedge osteotomy performed in a regional hospital.
Summary of background data: There have been several studies reporting on the results of surgical correction of deformity in ankylosing spondylitis all over the world. However, there has not been any local data published.
Methods: From 2003 to 2011, we had performed 12 transpedicular closing-wedge osteotomies in 9 patients with ankylosing spondylitis for correction of kyphotic and scoliotic deformity in thoracolumbar spine. Operative outcomes were assessed clinically by recording the Japanese Orthopaedic Association (JOA) scores, visual analogue scale (VAS) pain scores, Oswestry Disability Index (ODI) preoperatively and postoperatively and patient satisfaction postoperatively. Radiological outcome was assessed by measuring thoracic kyphosis, lumbar lordosis and sagittal plumb line preoperatively and postoperatively as well as the degree of surgical correction. Occurrence of complications was recorded by our standard audit protocol.
Results: All patients had a single level of osteotomy done at a time. Most of the osteotomies were done at L2 or L3. The mean amount of correction was 21.6°. Complications included dural tear, pseudoarthrosis and transient radiculopathy. The extent of correction and incidence of complications improved with experience.
Conclusion: Despite transpedicular closing-wedge osteotomy being a major operation that is not without complications, most of our patients had good clinical results and subjective satisfaction.

中 文 摘 要

研究設計引起強直性脊柱炎胸腰椎後凸畸形矯正手術的前瞻性研究。，背景：在世界各地已經有一些關於矯正強直性脊柱炎引致胸腰椎畸形的手術結果報告。然而，到目前為止並無任何本地公佈的數據。因此本研究將會評估本醫院進行椎弓根閉合式截骨矯正術矯正強直性脊柱炎駝背畸形的手術結果和並發症。

方法從2003年到2011年，我們已為九位強直性脊柱炎病人進行了十二次椎弓根閉合式截骨矯正手術　。並為病人進行術前和術後的臨床評估。記錄日本骨科協會（JOA）腰椎評分，視覺模擬評分法（VAS）疼痛評分，功能障礙指數（ODI），　和術後病人的滿意度。同時亦以X光照片測量胸椎後凸，腰椎前凸幅度，矢狀鉛垂線以及術前和術後的手術矯正幅度。

結果所有患者於同一時間只進行一節截骨　。大多數的截骨均在腰椎第二，三節進行　。　平均矯正幅度為21.6度。並發症包括硬膜撕裂，假關節和短暫神經受損。

結論儘管椎弓根閉合楔形截骨術是一項重大手術，並有不少並發症。但大多數患者均有良好的臨床效果和主觀滿意度

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http://dx.doi.org/10.1016/j.jotr.2013.08.001

Introduction

Ankylosing spondylitis (AS) is a chronic inflammatory arthritis. It is often associated with severe postural deformity. There is progressive ossification of the ligaments of the spine and major joints resulting in ankylosis of the spine.[1] AS is associated with a progressive loss in lumbar lordosis and an increase in thoracic kyphosis. The deformity often results in body imbalance and poor posture. The chief complaint of patients is difficulty in looking straight ahead due to the fixed deformity of the spine. The kyphotic deformity also restricts patients' daily activities such as driving a car, interpersonal communication, and personal hygiene. Some patients may experience back pain because of muscle imbalance or pseudoarthrosis caused by a fracture of the fused spine. In case of severe kyphotic deformity, a flexed posture may cause visceral compression.[2]

The goal of surgery in AS is to correct sagittal imbalance with extension osteotomy. Thoracolumbar transpedicular closing-wedge osteotomy is one of the widely accepted operations to correct this deformity.[2–5] Currently, there is no local study reporting the clinical outcome of this operation in Hong Kong. Therefore, our study aims to report the outcome and complications of this surgery performed in a regional hospital in Hong Kong.

Materials and methods

In the period from 2003 to 2011, nine patients (7 men and 2 women) with a known history of AS underwent closing-wedge osteotomy in Tuen Mun Hospital (Tuen Mun, Hong Kong). In total, 12 osteotomies were performed. A single surgical team carried out all the operations. Patients who had kyphotic deformity together with back pain, pseudoarthrosis, and subjective functional impairment were indicated to have surgery. All the patients who underwent transpedicular closing-wedge osteotomy were included in our study. Surgery was not performed in one patient because of small pedicles, as measured by computed tomography (CT) scan, through which screw insertion was impossible. The average follow-up period was 54 months, ranging from 7 months to 105 months. Three patients had a follow-up of less than 2 years. Surgical outcomes were measured by Japanese Orthopaedic Association (JOA) scores, visual analogue scale (VAS) pain scores, and Oswestry Disability Index (ODI), both pre- and postoperatively, together with subjective satisfaction since 2005.

Data on the following parameters were also recorded: age, sex, comorbidity, operative time, blood loss, operated level, surgical technique, length of stay, use of neural monitoring, and complications.

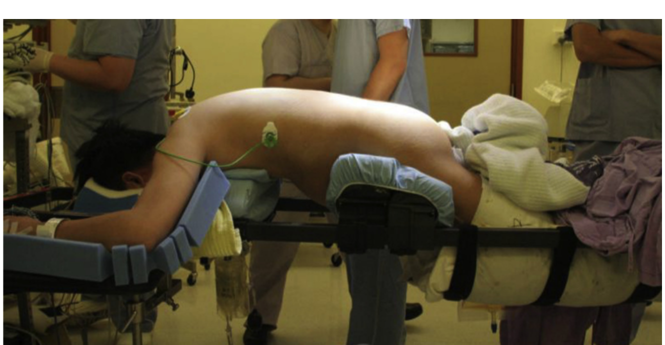

Figure 1. Position of patient on Jackson frame.

Assessment of deformity

The authors use the standard Cobb's method on standing lateral radiograph of the whole spine to measure the thoracic kyphosis and lumbar lordosis pre- and postoperatively. The degree of operative correction was measured by the Cobb's method at the upper end plate of the first fusion level and the lower end plate of the last fusion level. Sagittal alignment of the spine was measured by a sagittal plumb line, which measured the distance from T1 to S1, pre- and postoperatively.

Surgical planning and technique

Preoperative CT scan and magnetic resonance imaging were performed in all patients to assess the structural anatomy, presence of silent pseudoarthrosis, and narrowing of neural canal. The patients were placed in the prone position on a Jackson frame, with the chest and pelvic being supported and the abdomen allowed to hang free (Figure 1). A midline longitudinal skin incision was made to allow the exposure of the laminae and facet joints. Pedicle screws were inserted usually at three levels above and two levels below the osteotomy segment, under the control of an image intensifier. Most of the osteotomies were performed at L2 or L3 level. If a patient had concomitant pseudoarthrosis, fusion would be extended to two levels above the pseudoarthrosis segment.

The spinous processes of the osteotomy segment were excised and used for bone graft. Laminectomy was performed using a high-speed air drill and a Kerrison rongeur to expose the dura and nerve roots. Transverse processes were cut at the base. Bone cuts were made transpedicularly up to the anterior cortex of the vertebral body. The dura and roots were dissected free and protected during the whole procedure. Closure of the wedge was performed under the control of an image intensifier and the direct visualisation of the dural sac and nerve roots, with the anterior cortex acting as a hinge. Precontoured rods were applied and tightened, with nerve roots confirmed free from compression after correction of deformity. Cross-linked rods were applied. Bone grafts were placed posteriorly after decortication of the transverse processes. The wound was closed in layers, with a drain being inserted. Somatosensory- and motor-evoked potentials were monitored intraoperatively; this service was introduced to our centre in 2009.

All patients were monitored closely for their postoperative neurological status. Thoracolumbosacral orthosis was given to all patients for 3 months.

Results

In nine patients, transpedicular closing-wedge osteotomy was performed for correction of kyphotic deformity. Three of them had a concomitant pseudoarthrosis. All patients had single-level osteotomy (Figure 2) done at a time. Three patients underwent a second-level osteotomy 3–5 years after the first operation: one was performed for remedy of complications, one was performed for inadequate correction, and one was a planned two-stage operation performed to correct both sagittal and coronal malalignments. Osteotomies were performed at T12 in one case, L1 in one case, L2 in four cases, L3 in five cases, and L4 in one case.

Three patients had fixed flexion contractures of the hips. Two of them underwent bilateral total hip replacement prior to spinal osteotomy. The other one did not undergo hip replacement because the flexion contracture was mild and he did not have any symptoms related to hip contracture.

The average operative time was 428 minutes (Figure 3). Three patients had preoperative pseudoarthrosis, which required more levels of instrumentation, resulting in longer operative times in

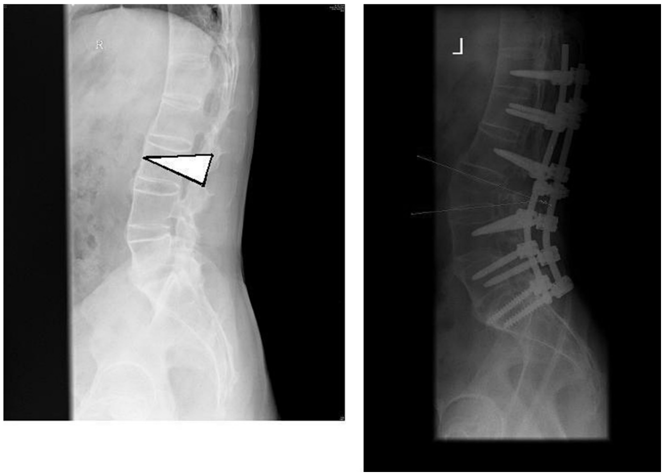

Figure 2. Lateral view of the vertebral resection (left) and the X-ray of the corrected spine with instrumentation (right).

these patients. The average length of stay in hospital was 17.3 days (6–39 days). Since 2009, when we incorporated this service in our hospital, six patients underwent somatosensory- and motor-evoked potential monitoring during the operation. The average blood loss during the operation was 3175 mL.

Complications

Complications (Table 1) were of three types: intraoperative, early postoperative, and late postoperative.

Regarding the intraoperative complications, three patients (25%) had dural tears during the operation. One of them was repaired successfully; the other two were beyond repair due to dural ectasia. All the dural tears were healed without subsequent complications. One patient (8.3%) had severe blood loss (15,000 mL) due to extensive fusion from T7–L5 and improper positioning prior to the operation. Massive blood transfusion was required. None of the patients had any major vascular injuries.

Four patients (33%) developed transient L2 or L3 radiculopathy as the early postoperative complications. All of them had complete recovery. No superficial or deep wound infection was reported in these patients. None of them developed deep vein thrombosis and postoperative ileus.

Regarding the late complications, one patient (8.3%) had nonunion at the osteotomy segment due to a faulty technique that resulted in pseudoarthrosis. Revision surgery was performed 4 years after the initial operation. One patient (8.3%) had junctional pseudoarthrosis; the involved segment healed spontaneously during subsequent follow-ups. One patient lost the initial correction with progressive kyphosis and required another level of osteotomy 4 years after the first osteotomy. None of the patients experienced implant loosening or failure.

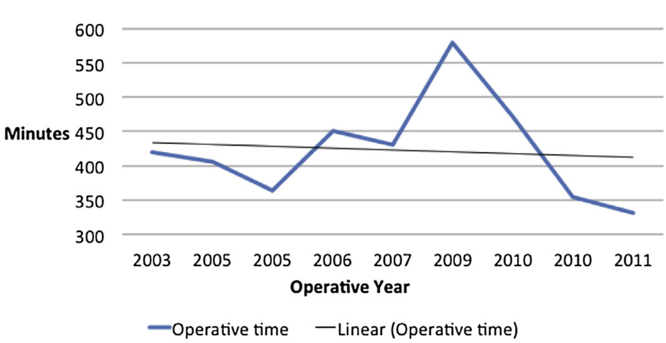

Figure 3. Operative time.

Table 1
Complications of spinal correction in ankylosing spondylitis

	No.	%
Dural tear	3	25
Massive blood loss	1	8.3
Neurological complication	4	33
Wound infection	0	0
Nonunion	1	8.3
Implant failure	0	0

Outcomes

The average preoperative deformity was 44.2° (33.9–48.9°), measured from T2–S1. The average correction achieved was 21.6° (9–38.5°; Figures 4 and 5). The average pre- and postoperative T1–S1 distance was 118 mm (65–180 mm) and 43 mm (5–88 mm), respectively. The average improvement in T1–S1 distance after operation was 75 mm (38–119 mm).

Since 2005, the authors had pre- and postoperative charting for the JOA score, ODI, VAS pain score, and subjective improvement (Table 2). Out of the 12 transpedicular closing-wedge osteotomies, the above clinical charting was recorded for six. The data were analysed by Wilcoxon signed rank test, and $p < 0.05$ was considered statistically significant. The average preoperative JOA lumbar score was 17.5/29. At 6 months after the operation, the average JOA lumbar score was 23.4/29 ($p = 0.043$). The average JOA lumbar score at the latest follow-up (12–36 months) improved to 25.4/29 ($p = 0.043$).

For the pain assessment, all patients demonstrated improvement immediately after the osteotomies. VAS scores were charted for back and leg symptoms. The average VAS score for back and leg improved from 6.5/10 to 2.5/10 ($p = 0.102$) and from 4.5/10 to 3.5/10 ($p = 0.705$), respectively, at 6 months after the operation. The VAS back and leg scores at the latest follow-up (12–36 months) were 4.1/10 ($p = 0.416$) and 2.1/10 ($p = 0.465$), respectively. However, the results were not statistically significant.

Functional outcome was assessed using ODI scores. There was a significant improvement of ODI from 41.6% preoperatively to 21.6% ($p = 0.028$) at 6 months and 22.2% ($p = 0.046$) at the latest follow-up.

In general, patients were satisfied with the results. Subjective improvement quoted from patients was 80% at 6 months after the

Figure 4. Photograph showing the posture of our patient preoperatively and postoperatively.

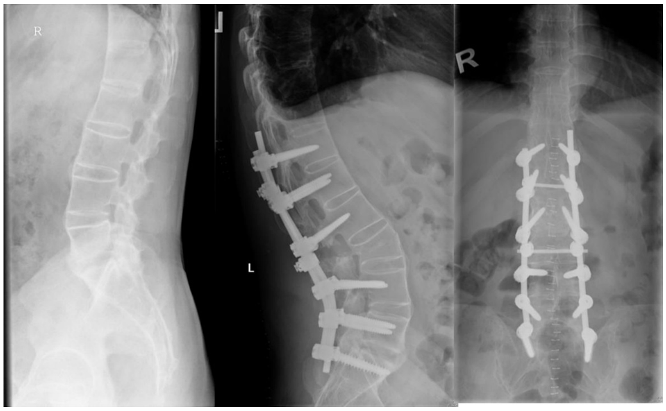

Figure 5. X-ray showing the alignment of the lumbar spine preoperatively and postoperatively.

operation, and the satisfaction remained until the latest follow-up. All patients would like to undergo the same operation if they were allowed to make a decision again.

Discussion

AS-related kyphotic deformity poses significant restrictions on patients' physical and psychosocial functions. Patients often have difficulties in daily activities as simple as changing clothes and taking care of personal hygiene. More importantly, they have low self-esteem due to their stooped posture, which affects their social life. Camargo et al[6] reported that an improvement of appearance is of psychological importance to patients, and results in better mental attitude and ability to participate socially. Therefore, correction of kyphosis is one of the goals of our operation. Another goal of our operation is to relieve patients' back symptoms. People used to believe that back pain in AS is related to the inflammatory nature of the disease. However, most patients had back pain because of muscle imbalance, pseudoarthrosis, or couching gait secondary to lower limb weakness. These can be improved by surgical correction of the deformity.

Different surgical techniques have been introduced to correct the kyphotic deformity in AS; of these, transpedicular closing-wedge, open-wedge, and polysegmental osteotomies are the three most popular techniques used nowadays.[7–9] In our hospital, transpedicular closing-wedge osteotomy is preferred due to a lesser chance of major vascular injury and higher union rate as compared to open-wedge osteotomy.[10–13] Kiaer and Gehrchen[7] and Kim et al[16] reported that thoracolumbar closing-wedge pedicular resection osteotomy is effective to correct kyphotic deformity in AS and with good clinical results. In our study also, patients showed good clinical results and high subjective satisfaction. We could achieve an average angle of correction of 21.6°. Patients had significant functional improvement, as demonstrated by the improvement of JOA scores from 17.5 to 25.4 and ODI values from 41.6% to 22.2%. The VAS pain scores also improved in 6 months' postoperative time. All patients would like to have the same operation if they were asked to make the decision again.

Table 2
Charting of clinical outcomes

	Preoperative	6 mo after operation	*p*	Latest follow-up	*p*
Average JOA score	17.5/29	23.4/29	0.043	25.4	0.043
Average ODI	41.6	21.6	0.028	22.2	0.046
Average VAS score (back)	6.5	2.5	0.102	4.1	0.416
Average VAS score (leg)	4.5	3.5	0.705	2.1	0.465

JOA = Japanese Orthopaedic Association; ODI = Oswestry Disability Index; VAS = visual analogue scale.

Table 3
Blood loss and operative time in first-time osteotomy

Age (y)	Sex	Operative year	Level of osteotomy	Levels of fusion	Blood loss (mL)	Operative time (min)
41	M	2003	L2	T12–L4	2600	420
41	M	2005	L3	T11–L5	2000	405
28	M	2005	L2	T11–L4	2100	363
34	M	2006	L3	T10–L5	2000	450
50	M	2007	L3	T12–L5	2000	430
32	F	2009	L3	T11–L5	1500	580
49	M	2010	L3	T12–S1	1300	355
32	M	2011	L2	T11–L4	2700	331
54	F	2010	L2	T7–L5	15,000	470

Despite the encouraging clinical outcomes and satisfaction associated with transpedicular closing-wedge osteotomy, it is still a major operation and not without complications. AS is an autoimmune disease, which is also associated with significant comorbidities. Patients usually have a limited chest expansion, resulting in high anaesthetic risk. Restrictive lung also increases the chance of postoperative chest infection. The operative time is expected to be long. The average operative time in our hospital is 428 minutes. Therefore, adequate padding to pressure points is important to prevent pressure sore. Prolonged prone positioning also increases the risk of ischemic optic neuropathy.[14] No ischaemic optic neuropathy was seen in our cases. Significant blood loss is another major concern of this operation (Table 3 and Figure 6), which may be caused by several reasons. First of all, a large wound is required for the fusion of long segments; bleeding is expected during soft tissue dissection and surgical exposure. Second, resection of the posterior spinal column and part of the vertebral body is required for closing of the wedge; significant bleeding from the bone and epidural venous plexus is also expected. The average blood loss in our cases was 3175 mL. In one extreme case, severe blood loss (15,000 mL) occurred, which required 16 units of pack cell transfusion as well as massive fluid replacement. This was a case of pseudoarthrosis at T9, and osteotomy was performed at L2 level; hence, extensive fusion from T7 to L5 was required. The case was positioned improperly preoperatively, not allowing the abdomen to hang free. Therefore, venous return was disturbed, resulting in massive blood loss. As significant blood loss is usually expected in this type of operation, pack cells should be prepared prior to the operation. Recently, we introduced a cell saver to reduce the use of pack cells, which may reduce the amount of blood transfusion, thereby reducing the complications related to transfusion.

Comparing the operative times and blood loss of the first-time osteostomy cases, we reduced our operative time from 440

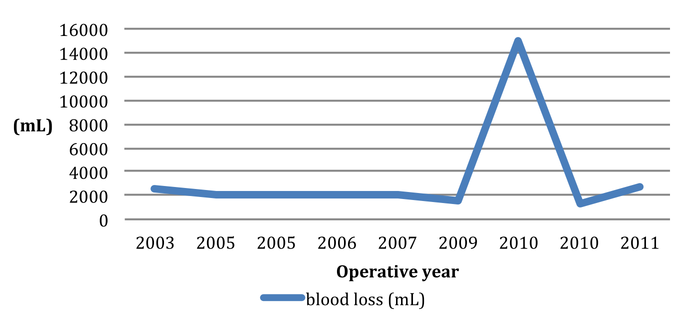

Figure 6. Total blood loss during operation.

minutes to 340 minutes in the recent two cases. The blood loss remained almost static. We believe that with experience, the operative time can be further reduced.

Infection

Several factors may attribute to the chance of wound infection, including the autoimmune character of the disease, long operative time, massive blood loss, haematoma, and immunosuppressive effect of blood transfusion. No wound infection was reported in our patients, which may be related to the small number of cases.

Dural tear

Dural ectasia is common in AS patients due to the inflammatory nature of the disease[7]; this makes dissection more difficult and the risk of dural tear is high. Three out of 12 cases (25%) had dural tears during transpedicular closing-wedge osteotomy, the incidence of which is higher than that during other spine surgeries in our hospital (10%). For the two patients who had dural tears beyond repair, we kept the drain for a longer time to observe for any CSF leak. We also advised the patients to have bed rest for a longer time if there was CSF leakage.

Neurological deficit

During closing-wedge osteotomy, neural structures are at risk.[15] Nerve entrapment may occur during the closure of the wedge. Intraoperative assessment of any nerve root entrapment after closing the wedge is important. The use of somatosensory- and motor-evoked potential monitoring may further decrease the risk of nerve root entrapment. Despite the use of the above measures, we still observed transient radiculopathy in four out of 12 cases (33%). All of them have complete recovery within 3 months, without further surgical exploration. In two of them, no somatosensory- and motor-evoked potential monitoring was performed, as we incorporated this service only in 2009. Two of them had the above monitoring, but did not show any abnormality from the monitor during operation.

Pseudoarthrosis

Among our patients, one had junctional pseudoarthrosis. We believed that in this case, the fusion was just extended to the apex of thoracic kyphosis level; the increase in stress at that level led to pseudoarthrosis. The residual kyphosis above the level of fusion was also biomechanically unfavourable to the implants, increasing the chance of pull-out. Although pseudoarthrosis finally healed spontaneously, it is recommended that fusion should not end at the apex of deformity. We also recommended a standard alignment X-ray of the spine for all patients to assess the sagittal alignment of the whole spine. Try to avoid the apex of deformity by extending the level of fusion or adjust the level of osteotomy accordingly.

Nonunion

One patient had nonunion due to technical error, which required revision. Osteotomy was made faultily through endplate into the intervertebral disc. There was inadequate bone contact, which resulted in nonunion.

Implant failure

Another concern of osteotomy in AS patients is the osteoporotic bone quality, which may increase the risk of implant pull-out or loosening. We did not have any complications related to loosening and pull-out of screws. This may be related to the higher number of fusion levels. We fused at least three levels above and two levels below, which reduced the stress at each level. Moreover, our patients were relatively young and their bone quality was expected to be better. The design of implants also accounts for the low pull-out rate. Larger-size pedicle screws and screw heads with variable angles were used, which increased the stability of fixation and decreased the stress on implants. Furthermore, most of our patients achieved an acceptable sagittal alignment after correction. This can reduce the stress on implants as well.

Conclusion

Kyphotic deformity in AS affects patients' physical and psychosocial functions. Transpedicular closing-wedge osteotomy is an operation that can correct the malalignment. It has a good clinical outcome, with high patient satisfaction. However, it is also a major operation and is not without complications. It has a steep learning curve. The authors believe that with more experience the operative time, blood loss, and associated complications can be reduced.

Conflicts of interest

The authors declare that they have no financial or non-financial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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