Surgical correction of kyphosis

Posterior total wedge resection osteotomy in 32 patients

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Background Many surgical procedures have been developed for the treatment of kyphoscoliosis. We present our experience of one technique for posterior total wedge resection osteotomy, with clinical and radiographic results. This is a one-stage solution which results in a shortened posterior column and reduced tension on the spinal cord in rigid angular kyphosis.

Patients and methods Between 1990 and 2000, we treated 32 patients with rigid local kyphosis by posterior wedge osteotomy and instrumentation. The etiology was congenital malformation in 17 cases, infection in 11 and previous laminectomy in 4 cases. The osteotomy is performed at the apex of the kyphotic deformity and covers two vertebrae. The upper and lower borders of the osteotomy are right inferior to the transverse processes of the upper and lower vertebrae respectively. The apex of the posteriorly based triangular osteotomy is either at the anterior vertebral body or anterior longitudinal ligament.

Results The mean preoperative angle of local kyphosis was 72 (25–112) degrees mainly at the thoracolumbar region, and it improved to a mean of 23 (0–48) degrees after an average follow-up of 57 (24–108) months. The mean preoperative sagittal plumbline imbalance of 5.5 (2–12) cm was improved to 1.2 (-2–3.5) cm postoperatively. The mean loss of correction since operation was 3.4 (0–11) degrees. Radiographically, solid anterior and posterior fusion was achieved in all patients by 6 months. 1 patient had irreversible paraplegia and 2 others had transient nerve root injury postoperatively.

Interpretation Posterior total wedge resection osteotomy eliminates the need for anterior procedure and does not cause tractional force on the spinal cord, since the posterior column is shortened. This is an effective one-stage procedure, especially for the treatment of sharp and rigid kyphosis.

Severe angular kyphosis or kyphoscoliosis may develop secondary to fracture, infection, laminectomy, and congenital malformation. Irrespective of the etiology, severe, rigid and localized kyphosis usually requires surgical treatment to prevent progressive deterioration of the sagittal imbalance and neurologic function. Many anterior, posterior or combined procedures have been developed and used by various authors (La Chapelle 1946, Malcolm et al. 1981, McAfee et al. 1985, Robertson and Whitesides 1985, Kostuik et al. 1988, Bridwell 1997, Weidenbaum and Farcy 1997, Sar and Eralp 2002), all of which are technically demanding.

In 1994, Lehmer et al. (1994) presented a new technique which was a true-closing wedge posterior transvertebral osteotomy for the treatment of adult thoracolumbar kyphosis. We present our experience of this method in 32 patients.

Patients and methods

Between 1990 and 2000, 32 patients (18 men) with rigid and localized kyphotic deformities underwent surgical treatment at our institution, involving posterior total wedge resection osteotomy and posterior instrumentation. Average age at the time of operation was 20 (10–40) years. All patients had disabling pain and severe deformity.

Summary of data on patients and radiographs

A	B	C	D	E	F	G	H	I	J	K
1	20	F	PL	T12–L1	25	5	1	27	2.8	0
2	11	M	CM	T10–11	85	35	2	102	4	1.2
3	13	M	CM	L2–3	70	0	11	26	3.6	1
4	10	F	CM	T12–L1	50	26	1	45	5	1.5
5	13	F	PI	T8+T10	76	26	0	72	9	2.7
6	22	F	PL	T12–L1	80	20	5	30	7.2	1
7	36	M	PI	L2–3	40	0	2	31	4.5	0
8	22	F	CM	L1–2	40	15	0	44	3.2	–0.5
9	25	M	PL	L1–2	45	10	1	52	4	0
10	18	F	CM	T12–L1	62	15	4	42	5	1
11	18	F	PI	T12–L1	55	10	2	96	4.6	0
12	17	M	CM	L1–2	90	40	5	104	8	2.5
13	12	M	CM	L1–2	78	32	3	88	6	1.5
14	26	F	PI	T12–L1	112	48	1	74	12	3.5
15	23	M	CM	L1–2	85	27	7	66	5.4	1.5
16	18	M	PI	T12–L1	105	46	8	84	10	3
17	15	F	CM	T12–L1	81	29	1	66	3	1.5
18	16	F	CM	L1–2	95	36	3	83	4	1.5
19	26	M	PI	L1–2	80	20	2	72	5.2	1.4
20	25	F	CM	T12–L1	92	33	4	80	4.2	2
21	34	M	PI	L3–4	70	18	4	71	6	1
22	13	F	PI	L2–3	75	27	5	80	3	0
23	18	M	PL	T12–L1	94	41	2	108	8	2.4
24	20	F	CM	L1–2	48	5	3	28	2	–2
25	27	M	CM	L1–2	54	8	8	27	4	0
26	16	F	PI	L1–2	67	24	2	26	3.6	1
27	40	M	CM	L2–3	58	14	1	30	7	1.4
28	18	M	CM	T12–L1	86	24	6	24	6.4	1.8
29	13	M	CM	L1–2	66	29	2	40	5	1.2
30	11	M	CM	L1–2	74	23	5	38	4.8	1.6
31	21	M	PI	T12–L1	94	30	4	24	9	2
32	24	M	PI	L1–2	72	23	4	46	5.6	1
Average	20				72	23	3.4	57	5.5	1.2

A Case
B Age (year)
C Sex
D Diagnosis
CM congenital malformation
PI postinfection
PL postlaminectomy
E Osteotomy level(s)
F Preoperative local kyphosis angle
G Postoperative local kyphosis angle
H Loss of correction
I Follow-up (months)
J Preoperative plumbline imbalance (cm)
K Postoperative plumbline imbalance (cm)

The etiology was congenital malformation in 17 cases, healed tuberculous infection in 11 and previous laminectomy in 4 cases. None of the patients had preoperative neurological deficit. The preoperative and postoperative local deformity was measured according to Cobb from the superior end-plate above the deformity and from the inferior end-plate below the deformity. The mean preoperative angle of local kyphosis was 72 (25–112) degrees, mainly at the thoracolumbar region. The average preoperative sagittal plumbline imbalance was 5.5 (2–12) cm. The osteotomy and wedge resection level was at T10–T11 in 1 patient, at T12–L1 in 12 patients, at L1–L2 in 13 patients, at L2–L3 in 4 patients and L3–L4 in 1 patient. 1 patient had two osteotomies, one at T8 and one at T10 (Table).

The posterior spinal instrument used was the Cotrel-Dubousset instrumentation in the first 20 consecutive patients, the Synergy system in 4 patients and the Moss-Miami system in 8 patients. Instrumentation in the first 20 patients consisted of long segment fixation with a configuration of hooks and screws. Instrumentation in the other

12 patients was short and consisted of segmental pedicle screws.

All patients underwent the Stagnaras wake-up test at the end of the osteotomy and instrumentation, and before closure. They were also monitored in an intensive care unit and received intravenous antibiotics for 48 hours. Urinary catheters and suction drains were usually removed before the last dose of antibiotics. Ambulation was usually begun on the second or third postoperative day and a thoraco-lumbo-sacral orthosis (TLSO) was used for 6–12 weeks. The average follow-up was 5 (2–9) years. Radiographs were taken immediately postoperatively and on the day of discharge. Follow-up radiographs were performed at 6 weeks and at 3-, 6- and 12-month intervals. Radiographic fusion was determined to be solid if there was bone bridging at the osteotomy site in anteroposterior, lateral and bilateral oblique projections. Sagittal alignment was evaluated preoperatively and at last follow-up by standard standing 36-in. lateral radiographs. Normal sagittal balance was defined as a plumbline dropping from C7 and intersecting the posterosuperior corner of the S1 vertebral body (Bernhardt 1997). The distance between the plumbline and the posterosuperior corner of the S1 vertebral body was measured. The distance was positive when the plumbline passed anterior to the posterosuperior corner of the S1 vertebral body, and negative when it was posterior (Table).

Operative technique

The patient is placed in the prone position on the operating table, on chest rolls. A single midline posterior longitudinal incision is used to expose the area and previously determined levels. Paraspinal muscles and all soft tissues are stripped subperiostally from the bone laterally to the tips of the transverse processes. An intraoperative radiograph with guide pins is obtained for accurate localization of the deformity and determination of the level and extent of the osteotomy. A complete laminectomy and facetectomy is performed, firstly at the posterior resection site, and the lateral walls of the spinal canal are excised bilaterally thereafter. The spinal nerves are carefully dissected and preserved. The osteotomy is performed at the apex of the kyphotic deformity, usually covering 2 vertebrae. The upper and lower borders of the osteotomy are right inferior to the transverse processes of the upper and lower vertebrae, respectively. The apex of the posteriorly-based triangular osteotomy is planned to be either at the anterior vertebral body or anterior longitudinal ligament (Figure 1). The osteotomy is performed carefully to avoid over-penetration of the anterior cortex or anterior longitudinal ligament, for the purpose of providing a hinge point to avoid translation and also to prevent injury to the major or radicular vessels. Once the osteotomy and wedge resection have been completed, the remaining portions of the upper and lower vertebrae usually form an intervertebral foramen containing two spinal nerves on both sides at the resection site. Facets to be included in the fusion area are resected, screws and hooks are placed, and a previously bent rod is loosely attached on one side before completing the osteotomy so that the step-off is avoided. Upon completion of the osteotomy, a second rod is attached and both are compressed to equal extents so that correction and stabilization are achieved. In order to avoid dural buckling while closing the osteotomy site, partial laminectomy should be performed one level above and one level below the osteotomy. Decortication and bone grafting follow the instrumentation. Hypotensive anesthesia and perioperative autotransfusion by means of cell-saver were used in all cases to reduce the need for homologous bank blood.

Figure 1. Osteotomy planned to be at the apex of the deformity and to end at the anterior longitudinal ligament (left). Kyphosis is corrected after removal of the wedge (right).

Results

The mean operating time was 320 (210–450) min and the average estimated blood loss was 1.3 (0.7–2.5) L. The average length of hospitalization was 8 (5–46) days.

The mean preoperative angle of local kyphosis was 72 degrees and it improved to a mean of 23 (0–48) degrees. The mean loss of correction since operation was 3.4 (0–11) degrees and was seen only within the first 3 months. The average preoperative sagittal plumbline imbalance of 5.5 (2–12) cm improved to 1.2 (-2–3.5) cm. Radiographically solid anterior and posterior fusion was achieved in all patients by 6 months (Figure 2). Other than occasional technical difficulties due to adhesions in postinfectious deformity cases, there were no clear differences in the results, nor in pre- and postoperative data for different etiologies or different lengths of fusion.

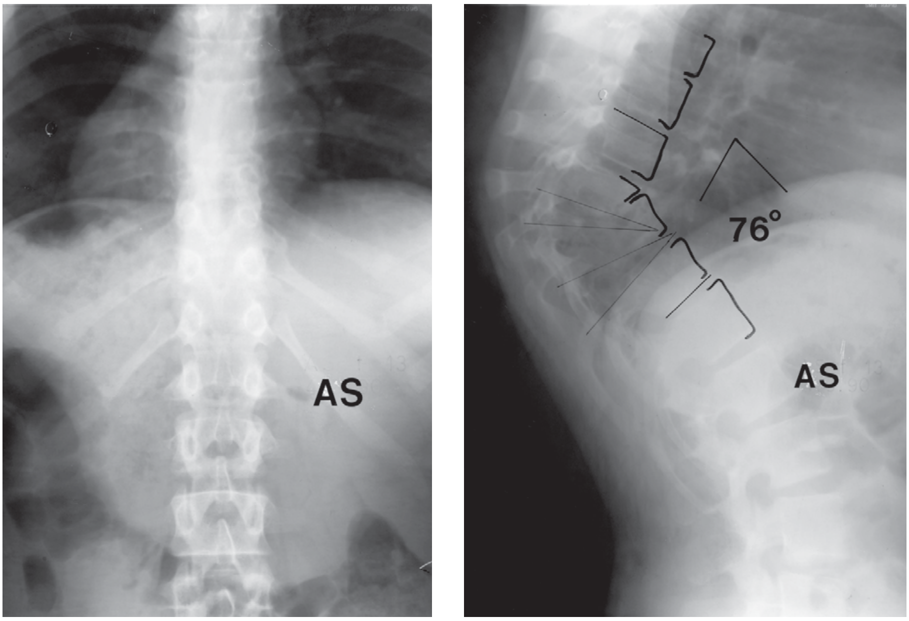
There were no fatal complications. However, the intraoperative wake-up test was positive in 1 patient who developed irreversible paraplegia. Removal of instruments did not help and thorough exploration of the osteotomy site did not reveal any mechanical problem or pathology. 2 other patients had transient nerve root injury which recovered completely by 6 months. 2 patients developed early deep infection which responded to early aggressive debridement without removal of the instruments. Regarding minor complications, dural tear occurred intraoperatively in 2 patients. Repair was effective without any leakage. In 2 patients implant failure occurred as hook pull-out, which was noted at 3 months. One was revised and the other one was not reoperated, as it did not cause mechanical problems or irritation.

Discussion

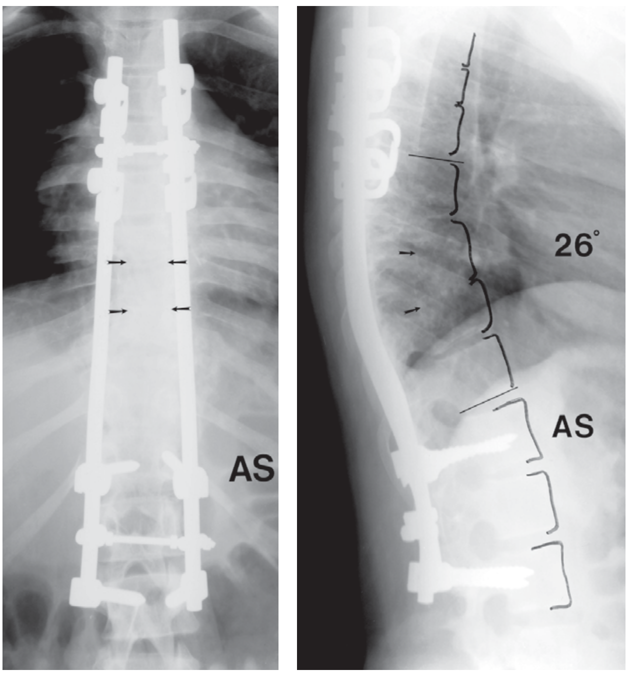
As emphasized by Van Royen and Slot (1995), closing wedge osteotomy of only the posterior elements must cause elongation of the anterior column. This might cause elongation of the spinal cord beyond its tolerance level and be dangerous in terms of neurological outcome. Also, this approach may be effective for long-segment kyphotic deformities as seen in ankylosing spondylitis (McMaster 1962, Simmons 1977) or rheumatoid arthritis patients (Smith-Petersen et al. 1945), but not in short-segment and angular kyphotic deformities in our series. One advantage of the one-stage posterior closing wedge resection osteotomy that we present is that it results in shortened posterior column and decreased tension on the spinal cord, since the anterior column is also resected and shortened. As Lehmer et al. (1994) and Gertzbein and Harris (1992) have also pointed out, closing wedge resection osteotomy is mechanically superior for correction of a kyphotic deformity by the fact that the fulcrum is placed anteriorly, and by not opening but providing bone-to-bone contact in the anterior column. On the other hand, closing total wedge resection osteotomy has some disadvantages. It is a spinal shortening procedure and dural buckling can result from closure of the osteotomy. This factor limits our correction to a maximum of 60 degrees. Lehmer et al. (1994) recommend duraplasty for the problem of dural buckling while closing the osteotomy. Dural buckling is a problem, but in our experience it rarely disturbs the dural pulsation or cerebrospinal fluid mechanics. As a preventive measure we always perform a wide laminectomy one level above and below the osteotomy site, and this relieves the tension on the spinal cord.

The average correction of 49 degrees that we achieved at a single level is greater than has been reported in most series in the literature (Thiranont and Netrawichien 1993, Lehmer et al. 1994, Van Royen and Slot 1995, Shing et al. 1996), since most pedicle subtraction osteotomies or closing wedge osteotomies occur within one vertebral body and leave the disc space intact. Kawahara et al. (2001) also performed an osteotomy within one vertebral body in seven patients and obtained a correction rate similar to our series, but these authors corrected the first 30–35 degrees of kyphosis by closing wedge technique and then converted from closing to opening technique by inserting a strut autograft or a vertebral spacer to the anterior intervertebral gap. The osteotomy we present covers 2 vertebrae and we resect the disc space along with the inferior part of the upper vertebral body. Thus, a higher degree of correction can be obtained with a single osteotomy, which is especially effective in cases with localized and acute angle kyphosis.

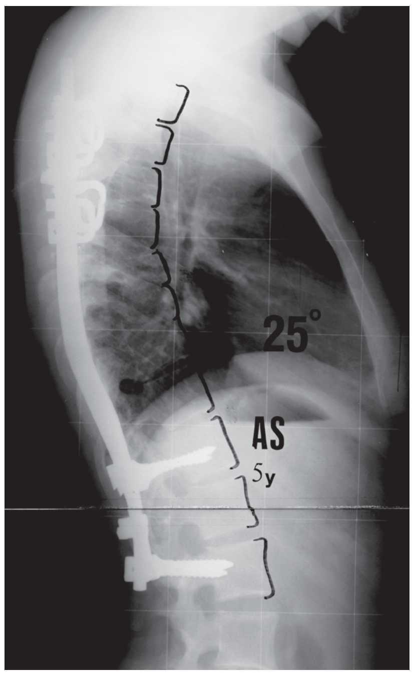
Figure 2. One of the early cases (1990), a 13-year-old girl with a rigid and angular kyphosis at the lower thoracic spine due to healed tuberculous infection.



AP and lateral radiographs show a 76° rigid and angular kyphosis at the lower thoracic spine. Osteotomy is planned to be performed at two different levels as drawn.



AP and lateral radiographs at 3 months postoperatively. Osteotomy levels are shown (arrows). A good sagittal balance is achieved with 50° correction.



Lateral radiograph at 5 years postoperatively, showing good balance and no loss of correction.

If one needs even more correction, the solution would be a second osteotomy depending on the deformity. Or, if there is substantial residual kyphosis despite the osteotomy, one may prefer to add anterior strut-graft in order to avoid the risks of pseudarthrosis or implant failure. Another option for more correction would be careful disruption of the anterior hinge (either bone or ligament), or total vertebrectomy to open up the anterior column; but this gap should then be reconstructed with a strut graft, or preferably with a titanium mesh to improve primary stability. This would be a safer and preferable approach especially in patients with thoracic apex of kyphosis (Kawahara et al. 2001). Another, but surgically more traumatic, approach would be three-stage (posterior and then anteroposterior) surgery (Sar and Eralp 2002) in a young and fit patient.

Posterior total wedge resection osteotomy is nevertheless a high-risk procedure for neurological complications requiring experience. In our series we had one major and two minor neurological complications (irreversible paraplegia and transient nerve root dysfunction, respectively). This rate of complications is similar to that reported by Lehmer et al. (1994). The possible etiology of these cord lesions could be direct injury to the spinal cord, dural compression, impaired vascular supply or spinal canal misalignment.

Area of fusion and length of instrumentation depends on the amount and flexibility of the compensatory sagittal and/or frontal plane deformity, and this should be decided on an individual basis for each patient and deformity. New-generation strong instrumentation systems, especially segmental pedicle screw constructs, can provide powerful correction and adequate stability as long as sagittal balance is restored. Lehmer et al. (1994) preferred short segment fusion and instrumentation, but reported a high rate of pain and additional procedures. This may be related to degeneration and pain in adjacent noninstrumented segments. Our patients did not experience postoperative pain or adjacent segment problems, and we attribute this to the long segment of fusion and instrumentation in the initial group of 20 patients. The latter group of 12 patients had shorter areas of fusion and instrumentation which provided a normal sagittal balance. These patients have also had no complaints to date, but they have had a comparatively shorter follow-up time.

No competing interests declared.

Bernhardt M. Normal spinal anatomy: Normal sagittal plane alignment. In: The textbook of spinal surgery (2nd edition) (Eds. Bridwell K H and DeWald R L). Lippincott-Raven, Philadelphia 1997: 185-91.

Bridwell K H. Osteotomies for fixed deformities in the thoracic and lumbar spine. In: The textbook of spinal surgery (2nd edition) (Eds. Bridwell K H and DeWald R L). Lippincott-Raven, Philadelphia 1997: 821-35.

Gertzbein S D, Harris M B. Wedge osteotomy for the correction of post-traumatic kyphosis. Spine 1992; 17: 374-9.

Kawahara N, Tomita K, Baba H, Kobayashi T, Fujita T, Murakami H. Closing-opening wedge osteotomy to correct angular kyphotic deformity by a single posterior approach. Spine 2001; 26: 391-402.

Kostuik J P, Maurais G R, Richardson W J, Okajima Y. Combined single stage anterior and posterior osteotomy for correction of iatrogenic lumbar kyphosis. Spine 1988; 13: 257-66

La Chapelle E H. Osteotomy of the lumbar spine for correction of kyphosis in a case of ankylosing spondylarthritis. J Bone Joint Surg (Am) 1946; 28: 851-8.

Lehmer S M, Keppler L, Biscup R S, Enker P, Miller S D, Steffee A D. Posterior transvertebral osteotomy for adult thoracolumbar kyphosis. Spine 1994; 18: 2060-7.

Malcolm B W, Bradford D S, Winter R B, Chou S N. Post-traumatic kyphosis: A review of forty-eight surgically treated patients. J Bone Joint Surg (Am) 1981; 63: 891-900.

McAfee P C, Bohlman H H, Yuan H A. Anterior decompression of traumatic thoracolumbar fractures with incomplete neurological deficit using a retroperitoneal approach. J Bone Joint Surg (Am) 1985; 67: 89-104.

McMaster P E. Osteotomy of the spine for fixed flexion deformity. J Bone Joint Surg (Am) 1962; 44: 1207-16.

Robertson J R, Whitesides T E. Surgical reconstruction of late posttraumatic thoracolumbar kyphosis. Spine 1985; 10:3 07-12.

Sar C, Eralp L. Three-stage surgery in the management of severe rigid angular kyphosis. Eur Spine J 2002; 11: 107-14.

Shing S W, Hwa S Y, Lin L C, Pai W M, Chen P Q, Au M K. Management of rigid post-traumatic kyphosis. Spine 1996; 21: 2260-7.

Simmons E H. Kyphotic deformity of the spine in ankylosing spondylitis. Clin Orthop 1977; 128: 65-77.

Smith-Petersen M N, Larson C B, Aufranc O E. Osteotomy of the spine for correction of flexion deformity in rheumatoid arthritis. J Bone Joint Surg (Am) 1945; 27: 1-11.

Thiranont N, Netrawichien P. Transpedicular decancellation closed wedge vertebral osteotomy for treatment of fixed flexion deformity of spine in ankylosing spondylitis. Spine 1993; 18: 2517-22.

Van Royen B J, Slot G H. Closing-wedge posterior osteotomy for ankylosing spondylitis. Partial corporectomy and transpedicular fixation in 22 cases. J Bone Joint Surg (Br) 1995; 77: 117-21.

Weidenbaum M, Farcy J P C. Surgical management of thoracic and lumbar burst fractures. In: The textbook of spinal surgery (2nd edition) (Eds. Bridwell K H and DeWald R L). Lippincott-Raven, Philadelphia 1997: 1839-80.