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Indications for surgery in so-called “regular” thoracic and thoracolumbar kyphosis

Received: 3 January 1995
Revised: 22 July 1996
Accepted: 23 July 1996

Paper read at the ESDS Meeting, Birmingham, 1994, and selected for full publication.

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Abstract Idiopathic thoracic, thoracolumbar, and Scheuermann’s kyphosis do not figure in the same global entity. We propose a classification for so-called “regular” kyphosis. This classification is based on the location of the most rigid curvature segment. Segmental kyphosis may be short, in which case we can distinguish between four types: high kyphosis (type I), middle kyphosis (type II), low or thoracolumbar kyphosis (type III), and segmental kyphosis, which can extend along the entire thoracic spine (type IV). The symptomatology and therapeutic indications are different for each type. We report a series of 15 patients (6 female, 9 male), aged between 18 and 33 years (average age 24 years). The mean kyphosis angle (Cobb angle) in type I patients ($n = 3$) was 75° in type II patients ($n = 3$) it was 82° , and in type III patients ($n = 9$) it was 78° . The pain was greater in type III patients. All patients were

operated on using a double approach. As the first step, we performed an anterior approach, disc excision, and bone graft. Ten days later, a posterior approach with CD instrumentation was carried out on ten levels. The mean follow-up is 4 years (range 9 months in 7 years). We noticed no neurological complications and one case of late sepsis. Mean angular loss of correction was 6° . The correction obtained depended on the type of kyphosis. We obtained a mean postoperative Cobb angle of 63° in type I curves, 55° in type II, and 45° in type III. The new classification allows a better understanding of regular kyphosis and helps to define clinical and therapeutic approaches. An analysis of the resulting surgical correction can also be made by comparing homogeneous groups of patients.

Key words Regular kyphosis · Scheuermann’s kyphosis · Idiopathic kyphosis · Curve topography

Introduction

Some patients who suffer sequelae of Scheuermann’s disease developed during the period of growth require corrective surgery at an adult age because of persistent back pain and lumbago that does not respond to conservative treatment [4, 5, 9, 12, 19].

It is notable that patients suffering the worst pain are mainly those with curves located in the lower thoracic or thoracolumbar region. Surgery is chosen more on the basis of the topography of the deformities than on the angulation. In fact, all these so-called “regular kyphoses”

(Scheuermann’s or idiopathic kyphosis) are very different in their anatomic-pathology.

In this paper, we will propose a definition of the initial indications in so-called regular kyphosis, based on a new classification after reviewing 15 cases with a mean follow-up of 4 years.

Materials and methods

Patients

We reviewed a series of 15 patients with short kyphosis all treated surgically. These patients were operated on between October 1986

and July 1993. There were nine men and six women. The average age at operation was 24 years (range 18–33 years).

All had achieved bone maturation. Out of a total of 15 patients, 13 had complained of back pain. The preoperative pain had lasted an average of 35 months (range 16–61 months). The pain had not responded to medical treatment or to prolonged physiotherapy (more than 1 year). Two patients had complained about the aesthetic effect of the deformity. No patient had suffered any neurological complications. One patient had undergone unsuccessful orthopedic treatment: a corset had been prescribed during his growth period.

All the patients underwent preoperative evaluation of their respiratory function. Average vital capacity was $102 \pm 10\%$, which means it had the same standard value as the forced vital capacity.

Classification proposal

As with scoliosis, the topography of kyphosis is variable. Every curvature has a stiffer segment with two end vertebrae and one apex vertebra. The upper and lower end vertebrae are the ones most inclined in the horizontal plane, the most horizontal being the apex vertebra. The two end vertebrae determine the segmental angulation. We differentiate between this segmental angulation and the global value of the measured kyphosis, usually measured between T3 and L1. We then distinguish between four types of kyphosis based on the location of this stiffer segment.

- Type I (Fig. 1 A): upper thoracic kyphosis. The apex vertebra is T4 or T5. The most inclined vertebrae in the horizontal plane are T3 and T7. They limit the most rigid segment.
- Type II (Fig. 1 B): mid-thoracic kyphosis. The apex vertebra is T8 or T9. The most inclined vertebrae are T6 and T10.
- Type III (Fig. 1 C): lower thoracic or thoracolumbar kyphosis. The apex vertebra is T11 or T12. The most inclined vertebrae are T9 or L1.

- Type IV (Fig. 1 D): kyphosis extended along the whole thoracic spine. This is an exaggeration of physiological kyphosis, and is the most common type.

Radiological evaluation

Topography of the curvature

Nine patients showed signs of sequelae of spinal dystrophy, six had idiopathic kyphosis without dystrophic lesions. According to this classification there were three type I curves, where the most rigid segment was from T3 and T7; three type II, with the most rigid segment from T6 to T10, and nine type III, with the most rigid segment from T9 to L1. No type IV curves appear in this series because they would all have been treated orthopedically. The mean segmental angle of each curvature, i.e., the stiffer segment previously defined, was 60° in type I curves, 55° in type II, and 40° in type III. The mid-apex vertebra was T5 in type I curves, T8 in type II, and T11 in type III. The mean number of vertebrae included in each rigid segment was five in type I curves, five in type II, and four in type III. The mean global curvature, measured from T3 to L1, was 75° for type I curves, 82° for type II, and 78° for type III.

Curvature reducibility

Curvature reducibility was measured in the lying position on a block facing the kyphosis apex, with lower limbs raised and the knees fully extended, in order to reduce lumbar lordosis. For each curve type, two measurements of reducibility were recorded: the reducibility of the involved segment, and the global reducibility measured over the entire spine. Mean segmental reducibility was 9° in type I curves (reducing from 60° to 51°); 15° in type II (reducing from 55° to 40°); and 28° in type III (reducing from 40° to 12°). Mean global reducibility in type I curves was 9° (from 75° to 66°); in type II curves it was 22° (from 82° to 60°); and in type III curves it was 31° (from 78° to 47°).

Fig. 1A–D Classification of regular kyphosis. **A** Type I, high kyphosis, **B** type II, middle kyphosis, **C** type III, low or thoracolumbar kyphosis, **D** type IV, kyphosis extended along the whole thoracic spine

Spine balance

The balance of the spine in relation to the pelvis was evaluated according to Marnay's method [14], by drawing two vertical lines

Fig. 2 A–C Balance of the spine with reference to the pelvis according to Marnay's method. **A** Anteverted, **B** balanced, and **C** retroverted

(Fig. 2). One descends through the middle of the lumbosacral joint, the other ascends through the middle of the femoral head. The pelvis is balanced when these two vertical lines are in alignment, it is retroverted when the center of the lumbosacral joint is behind the femoral head, and it is anteverted when the center of the lumbosacral joint is in front of the femoral head. In our series, all the pelvises were in a retroverted position.

Associated scoliosis

Four out of 15 kyphoses were in combination with a scoliosis. Of these, one was a type I kyphosis with a right thoracic curvature, two were type II, one with a right thoracic curvature and the other with a right thoracolumbar curvature, and one was type III with a right thoracolumbar curvature. Mean angulation was 10° (range 8° – 14°), and the kyphosis and scoliosis shared the same apex [1].

Surgical technique

All of the patients underwent a staged double surgical approach.

The first surgical approach is an anterior right thoracotomy or thoraco-phrenico-lumbotomy located on the apex of the kyphosis. The rib subjacent to the first disc to be removed is resected, the parietal pleura is incised in front of the head of the ribs, and the intercostal vessels are ligatured. An incision of the retracted anterior longitudinal ligament is carried out. Discectomy is performed at about six levels. In type I curves the approach extends from T4 to T9, in type II, from T4 to T10, and type III, from T7 to L1. Increased mobility of the kyphosis is then achieved by applying direct pressure on the curvature apex. The cortico-cancellous grafts are harvested from each resected rib end and from the iliac crest. They are inserted in each previously curated discal space.

The second surgical approach is carried out 10 days later. The patient is placed in a prone position for a posterior approach. The lamina and spinous process wedges are resected. A large arthrec-

tomy of the non-instrumented area is performed to improve the curves' reducibility and to prepare the arthrodesis area. The aim of the correction with CD instrumentation [6] is to obtain a good stable inferior and superior hold, using claws for the vertebral fixation. The top instrumented vertebrae are generally the second and fourth thoracic vertebrae. Transverse claws are applied while preserving the cervicothoracic junction. The bottom fixation is ensured by a laminar claw along with a sublaminar hook placed on the lowest fixed vertebra. The level chosen for the bottom instrumentation is determined according to the kyphosis reducibility radiograph. This bottom level is located just above the first horizontal disc as shown on dynamic radiographs. In type I curves, the lowest instrumented vertebra was L2, in type II it was L2 in two patients and L3 in one. In type III curves it was L3 in seven patients and L4 in two.

At the end of the operation, cortico-cancellous grafts are inserted between the previously curated discal spaces. The patient may stand unsupported 2 days following surgery. For follow-up treatment we recommend 1 month of physiotherapy in a specialized clinic. The patient can begin light physical activity, i.e., walking, sitting, and swimming, without assistance. Normal daily activity can be resumed after 6 months, but in all cases excessive strain must be avoided.

Results

The results were recorded both immediately after surgery and at long-term follow-up.

Postoperative results

Clinical

The patients in this series showed no neurological complications, sepsis, or thrombo-embolic complications, and there were no deaths.

Radiological

Global and segmental postoperative Cobb angle and correction were studied according to curve type.

Global results. The mean global postoperative Cobb angle for all curve types was 54° (max 65° , min 34°). Considering each type separately, in type I curves the postoperative kyphosis averaged 63° with a reduction of 12° , representing a 16% curve correction (Fig. 3); in type II curves the postoperative kyphosis averaged 55° with a reduction of 27° , representing a 33% curve correction (Fig. 4); and in type III curves the postoperative kyphosis averaged 45° with a reduction of 33° , representing a 43% curve correction (Fig. 5).

Segmental results. In type I curves the postoperative kyphosis at the T3–T7 segment averaged 50° with a 10° reduction, representing a 17% curve correction. In type II curves the postoperative kyphosis at the T6–T10 segment averaged 35° with a 20° reduction, representing a 37% curve correction. In type III curves the postoperative kyphosis at the T9–L1 segment averaged 10° with a 30° reduction, representing a 75% curve correction.

Fig. 3A–C Patient 9, a 28-year-old woman with a type I curve, who suffered severe cervicothoracic pain. **A** Preoperative roentgenogram showing a kyphosis of 70°. **B** Postoperative roentgenogram showing the correction after a double approach. **C** Follow-up roentgenogram taken in March 1994

The results in the frontal plane are very difficult to assess immediately after operation. Among the four patients suffering from scoliosis, the mean angulation was reduced to 6° (max 9°, min 3°).

Long-term results

All patients were reviewed with an average follow-up of 4 years (range 1–7 years).

Clinical

A septic problem (patient 5, type III curve) 18 months after operation, led to removal of the implants. The entire fusion of the instrumented area was checked preoperatively and, after a follow-up of 56 months, only 9° of angulation loss was found.

Among the 15 patients, 11 were without pain at the last follow-up, and three (patients 4, 7, and 15) suffered occa-

sional pain. Two type III patients (patients 4 and 7), one instrumented up to L3, the other up to L4, complained of lumbago located in the area subjacent to the fused spine. A type I patient (patient 15) complained of scapular and cervical pain, similar to the pain he had suffered before surgery. One type III patient (patient 14), instrumented down to L3, complained of chronic lumbago in the area subjacent to the fused spine. The two type I patients (patients 3 and 9) who were concerned with aesthetic considerations, said they found an improvement. After surgery, the three type II patients and seven of nine type III patients also noted an improvement. Regarding pulmonary function, vital capacity, measured at the end of the 1st postoperative month, remained at a standard level. However, forced vital capacity increased up to $80 \pm 11\%$, which is normal for all the patients between the 3rd and the 4th month. The residual volume remained unchanged.

Fig. 4A–E Patient 1, a 20-year-old man with a significant type II kyphosis. The operative results were satisfactory functionally and cosmetically. **A** Preoperative roentgenogram, **B** postoperative roentgenogram, **C** follow-up roentgenogram, **D** preoperative appearance, **E** postoperative appearance

Fig. 5A, B Patient 7, a 26-year-old man with a type III curve, who suffered severe lumbar pain. **A** preoperative roentgenogram, **B** postoperative roentgenogram after 9 months, showing excellent fusion

Table 1 Results of operative treatment in 15 patients with kyphosis

Patient	Age (years)	Sex	Curve type	Kyphosis before correction (degrees)		Follow- up period (months)	Kyphosis after both fusions (degree)		Anterior fusion	Posterior fusion	Complications	Status at last follow-up			
				Global	Segmental		Postop	At last follow-up							
								Global					Seg- mental	Global	Seg- mental
1	20	M	II	65	T6-T10	55	25	47	33	49	34	T5-T10	T3-L2	-	Asymptomatic, full activity
2	18	M	III	74	T9-L1	38	48	39	12	41	12	T7-L1	T4-L3	-	"
3	20	F	I	71	T3-T7	63	58	65	48	78	49	T4-T10	T2-L2	-	"
4	22	M	III	75	T9-L1	42	45	41	8	45	9	T7-L1	T3-L3	-	Occasional lumbar pain
5	26	M	III	71	T9-L1	35	56	46	14	55	16	T7-L1	T4-L3	Infection, removal of material, loss of correction	Asymptomatic, full activity
6	19	F	II	84	T6-T10	54	47	58	36	64	37	T4-T10	T3-L2	-	Occasional lumbar pain
7	26	M	III	65	T9-L1	41	76	42	13	43	13	T7-L1	T3-L3	-	Asymptomatic, full activity
8	24	M	III	77	T9-L1	37	61	52	6	54	8	T7-L1	T4-L4	-	"
9	28	F	I	76	T3-T7	59	12	64	53	74	55	T4-T9	T2-L2	-	"
10	18	F	III	82	T9-L1	43	64	43	14	47	15	T7-L1	T3-L3	-	"
11	33	M	III	79	T9-L1	41	51	48	2	51	4	T8-L1	T4-L3	-	"
12	25	M	II	83	T6-T10	56	29	56	36	60	4	T4-T10	T3-L3	-	"
13	27	F	III	80	T9-L1	40	84	46	11	49	13	T7-L1	T4-L4	-	"
14	29	M	III	83	T9-L1	43	52	44	10	47	11	T8-L1	T4-L3	-	Chronic lumbar pain
15	26	F	I	78	T3-T7	58	35	59	48	70	48	T4-T9	T2-L2	-	Scapular pain

Radiological

Mean global angular loss was 6° (range 3°–13°). Considering the different curve types separately, mean loss of correction was 11° for type I curves, 4° for type II, and 3° for type III curves. Concerning anterior fusion of all the fused levels in all of our 15 patients, we recorded 81 fused levels out of a total of 84 segments healed with arthrodesis. Concerning posterior fusion, we recorded no instances of non-union. In two patients (patient 4, type III curve and patient 12, type II curve) we noted absence of fusion in the lower part of the fixation. Patient 4 suffers from occasional lumbago, while patient 12 is without pain.

Concerning the sagittal balance between spine and pelvis according to Marnay's method, one patient out of three with type I curves regained a balanced pelvis, against two out of three with type II curves and all of the patients with type III curves.

Discussion

The mean postoperative global kyphosis of our 15 patients is not very high. The best functional results were obtained in the worst deformations, which were found in type III curves, where the kyphosis is located at the thoracolumbar junction. This type of curves combine is a retroversion of the pelvis with a posterior translation of the trunk, inducing a maximum of stress. Type III is the curve most frequently found in literature. Bradford et al. [4] believe that no thoracolumbar junction kyphosis should exist. Wambolt and Spencer [23] proved that the T12–L1 disc is oriented about 3° in the lordosis direction. Thoracolumbar kyphosis is always badly tolerated. It results in a subjacent flat back with hyperlordosis below [24]. It is in this group of curves that we obtained segmental correction, we find a mean kyphosis of 10° between T9 and L1 comparable to physiological kyphosis [10] in this area.

The type II curve is rarely a surgical indication. In most cases, the spine above and below the deformed section allows for the proper balancing of the curvature. However, sometimes the severity of the deformation of the vertebrae is such that the spine cannot find proper balance. In this case, a type II curve has a surgical indication. This particular type II curve must be considered separately from type IV curves, because the lesions are spread throughout the entire vertebral body. The pathological area is located at the level T6–T10. Thus, a type II and a type IV curve, though they may look similar, do not have the same consequences. Winter and Hall [25], without classifying the different curvatures, confirm that the severity of a curvature does not depend on its angular degree. Herndon et al. [9] say that curvatures located on a small segment require surgical treatment.

Concerning type I curves, indications for surgery are mainly based on aesthetic considerations. This type, which involves a very unaesthetic upper kyphosis, is com-

pletely ignored in the literature. Ascani and Montanaro [3] find some treated kyphoses, but these had an apex located at T7, whereas in type I curves the apex is at T4 and T5. However, it is in this group that we obtained the worst angular results. Furthermore, it is also in this group that the angular loss was the greatest. We notice, however, that the angular loss occurs above the arthrodesis area with an anterior approach above T3. Although all the patients with type I curves believe that the operation led to an aesthetic improvement, we are reluctant to accept this as a surgical indication because of the very difficult anterior approach conditions above T3. The advantage of this classification regarding the surgical treatment of kyphosis is that it lays the basis for a common language enabling a better understanding of regular kyphosis for clinical and therapeutic treatments.

This classification is of less interest regarding surgical strategy. On the one hand, the classification can be used in defining the area where the disc should be excised and the level of the intersomatic fusion. On the other hand, as far as both instrumentation and posterior arthrodesis are concerned, this classification is useless when the entire curvature has to be fully fused. The choice of the inferior level is determined by using the reducibility test to identify a horizontal vertebra with a sector of balanced lordosis. Short fixation devices [8] showed a higher risk of kyphosis recurrence above and below the arthrodesis area. This raises the question of whether Scheuermann's disease sequelae should be operated on after bone maturation. The study by Murray et al. [15], which looks at the natural history of Scheuermann's disease in a large patient population using multiple parameters, raises doubt as to the reasons justifying surgical correction. We think that their analysis is incomplete when dealing with the topography of curvature, which was classified as cephalic or caudal, since it does not include the apex vertebra. In our series, the surgical indication involved the apex vertebra level. The severity of the curvature lies in the topography of the curvature and not in its angulation. We fully share their analysis with regard to the few patients we operated on. Indications for surgery must remain limited and, concerning surgical techniques, a double anterior and posterior approach should be used. Very few authors [4, 7, 17–22] propose an isolated posterior approach, and it is with this technique that we find the most frequent angular loss. A double approach is recommended by nearly all the authors [5, 9, 13, 16–19] including our department [2]. We emphasize that the anterior approach is required not to obtain better correction but to avoid angular loss. This procedure is also used to avoid neurological complications, with disc protrusion following an isolated posterior approach. Comparative studies with other series are difficult, as curvatures will have been analyzed in a global and not a segmental way.

Until now, most authors used a fixation with transverse pedicular claws for the upper level and hooks or screws [6] for the lower one. Sublaminar wiring seems inade-

quate for restoring a harmonious curvature [8, 12], and it is sometimes associated with neurological complications. Concerning postoperative complications, the literature [7, 9, 12, 19] reports a certain number of neurological complications that may lead to regrets about having opted for surgical treatment. We did not come across any of these complications in our series.

It is obvious that the chief aim of surgical treatment is to correct the sequelae [25]. We never recommend surgical treatment before the end of bone maturation as do Speck and Chopin [19]. Before reaching Risser 3, the treatment should be conservative, using cast and corset. The work of Stagnara et al. [20, 21] showed that it is possible to modify the natural evolution of Scheuermann's disease with orthopedic treatment, thus avoiding surgery at the adult age.

Conclusion

Surgical treatment in kyphosis must be used cautiously. Analysis of deformity and topography, and of its functional consequences on the balance of the pelvis, should determine the use of surgical treatment. A classification based on an analysis of the rigid segment of the deformation may help to define appropriate indications. We think that thoracolumbar hyperkyphoses of disability type III form the clearest indications for surgical treatment.

The exceptional indications of type IV deformations correspond in fact to unrecognized type II curves.

Recourse to surgical treatment for aesthetic reasons in type I curves should be much more moderate.

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