Acta orthop. Scandinav. 40, 237–245, 1969

From the Orthopaedic Clinic, Karolinska Institutet, Stockholm.
(Head: Professor S. Friberg).

VERTEBRAL EPIPHYSEODESIS OF THE THORACIC CURVE IN THE OPERATIVE TREATMENT OF IDIOPATHIC SCOLIOSIS

By

ULF NILSONNE

Received 6.iii.68

It seems logical to suppose that a progressive scoliosis can be inhibited by arresting growth through vertebral epiphyseodesis on the convex side of the scoliotic curve. Ideally, the growth potential in the remaining vertebral epiphyses on the concave side would cause the curve to straighten out. Scoliosis has been produced in animal experiments by unilateral arrest of vertebral growth (*Haas* 1939, *Pacher* 1939, *Nachlas & Borden* 1950) and has even been made to regress by subsequently destroying the remaining epiphyses on the convex side (*Nachlas & Borden* 1951). In clinical work, *Roaf* (1963) in particular has employed surgical control of growth in the treatment of scoliosis. Using a dorsal approach and costo-transversectomies, he combines vertebral epiphysectomies on the convex side with fusion. Roaf reports that the scoliosis was arrested in all the operated cases, while in about half the deformity has even been reduced.

In an earlier paper (*Nilsonne* (1964) I emphasized the advantage of the transthoracic approach for vertebral epiphyseodesis, which has also been pointed out by *Le Coeur & Charleux* (1960). The thoracotomy gives the surgeon a very good picture of the deformation of the thoracic spine and makes the vertebral bodies readily accessible. The operation involves chiselling out—on the convex side of the scoliosis—the epiphyseal plates in the 4–5 vertebral bodies that correspond to the main part of the scoliotic curve. The intermediate discs are resected to half the depth of the vertebral bodies but fusion of the vertebrae is not used (Figure 1).

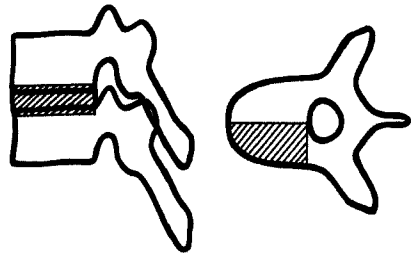


Figure 1. Schematic drawing representing the extent of the vertebral epiphysectomies.

MATERIAL AND METHODS

The operation described was performed on 11 patients with idiopathic scoliosis in whom the primary curve was located in the thoracic spine. All the patients were female, aged 8–14½ years at the time of the operation. The pre-operative period of observation varied from 6 years to 6 months. A few of the patients had been treated with a plaster bed but most of them were untreated. Active correction of the scoliosis had not been tried before the present operation, the indication for which was rapid progression of the scoliosis during the past three months as demonstrated roentgenologically. Risser's sign was used as an indication that the longitudinal growth of the spine was not yet complete: in no case were the iliac apophyses found to have capped at the pre-operative X-ray examination.

In all the patients but one the scoliotic curve was convex to the right. In case 7, in which the curve was convex to the left, the thoracotomy had to be performed from the left side and it was feared that the location of the heart and the aorta would make it difficult to get at the vertebral bodies. It transpired, however, that the heart and the great vessels had a central position in the mediastinum and had not been dislocated by the scoliosis. There was consequently no difficulty in performing the epiphysectomies.

The patients were allowed up on the 3rd-5th postoperative day. They were discharged from the hospital after 3–4 weeks and were able to return to school 6–8 weeks after the operation. Cases 1–10 did not receive any special postoperative treatment in the form of physiotherapy, a brace or the like. In case 11, the patient was given a Milwaukee brace (fitted before the operation) for continuous use.

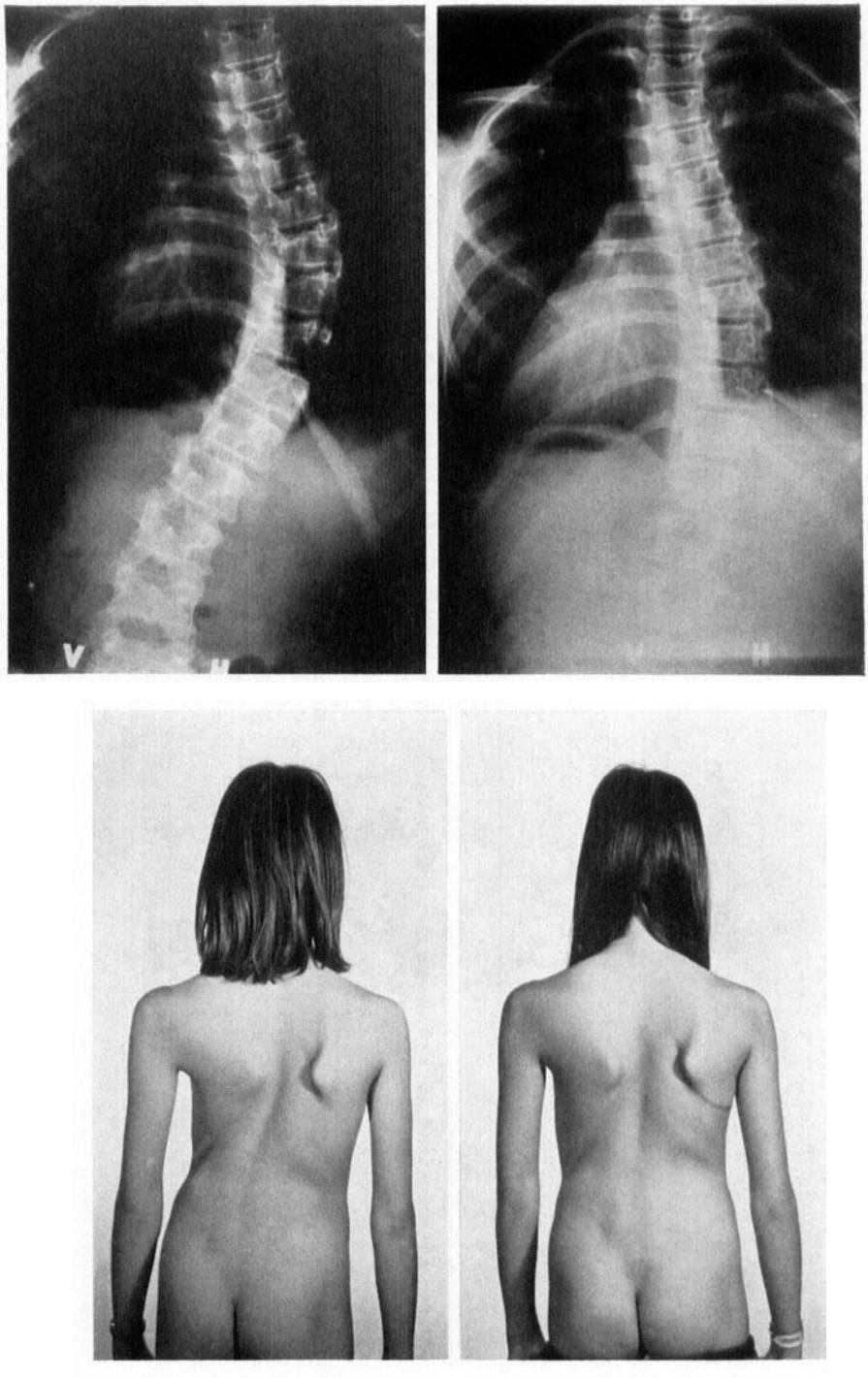
The patients were checked up with a clinical and X-ray examination every 3rd month to start with, subsequently twice a year. The interval between the operation and the last examination varies between 11 months and 6 years. As will be seen from Table 1, most of the patients had reached such a mature age by the time of this follow up that further progression of the scoliosis could be ruled out.

RESULTS (Table 1)

No serious complication developed either during the operation or subsequently. In one case a superficial infection arose in the anterior part of the thoracotomy incision. The wound nevertheless healed with

Table 1. Clinical data in 11 operated cases of idiopathic scoliosis.

Case No.	Observation time before operation years	Age at operation years	Levels of epiphysectomies	Apex of curve	Degree of curve			Standing height cms			Age at follow up	Capping of iliac apophyses, years after operation
					before operation	at follow up	gain + loss —	before operation	at follow up	gain		
1	1 2/12	14 1/12	Th V–Th IX	Th VII	73	88	—15	159	160	1	20	2
2	6	13 8/12	Th V–ThIX	Th VIII	74	105	—31	140	147	7	19 8/12	3
3	1 6/12	11 10/12	Th V–Th X	Th VIII	37	37	±0	152	157	5	17 6/12	1 6/12
4	9/12	12 2/12	Th VI–Th X	Th VIII	50	44	+6	152	156	4	16 9/12	3
5	1	11 7/12	Th VI–Th X	Th VIII	40	47	—7	159	167	8	16 1/12	3
6	1	14 3/12	Th V–Th X	Th VIII	54	58	—4	160	162	2	18 3/12	1 6/12
7	8/12	12 9/12	Th VIII–Th XI	Th IX	70	65	+5	150	156	6	16 2/12	2
8	1	8 9/12	Th V–Th IX	Th VII	42	60	—18	133	150	17	11 10/12	no capping
9	3 6/12	11 7/12	Th V–Th IX	Th VII	72	102	—30	143	143	0	14 4/12	2
10	6/12	7 11/12	Th VI–Th IX	Th VIII	36	60	—24	131	142	11	10 8/12	no capping
11	5	12 1/12	Th VII–Th X	Th IX	46	25	+21	140	146	6	13	11/12



a cosmetically acceptable scar. The patients had typical thoracotomy pains during the first postoperative day. True back pains were not experienced either in the postoperative period or later. In some of the more pronounced cases of scoliosis, moderate insufficiency symptoms in the form of fatigue appeared later in the period of observation.

There was some loss of mobility in all cases, particularly in respect of the lateral flexions that corresponded to the operated region. This loss was moderate as a rule but in cases 2 and 9 complete rigidity was noted at the follow-up examination.

A histological examination was made of the resected epiphyseal plates and the discs. This confirmed that the epiphyseal plates had been excised to the desired extent in all cases. Nothing abnormal was observed in the epiphyseal plates or adjacent osseous tissues. The disc specimens also presented a normal histological structure.

The degree of scoliosis measured according to *Cobb* (1948) is given in Table 1. Pre-operatively there were 2 cases with less than 40° (mild), 5 between 40° and 60° (moderate) and 4 with more than 60° (severe). After the operation, a reduction of the scoliosis was noted in three cases. This improvement was very marked in case 11, with a gain of 21° and a visible straightening of the thoracic spine (Figure 2). In cases 4 and 7, however, the gain was only slight—about 5°—and was not outwardly visible. The degree of scoliosis remained unchanged in case 3, while it progressed in the other seven cases. In two of the latter (cases 5 and 6) the deterioration was slight and not outwardly visible. The increase of the scoliosis measured in the other cases varied between 15° and 30°, resulting in a pronounced thoracic deformity in cases 2 and 9.

Capping of the iliac apophyses occurred an average of 2 years after the operation in 9 patients, which means that the spine continued to grow longitudinally during this period. In 2 patients (cases 8 and 10) capping of the iliac apophyses had not occurred at the time of the follow-up study.

DISCUSSION

During the period from which the present cases are taken, 358 patients with idiopathic scoliosis attended the orthopaedic clinic. The

Figure 2. Left: Case 11 before operation. Thoracic scoliosis 46°. Right: The same case 11 months after epiphyseodesis on the convex side of vertebrae Th. 7–Th. 10. Scoliotic curve reduced to 25°. Note the marked improvement in the external appearance of the scoliosis.

scoliosis was slight or moderate in the great majority of these patients and did not call for special treatment. Vertebral epiphyseodesis was the only type of operative treatment considered. The 11 operated cases comprise 3 per cent of the total number of idiopathic scoliosis. This frequency is in good agreement with *Cobb*'s (1958) opinion that only a very small proportion of scoliosis cases require operative treatment.

An analysis of the effect of the epiphyseodeses in cases 1–10 gives a disparate picture. A minor improvement was noted in some cases, a minor deterioration in others. The values given for the change in the scoliosis must be judged with caution, however, owing to the difficulty of applying the methods of measurement exactly and the fact that it is not easy to obtain identical projections at the various X-ray examinations. I therefore consider it most correct to regard cases 3–7 as unimproved. A more positive assessment would be that the epiphysectomies prevented or curtailed further progression. In cases 1–2 and 8–10, on the other hand, there was a slight—severe increase in the lateral curve and in these cases the epiphysectomies did not affect the progression of the scoliosis. Le Coeur & Charleux report that all 7 assessable cases out of 14 operated with epiphyseodesis displayed an improvement of the scoliosis, though they do not specify the degree of correction. Their cases, moreover, differ from the present ones in that they were paralytic scolioses and that correction with plaster was used postoperatively.

It is not easy to determine which factors are responsible for the variety of the results in cases 1–10. Since capping of the iliac apophyses had not occurred in any of the cases before the operation, it was to be expected that the vertebrae would continue to grow. It has been calculated (*Tupman* 1962) that for girls in the age groups with which we are concerned here, the annual increment to the height per vertebral body is 1.5 mm. If growth is completely blocked on the convex side of five vertebral bodies, the concave side would have a total relative increase in height of 7.5 mm per annum provided its epiphyses functioned normally. Such a small increment naturally has less effect on a scoliotic curve as the subject approaches the termination of growth. On the other hand, the relationship between longitudinal growth and pregression of the scoliosis is very irregular in these operated cases. Cases 2 and 7, for instance, both had a pre-operative scoliosis angle of about 70° and roughly the same total growth. But whereas the scoliosis progressed markedly in the former case, it regressed if anything in the latter.

It was disappointing to find a deterioration in cases 8 and 10, which had been operated on as early as in their 9th year. Theoretically, it is just in these cases that the chances of improvement were greatest. A possible explanation is that the epiphyseal plates on the concave side did not have a normal function. It has been shown by *Blount* (1949) and others that blockade of an epiphysis inhibits the growth in this. In the disbalanced, scoliotic spine there is probably increased pressure on the epiphyses of the concave side. After the epiphysectomies on the convex side, growth on the concave side may be too weak to result in any correction.

Another possible explanation of the progression is that the epiphysectomies were performed in too few levels. The problem here, however, is that the epiphysectomies involve ligature of the intercostal arteries, which also supply the spinal medulla. While the collateral circulation in the spinal medulla is manifestly sufficient to compensate for the arterial supply being cut off on one side of a limited number of segments, a more extensive, unilateral closure of the arterial flow might endanger the function of the spinal medulla. This problem requires further study.

There is no doubt, on the other hand, that the epiphysectomies performed were sufficiently radical in each vertebra. The good view of the operation field made it easy to ensure that the epiphyseal plates were resected to half the depth of the vertebral body, while the microscopic examinations confirmed that the resection was sufficiently radical in a cranio-caudal direction. One can therefore rule out the possibility that epiphyseal remains on the convex side of the operated region were responsible for the progression of the scoliosis.

Ponseti & Friedman (1950) report that the higher an idiopathic scoliosis is located in the thoracic spine, the worse the prognosis. The present cases show a similar tendency. Scolioses with the apex in the region Th. 7–Th. 8 generally responded less to the epiphysectomies than those with the apex in the region Th. 8–Th. 9. This may indicate that the structure of the scolioses, besides being influenced by the control of growth, is also subject to other biomechanical factors that are difficult to define at present.

An undisputable, pronounced correction of the scoliosis was obtained in Case 11. This differed from the other cases in that the patient was treated postoperatively with a Milwaukee brace, the intention being to apply a continuous distractive force against the spine and thereby relieve the pressure of the epiphyseal plates on the concave

side. The internal control of growth was thus combined with external control mechanism. The favourable effect seems to support this hypothesis and justifies further attempts.

In this context one can consider whether the concave side of the scoliosis should not be relieved for some time before the operation as well, for instance by means of a Milwaukee brace. An extra stimulation of growth on the concave side before the operation might possibly help to produce a more rapid effect from the epiphysectomies on the convex side.

Finally, it is worth pointing out that the transthoracic approach involves only a moderate trauma for the patient. Fusion operations, on the other hand, generally involve a considerable surgical trauma and a danger of shock even when they are undertaken in several seances. Furthermore, compared with the prolonged pre- and post-operative treatment with plaster that is required for fusion operations, the total period of hospitalization is considerably shorter for vertebral epiphyseodesis and the subsequent treatment is also less complicated.

To sum up, the results in the present cases seem to show that progression of the scoliosis can be prevented in some cases simply by operative treatment in the form of vertebral epiphyseodesis on the convex side. The effect is unpredictable, however, and the possibility of further deterioration cannot be ruled out in the individual case. Combined with external correction, for instance a Milwaukee brace, this type of operation may be able to make a scoliosis reversible.

SUMMARY

Eleven cases of idiopathic scoliosis were treated with an operation involving vertebral epiphyseodesis on the convex side after thoracotomy. A pronounced and lasting reduction of the scoliosis was achieved in the only case that was treated postoperatively with a Milwaukee brace. In the other 10 cases, in which postoperative correction was not attempted, the scoliosis stopped progressing in 5 cases but deteriorated in the other 5, becoming considerably worse in two. The reasons for these contradictory results are discussed.

REFERENCES

Blount, W. P. & Clarke, G. R. (1949) Control of Bone Growth by Epiphyseal Stapling. *J. Bone Jt Surg.* **31**-A, 464.

Cobb, J. R. (1948) Outline for the Study of Scoliosis. Instruct. Course Lectures. *Amer. Acad. Orthoped.*

Cobb, J. R. (1958) Scoliosis Quo Vadis? *J. Bone Jt Surg.* **40**-A, 507.

Haas, S. (1939) Experimental Production of Scoliosis. *J. Bone Jt Surg.* **37**, 963.

Le Coeur, P. & Charleux, H. (1960) L'abord direct du rachis. Sa place dans le traitement des scolioses. *Rev. Chir. Orthoped.* **46**, 595.

Nachlas, W. & Borden, J. (1950) Experimental scoliosis—the role of the epiphysis. *Surg. Gyn. Obst.* **90**, 672.

Nachlas, W. & Borden, J. (1951) The cure of experimental scoliosis by directed growth control. *J. Bone Jt Surg.* **33**-A, 24.

Nilsonne, U. (1964) Transthoracic approach for vertebral epiphyseodesis. *Acta orthop. scand.* **34**, 37.

Pacher, W. (1939) Operative Erzeugung einer Skoliose im Tierversuch. *Z. Orthop.* **69**, 140.

Ponseti, I. V. & Friedman, B. (1950) Prognosis in idiopathic scoliosis. *J. Bone Jt Surg.* **32**-A, 381.

Roaf, R. (1963) The late results of unilateral growth arrest of the spine for scoliosis. *Acta orthop. scand.* **33**, 393.

Tupman, E. S. (1962) A study of bone growth in normal children and its relationship to skeletal maturation. *J. Bone Jt Surg.* **44**-B, 42.