Acta orthop. scand. *46*, 400–424, 1975

Minneapolis, Minnesota, U.S.A.

# SCOLIOSIS AND OTHER SPINAL DEFORMITIES

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## I. RECENT SCIENTIFIC DEVELOPMENT

The past 20 years have brought about tremendous change in the field of scoliosis and related spine deformities. There has been considerable improvement in surgical technique in terms of the quality of fusion and strength of the fusion mass. We have seen the development of two major techniques of internal correction and fixation: Harrington rods and Dwyer instruments. We have seen the development of more powerful methods of external spine correction, including Cotrel traction, halo-femoral traction and halo-hoop techniques. We have seen advancement of surgical technique into new and innovative attacks upon spine deformity, most particularly the development of anterior spine fusion as well as corrective osteotomy of the spine. Finally, we have seen improvement of non-operative techniques with the introduction of new types of braces as well as refinement of traditional braces.

This wealth of new techniques, materials, and methodologies has brought tremendous change and provided a quality of care previously thought impossible. Previously hopeless problems have become possible, and previously difficult problems are now routine.

The innovative surgical techniques of anterior surgery and wedge osteotomy, as well as the more powerful corrective forces involved in Harrington rods, halo-hoops and halo-femoral traction, have brought about an *increase* of neurologic complications related to either direct spinal cord trauma or to ischaemia of the cord. Thus, the advancements in techniques have not always been coupled with increased safety to the patient.

## II. IMPORTANT DATA

The most common cause of spine deformity, idiopathic scoliosis, remains as much an engima as it has previously been. Although there

have been small inroads into the basic nature of this problem, the ultimate cause is still unknown.

A. *School screening*

Probably the most significant new information regarding idiopathic scoliosis has come from those studies involving screening of large numbers of schoolchildren for spine deformity. These screening procedures have been done in many different areas, including Johannesburg, South Africa, and California, Minnesota and Delaware, and have shown that idiopathic scoliosis is a far more common problem in most countries than was previously realized. Earlier studies had indicated an incidence of 0.1 to 0.2 per cent based on the number of patients coming to physicians for treatment or for evaluation of mass X-ray screenings for tuberculosis.

Evaluation of large numbers of schoolchildren has revealed an incidence of scoliosis of up to 12 per cent when screening children aged 10–14 years. Most of these patients have very small curvatures, i.e. in the range of 5–15 degrees (Cobb). At the younger age levels, that is, ages 10 and 11, the condition is found almost equally in males and females. As the children mature, the percentage of significant curvature rises most in the female. Thus, the number of older children requiring treatment (having progressive curves or curves greater than 20 degrees) shows a predominant female incidence similar to that previously known (approximately 80 per cent female – 20 per cent male).

These findings indicate that perhaps the feminine dominance of the condition is not a genetic one, i.e., it is not a sex-linked dominant factor, but rather the incidence is the same but the tendency towards progression may be governed by hormonal factors. Thus, investigations into growth and sex hormones have assumed a greater significance in the search for the cause of idiopathic scoliosis.

The school screening studies in South Africa revealed a significant difference between Negroes and Caucasians, the incidence in Negroes being approximately 2 per cent and that in the Caucasians approximately 6 per cent. Both of these studies were conducted in the Johannesburg school system, so the quality of analysis appears to be the same in the two groups. These results indicate a very definite ethnic relationship of this condition.

The school screening program has not only given us intriguing

information regarding cause of idiopathic scoliosis, but has, from the point of view of practical application of treatment, given us the ability to control idiopathic scoliosis without surgery in the majority of patients.

It has become increasingly evident that non-operative brace treatment, regardless of what type of brace is used, is effective only when curvatures can be detected early in the course of the curve before significant rigid structural deformity develops. The only way to find children when they are in this early, treatable stage is by mass screening techniques.

B. *Surgical treatment of idiopathic scoliosis*

The significant data that have evolved during the past 5 years concerning surgical treatment of idiopathic scoliosis are primarily related to the quality of the correction as well as the quality of the fusion mass created. There is now a good guarantee of permanent stability of correction. Operative techniques have gradually been improved to the point where the surgical treatment of idiopathic scoliosis in the adolescent should yield correction of between 50 and 60 per cent of the original curve, with an infection rate of 1 per cent or less, a pseudarthrosis rate of 2 per cent or less, and a minimum of other complications.

This high degree of success has come from a combination of facet joint excision, replacement of the facet joint with autogenous iliac cancellous bone, thorough decortication of the entire fusion area, and addition of further autogenous iliac bone. These results are being duplicated by many scoliosis surgeons throughout the world at this time. The days of considering a 10 per cent pseudarthrosis rate as acceptable are past.

C. *Early ambulation*

Reports from several centres now indicate that early ambulation following surgery can produce results equal to or better than those obtained by 3–6 months of bedrest. Early ambulation has been possible by a combination of secure internal fixation with Harrington or Dwyer instruments followed by application of snug, well-fitting, comfortable, total contact casts or expertly designed braces. Statistical analysis of such treatment indicates an average loss of only 5 degrees from the time of surgery until 1 year later in adolescent idiopathic scoliosis.

The arthrodesis appears to heal more strongly with vertical loading of the spine. Thus, the fusion appears to be stronger at the time of cast removal and there is less tendency for loss of correction following cast removal. Furthermore, there are tremendous psychologic benefits to the child in being able to leave the hospital, to return to regular school, and to participate in most activities with his or her peers.

D. *Dwyer instrumentation*

The Dwyer procedure has gained increasing acceptance during the past 5 years. It is still considered to be in an experimental phase with relatively few statistics available as to the results, but some facts are clear. It is a very powerful correcting device. It is most applicable to the thoracolumbar area, that is, between T 9 and L 4. The instruments themselves are sufficiently strong and durable to maintain correction, providing that firm external support is also used in the form of a cast or brace.

The major problems with the Dwyer procedure have been: a) the necessity for an anterior approach; b) the inability to fuse extensive areas of the spine, as one is limited by convenience to approximately six levels; c) the still somewhat awkward design of the instruments of insertion; d) inability to reach and anchor well in the sacrum. In most centres, the Dwyer procedure is used predominantly in neuromuscular problems, usually combined with a secondary posterior operation of greater length, and usually with Harrington instrumentation. The risk of paralysis due to interruption of the blood supply to the spinal cord was felt by many to be a strong contraindication to the Dwyer procedure. This has, however, not proved to be a significant factor to date.

E. *Anterior spinal surgery*

Anterior spinal surgery, initiated primarily for the treatment of tuberculosis of the spine, has come to play a significant role in the treatment of many other causes of kyphosis. Progressive or severe kyphosis is seldom permanently stabilized by posterior arthrodesis. From a biomechanical point of view, a posterior arthrodesis is under tension or distraction forces and does not knit solidly. However, an anterior arthrodesis is under compression forces and tends to knit strongly.

Therefore, for such conditions as neurofibromatosis kyphosis, ad-

vanced Scheuermann's kyphosis, the kyphosis of various osteochondrodystrophies, congenital kyphosis, and postlaminectomy kyphosis, anterior spinal fusion has become virtually routine.

The most significant role of the anterior approach besides that of anterior fusion has been anterior decompression of the spinal cord when the cause of the compression of the cord is anterior. There are a multitude of reasons for anterior cord compression, but statistically the most common are: a) congenital kyphosis; b) trauma; c) neurofibromatosis kyphoscoliosis, d) postlaminectomy kyphosis; e) the kyphosis due to various types of osteochondrodystrophies and f) tuberculosis. The pioneering work of the tuberculosis physicians which achieved such excellent results in the decompression of the spinal cord has led to greater recognition of the role anterior cord decompression plays in other aetiologies. The transthoracic route has been the most beneficial, since it is possible to perform an adequate anterior arthrodesis at the same time, thus stabilizing the kyphosis and preventing continued collapse. The Capener costrotransversectomy approach does not provide adequate exposure for arthrodesis or abcess excision.

F. *Brace treatment*

Statistical anlyses of the results of the Milwaukee brace and other braces in treatment of idiopathic scoliosis are now available. Three independent review articles indicate that the Milwaukee brace is most effective in adolescent idiopathic scoliosis of between 20 and 40 degrees. Between 40 and 50 degrees, the results are only fair and above 50 degrees the results are poor. Curvatures of 50–60 degrees in juveniles (ages 3–10) can well be treated by braces. These are less frequent patients. The average results from three different centres indicated approximately 20 per cent improvement of the curve at the conclusion of treatment. Analysis by Dr. Blount of patients who had been out of their braces several years has indicated that there is a tendency to lose a few degrees of correction, particularly following pregnancy. At the present time, no statistical results are available on patients several years after the completion of brace treatment.

Statistical analysis of end results of Milwaukee brace treatment for Scheuermann's disease are now available. Excellent improvement was obtained in the brace and maintained after brace removal. The final results indicated approximately 40 per cent correction of the kyphosis and also 40 per cent correction of the wedging of the apical vertebrae.

## III. TODAY'S LEVEL OF PERFORMANCE

### A. *Idiopathic scoliosis*

The treatment of idiopathic scoliosis involves only three methods. The first is controlled observation, the second is non-operative treatment with a brace, and the third is surgical correction and fusion. The physician treating the child has relatively few choices to make, but he may have difficulty deciding which is the best method.

Careful observation without active treatment can be done for slight curves, that is curves of 0 to 15 or 20 degrees. As long as the child is growing, periodic observation is necessary. Upright X-rays should be carefully measured to see if progression is or is not taking place. If the curve is progressive, then brace treatment is indicated.

The choice then lies between which type of brace is the most effective. At the present time, the Milwaukee brace is the treatment of choice for thoracic curves. Underarm-level corrective braces appear to be quite satisfactory for flexible thoracolumbar and lumbar curves.

A properly made Milwaukee brace has a well-fitting pelvic girdle with elimination of lumbar lordosis in the taking of the model and in the manufacturing of the brace. There are two posterior uprights and a single anterior upright with a metal neck ring containing two small occipital pads and a throat mold. The old flat chin pad is no longer used due to the high incidence of resulting dental abnormalities. The occipital pads must be situated *below* the occiput and there must be at least 1.0 cm between the throat mold and the tissues beneath the chin when the patient is standing in a neutral position and looking straight ahead.

Various lateral holding pads are used, depending upon the nature of the curve. There are lumbar pads, oval pads, L-shaped thoracic pads, shoulder rings and trapezius pads. The lumbar pad is used only for lumbar curves. For thoracolumbar curves, a lumbar pad plus an oval pad on the lower-most ribs (both on the same side) is the preferable application. For the usual thoracic curve, the L-shaped thoracic pad is used plus an axillary sling on the opposite side to balance the neck in the centre of the brace. The axillary sling is a balancing device, not a curve correction device. The trapezius pad and shoulder ring are used for high thoracic or cervicothoracic curves.

The Milwaukee brace is combined with an active exercise program which obtains a better correction of the curve due to active curve-correcting exercises, and maintains good spinal muscle tone so that

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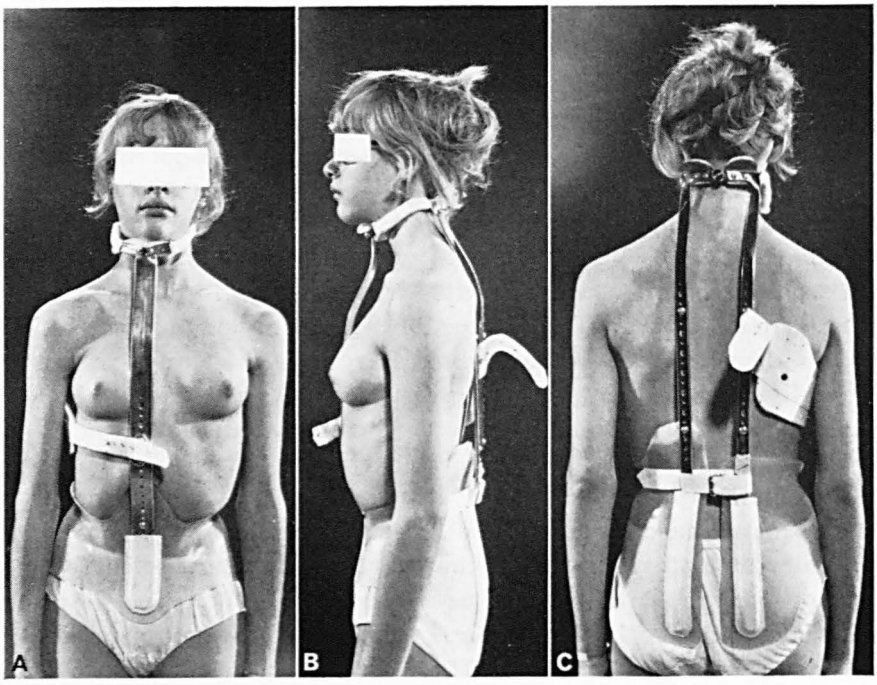
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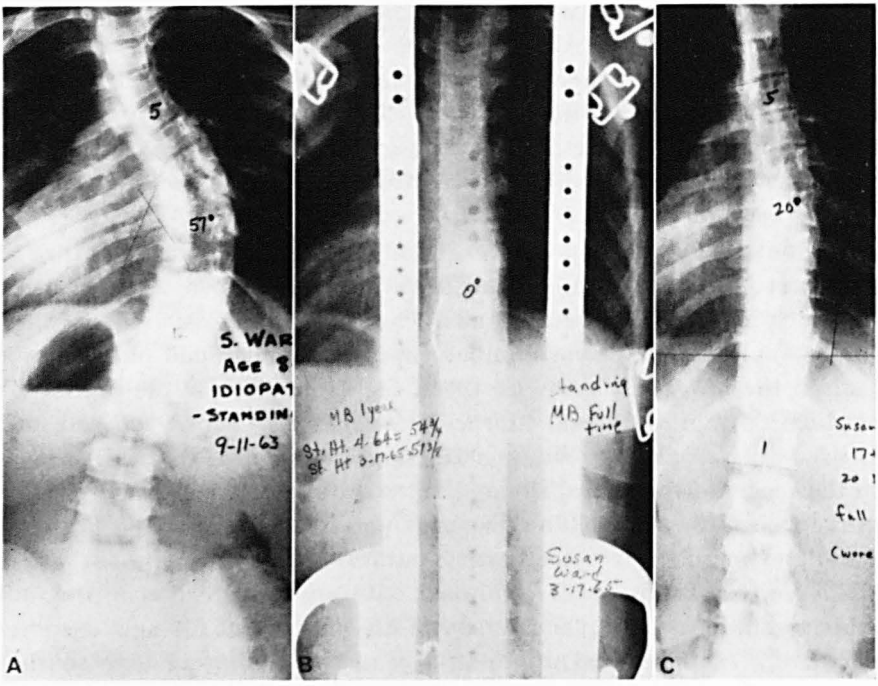
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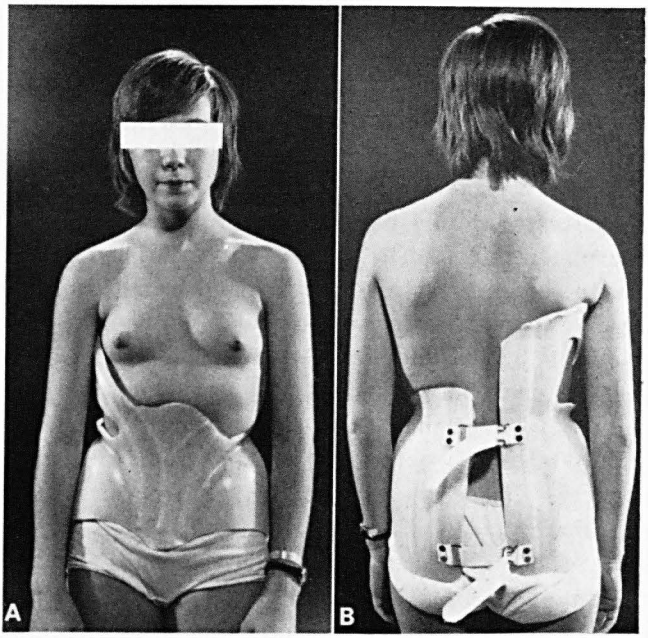


*Figure 3. A–B. Front and back views of a patient with a brace for a lumbar idiopathic scoliosis. Her 25° left lumbar curve is reduced to 6° in this brace.*

at the time of brace removal, good muscles are available to maintain the upright and corrected position.

Exercises without brace treatment are of no value in the treatment of any kind of scoliosis. They do not correct a curve and they delude the patient and physician into thinking that something positive is being done.

For thoracolumbar and lumbar curves, the new underarm-level corrective braces appear to be excellent. Newer designs are made of strong plastic materials and are psychologically very pleasing to the patients. These are made with the patient in the corrected position and

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*Figure 1. A modern Milwaukee brace. The pelvic girdle is made of a plastic (polypropylene).*

*Figure 2. A. An 8-year-old girl with a 57° right thoracic idiopathic scoliosis. B. After 1 year of treatment in a Milwaukee brace, the curve has been corrected to zero degrees. C. Age 17 years, 5 months. One year after complete brace removal. The curve measures 20°.*

must eliminate lumbar lordosis. For this reason, they must be brought low in the region of the buttocks but cut high in the front to permit comfortable sitting. The abdomen must be kept firmly supported to prevent lumbar lordosis, thus allowing the lateral component of the corrective force to be effective against the lumbar spine. These braces are not effective for curves greater than 40 degrees.

The experiences of the past 5 years would indicate that all types of braces are primarily devices to prevent curves from increasing rather than devices to correct an already significant curvature. Therefore, to be effective, any type of brace must be applied when the curve is mild, with the thought that it will keep the curve mild. The physician who believes that he can correct a 60-degree curve with a brace is only deluding himself. There may be some application for braces in the traatment of 60-degree curves in idiopathic, infantile and juvenile idiopathic curves- but certainly not for the treatment of adolescent idiopathic scoliosis.

The main problem areas confronting the physician using brace treatment are the two borderline areas of the mild curve and the more major curve. In the mild curve, the question arises, should the child be observed or braced? Curves of less than 20 degrees usually are not braced unless it is known that they are progressing. For example, if a child is seen for the first time with an 18-degree curve and is 13 years of age, then treatment is usually postponed until a check-up 3 months later can show whether progression has taken place. If it is progressive, then a brace will be applied.

If, however, the patient has previously been seen with a 10-degree curve and on follow-up has progressed to 18 degrees, then brace treatment would be instituted without further delay.

The reason for using 20° as the dividing line is that school screening examinations of large numbers of children have indicated a very large number of children with curves of under 20° that are non-progressive or even self-resolving. Above 20°, however, the curves usually progress and do not resolve spontaneously.

The other major area of difficult decision-making is that of the more significant curve and here it is a question of whether it requires a brace or surgery. The past 5 years have brought the realization that braces cannot correct major structural curves. Thus, the indications for the brace have narrowed and the indications for surgery have increased somewhat as compared to 5 or 10 years ago. Curves up to 40 degrees can easily be braced and curves above 50 degrees should be

operated on (adolescent idiopathic scoliosis) and thus the area of difficult decision-making is in the range of 40–50 degrees. Under these circumstances, the younger the child or the more structural the curve, the more likely it is that surgery is necessary. Thus, a 45 degree curve which corrects on supine side bending to 10 degrees and is associated with a 1.0 cm rib hump in a child prior to menarche would be a brace candidate, whereas a 45 degree curve in a 14-year-old girl 1 year after the onset of menses with side bending to 30 degrees and a 3.0 cm rib hump would be a surgical candidate. Curves above 60 degrees in adolescents should be corrected and fused without question. With curves of this magnitude, the incidence of complications in adult life are so frequent as to justify treatment in the child. Curvatures above 60 degrees are now known to be progressive in adult life. Thoracic curves above 60 degrees tend to give respiratory complications. Lumbar curves are more controversial than thoracic curves; many physicians believe that lumbar curves do not cause problems later and therefore do not need surgical correction and fusion. Other surgeons, particularly those who see a large number of adult scoliotics, believe that lumbar curves produce a high incidence of arthritis and progression during adult life and therefore should be corrected and fused. The statistics needed to definitely answer these questions are not available at the present time.

Surgical treatment of idiopathic scoliosis has slowly evolved to a standardized procedure in the major centres throughout the world. At the present time, the most commonly used method is spinal fusion supplemented by Harrington instrumentation. The Harrington instruments have become standardized throughout the world and have, in essence, become the routine method of treatment for adolescent idiopathic scoliosis.

The operative procedure consists of a straight incision with careful subperiosteal dissection of the entire fusion area of the intended arthrodesis. With extremely careful subperiosteal dissection, blood loss can be maintained at a minimum level, a level which previously had not been thought possible. After careful exposure and removal of all soft tissues from the spine, from the tip of the transverse process to the tip of the opposite transverse process, the facet joints are then excised completely and all cartilaginous surfaces removed. The area of the excised joint is then filled with a bone graft of autogenous material, while others prefer to use plugs of autogenous iliac cancellous bone. The author much prefers the autogenous iliac bone plug in each and

every facet joint throughout the fusion area. After these have been inserted, the entire fusion area is decorticated thoroughly down into the cancellous bone, again from tip of transverse process to tip of transverse process. The Harrington instrument is then inserted, placing the distraction rod along the concave side of the curve, the upper hook being inserted into the facet joint and the lower hook being inserted underneath the lamina of the end vertebra in the fusion area. The Harrington contraction assembly is a more controversial part of the instrumentation. Some physicians are routinely using it and others routinely not using it. The Cotrel transverse osteotomy to correct the rib hump has been adopted by many surgeons and does give a more significant improvement in the rib hump than can be achieved by any other means.

The use of an abundant autogenous iliac bone graft in each and every case has provided a fusion mass of consistently high quality. The pseudarthrosis rate has steadily dropped thanks to competent surgeons and is now approximately 1 per cent in the major centres healing idiopathic scoliosis.

After insertion of the Harrington rod and placement of the bone graft, the incision is then closed with a careful cosmetic suture of the skin using intra-cuticular wire or other suture material. Heavy, tight sutures in the skin produce an ugly scar and thwart the cosmetic intentions of the surgery.

Approximately 1 week after surgery, the patient is placed in a very snug type of cast that uses traction, derotation and lateral flexion forces at the time of cast application. If the Harrington instruments have been properly applied, they will not be loosened by application of the cast. A very snug form-fitting plaster provides total contact and permits early ambulation. Ambulation is begun during the second week after surgery and the plaster is maintained for 6–9 months, depending on the age of the child, the quality of the fusion and the experience of the surgeon. A cast time of less than 6 months is to be condemned, as bone simply does not mature in less time than that. Large windows are placed anteriorly in the thorax to allow maximal inspiration and expiration. This permits the ribs to continue moving and avoids a "frozen thorax". It also avoids pressure on the breasts and maintains a normal vital capacity.

For the patient with adolescent idiopathic scoliosis, it is not necessary to apply a brace or other device once the cast is removed at the end of the healing period. A solid fusion in an adolescent will

not regress unless there is a pseudarthrosis. Pseudarthroses should be surgically repaired.

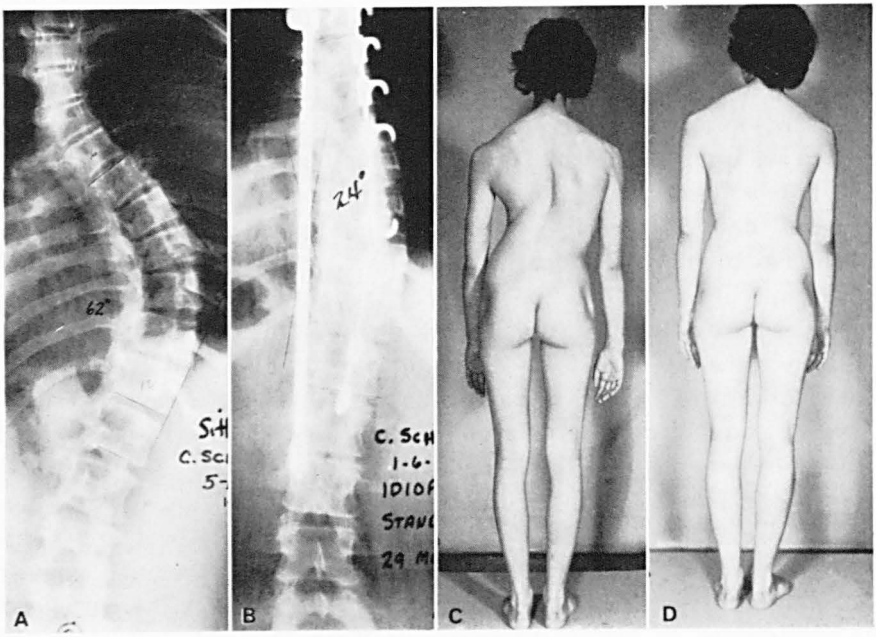
Juvenile idiopathic scoliosis, that is idiopathic scoliosis occurring between the ages of three and the onset of puberty, continues to be more rare than adolescent scoliosis, particularly in the United States. The Milwaukee brace has proven to be extremely valuable in the treatment of these children by preventing rapid deterioration of the curve. In some patients with idiopathic scoliosis the Milwaukee brace provides such superior correction that surgery is permanently avoided. Other children do not benefit as well, in that the brace delays the need for surgery until the age of 10–12 but then, with the growth spurt, the curve begins to deteriorate and surgery cannot be delayed further. Surgery should never be delayed until the end of growth and should always be done prior to this time.

Infantile idiopathic scoliosis continues to remain an enigma. The most beneficial recent development is the "rib vertebral angle difference" measurement of Mehta, who demonstrated that one can use this special measurement technique to predict whether the curve will be progressive or not. A difference of more than 20 degrees in the relationship of the angle of the rib to the vertebral body when comparing the two sides is an indication of a progressive curve. It is a measurement of the structural character of the curve. Infantile idiopathic curves which are progressing or which have gone more than 30 degrees or have a rib-vertebral angle difference of greater than 20 degrees, should be treated by brace, preferably the Milwaukee brace. It is now possible to treat children as young as 6 months of age with a well-fitting Milwaukee brace.

### B. *Congenital spine deformities*

With the disappearance of poliomyelitis scoliosis from many parts of the world, congenital spine deformities have assumed a more prominent place in scoliosis clinics. With increasing surgical ability, it has been possible to do many more things for congenital spine deformity than has previously been thought possible.

The fundamental treatment of congenital scoliosis still remains standard cast correction and posterior spine fusion at an early age before the curvature becomes severe. In congenital scoliosis, the severe curvatures resist correction and, therefore, surgery must take place early. Early fusion is not as harmful in congenital scoliosis as in

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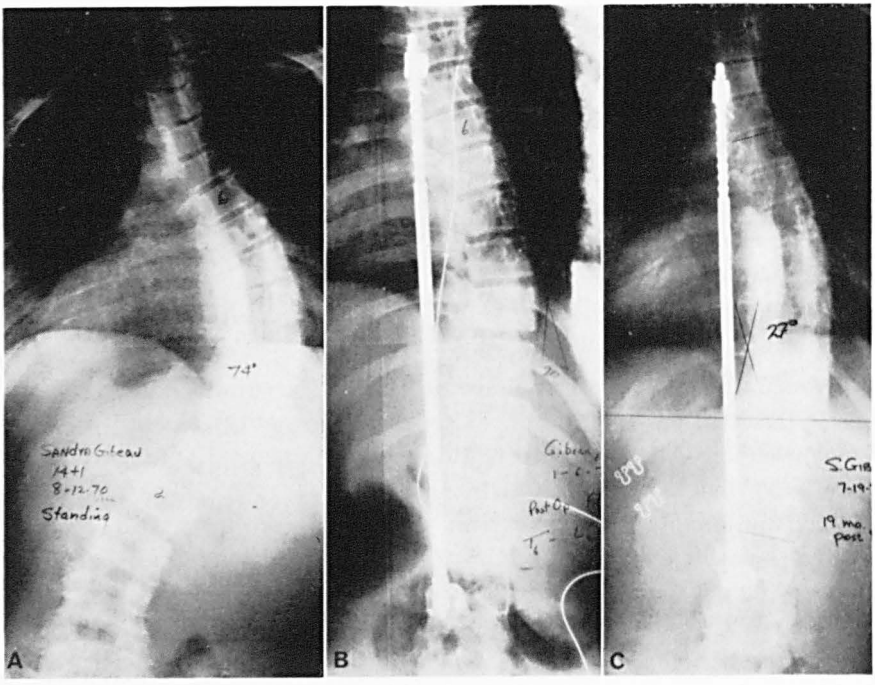


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other scolioses, since the fusion area can be relatively short and the anomalous area does not grow normally anyway, thus taking away the potentially negative growth effects of surgical arthrodesis.

Sometimes a four or five level arthrodesis at the age of 4 or 5 years can solve a curve problem for life. In such circumstances, it is the ideal thing to do, thus avoiding years and years of brace treatment or progressive curvature. Brace treatment remains relatively poor for congenital scoliosis, being applicable only to those curves which are long and flexible. Short, rigid curves should be fused promptly.

Congenital kyphosis has been increasingly recognized as a very dangerous problem because of the high incidence of spinal cord involvement. Statistics from several centres have indicated that the single most common cause of spinal cord compression due to spine deformity (excluding tuberculosis) is congenital kyphosis. It may be either congenital kyphosis or congenital kyphoscoliosis.

The essence of treatment of this dangerous problem is early recognition and early, prompt and abundant posterior fusion. Once beyond 50 degrees of kyphosis, these deformities are very difficult to correct and to fuse by posterior arthrodesis alone. Over 50 degrees and beyond age five, both anterior and posterior spine fusion are required.

Anterior spine fusion has come to play a very important role in any neglected and difficult cases of congenital kyphosis. It offers an opportunity not only to obtain a stable arthrodesis, but also to do anterior osteotomy and correct the spine deformity as well.

When the patient with congenital kyphosis develops paraplegia, anterior transthoracic spinal cord decompression and anterior spine fusion plus posterior spine fusion is the procedure of choice. Laminectomy must be avoided.

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*Figure 4. A. C.S. A 14-year 10-month-old girl with a 62° right thoracic idiopathic scoliosis. This amount of curve requires surgery and cannot be treated by braces. B. C.S. 29 months following surgery. The curve has been permanently corrected to 24°. Note the use of both distracting and contracting instruments. C. The patient before surgery. D. The patient 1 year after surgery.*

*Figure 5. A. S.G. A 14-year-old girl with a 74° right thoracic idiopathic scoliosis. B. S.G. A spine x-ray taken the day of surgery showing correction to 20° utilizing a preoperative Risser cast and a single distraction rod. C. S.G. 19 months after surgery. Curve is solid at 20°. Her postoperative cast was applied on the 6th postoperative day; she was ambulated on the 7th postoperative day, was discharged from the hospital on the 10th postoperative day and returned to school on the 16th postoperative day.*

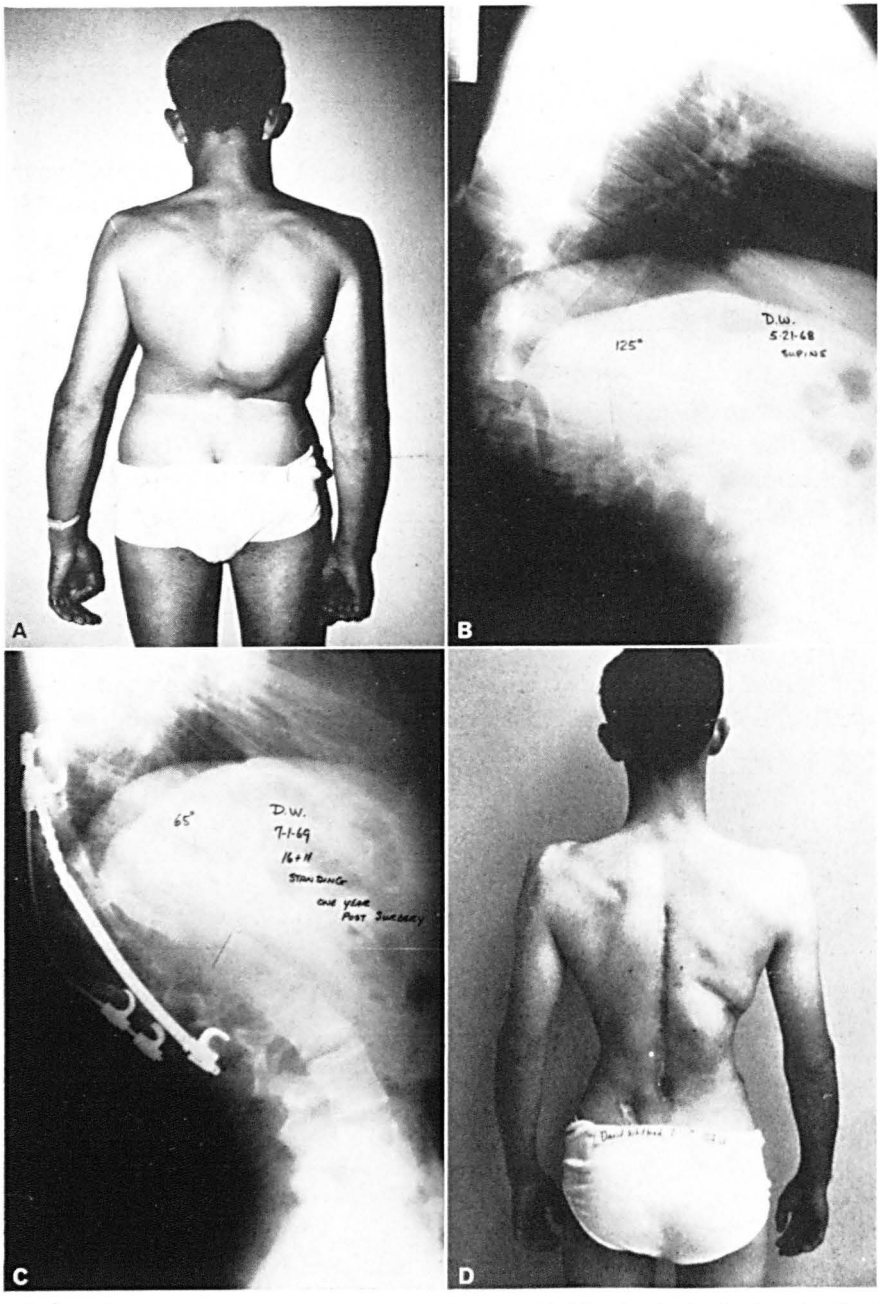


*Figure 6. A. D.W. A 15-year-old male with congenital kyphosis, back view (patient of Dr. Moe's). B. Lateral supine x-ray, kyphosis 125°. C. Lateral standing x-ray 1 year after surgery (anterior release, osteotomy, sib grafting Harrington instrumentation and halo cast). D. Posterior view 1 year later.*

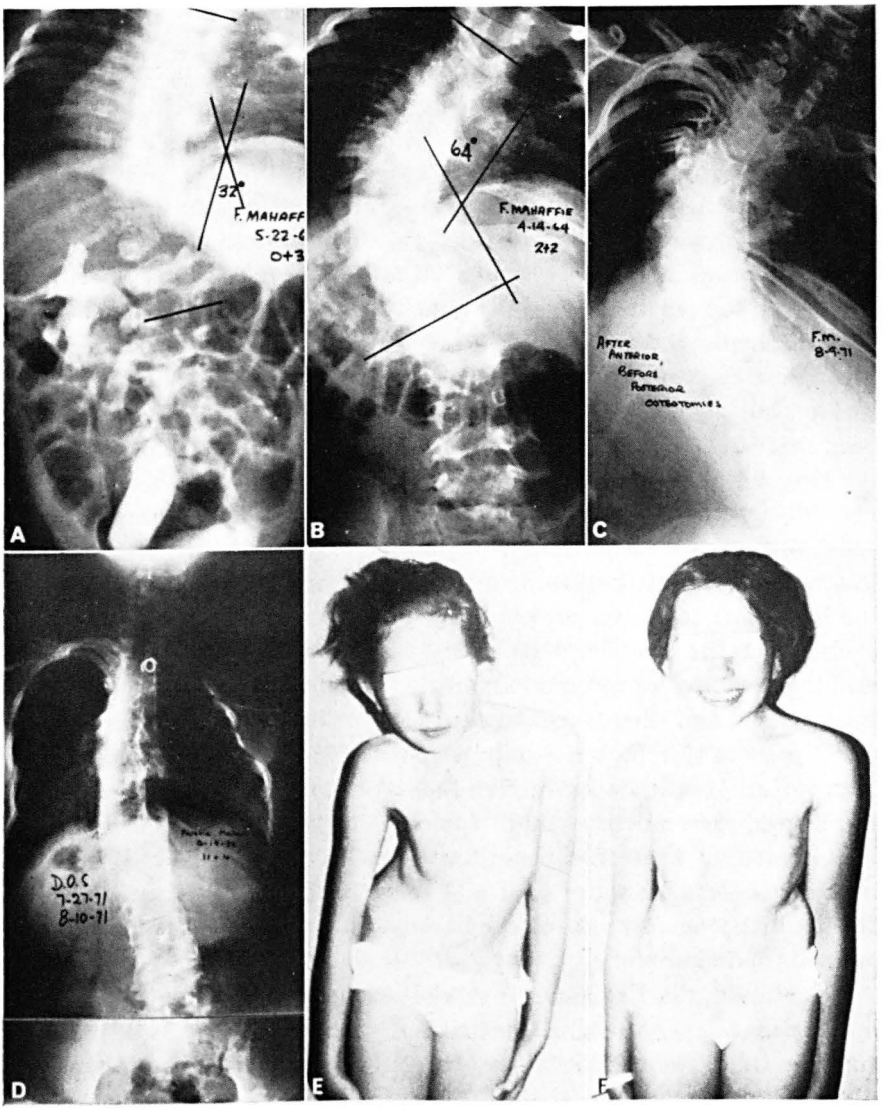


*Figure 7. A. F.M. A 3-month-old infant with a 32° congenital scoliosis due to an unsegmented bar. Note the single kidney, hydroureter and hydronephrosis. There is obstruction at the uretero-vesicle junction. She was seriously ill with a urinary tract infection at this time, but was saved by ureteroplasty and antibiotic therapy. B. F.M. at age 2 years, 2 months. Note the rapid increase in her scoliosis, now 64°. A posterior fusion was done elsewhere at age 3. C. F.M. Age 9 years. Curve measurement 74°. The curve is extending both upward to T 1 and downward to L 3. D. F.M. Two years after anterior wedge osteotomy at T 6 and L 1 on the left, followed 2 weeks later by posterior wedge osteotomy and halo-turnbuckle cast correction. E. F.M. Front view at age 9, before surgery. F. F.M. Front view at age 11, 2 years after surgery.*

Osteotomy of the spine or hemivertebra excision has been performed increasingly often during the past 5 years. Indications still remain difficult to define precisely. As an absolute indication, wedge osteotomy is indicated in fixed deformities which are life-treatening if this procedure is not carried out. It is not indicated purely as a cosmetic procedure. It seems to be most helpful in those patients with lumbar hemivertebra which create a marked lateral translation of the thorax relative to the pelvis. In these cases, the hemivertebra is usually in the L 5 area, below the conus, and therefore less dangerous to remove.

Single-stage anterior-posterior hemivertebra excision has been performed but carries a very high risk as the incidence of paralysis has been three or four times higher than with two-stage removal. Therefore, the two-stage excision technique as recommended by Leatherman is the procedure of choice if hemivertebra excision is deemed necessary. The procedure consists of an anterior approach, either transthoracic if the hemivertebra is in the thoracic spine or retroperitoneal if it is in the lumbar spine, excision of the body portion of the hemivertebra and excision of the pedicle. Nothing is done for 2 weeks, and then the midline posterior approach is made, excising the lamina, remainder of the pedicle and the transverse process. The wedge is then closed, usually by a Harrington compression assembly, and a fusion of the appropriate length, depending on the nature of the curve, is performed. Hemivertebra removal without fusion is not recommended. It should be understood that this procedure does involve significant risk, as hemorrhage can be significant and there is always a risk of paralysis. It should be performed only by individuals extremely competent in anterior spinal surgery.

The Harrington instruments have been used for congenital scoliosis, but appear to carry a significant risk of paralysis. Analysis of paralytic complications from Harrington instrumentations shows that a very high percentage were patients with congenital scoliosis. It appears that the spinal cord is often tethered either by diastematomyelia or other tethering structures and that the spinal cord does not have normal elasticity. Thus, a relatively high percentage of patients having had Harrington instrumentation for congenital scoliosis have had varying degrees of paralysis. Thus, Harrington instruments are not recommended as a method to obtain correction in patients with congenital scoliosis. Harrington instruments can be used, providing correction is obtained by other methods, either cast or traction and the Harrington instrument is inserted only as a supporting structure without attempt to gain further correction.

C. *Paralytic scoliosis*

Although there has been a continued decline in the incidence of poliomyelitis, there continues to be a significant number of poliomyelitis patients in the world, and there continues to be a significant number of other types of neurologic disorders producing scoliosis. The major improvements have concerned treating patients previously thought untreatable because of respiratory insufficiency. This has been done through the use of positive respiratory support mechanisms. This requires a very sophisticated medical technology and the assistance of people knowledgeable in respiratory management, particularly positive pressure and respirator care.

The methods of correction have also improved and the use of halo-hoop and halo-femoral traction has given remarkably greater corrections for severe scoliosis than previously thought possible. Cast correction in paralytic patients is of very limited usefulness because these patients cannot tolerate corrective casts.

Patients with significant lumbar curves (over 60 degrees) are quite often benefited by a combined anterior and posterior approach using halo-femoral traction to obtain the maximum correction, followed by Dwyer instrumentation anteriorly of the T 10 or 11 to L 4 area, followed 2 weeks later by posterior fusion with or without Harrington instrumentation. This has provided magnitudes of correction previously thought impossible and a very secure internal fixation. The interbody arthrodesis accomplished by the Dwyer reduces significantly the pseudarthrosis problem, but the need for posterior fusion in addition to the Dwyer cannot be urged strongly enough. It is very tempting to feel that the Dwyer procedure anteriorly is sufficient by itself for these paralytic curves, but it is not. Posterior fusion must also be accomplished and is the easiest way to obtain lumbosacral fusion.

Previously, patients with paralytic curves fused to the sacrum were kept in bed for at least 6 months and in plaster for up to 12 months. With these new management techniques, it has been possible to return a patient to an upright ambulatory position in a well-fitting cast or molded plastic brace 2 weeks after the second operation. This cast or brace incorporates only the pelvis and does not immobilize either hip joint.

This program does not totally eliminate the possibility of pseudarthrosis, but pseudarthrosis has been no more frequent under this programme than it has previously been with a cast down the legs and

with prolonged bedrest. The upright position seems to stimulate better fusion mass and can result in a reduced cast time by stimulating vertical trabecular formation. The halo-hoop has often been recommended for paralytic curves, but it carries with it a significant problem of making it very difficult to fuse the lumbosacral area when the device is in place. It is recommended that the correction be obtained by halo-femoral traction if strong traction techniques are necessary and if ambulatory care in the halo-hoop is desired, the pelvic halo should be applied approximately 3 weeks *after* the arthrodesis. Because of this problem, the halo-hoop is most applicable to those types of problems where arthrodesis to the sacrum is *not* necessary.

Braces have continued to be useful in paralytic curves providing the curve is small and flexible. Orthotic treatment of paralytic scoliosis is not recommended for curves above 50 degrees, rigid curves or patients over 12 years of age. Arthrodesis is usually preferable in such cases. Brace treatment seldom provides permanent correction of the curve, but it is quite useful for delaying surgery until the optimal age. The Milwaukee brace is most effective for thoracic curves and the molded plastic brace seems to be the most effective for lumbar curves.

D. *Neurofibromatosis*

Neurofibromatosis continues to remain a very troublesome cause of spinal deformity. The incidence of pseudarthrosis remains high and the incidence of paraplegia is second only to congenital kyphosis (tuberculosis excluded). Paralysis is most likely to occur in those cases which have a kyphotic component in addition to the scoliosis. The Milwaukee brace or other braces do not appear appropriate since statistical analysis of brace-treated patients has shown them to be not effective in controlling the curve. The procedure of choice remains arthrodesis. There is a more than usual pseudarthrosis rate, and for most patients it is recommended that the fusion mass be explored 6 months after surgery and additional autogenous bone added regardless of how good the fusion appears to be at the time of the exploration. A period of 1 year in a cast followed by Milwaukee brace or other brace treatment is recommended until the end of growth. Patients with neurofibromatosis appear to easily tolerate correction with halo-femoral traction, Cotrel traction or halo-hoop traction. Harrington instrumentation in addition to the above fusion technique is a good method for neurofibromatosis curves provided the serious curves have previously been corrected by traction techniques.

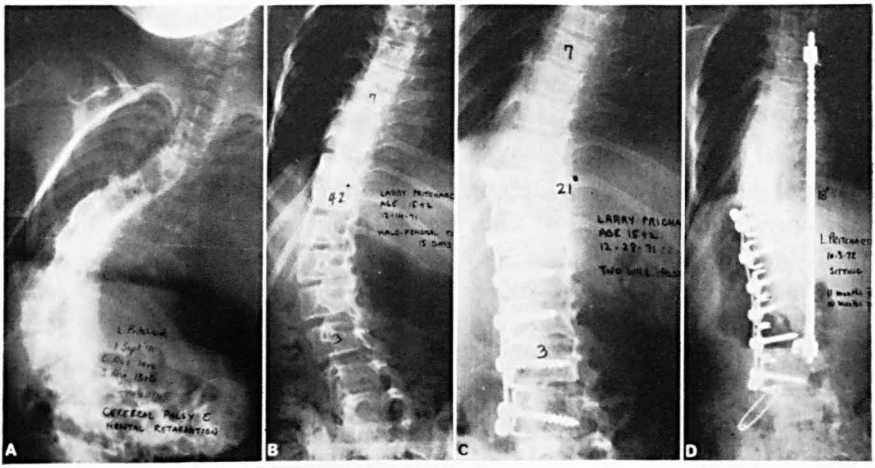


*Figure 8. A. A 13-year-old boy with a 100° scoliosis due to cerebral palsy. B. In halo-femoral traction, correction to 42°. C. Day of Dwyer instrumentation and anterior fusion, T11–L4. D. One year after posterior fusion, T4 to sacrum with Harrington instrumentation from T4 to L3 (should have gone to S1). Curve: 18°.*

## E. *Adult scoliosis*

One of the most interesting developments in the past 5 years has been in the treatment of the adult scoliotic. As various centres have become increasingly proficient in the treatment of scoliosis, large numbers of adults have come to these centres with problems related to curvature of the spine. The most frequent complaint appears to be pain and this is most prominent in lumbar curves. Patients with thoracic scoliosis are being seen because of progression of their curve during adult life.

Previous statements indicating that scoliosis does not progress in the adult have proven to be wrong, and various reports have indicated a definite tendency for progression in the adult, particularly if their curves are greater than 50 degrees at the end of growth.

Thus, an increasing number of adults are being treated for loss of lung capacity in thoracic curves or progressive pain problems in lumbar curves. Adults can be treated and a solid fusion obtained, but it is not as easy as in children or adolescents. The complication rate is higher and such problems as wound infection, pulmonary embolism, urinary tract infection and pseudarthrosis have been significantly higher in almost every series reported.

Nevertheless, the improved technologies, especially Harrington in-

strumentation and Dwyer instrumentation, have allowed adults to have surgery previously thought impossible. Adults require ambulation following surgery as they do not tolerate bedrest well, either physically or psychologically. Unfortunately, they require a longer period of immobilization to obtain a solid fusion and are less able to tolerate the external mobilization. Therefore, it is important that they understand very carefully the length of time involved in treatment program.

### F. *Scheuermann's disease*

One of the most ignored of orthopaedic problems has been Scheuermann's disease. In the past 2 years, significant series have been reported in terms of both surgical as well as brace treatment. It seems apparent that not all patients with Scheuermann's disease can be ignored, as many both need and will benefit from treatment. The best methods of treatment are plaster cast immobilization and Milwaukee brace treatment; both require correction of the curve and maintenance of the curve in the corrected position for a minimum of 1 year. By this time, many of the patients with Scheuermann's disease will have healed spontaneously, and can be removed gradually from support without regaining their deformity. Attempts to treat Scheuermann's disease by exercise alone or by underarm-level braces have universally failed.

Surgical treatment of Scheuermann's disease has been attempted, but posterior fusion alone for the individual who has completed growth and has painful Scheuermann's disease has not been successful. The posterior fusion mass is under distraction and usually most of the correction obtained at the time of surgery is lost. Therefore, most centres treating these types of problems have concluded that both anterior and posterior arthrodeses are necessary if Scheuermann's disease is to be operated upon. Surgery is rarely necessary for children with Scheuermann's disease since adequate brace or cast treatment will usually solve the problem in the growing child. Surgery is recommended for the individual who has completed growth and has a significant amount of pain in the curve area.

### G. *Tuberculosis of the spine*

Tuberculosis of the spine continues to be a major health problem in many of the less developed areas of the world. Even in highly civilized countries, an occasional case of tuberculosis of the spine is still found

and the lack of familiarity with its management can create problems.

Very considerable progress has been made in the past 10 years in treating this ancient and difficult problem. Controlled studies in many areas have indicated that ambulatory treatment with drugs is successful in many cases, but 15–20 per cent of patients still have unresolved lesions or progressing deformities. When surgical facilities are available, it appears most reasonable to excise the lesion, graft bone and immobilize. This, of course, requires an anterior approach to the lesion by the transthoracic route. The costotransversectomy approach provides the opportunity to drain an abcess but does not allow adequately excising a lesion or adequately bone grafting the spine.

For patients with paraparesis or paraplegia secondary to tuberculosis of the spine, the procedure of choice is the institution of drugs, stabilization of the patient's general condition, anterior transthoracic excision of the abscess with decompression of the spinal cord, plus anterior spinal fusion. This should be followed by posterior spinal fusion and adequate immobilization in a cast, usually a halo cast for thoracic spine, and a Risser cast for lumbar spine. Drug treatment alone is not recommended.

Drug treatment alone is indicated for early and mild lesions without significant collapse of vertebral bodies. If there is destruction of one or more vertebral bodies, then surgical excision in addition to drugs appears to be necessary. Thus, it is not a matter of surgery versus non-surgery, but selected patients should have only drugs and others should have both surgery and drugs.

Severe fixed kyphotic deformities have been most successfully treated in Hong Kong by anterior osteotomy of the spine, and correction in halo-hoop traction, posterior closing wedge osteotomy and fusion, and then anterior fusion. This is a long and extensive series of operations, but truly astounding results have been obtained in patients previously considered hopeless. Hopefully, the need for this extensive surgery will be eliminated by a more aggressive treatment of tuberculosis in its early stages.

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*Key words:* deformities, spinal; Dwyer instrumentation; Milwaukee brace

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