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ALTERATIONS IN VERTEBRAL GROWTH FOLLOWING PROLONGED PLASTER IMMOBILISATION

I. W. McCall, E. Galvin, J. P. O'Brien & W. M. Park

Departments for Spinal Disorders and Radiology, Institute of Orthopaedics, The Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire, U.K.

Long-term immobilisation in serial plasters for scoliosis, including the period of the adolescent growth spurt, leads to an increase in height of the vertebral bodies and a decrease of their height to width ratio. These changes are at the expense of the disc which is reduced in thickness. This stimulating effect on the vertebral body growth is probably due to the changes in mechanical forces.

Key words: idiopathic scoliosis; plaster immobilisation; vertebral growth

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The use of corrective plaster jackets for scoliosis was popularised by Abbott (1911), and became a common form of treatment until it was replaced by extensive posterior fusion with Harrington instrumentation. This treatment extended for prolonged periods of time including the adolescent growth spurt and fusion was not considered an integral part. We have had the opportunity to review three cases of idiopathic scoliosis treated in this way and have noted resultant growth abnormalities of the discs and vertebral bodies. These changes form the basis of this report.

MATERIAL AND METHODS

Three patients with infantile idiopathic scoliosis underwent treatment for an average period of 9.3 years. Serial AP X-rays were taken and measurements of the initial and final curves have been recorded (Table 1). Vertebral body measurements of L2 were made on the AP film. This vertebra was chosen as it was not distorted by the thoracic curve or by the angle of the X-ray beam.

The height was taken as the distance between the lines of the vertebral end plates and the width as the distance between the lateral limits of the lower vertebral end plate (Figure 1). The ratio of height to width was then calculated and recorded.

Table 1. Measurement of spinal curve

	First visit	Prior to fusion	Final curve
B.H.	21°	73°	63°
M.H.	48°	89°	99°
P.R.	53°	–	54°

Five cases of infantile idiopathic scoliosis not requiring therapy and for whom a similar series of films were available were used as controls. These were supplemented in the older age group with further controls taken from a school screening group for scoliosis.

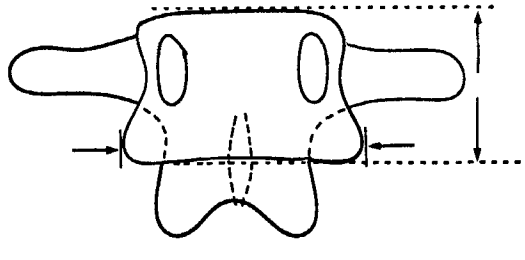

Figure 1. The reference points on L2 for the measurements of height and width are demonstrated.

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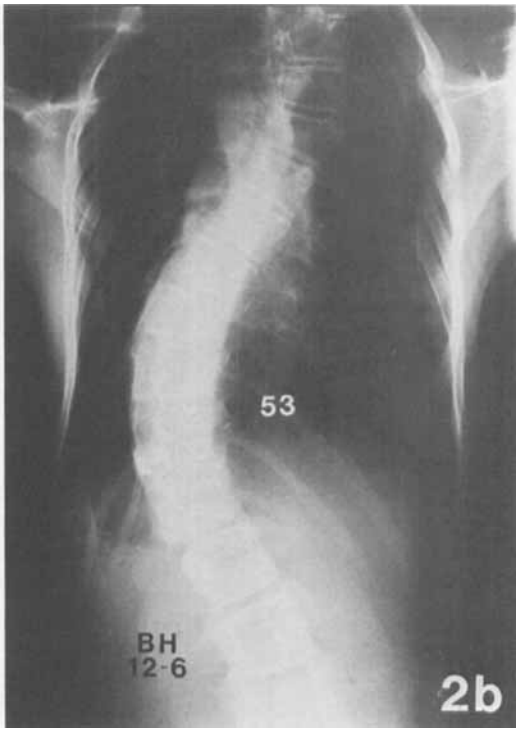

Figure 2a. B.H. The initial radiograph shows a 41° dorso-lumbar curve in a patient aged 1 year and 10 months. The height/width ratio of the vertebral bodies is normal.

Figure 2b,c. AP (b) and lateral (c) radiographs of the same patient, aged 12 years and 6 months. There is marked vertical elongation of all the lumbar vertebrae with decreased height/width ratio. The narrow 'rat-like' thoracic cage is also demonstrated in the AP view.

The disc height between L2/3 was measured and related to the L2 vertebral body height on the treated subjects at the time of cast removal.

Illustrative case report

B.H., with infantile idiopathic scoliosis, began treatment with repeated serial corrective Abbott's plasters at the age of 1 year 10 months (Figure 2A). At this stage the curve measured 41°. Treatment by plasters was carried out for 9 years and 3 months, the plasters being changed every 3 to 6 months, when they had become uncomfortable. Radiographs confirmed that the curve measured 52° when the patient was 12.5 years old.

The vertebral body height was by then clearly increased in relation to the width (Figure 2B and C).

However, the curve deteriorated during the growth spurt and measured 73° three years later. As she was one of the later patients she was treated by posterior arthrodesis. At postoperative follow-up, her curve measured 63° at which angle it had stabilised and was solidly fused.

RESULTS

The average period of treatment was 9.3 years. In two cases the final curve showed a considerable deterioration over the initial curve. In the third case, the curve was maintained unchanged by the treatment (Table 1). There was marked restriction of thoracic capacity due to the constrictive effects of the plaster and this was associated with tapering of the ribs as a structural response, which was reminiscent of a rodent thoracic cage (Figure 2B).

The vertebral height/width ratios are shown in Table 2. These figures confirm the visual impression that the vertebral height is significantly increased in relation to the width as compared to the controls. The major reduction in the ratio takes place in the first few years of treatment and becomes more stabilised at later stages. The growth spurt does not appear to have a significant effect on the ratio. The control series suggests that there is little change in this ratio over the period of growth of the vertebral bodies in a normal situation. The increase in height is shown to occur at the expense of the discs (Figure 3), where the ratio of vertebral height to disc height averaged 1:5 (Table 3). The normal range is 1:3–1:4.

Figure 3. The increased vertebral height is at the expense of disc height.

Table 2. Height to width ratio of L2

Age	Controls	B.H.	P.R.	M.H.
1½	1.76	*1.85		
3	1.76	1.57		*1.82
5	1.73	1.55	*1.88	1.58
7	1.63	1.31	1.79	1.44
9	1.65	1.26	1.44	
11	1.80	1.22		1.48
12	1.72		1.34	1.38
13	1.70	1.20	1.21	
15	1.70		1.20	1.36

* indicates the measurement at commencement of cast treatment.

Table 3. Ratio of body height to disc height

B.H.	1: 4.8
M.H.	1: 4.9
P.R.	1: 5.3

DISCUSSION

The treatment of progressive infantile idiopathic scoliosis by long-term plaster immobilisation of the spine aims to counteract the aggravating factors of mechanical and gravitational forces. Its effect on bone growth has not previously been given any attention. Indeed, the measurement of absolute growth and physiological studies of bone growth in the spine appear to be neglected areas (Burwell 1971). However, response of the

growth cartilage of the long bone to outside influences has received more attention. In particular, its reaction to mechanical stress has been described as the Heuter-Volkmann phenomenon. According to this mechanical law, when pressure is decreased across an epiphyseal centre, increased growth will ensue (Heuter 1862) and vice-versa (Volkmann 1869). The growth behaviour of the vertebral body is similar to any long bone in that it increases its height from cartilage growth plates at either end of the vertebral body (Bick & Copel 1950). It would, therefore, seem likely that the response to pressure of the vertebral body growth would follow the same principle. Experimental support has come from Nachlas & Borden (1951), who showed that a staple applied unilaterally across the vertebral bodies and discs of the spines of dogs would produce a curve and that subsequent removal and replacement on the opposite side reversed the deformity.

The reversal of wedging of the vertebrae in patients wearing a Milwaukee brace, reported by McEwan (1971), would appear to verify this.

It is therefore probable that the reduction in mechanical force on the growing spine at such an early age is a major factor in this elongation process, especially as it occurs progressively and from the start of treatment and is not related directly to the growth spurt.

The increase in the vertebral height is at the expense of the disc space, which shows a significantly altered ratio of disc height to vertebral body height. This loss of disc height/vertebral body ratio has also been shown to occur after posterior fusion (Risser et al. 1966) and is due to the compressibility of the disc material.

Other circumstances have produced altered vertebral growth. In patients with severe neglected tuberculosis or congenital kyphoses, it is common for the lumbar vertebral bodies in the lower limb of the kyphosis to have increased vertebral height (Hodson et al. 1969).

These authors stated that the changes were due to the fact that the weight was no longer being transmitted directly from the upper to the lower surface of the vertebral body, and the growth plate, no longer in compression, grows more rapidly. Burwell (1971) has stated that there is no convincing evidence that relief from weight-bearing has a stimulatory effect on the longitudinal limb-bone growth, but it would seem that such a situation does exist in the spine. Despite its effect on vertebral wedging, an increase in vertebral body height to width ratio has not been seen in patients in a Milwaukee brace (Blount 1978, personal communication). The lack of significant distraction and the positive use of muscular activity are key features with this form of support therapy. This distinction from the constrictive and distractive forces of the Abbott plaster is clearly fundamental in the differing vertebral growth responses of the two treatments.

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Correspondence to: I. W. McCall, F.R.C.R., The Department of Radiology, Institute of Orthopaedics, The Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire, United Kingdom