THE INFLUENCE ON THE SPINE OF LEG-LENGTH DISCREPANCY AFTER FEMORAL FRACTURE

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We investigated the spines of 15 patients who had significant leg-length inequality as a result of femoral shaft fractures sustained after skeletal maturity but below the age of 21 years. The patients were examined at least 10 years after fracture. The spines were studied clinically and radiographically before and after correction of leg-length inequality with a shoe-raise. Lateral spinal flexion was measured from radiographs. The lumbar scoliosis associated with the leg-length inequality was compensatory: after equalisation of leg-length the overall curve and the axial rotation were corrected completely. There was also an equal range of lateral flexion to either side after correction. Minor malalignments of the whole spine remained despite correction of the compensatory scoliosis, and within the lumbar spine correction of the scoliosis had not occurred equally at all levels. No patients complained of significant discomfort and neither structural abnormalities nor degenerative changes were seen on the radiographs.

There has always been considerable controversy about the relation between leg-length inequality and the development of spinal pathology. Though the scoliosis associated with leg-length inequality is usually described as compensatory, non-structural and non-progressive (James 1976; Moe et al. 1978), some studies have shown that structural changes as well as back pain may develop (Scheller 1964; Giles and Taylor 1981, 1982).

A recent study of young adults who had significant untreated leg-length inequality from a very early age has shown that abnormalities of the Cobb angle and of spinal rotation remain after correction of the leg-length discrepancy (Papaioannou, Stokes and Kenwright 1982); significant asymmetry of lateral spinal bending also remains after correction.

This previous study has been extended here to assess structural changes in the spine following leg-length inequality developing after skeletal maturity, and to assess the effect upon the spine of correcting the inequality.

METHODS

The patients investigated had acquired leg-length discrepancy as a result of femoral shaft fractures sustained after skeletal maturity (between the ages of 15 and 21 years). Forty such patients were examined at least 10 years after injury. Those patients with isolated femoral fractures with 1.5 centimetres or more of shortening were investigated further. Those with painful joints of the lower limbs were excluded. No patients had sustained spinal injury.

Fifteen patients fulfilled the above criteria. Their average leg-length discrepancy was three centimetres (range 1.5 to 5.5 centimetres); only one patient had less than two centimetres of shortening and only one had worn a shoe-raise for any period of time. The clinical examination included measurement of spinal movements.

Standing anteroposterior radiographs of the spine were taken, first with the patient barefoot with both heels on the floor and both knees fully extended. The cassette was placed behind a sheet of methylmethacrylate with accurately aligned horizontal and vertical steel wires set on its surface. These wires provided reference lines for each film. The exposure was made on a $350 \times 430$ millimetre film that showed the position of the femoral heads, the iliac crests and most of the dorsolumbar spine. The beam was centred at the level of the fifth lumbar vertebra. The distance from the horizontal reference line to each femoral head was measured from this film. The tube to film distance for these exposures was one metre. The standing position of the patient was such that the femoral heads were approximately 20 centimetres from the film, which gave a magnification factor of 20 per cent. After correction for magnification we calculated the leg-length inequality in millimetres.

A second exposure was made under identical conditions after equalising leg length by placing an appropriately sized wooden block beneath the short leg. The beam was raised 60 millimetres to minimise gonadal irradiation.

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The following measurements were made from the two films: the angle to the horizontal reference line made by a line drawn along the upper surface of the sacrum; and the angle to the horizontal made by a line drawn through the superior articular surface of both femoral heads. The Cobb angle of the spine was also measured (the upper and lower vertebrae used in this measurement were recorded).

A further series of films was taken to assess lateral bending. The patient was asked to bend maximally to the right and then to the left. Radiographs in both positions were taken before and after the correction of leg-length discrepancy. The range of lateral bending was assessed as the angle subtended between a perpendicular line drawn from the superior surface of the uppermost vertebra in the thoracic region visible on the film, to a perpendicular drawn from the superior surface of the first sacral vertebra. The radiographic technique in the lateral bending films employed a large air gap and this minimised the exposure to irradiation (Ardran et al. 1980). Axial rotation of vertebrae was measured by the method of Nash and Moe (1969). Degenerative changes were looked for as well as wedged vertebrae, asymmetric end-plates and traction spurs (Giles and Taylor 1982).

Figure 1—Anteroposterior radiograph showing the compensatory thoracolumbar scoliosis in a patient with a leg-length discrepancy of four centimetres. The horizontal and vertical reference lines used for calculating the angle of sacral tilt can be clearly seen. Figure 2—Anteroposterior radiograph of the same patient demonstrating correction of the curve after equalisation of leg length. There is a minor residual tilt of the whole spine. This spine showed normal symmetrical lateral flexion.

RESULTS

There was no evidence of pelvic asymmetry as judged by the angle between the horizontal reference line and the upper border of the sacrum, and the angle between the reference line and a line joining the top of both femoral heads. After correction of leg-length discrepancy the upper border of the sacrum became horizontal in nearly all patients (mean angle of sacral tilt 1.36 degrees ± 1.3 degrees).

Fourteen of the 15 patients had the expected lateral curve convex to the short limb. The lowest vertebra in the curve was the first sacral segment in each case. In six of the patients examined the curve was restricted to the lumbar region, the first lumbar vertebra being the uppermost vertebra in the curve. In the remaining eight patients there was a longer thoracolumbar curve extending as far as the upper border of the eighth thoracic vertebra. There was no correlation between the length of the curve and the leg-length inequality.

The Cobb angle of the scoliosis was related to the amount of sacral tilt and to the leg-length discrepancy, so that the spine was compensated above the pelvic tilt. However, the compensation was not accurate and in most spines the upper vertebra of the compensatory curve was not directly above the sacral body (Fig. 1).

Figure 3—Anteroposterior radiograph showing the compensatory lumbar scoliosis in a patient with a leg-length discrepancy of 3.5 centimetres and a Cobb angle of 15 degrees. Figure 4—The same patient after the leg lengths had been equalised. The total Cobb angle has been corrected to 0 degrees. Most of this correction has occurred in the lower lumbar spinal segment.

After correction of the leg-length discrepancy the spines of five patients corrected to normal with a residual Cobb angle of less than two degrees. In the ten other patients, though there was a similar degree of correction of the spinal curve, there was a minor residual tilt of the spine above the lumbar region (Fig. 2). Also, in six of these 10 patients, though the overall Cobb angle was reduced after leg-length equalisation, the correction of scoliosis was not evenly distributed within the lumbar spine and local asymmetries of vertebral alignment developed (Figs 3 and 4). There was no relationship
between the size of the leg-length discrepancy and the magnitude of these abnormal tilts or asymmetries.

Clinical assessment of lateral bending of the spine before correction of leg inequality showed there to be a greater range of movement towards the shorter leg. Paradoxically, because of the pre-existing sacral tilt, this is not reflected in the radiographic measurement of lateral flexion where mean lateral flexion towards the short leg measured 26.9 degrees ± 10.2 degrees (range 5 to 44 degrees), and mean lateral flexion towards the long leg was 37.2 degrees ± 7.4 degrees (range 23 to 48 degrees). These values represent a statistically significant difference between the range of lateral flexion in each direction (t = 3.995, P = < 0.001).

After equalisation of leg length there was no significant difference between the range of flexion to either side. Mean lateral flexion towards the previously short leg was 32.1 degrees ± 5.2 degrees (range 26 to 43 degrees), and mean flexion towards the long leg was 34.1 degrees ± 5.5 degrees (range 22 to 45 degrees). Although the total range of movement to each side was almost equal, there were still minor asymmetries of lateral flexion between individual segments (Figs 5 and 6).

In only one patient was any significant rotatory abnormality measured in the lumbar spine after equalisation of leg length. Degenerative changes were not seen in the lumbar spine on any of the radiographs. Wedged vertebrae and traction spurs were not seen. Asymmetrical concavities of end-plates were seen in two spines. No patients complained of low back pain nor had any had significant back pain during the previous 10 years.

DISCUSSION

The patients selected for investigation had sustained femoral shaft fractures shortly after skeletal maturity and had been left with quite significant leg-length discrepancies. During the 10-year period between fracture and review only one patient had worn a raised shoe and that for only a short period of time.

After correction of leg length these patients were found to have mobile spines with symmetrical ranges of total lateral flexion as assessed radiographically and normal flexion and extension as assessed clinically. Cobb

![Fig. 5](image1)

![Fig. 6](image2)

Figures 5 and 6—Anteroposterior radiographs showing lateral flexion. When flexing laterally all segments of the lumbar spine show mobility and the total range of movement to the right (32 degrees) and to the left (28 degrees) is almost equal. However, there is residual stiffness in the upper lumbar region when flexing towards the previously shorter left leg.

angles of the lumbar spine corrected almost completely in all patients after leg equalisation and a residual rotatory deformity was seen in only one patient. There were minor lateral angulatory asymmetries within the corrected lumbar spine; these caused a trivial “scoliosis” and localised restrictions of movement which were reversed on lateral flexion. There were, however, some minor tilts of the upper spine.

These radiographic abnormalities were very variable in degree and not related to the amount of leg-length inequality. The abnormalities were not significantly different from those recorded in a previous study of young adults who had had leg-length discrepancies since childhood (Papaioannou et al. 1982). The only significant difference between the two groups of patients is that the
range of lateral flexion after correction of shortening is markedly asymmetrical in those who have had leg-length inequality since childhood, and is symmetrical in those who have acquired the discrepancy after skeletal maturity.

The observations on the effect of equalising leg-length were based on examinations carried out on one day; we have no evidence as to whether they would have been the same if leg length had been equalised over a long period of time.

If operative correction of leg-length inequality is to be considered, perhaps a corrective shoe-raise should first be worn for several months. Radiographs of the type described in this paper could then be taken and an assessment made of the effect of correcting sacral tilt upon spinal balance.

It would appear, therefore, that in this group of patients, acquired leg-length discrepancy produced little permanent structural abnormality in the lumbar spine and no degenerative change in the 10-year period after the fracture which led to shortening.

The patients were still young adults at the time of examination and it is possible that structural or degenerative changes would develop later.

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REFERENCES


