Pelvic remodelling after the Chiari osteotomy

A LONG-TERM REVIEW

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Survivorship analysis of 215 medial displacement pelvic osteotomies undertaken for symptomatic, incongruent dysplasia of the hip since 1966 showed that four of every five hips had not required conversion to a total hip arthroplasty.

The radiological characteristics of 86 osteotomies were evaluated at a mean of 18 years (5 to 30) after surgery which was performed at the age of 15.9 ± 9.5 years. Revision was significantly (p < 0.05) more likely in those patients operated on after the age of 25 years. The centre-edge (CE) angle increased from 2.5 ± 13.9˚ before to 41.8 ± 15.0˚ immediately after operation. The increase in CE angle was maintained at later review (38.5 ± 16.5˚). Even with severe dysplasia with a CE angle less than zero a substantial improvement in the cover of the femoral head was achieved, usually by medial shift of the lower pelvic fragment. However, the head was not invariably medialised by the osteotomy and lateral movement of the ilium was noted when the position of the joint was relatively medial before operation or when the hip was arthritic. In the longer term pelvic remodelling did not reverse the medialisation produced by the osteotomy, and the cover of the femoral head was maintained.

The medial displacement pelvic osteotomy of Chiari1 has been of value in the management of symptomatic, incongruous dysplasia of the hip when redirectional osteotomy has not been effective. It is a procedure best reserved for late adolescence or early adult life, either in patients who have undergone previous reconstructive osteotomies of the pelvis and femur or in those presenting de novo with established dysplasia, acetabular laterisation, deformity of the femoral head, incongruity and early degenerative change. The procedure may occasionally be required to salvage the unstable hip in childhood.

In 1974 Chiari2 reviewed the records of 200 of his patients and his results have been mirrored by our own experience of the operation.3 The technique, radiological appearances and longer term outcome of the osteotomy were reported in 19874 and we now wish to present the post-operative survival at up to 30 years, assessing the maintenance of cover of the femoral head and late remodelling of the pelvis.

Patients and Methods

The osteotomy was carried out in 215 dysplastic hips in older children, adolescents and young adults. Of the total of 191 patients (12 bilateral procedures), 155 (81%) were female.

The survival of these hips after surgery was recorded using conversion to hip arthroplasty or arthrodesis as the end-point. All the patients were contacted about their progress after operation and their case notes retrieved.

We were able to review the immediate post-operative and current pelvic radiographs of 86 unilateral pelvic osteotomies which had been followed for 5 to 30 years and had a similar survival curve to the full series.

The centre-edge (CE) angle of Wiberg5 was used to evaluate the pre-operative and all post-operative films. This measurement can be difficult since the femoral head may be aspherical and the lateral edge of the acetabulum is often notched or sloping.4 Nevertheless, calculation of the CE angle was preferred to assessment of the cover of the femoral head expressed as a percentage4,6 since anatomical variations again make the calculation difficult. It is accepted that both measurements offer no more than a means of monitoring lateral support for the femoral head when articular cover is incomplete.

The centre of the femoral head in relation to the midline was compared with the contralateral, asymptomatic hip using the ratio A/A+B (Fig. 1) in which A is the distance perpendicular to the midline of the sacrum on the side of


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the abnormal hip and B the distance on the opposite side. If the hips are symmetrically disposed to the midline A = B and the ratio will be 0.5. Medialisation produces a ratio less than 0.5 and lateralisation a ratio greater than 0.5. This measurement does not take into account forward or backward shift of the hip in the sagittal plane.

**Results**

The survival of the osteotomy at five years was 99%. By 20 years, 5.3% of hips had required revision to a total joint replacement. The overall predicted survival at 30 years decreased to 85.5%. One patient in the series died before revision. The survival curve for the complete series of 215 Chiari osteotomies is shown in Figure 2. In the smaller group of 86 osteotomies evaluated radiographically at a mean of 18 years (5 to 30) after the operation, the mean age at revision was 41.4 ± 9.5 years (30 to 64) and the survivorship of 83.3% was similar to that of the whole group. Those who required further surgery were significantly older (27.4 ± 9.7 years) at the initial operation than those whose hips continued to function well (p < 0.05). This was not solely a function of the degree of osteoarthritis or clinical stiffening encountered post-operatively.

The CE angle was increased from 2.5 ± 13.9° to 41.8 ± 15.0° immediately after operation and this improvement in cover of the head was maintained on the current radiograph (38.5 ± 16.5°). In patients below the age of 15 years the post-operative CE angles for the right and left hips were 42.3 ± 14.8° and 43.7 ± 15.8°, respectively. For those aged between 15 and 25 years the results were similar but in those aged over 25 years these values were less being 37.1 ± 17.3° and 38.3 ± 12.4° for right and left sides. These results were not significant. The scatter diagram (Fig. 3) illustrates that the CE angle was always increased by the osteotomy, and even in cases of severe hip dysplasia with a CE angle of less than 0° a substantial improvement in cover was achieved. Most patients gained more than 20°. Ideally, the CE angle should be 30° or more after the operation producing cover of approximately 80% of the head.

The displacement produced by the osteotomy (Fig. 4) gave most patients better cover of the head secondary to medial shift of the distal pelvic segment or by a combina-

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**Fig. 1**

Diagram showing that the position of the dysplastic femoral head is expressed as the distance from the midline of the pelvis compared with the contralateral femoral head (A/A+B). Medialisation produces a ratio less than 0.5 and lateralisation a ratio greater than 0.5.

**Fig. 2**

Kaplan-Meier survival curve of the dysplastic hip after the Chiari osteotomy in 215 hips using conversion to a hip arthroplasty or arthrodesis as the end-point.

**Fig. 3**

The scatter diagram shows that the CE angle was increased in all of the 86 hips reviewed.
tion of this together with lateralisation of the wing of the ilium. Three heads shown in the top left quadrant of Figure 4 were slightly lateralised post-operatively, and the lower left quadrant indicates that of the remaining five dysplastic hips which were not obviously lateralised pre-operatively, only one was convincingly moved further medially (Fig. 4, lower left quadrant). Figure 5 shows that the percentage change in medialisation lay principally between 0 and 10 (0.50 ± 0.05). Greater medial displacement was more readily achieved in the younger patients.

In the longer term remodelling changed the distribution of the medialisation curve to a minor extent (Fig. 6) with a

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**Fig. 4**

The scatter diagram of the displacement produced by the osteotomy.

**Fig. 5**

The percentage change in medialisation, showing that the osteotomy failed to medialise the femoral head in four cases (<-1%).

**Fig. 6**

Graph showing that when the pre-operative radiograph is compared with the initial and last post-operative radiographs, pelvic remodelling affects the immediate medialisation of the hip to a relatively minor degree in the long term.
lessening of extreme medialisation (<0.45) and greater clustering around the ratio of 0.5. However, the beneficial effects of the osteotomy were maintained, with all but one measurement remaining within 0.1 of the ratio achieved immediately after operation. Lateralisation of the iliac wing was also apparent from a change in the orientation and width of the proximal pelvic segment, although this was difficult to quantitate and did not correlate with obvious lateralisation derived from the measurement of the A/A+B ratio. A change in the ratio did not occur after the age of 38 years, the increase in the CE angle being the result of lateral shift of the iliac wing since the inferior pelvic fragment was presumably too rigid to alter its position.

Discussion
Despite Chiari’s espousal of the osteotomy in younger children (Fig. 7) it is generally agreed that it gives the best results in adolescence and young adult life (Fig. 8).7-9 The operation is occasionally required to salvage the hip in childhood when more appropriate reconstructive surgery has failed (Fig. 9). The extent to which the inferior pelvic fragment displaces medially is variable,4,10,11 and attention to surgical technique is important. Even then, posterolateral cover is often deficient.12 Posterior hinging should be avoided by careful displacement of the osteotomy at the sciatic notch, with radiolucent retractors in place13,14 to prevent injury to the sciatic nerve. In spite of the care taken to produce a displacement in the mature pelvis of approximately 1 cm, some of the relative shift will occur above the osteotomy by lateral opening of the iliac wing anteriorly. This improvement in cover of the femoral head does not change with time in developmental dysplasia of the hip. By contrast, the long-term results in patients with myelomeningocele are disappointing.15
Using the ratio A/A+B to define displacement of the femoral head in relation to the midline, it has been shown that there is a perceptible medialisation of the joint after the osteotomy. However, as noted by Reynolds,9 the pelvis becomes more rigid in later adult life and both the ability to shift the osteotomy and the subsequent clinical results are impaired after the age of 35 years. The procedure is of dubious benefit when the hip is stiffening from osteoarthritic change and should rarely be recommended after the age of 40 years (Fig. 10). The Chiari osteotomy is more likely to achieve medialisation when the dysplastic hip is convincingly lateralised. When the pivot is less displaced compared with the other side a redirectional periacetabular or triple osteotomy is indicated provided that congruency and the range of movement in the hip allow.

The CE angle is reliably increased if the osteotomy is executed properly, and even a very shallow acetabulum with a negative CE angle may benefit. In our patients the CE angle was increased from 2.5 ± 13.9° to 41.8 ± 15.0° and we have previously shown that this reorientation improved other parameters measured from the anteroposterior radiographic projection of the pelvis. Lack et al16 confirmed that a commensurate improvement in cover of the anterior aspect of the femoral head occurred on the ‘faux-profile’ lateral projection. Cover of at least 80% should be achieved, but there is no merit in excessive displacement producing greater than 100% cover since union of the osteotomy may be impaired and a limp may persist.17 Remodelling of the pelvis does not reduce support of the head although associated coxa valga may require correction.3,18 The alteration in architecture of the pelvic wall largely affects the medial pillar and the brim, producing remodelling which may not be seen after a Salter osteotomy of the mature pelvis.19

Mannor et al15 recorded a revision rate of 20% two to 19 years after Chiari osteotomy. As with any other osteotomy of the hip, patient selection is paramount. Long-term review inevitably shows a decline in the relief from pain, with an associated decrease in function.16,17 As shown in the Kaplan-Meier survival graph (Fig. 2) there are some relatively early revisions, although the survival at 20 years was almost 95%.

There have been few reports of the survival of the hip following the osteotomy after 20 years.6,18,20 Studies describing the outcome over two to 20 years have suggested that the degenerative changes are retarded but not halted.4,5,7,9,16,19 Høgh and Macnicol4 and Calvert et al8 confirmed that the radiographic progression of osteoarthritis was linear over time. Better function was achieved if the hip was operated on when the patient was younger, preferably by the age of 20 to 25 years. We found a significant difference in the age of those patients whose hips continued to function well, 18.7 ± 13.9 years old at operation, compared with those in whom revision was required, 27.4 ± 9.7 years at the time of the procedure. While some of the improved survival can be attributed to the hip being less degenerative
in the younger group, the evidence does suggest that earlier osteotomy, within ten years of skeletal maturity, will produce the most satisfactory outcome in terms of symptomatic relief and survival of the joint. In later childhood the Chiari osteotomy is rarely indicated and in these cases we have not encountered any evidence of the ‘anti-Chiari effect’ described by Purath.

We conclude that the medial displacement pelvic osteotomy of Chiari provides durable support of the femoral head in patients with symptomatic dysplasia of the hip when deformity of the head and acetabular distortion preclude acetabular realignment. The biomechanics of the displacement osteotomy are complex and inevitably involve some lateralisation of the iliac wing which becomes more likely when the procedure is undertaken in the older patient. Although the slope of the acetabulum is increased slightly by the osteotomy, support of the femoral head is substantially improved. The technique produces some variability in the post-operative radiographic appearance, but improvement in the CE angle and medialisation of the femoral head will stabilise the hip for periods of up to 30 years. After early adult life the osteotomy is less capable of producing adequate displacement and the outcome becomes unpredictable. As a guiding principle, realignment of the dysplastic acetabulum should be attempted in childhood, or cover of the femoral head normalised by a periacetabular procedure in the symptomatic adolescent. The Chiari osteotomy still has a role in those cases in which incongruity and poor acetabular development make other reconstructive procedures inappropriate.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


