Bilateral hip reconstruction in severe whole-body cerebral palsy

TEN-YEAR FOLLOW-UP RESULTS

The results of a functional, clinical and radiological study of 30 children (60 hips) with whole-body cerebral palsy were reviewed at a mean follow-up of 10.2 years (9.5 to 11). Correction of windsweep deformity of the hips was performed by bilateral simultaneous combined soft-tissue and bony surgery at a mean age of 7.7 years (3.1 to 12.2).

We were able to recall 22 patients; five had died of unrelated causes and three were lost to follow-up. Evaluation involved interviews with patients/carers and clinical and radiological examination.

The gross motor functional classification system was used to assess overall motor function and showed improvement in seven patients. Of the 12 patients thought to have pain pre-operatively, only one had pain post-operatively. Improved handling was reported in 18 of 22 patients (82%). Those with handling problems were attributed by the carers to growth of the patients. All patients/carers considered the procedure worthwhile. The range of hip movements improved, and the mean windsweep index improved from 50 pre-operatively to 36 at follow-up.

The migration percentage and centre-edge angle were assessed on plain radiographs. Radiological containment improved, the mean migration percentage improved from 50 pre-operatively to 20 at follow-up and the mean centre-edge angle improved from -5˚ to 29˚.

No statistical difference was noted between the three-year and ten-year follow-up results, indicating that the improvements in clinical and radiological outcome had been maintained.

Cerebral palsy is a disorder of posture and movement caused by a non-progressive injury to the immature brain, which is seen in 1.5 to 2.5 children per 1000 live births.1 The non-progressive central pattern of the disease contrasts with the progressive deterioration of peripheral motor function that occurs during growth, associated with increasing muscle contracture and secondary bony deformity. The hip is commonly involved with abnormalities, including coxa valga, malorientation of the proximal femur and acetabular dysplasia. These may deteriorate, leading to progressive subluxation and dislocation.2,3

The incidence of hip dysplasia and dislocation in patients with cerebral palsy varies according to the clinical pattern. The frequency correlates to the severity of motor and intellectual impairment6 and the level of independent mobility.5 Patients with spastic diplegia who can walk rarely present with subluxation of the hip.6 In patients with severe whole-body involvement, instability of the hip has been reported in up to 60%.7 This figure increases as fixed flexion-adduction contractures develop.8 Subluxation or dislocation of the hip in total body involvement is often bilateral,4 with the clinical pattern of contractures being asymmetrical and often associated with pelvic obliquity and spinal deformity.4

A windsweep deformity may develop, with the adducted, flexed and internally-rotated hip tending to sublux posteriorly7 and the contra-lateral abducted, extended and externally-rotated hip becoming displaced anteriorly (Fig. 1). Subluxation of the abducted hip is difficult to identify on anteroposterior (AP) pelvic radiographs, but can be detected clinically by palpation of the prominent femoral head in the groin.

The aim of this study was to determine whether bilateral, simultaneous, soft-tissue and bony hip surgery can produce sustained clinical, radiological and functional improvement in the mid- to long-term.

Patients and Methods

A group of 30 children (60 hips) with whole-body cerebral palsy were reviewed ten years after surgery following approval by the
Hospital Ethical Committee. All had undergone bilateral simultaneous combined soft-tissue and bony hip reconstruction between 1990 and 1997.

There were 12 boys and 18 girls, with a mean age at the time of surgery of 7.7 years (3.1 to 12.2). In the 19 dystonic patients (64%), five were windswept to the left and 14 to the right; in 11 spastic patients (36%), five were windswept to the left and six to the right.

Seven of the dystonic patients and three of the spastic patients had undergone previous soft-tissue procedures at other centres before being referred to us. The effect of previous surgery on the outcome was investigated.

All patients were assessed at a designated research clinic at a mean follow-up time of 10.2 years (9.5 to 11). Three were unavailable for review and five had died from unrelated causes and were excluded. For the remaining 22 patients, radiological and functional records were complete.

Clinical assessment. The range of passive movement and fixed-flexion contractures of each hip were recorded preoperatively under general anaesthesia and were repeated at a median of three and ten years postoperatively. The total range of hip movement was also assessed before surgery and three and ten years afterwards, as the sum of the difference between hip flexion and fixed-flexion deformity, plus the internal rotation, external rotation and abduction and adduction of each hip recorded in flexion.

The windsweep deformity was assessed by measuring abduction and adduction in flexion. The windsweep index9 was calculated as the difference between the sum of the abduction of one hip and adduction of the contralateral hip and vice versa (i.e. abduction R + adduction L minus adduction R + abduction L), and was also recorded preoperatively and at three and ten years postoperatively. A reduction in windsweep index at follow-up was considered to be an improvement in the symmetry of the pelvis and hips.

Radiological assessment. The Reimers migration percentage and centre-edge angle were measured for both hips on AP radiographs of the pelvis.10-12 Hips were considered to be subluxed when the migration percentage was greater than 33% and dislocated when it was 100%.10

Functional assessment. The gross motor function classification system for cerebral palsy was used to assess gross motor function. This system was published in 1997 after the initial functional assessment of our patients.13 Our recorded functional data were sufficient to allow us to apply this system retrospectively to our preoperative patients for comparison with its prospective use at ten-year follow-up.

This group of patients had little verbal communication and pain could only be subjectively assessed by the carers and physiotherapist. This depended on apparent distress on movement of the hip during examination and daily activities. A confidential questionnaire was given to all parents and carers to establish their opinion on the ease of handling of the patient and function, including transfers, seating, and nursing before and after the operation, in addition to their overall satisfaction with the outcome.

Operative technique. The indications for surgery were increased asymmetry, radiological subluxation or dislocation, and pain. All patients underwent bilateral femoral varus derotation osteotomy with shortening, placing the femur in the mid-range of rotation in flexion and extension. The acetabular osteotomy was hinged on the triradiate cartilage to provide optimum cover. All hips were reduced and placed in a hip spica, as was common practice at that time. Satisfactory reduction was confirmed by an AP radiograph of the pelvis in the spica. Soft-tissue surgery was performed selectively, depending on the preoperative assessment and the examination of hip movements under anaesthesia after the corrective bony procedure had been carried out.

In the 11 spastic patients, six underwent acetabuloplasty on the adducted side and three bilateral acetabuloplasty. Psoas and/or adductor release was carried out unilaterally in three patients and bilaterally in seven.

Acetabuloplasty on the adducted side was performed in eight of 19 dystonic patients and bilateral acetabuloplasty in three. Psoas and/or adductor release was carried out unilaterally in 11 patients and bilaterally in six.
lateral release of gluteus maximus and tensor fascia lata was carried out in four patients.

All patients were put into a full hip spica for six weeks and given a spica transporter to take home, allowing early re-integration of the child into the community. Pain and spasm were controlled post-operatively by intravenous midazolam and epidural anaesthesia for two to four days, with close supervision by the pain control team.

At six weeks, all patients were re-admitted to hospital for removal of the spica and controlled mobilisation in gaiters with physiotherapy for five days. The aim was to reduce the risk of fractures in osteoporotic bone and to retrain the carers in handling and positioning. They were then discharged home with a fitted sleeping shell, and continued physiotherapy for one month. Post-operative complications in both groups were recorded. All metalwork was removed at a mean of 12 months after surgery.

**Results**

**Clinical outcome.** The combined range of abduction and adduction in flexion for each hip increased significantly from a mean of 48˚ (SD 10˚) to 78˚ (SD 19˚) at ten years. There was no difference between the dystonic and spastic groups (Mann-Whitney U test, p = 0.57) or between those who had previous surgery and those who had not (Mann-Whitney U test, p = 0.81). Fixed-flexion deformity improved from a mean of 15˚ (SD 12˚) pre-operatively to 7.4˚ (SD 12˚). The total range of movement was also significantly improved, from a mean of 201˚ (SD 23˚) to 244˚ (SD 32˚). Mean hip flexion was significantly reduced from a mean of 113˚ (SD 7˚) to 97˚ (SD 16˚) (Table I). The windsweep index was significantly reduced from a mean of 50˚ (SD 39˚) pre-operatively to 36˚ (SD 38˚) at the ten-year follow-up.

There was no statistical difference between the dystonic and spastic groups (Mann-Whitney U test, p = 0.55), or between those who had previous surgery and those who had not (Mann-Whitney U test, p = 0.21) in the evaluation of change in mean windsweep index (Table II).

**Radiological outcome.** Complete radiological records were available for all 22 patients. Post-operative radiographs demonstrated a significant reduction in the incidence of subluxation and dislocation of the hips at the most recent follow-up. At the ten-year follow-up review, 91% of the patients had achieved skeletal maturity radiologically.

Pre-operatively, 32 of 44 hips (73%) had a migration percentage > 33, and eight of the 22 patients (36%) had bilateral subluxation or dislocation. Of the 32 hips with a migration percentage > 33 pre-operatively, five (15.6%) had a migration percentage of 100 and were, by definition, dislocated. This compares to five of 44 hips (11%) found to be subluxed and none dislocated ten years after operation (Table III).

The mean migration percentage improved from 50˚ (SD 5˚) pre-operatively to 20˚ (SD 3˚) at the ten-year follow-up (p < 0.001). The mean centre-edge angle (also improved significantly, from -5˚ (SD 1˚) to 29˚ (SD 2˚) p < 0.001).

**Table I.** Pre- and post-operative data for 22 children with quadriplegic cerebral palsy who underwent bilateral hip surgery

<table>
<thead>
<tr>
<th>Pre-operative (mean, SD)</th>
<th>Three-year post-operative (mean, SD)</th>
<th>Ten-year post-operative (mean, SD)</th>
<th>Pre-operative and ten-year post-operative difference (mean, SD)</th>
<th>95% CI p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abduction and adduction in flexion (˚)</td>
<td>48 (10)</td>
<td>125 (30)</td>
<td>78 (19)</td>
<td>29 (16)</td>
</tr>
<tr>
<td>Fixed-flexion deformity (˚)</td>
<td>15 (12)</td>
<td>9 (11)</td>
<td>7.4 (12)</td>
<td>-7.6 (6)</td>
</tr>
<tr>
<td>Flexion (˚)</td>
<td>113 (7)</td>
<td>112 (15)</td>
<td>97 (16)</td>
<td>-16 (14)</td>
</tr>
<tr>
<td>Total range of movement (˚)</td>
<td>201 (23)</td>
<td>246 (42)</td>
<td>244 (32)</td>
<td>43 (23)</td>
</tr>
<tr>
<td>Windsweep index (˚)</td>
<td>50 (39)</td>
<td>44 (44)</td>
<td>36 (38)</td>
<td>-14 (5)</td>
</tr>
</tbody>
</table>

* 95% CI, 95% confidence interval

**Table II.** Mean pre- and post-operative windsweep index values (˚) for 22 patients, divided into their different patient groups and according to whether they had undergone previous surgery

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>Windsweep index</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Pre-operative</td>
</tr>
<tr>
<td>Spastic group</td>
<td>9</td>
</tr>
<tr>
<td>Dystonic group</td>
<td>13</td>
</tr>
<tr>
<td>Previous surgery</td>
<td>10</td>
</tr>
<tr>
<td>No previous surgery</td>
<td>12</td>
</tr>
</tbody>
</table>
There was no significant difference in the change in migration percentage ($p = 0.90$) or centre-edge angle ($p = 0.85$) between the two groups. There was also no difference in migration percentage ($p = 0.80$) or centre-edge angle ($p = 0.65$) between those who had previous surgery and those who had not.

**Functional outcome.** The patients’ level of function was assessed and recorded by the physiotherapist. Using the gross motor functional classification system, of the 22 patients, five were grade III, seven were grade IV, and ten were grade V pre-operatively; nine were grade III, six were grade IV, and seven were grade V at the ten-year follow-up, demonstrating improved gross motor function in a total of seven patients.

Of the 12 patients who were thought to have pain in the hip before operation, 11 (92%) were free from pain at follow-up (Students $t$-test, $p < 0.001$).

From the completed questionnaires, 18 of 22 carers (82%) reported ‘easier handling’ of their children at the ten-year follow-up. The four carers who reported more difficult ‘handling’ attributed this to their children’s growth. Parent carer satisfaction with their child’s management was 100%.

**Complications.** Complications in the original 30 patients included four supracondylar fractures of the femur in three, and one case each of trochanteric bursitis, a sinus over a plate and a plaster sore. Five patients had died from unrelated causes at a mean of five years post-operatively.

**Discussion**

In patients with whole-body cerebral palsy, pelvic asymmetry can be associated with both hips being ‘at risk’ of subluxation and dislocation. Muscle imbalance and bony dysplasia are progressive, bilateral, and often asymmetrical. A windswept posture of the lower limbs often develops, associated with pelvic and spinal deformity, possibly as a result of asymmetrical central involvement of the motor cortex. When deformity is established, mobility, seating and nursing care deteriorate. In the long term, instability of the hip causes premature and progressive degenerative changes, with dislocation and severe pain in at least 50% of patients. A number of procedures have been suggested to improve the containment and biomechanics of subluxing hips in these patients. Soft-tissue operations alone have had variable rates of success and uncertain long-term results. Early soft-tissue surgery may prevent further subluxation and dislocation, improve function and relieve pain compared to conservative treatment. When soft-tissue surgery is combined with bony operations, better long-term results are achieved.

The traditional concept of concentrating on the obviously subluxed or dislocated adducted hip frequently resulted in incomplete treatment. The rationale for simultaneous bilateral hip surgery in this group of patients was that both hips are ‘at risk’. Both hips were therefore addressed simultaneously in an attempt to minimise the risk of subsequent subluxation or dislocation of the abducted hip, which was found to be a problem in previous unilateral surgery. This approach aims to correct pelvic asymmetry and balance, creating a more anatomical basis for retraining and physiotherapy.

All patients had bilateral femoral varus derotation and shortening osteotomies, placing the femur in the mid-range of rotation. Femoral shortening effectively lengthens the muscles, which alters their action on the hip. This is necessary in addition to the soft-tissue surgery, particularly in the younger child with significant growth potential. The extent of soft-tissue surgery was tailored to each individual patient and depended on examination under anaesthesia and assessment of fixed flexion and/or abduction/adduction contractures after completion of the bony surgery. A balanced soft-tissue release prevented unnecessary disruption of the soft tissues and produced an improved range of movement while preserving the stability of the hip joint.

Patients with severe cerebral palsy are difficult to evaluate. Clinical assessment is complicated by the variability of tone affecting the range of movement at different times. In order to minimise the inter- and intra-observer error, all patients were assessed jointly by the same surgeon and the original physiotherapist.

Radiological evaluation of containment of the hip is commonly assessed by methods such as the migration percentage, the centre-edge angle or the acetabular index, but there may be significant intra- and inter-observer errors because of the established deformity of the pelvis and spine. We therefore attempted to standardise the position of the pelvis during radiography in all patients. The

**Table III. Summary of radiological outcome**

<table>
<thead>
<tr>
<th></th>
<th>Pre-operative</th>
<th>Three-year post-operative</th>
<th>Ten-year post-operative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reimer’s migration percentage mean (SD)</td>
<td>50 (5)</td>
<td>19 (3)</td>
<td>20 (3)</td>
</tr>
<tr>
<td>Centre edge angle mean (SD)</td>
<td>-5 (1)</td>
<td>22 (2)</td>
<td>29 (2)</td>
</tr>
<tr>
<td>Hips subluxed only</td>
<td>27</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Hips dislocated</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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results of migration percentage and centre-edge angle were used in combination to reduce errors in the measurement of hip congruity. We did not use the acetabular index as an indication of acetabular dysplasia because it does not correlate well with migration percentage. Radiological assessment of containment of the abducted hip can be difficult and should be supplemented by clinical examination.

Functional gross motor assessment of all patients showed an improvement between the pre-operative and the ten-year post-operative state, with more of the patients falling into category III and fewer falling into category V. No reliable standardised methods have been described for evaluating other aspects of functional outcome in patients with severe cerebral palsy. Pain can be difficult for an unfamiliar observer to determine in patients with little or no verbal communication, but we consider that the close relationship which develops between the patient, the carer and the physiotherapist allows this to be assessed, although no objective criteria are available.

Our results have demonstrated a significant improvement in the range of abduction and adduction of the hips in flexion, which is important for seating and nursing care. There was also a significant reduction of fixed-flexion and a significant improvement in the total range of movement of both hips.

The windsweep index is a simple useful method for assessing symmetry in such patients and evaluating windsweep deformity. At ten years post-operatively, symmetry using the windsweep index had improved from the pre-operative state in 16 of 22 patients (73%). There was a significant reduction in the mean degree of passive hip flexion. This has been described in several biomechanical studies in which ranges of movement decreased with growth, most notably passive hip flexion. This was despite corrective orthopaedic intervention.

There was a statistically significant improvement in both radiological indices of hip containment at the ten-year post-operative follow-up (Fig. 2). Re-subluxation was more common in the dystonic group and occurred in younger patients in the spastic group.

Surgery was apparently effective in relieving hip pain in 11 of 12 patients (92%), although objective assessment of pain in this group of patients is not possible.

Our management appears to have some beneficial effect on the mobility of these patients, although not to a significant extent. Ease of patient handling improved, and satisfaction of the carers with the outcome was very high. The rate of supracondylar fracture was low compared to other series.

There were no significant differences between the pre- and post-operative changes for the two groups in all parameters measured. Dystonic patients have often received minimal treatment in previous series because of the unpredictability of their response to surgery; however, this was not the case with our patients.

There was no statistical difference between the clinical and radiological results three years and ten-years after operation (Tables I to III).
These results, at a mean ten-year follow-up, suggest that bilateral simultaneous combined soft-tissue and bony surgery is effective in the intermediate to long term, and should be considered in this challenging group of children with cerebral palsy.

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


