The aims of this study were to report functional outcomes of salvage procedures for patients with cerebral palsy (CP) who have chronic dislocation of the hip using validated scoring systems, and to compare the results of three surgical techniques.

We reviewed 37 patients retrospectively. The mean age at the time of surgery was 12.2 years (8 to 22) and the mean follow-up was 56 months (24 to 114). Patients were divided into three groups: 14 who underwent proximal femoral resection arthroplasty (PFRA group 1), 10 who underwent subtrochanteric valgus osteotomy (SVO group 2), and 13 who underwent subtrochanteric valgus osteotomy with resection of the femoral head (SVO with FHR group 3). All patients were evaluated using the Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD) and the Pediatric Quality of Life Inventory (PedsQL).

Significant improvements occurred in most CPCHILD and PedsQL subsection scores following surgery in all patients, without significant differences between the groups. There were 12 post-operative complications. Less severe complications were seen in group 1 than in groups 2 and 3.

Salvage surgery appears to provide pain relief in patients with CP who have painful chronic dislocation of the hip. The three salvage procedures produced similar results, however, we recommend the use of PFRA as the complications are less severe.

Take home message: Salvage surgery can be of benefit to patients with CP with chronic painful hip dislocation, but should be limited to selected patients considering complications.

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Dislocation of the hip in patients with cerebral palsy (CP) is difficult to manage, particularly in those with mental disabilities and in those who are unable to walk. This complication is related to several factors including abnormal gait, excessive femoral anteversion, muscle imbalance and spasticity. Problems associated with dislocation of the hip include difficulty with sitting and perineal hygiene, decubitus ulcers, and pain, which is the most serious problem for the patient and carer.

Salvage procedures are recommended to facilitate sitting, nursing care and pain relief. Several surgical techniques have been described to treat painful dislocated hips with varying results. These include proximal femoral resection arthroplasty (PFRA), subtrochanteric valgus osteotomy with femoral head resection (SVO with FHR), arthrodesis of the hip and arthroplasty. At our institution, we have performed PFRA using the McCarthy procedure, SVO with FHR using the McHale procedure, and SVO. The outcomes of these procedures are, however, rarely compared with those of a salvage procedure. Moreover, none of these previous studies used a validated measurement of function or quality of life to assess the outcome. The aims of our study were to report the outcomes of salvage procedures in patients with CP who have a painful chronic dislocation of the hip using validated scoring systems and to compare the functional outcome of three surgical techniques.

Patients and Methods

This retrospective study was approved by our Institutional Review Board. We identified 40 patients who had been treated with a salvage procedure between January 2007 and October 2012 for painful chronic dislocation of the hip. Inclusion criteria were: spastic quadriplegia and non-ambulatory status. We included patients who had undergone salvage procedures for chronic dislocation of the hip.
their wheelchairs and intrathecal baclofen or oral diazepam for at least six months. If there was no improvement, the indications for surgery included intractable pain at rest or disturbing sleep, pain with seating/positioning, problems with hygiene, long standing dislocation with degenerative changes of the femoral head on plain radiograph or CT, and severe limitation of movement of the hip.

A total of three patients had been lost to follow-up. Thus, 37 patients (47 hips) were enrolled in the study and the parents or caregivers gave informed consent. The mean age of patients at the time of surgery was 12.2 years (8 to 22). There were 14 male and 23 female patients. All were Level V on the Gross Motor Function Classification System (GMFCS). All of the ten patients who underwent bilateral operations were treated with the same technique simultaneously. Previous attempts to reduce and reconstruct the hip had been performed in three patients, and three patients had undergone an isolated soft-tissue release. The remaining 31 had no previous surgical treatment. The status of the patient pre-operatively was recorded by parents or carers. The mean follow-up was 56 months (24 to 114).

The operations were performed by three surgeons (HWK, JHH, HP) and the choice of procedure was determined by the surgeon's preference. The patients were divided into three groups according to the procedure performed. Group 1 included 14 patients who underwent a PFRA; group 2 included ten patients who underwent SVO and group 3 included 13 patients who underwent SVO with FHR.

Union at the site of the osteotomy, migration of the proximal femur, classified according to Ackerley et al., and heterotopic ossification, graded according to McCarthy et al., were assessed radiographically.

All patients were evaluated clinically using the Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD) and the Pediatric Quality of Life Inventory (PedsQL). These have been found to be reliable and valid measures for assessing patients with CP. As all patients were cognitively impaired, we focused on measurements of outcome reported by parents or carers. In order to ensure that the results were impartial, an orthopaedic resident and a nurse practitioner, rather than the treating surgeon, contacted the parents or caregivers to complete the survey at a minimum of two years after surgery.

The revised CPCHILD consists of 37 items in six sections representing: activities of daily living/personal care (nine items); positioning, transferring and mobility (eight items); comfort and emotions (nine items); communication and social interaction (seven items); health (three items) and overall quality of life (one item). Standardised scores from 0 (worst) to 100 (best) were calculated for each of the six domains and for the total survey.

The 35-item PedsQL 3.0 CP Module comprises seven scales including daily activities (nine items); school activities (four items); movement and balance (five items); pain (four items); fatigue (four items); eating activities (five items); and speech and communication (four items). Summary scores were calculated for each scale and range from 0 (worst) to 100 (best).

**Surgical technique.** The PFRA procedure was undertaken as described by McCarthy et al (Fig. 1). The proximal femur is exposed extraperiosteally and resected 3 cm to 4 cm below the lesser trochanter. The iliopsoas and glutei are interposed and sutured to the capsule of the hip. The vastus lateralis is sutured over the femoral stump. Prophylaxis against heterotopic ossification is not used routinely.

The SVO was undertaken as described by Hass, with modifications as described by Hogan et al (Fig. 2). A 45° to 60° lateral closing wedge osteotomy is performed at the inferior margin of the lesser trochanter and held with a contoured plate. The proximal fragment is held in valgus such that the lesser trochanter articulates with the acetabulum. Neither traction nor immobilisation is used post-operatively.
The SVO with FHR procedure was undertaken as described by McHale et al\(^\text{15}\) (Fig. 3). The hip is exposed via a lateral approach and the femoral head and neck are resected. A laterally-based wedge of bone is removed at the level of the lesser trochanter to create a valgus osteotomy, which is fixed with two plates. The lateral plate is contoured and a straight plate is applied anteriorly. A capsulorrhaphy is performed. The lesser trochanter is placed into the acetabulum. No traction or immobilisation is used post-operatively.

**Statistical analysis.** Statistical analysis was performed using SPSS software (version 19.0, SPSS, Chicago, Illinois). We performed a post hoc power analysis for the CPCHILD and PedsQL scores and found that our sample size achieved a statistical power of 0.65 with a significance of 0.05, and an effect size of 0.4. All continuous variables were tested for normality using the Shapiro–Wilk test and followed a normal distribution. The Student’s paired \(t\)-test was used to assess the difference between pre- and post-operative measures of all patients. In order to compare clinical results between the three groups, analysis of variance was used. The level of significance was set at \(p < 0.05\).

**Results**

The mean CPCHILD total score improved significantly at follow-up (\(p < 0.001\)) with a significant increase in the subsection scores (Table I) except for communication and social interaction and overall quality of life. Significant improvements in PedsQL scores occurred in movement and balance (\(p < 0.001\)) and pain and hurt (\(p < 0.001\)). There was no significant improvement in other PedsQL subscale scores.

There were significant improvements in the CPCHILD total score in all groups (\(p = 0.021, p = 0.018, p = 0.012, 1, 2\) and 3, respectively). All but two CPCHILD subsection scores (communication and social interaction, and overall quality of life) improved significantly (Fig. 4a). In the PedsQL system, a significant increase in movement and balance (\(p = 0.009, p = 0.043, p = 0.026\)) and pain and hurt scores (\(p = 0.007, p = 0.038, p = 0.026\)) was observed in each group (Fig. 4b). No significant improvement was noted in other PedsQL subscale scores.

There were no significant differences between the three groups with respect to age (\(p = 0.30\)), mean follow-up (\(p = 0.62\)), and pre-operative functional scores. The mean
CPCHILD and PedsQL scores were not significantly different between the three groups post-operatively (Table I).

**Complications.** A total of 12 complications occurred. In group 1, complications related to the surgery were identified in six patients (43%) and consisted of type I heterotopic ossification which resolved with conservative treatment in three, and asymptomatic migration of the proximal femur in three. In group 2, two patients (20%) developed bursitis over the femoral head in the gluteal region that interfered with sitting and positioning. This was treated by excision of the femoral head. In group 3, complications occurred in four patients (31%). Three had pain over the plate, which resolved when the plate was removed. A plate broke in one patient, which was treated by revision using two plates.

**Discussion**

Although various forms of surgical treatment have been described for painful chronic dislocation of the hip in patients with CP, the optimal form has not been established. We are the first to report outcomes of salvage surgery using a validated scoring system. We were able to show the benefit of salvage surgery with improvements in the CPCHILD and PedsQL scores post-operatively, regardless of surgical technique. Although the outcomes of these techniques were not significantly different, less severe complications occurred in group 1.

Pre-operative CPCHILD and PedsQL scores in our patients were lower than previously reported in quadriplegic patients with CP without dislocation of the hip.\(^{27,28,30}\) One study reported a mean total CPCHILD score of 24.3 in patients with GMFCS V.\(^{30}\) Our mean post-operative total CPCHILD score was 16.6 (3.2 to 46). Although scores improved significantly after treatment, they were still lower than those of quadriplegic patients without dislocation. This demonstrates the low quality of life in patients with painful chronic dislocation of the hip.

There were significant improvements in some pain-related scores of CPCHILD and PedsQL following salvage surgery. However, we found no significant increase in the subsection scores that was not related to pain. Thus, pain can be relieved, but the quality of life may not improve. Additionally, although most CPCHILD subsection scores improved significantly, only two PedsQL subsection scores did. A possible explanation for this is that the CPCHILD scoring system is more influenced by pain than PedsQL.

All three procedures appeared to provide pain relief and improved movement. There were no significant differences in post-operative functional scores between the groups. Thus, salvage surgery may provide similar benefits to patients from the parent or caregiver’s perspective, regardless of the technique.

Although the outcome scores were good, 12 complications occurred and six patients required further surgery. A previous study reported that the retained femoral head in SVO can cause pressure ulceration,\(^{16}\) and two patients in group 2 had bursitis in this region and subsequently underwent resection of the femoral head. In group 3, there was pain relief and improved movement, which is consistent with previous studies.\(^{8,14,15}\) However, there were complications relating to the hardware (31%), which appeared to affect comfort. The four patients with these complications underwent further surgery. Despite having the highest rate of complications (43%), the six patients with complications in group 1 were asymptomatic. Commonly reported complications of PFRA are proximal femoral migration and heterotopic ossification,\(^{5,11-13,31}\) both of which are usually treated non-operatively.\(^{5,11,13}\) These complications are, thus, not clinically significant.
Chronic dislocation of the hip is not in itself an indication for surgery. In addition, the migration index\textsuperscript{32} and the severity of dislocation are not criteria for selecting reconstruction or salvage surgery. Erosion or lateral notching of the femoral head is caused by the capsule of the hip, abductor muscles and ligaments in patients with CP and dislocation of the hip.\textsuperscript{33,34} Chronic dislocation tends to cause pain because of stiffness, joint contracture and degenerative changes of the femoral head.\textsuperscript{13} Reduction of the hip in patients with bony change in the femoral head does not lead to relief of pain and may exacerbate the local symptoms,\textsuperscript{34} and we believe that reconstructive surgery in patients with CP and painful chronic dislocation of the hip is contraindicated. Pitting and degenerative changes in the

<table>
<thead>
<tr>
<th>Pre-operative</th>
<th>Follow-up</th>
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<tr>
<td>0.048</td>
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<tr>
<td>0.018</td>
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<tr>
<td>0.012</td>
<td>0.012</td>
</tr>
<tr>
<td>0.015</td>
<td>0.015</td>
</tr>
<tr>
<td>0.018</td>
<td>0.018</td>
</tr>
<tr>
<td>0.012</td>
<td>0.012</td>
</tr>
<tr>
<td>0.042</td>
<td>0.042</td>
</tr>
<tr>
<td>0.017</td>
<td>0.017</td>
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<tr>
<td>0.012</td>
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<tr>
<td>0.021</td>
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<td>0.018</td>
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</table>

Fig. 4a

Graphs showing subsection scores pre- and post-operatively in each group for the a) Caregiver Priorities and Child Health Index of Life with Disabilities and b) Pediatric Quality of Life inventory. Values are expressed as means with standard deviation (with p-value indicating significant differences). (1, group 1: proximal femoral resection arthroplasty; 2, group 2: subtrochanteric valgus osteotomy; 3, group 3: subtrochanteric valgus osteotomy with femoral head resection).
articular cartilage of the femoral head were seen in all patients, and we consider these to be an absolute indication for resection of the femoral head.

It is difficult to determine whether there is hip pain in patients with dislocation who are not able to communicate well. Some authors report that short-term pain relief can be achieved by injecting the hip with bupivacaine, corticosteroid, and botulinum toxin A; however, we did not undertake this procedure. Although we made a decision whether to recommend surgery by interviewing parents or carers about the symptoms of their children and evaluating the bony shape of the femoral head radiographically, this technique may be used as a diagnostic test in patients who have symptoms but are unable to speak.

Total hip arthroplasty (THA) has been suggested as an option for these patients and good results have been reported. Some authors have also reported that THA gives better results than other salvage procedures; dislocation and revision operations are common because of bony abnormalities and muscular imbalance in patients with CP. We believe that THA should only be considered in carefully selected patients and should not be performed on relatively young patients with CP.

There are several limitations to this study. It was a retrospective study without randomisation. Our sample size was small because of the infrequency of these operations. This decreased the power for statistical analysis, especially in the comparisons between groups, and undermines the conclusion that there is no difference in the outcomes of the different procedures. The mean follow-up was different in the three groups and this can affect the outcomes and rates of complication. Three surgeons were involved and the operative technique and post-operative protocols were not standardised. The use of questionnaires can introduce recall bias in retrospective studies of this sort, however, this risk was minimal as pre-operative surveys were available. Lastly, we could not evaluate the patients directly because of their low cognitive function. Parents and carers hope to see improvement in their children after surgery; this participation effect may act as a confounding variable in patients with CP who cannot speak.

In conclusion, salvage surgery appears to provide pain relief in patients with CP who have painful chronic dislocation of the hip. The three salvage procedures studied here had similar outcomes. However, we currently prefer PFRA to the other procedures, as the complications are less severe.

Table II. Comparison of post-operative variables between groups. Data are expressed as mean (standard deviation)

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age (yrs)</td>
<td>12.3 (3.5)</td>
<td>13.7 (3.1)</td>
<td>11.3 (3.2)</td>
<td>0.30</td>
</tr>
<tr>
<td>Mean follow-up (mths)</td>
<td>52.1 (24.8)</td>
<td>54.2 (25.6)</td>
<td>61.7 (26.4)</td>
<td>0.62</td>
</tr>
<tr>
<td>CPCHILD</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal care/activities of daily living</td>
<td>9.2 (8.9)</td>
<td>17.1 (14.2)</td>
<td>12.6 (10.7)</td>
<td>0.33</td>
</tr>
<tr>
<td>Positioning, transferring and mobility</td>
<td>10.3 (7.3)</td>
<td>13.0 (11.7)</td>
<td>10.9 (6.8)</td>
<td>0.78</td>
</tr>
<tr>
<td>Comfort and emotions</td>
<td>29.1 (19.3)</td>
<td>26.7 (19.7)</td>
<td>27.1 (20.6)</td>
<td>0.96</td>
</tr>
<tr>
<td>Communication and social interaction</td>
<td>172 (173)</td>
<td>18.0 (20.4)</td>
<td>11.0 (12.4)</td>
<td>0.66</td>
</tr>
<tr>
<td>Health</td>
<td>18.3 (11.7)</td>
<td>20.9 (24.1)</td>
<td>24.1 (16.3)</td>
<td>0.75</td>
</tr>
<tr>
<td>Overall quality of life</td>
<td>18.3 (13.3)</td>
<td>20.0 (30.5)</td>
<td>20.0 (18.1)</td>
<td>0.97</td>
</tr>
<tr>
<td>Total Score</td>
<td>15.8 (11.1)</td>
<td>18.7 (16.3)</td>
<td>16.0 (11.8)</td>
<td>0.89</td>
</tr>
<tr>
<td>PedsQL parent-proxy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily activities</td>
<td>1.1 (1.4)</td>
<td>3.1 (3.3)</td>
<td>2.4 (3.1)</td>
<td>0.24</td>
</tr>
<tr>
<td>School activities</td>
<td>4.6 (4.7)</td>
<td>7.1 (7.5)</td>
<td>3.9 (4.6)</td>
<td>0.51</td>
</tr>
<tr>
<td>Movement and balance</td>
<td>24.5 (11.2)</td>
<td>29.3 (19.7)</td>
<td>275 (20.5)</td>
<td>0.87</td>
</tr>
<tr>
<td>Pain and hurt</td>
<td>67.7 (26.4)</td>
<td>50.0 (21.7)</td>
<td>65.6 (28.9)</td>
<td>0.34</td>
</tr>
<tr>
<td>Fatigue</td>
<td>26.0 (19.3)</td>
<td>28.5 (27.4)</td>
<td>35.9 (16.6)</td>
<td>0.39</td>
</tr>
<tr>
<td>Eating activities</td>
<td>30.8 (10.6)</td>
<td>35.0 (10.8)</td>
<td>32.5 (10.0)</td>
<td>0.70</td>
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<td>Speech/communication</td>
<td>38.5 (13.8)</td>
<td>32.1 (23.2)</td>
<td>179 (20.7)</td>
<td>0.07</td>
</tr>
</tbody>
</table>

CPCHILD, Caregiver Priorities and Child Health Index of Life with Disabilities; PedsQL, Pediatric Quality of Life Inventory

References