Adductor Surgery to Prevent Hip Displacement in Children with Cerebral Palsy: The Predictive Role of the Gross Motor Function Classification System

Benjamin J. Shore, MD, FRCSC, Xavier Yu, MBBS, BA, Sameer Desai, MS, MRCSEd, Paulo Selber, MD, FRACS, Rory Wolfe, BSc, PhD, and H. Kerr Graham, MD, FRCSEd, FRACS

Investigation performed at the Royal Children’s Hospital, Parkville, Australia

**Background:** The purpose of this study was to evaluate the relationship between walking ability, as determined with use of the Gross Motor Function Classification System (GMFCS), and the outcome of hip adductor surgery used to prevent hip displacement in children with cerebral palsy.

**Methods:** We performed a retrospective review of the records of all children with cerebral palsy whose index surgery, performed between January 1994 and December 2004 at one tertiary-level pediatric hospital, was bilateral hip adductor releases. All children had a hip migration percentage of >30% in at least one hip prior to the adductor surgery, and the minimum duration of follow-up was twenty-four months. Kaplan-Meier survivorship curves were generated by determining the time from the index surgery to “failure,” defined as either the need for subsequent surgical procedures or a migration percentage of ≥50% in either hip. Hazard ratios were calculated for sex, migration percentage at the time of the index surgery, and GMFCS level.

**Results:** Three hundred and thirty children were included in the study; 73% (242) were nonambulatory (GMFCS level IV or V). The mean age at the time of the index surgery was 4.2 years, the mean migration percentage was 43%, and the mean duration of postoperative follow-up was 7.1 years. Surgery consisted of open lengthening of the adductor longus and gracilis muscles in all children, with additional procedures as deemed necessary. “Success” was defined as the absence of subsequent surgical procedures during the study period and a migration percentage of <50% in both hips at the time of follow-up. One hundred and six children (32%) met these criteria for success. The success rate was 94% (thirty-one of thirty-three) in children at a GMFCS level of II, 49% (twenty-seven of fifty-five) in children at a level of III, 27% (twenty-eight of 103) in children at a level of IV, and 14% (twenty of 139) in children at a level of V.

**Conclusions:** Walking ability, as defined with use of the GMFCS level, is a strong predictor of success or failure after hip adductor surgery in children with cerebral palsy. The paradox of hip adductor surgery for children with cerebral palsy is that the children who are most severely affected and need the surgery the most have the poorest results.

**Level of Evidence:** Prognostic Level II. See Instructions for Authors for a complete description of levels of evidence.

**Disclosure:** None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. One or more of the authors, or his or her institution, has had a financial relationship, in the thirty-six months prior to submission of this work, with an entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, one or more of the authors has had another relationship, or has engaged in another activity, that could be perceived to influence or have the potential to influence what is written in this work. The complete Disclosures of Potential Conflicts of Interest submitted by authors are always provided with the online version of the article.
Adductor Surgery to Prevent Hip Displacement in Children with Cerebral Palsy

Hip displacement, defined as a migration percentage of >30%, affects 35% of children with cerebral palsy. The incidence is directly related to the functional level as determined with use of the Gross Motor Function Classification System (GMFCS) but not to the type of movement disorder. The GMFCS is a five-level ordinal grading system that has been confirmed in a number of studies to be a valid, reliable, stable, and clinically relevant method for the classification and prediction of motor function of children with cerebral palsy who are between two and twelve years of age. Hip displacement in children with cerebral palsy may result in pain and diminished function, including difficulties with simple tasks such as standing for transfers or with higher functions such as standing and walking.

Nonoperative interventions, including bracing and injections of botulinum toxin A, do not demonstrate a clinically important treatment effect. Surgical approaches to the management of hip displacement in children with cerebral palsy have been classified as preventive, reconstructive, or salvage. Preventive surgery is the term applied to various approaches designed to treat or prevent early hip displacement in younger children whose hip is still in joint but shows signs of being “at risk.” Miller and Bage demonstrated that the migration percentage affects the risk of progression of hip displacement and concluded that children with a migration percentage of between 30% and 60% would have a continued risk (25%) of further displacement as they aged. Preventive surgery applies to surgical procedures that involve lengthening of some of the hip adductors and may also involve lengthening of the hip flexors and occasionally phenolization of the obturator nerve or anterior-branch obturator neurectomy. However, there has been disagreement about the timing and indications for these procedures, the specific muscles to release, and postoperative management. Reconstructive surgery for hip displacement in patients with cerebral palsy includes osteotomy of the proximal aspect of the femur, the pelvis, or both that can be used to treat residual hip subluxation and early dislocation. The typical outcome of one-stage reconstruction for a subluxated or dislocated hip in children with cerebral palsy has been described as successful in several large studies.

Given the heterogeneity of the cerebral palsy population and the variability in treatment protocols, including the multiplicity of hip adductor surgical procedures that have been employed, it is difficult to draw firm conclusions from the many studies regarding the success of adductor procedures in preventing hip displacement. Soft-tissue releases (muscle recessions and tenotomies) have been reported to be helpful in the prevention of hip displacement. It has been suggested that if early detection and screening programs are used, 80% of children with spastic hip disease should have a “good” or “fair” outcome, defined as a migration percentage of <40%, following one simple operation. However, in an extensive review of adductor releases for hip displacement in patients with cerebral palsy, Stott and Piedrahita concluded that the current evidence base was poor and that it was difficult to draw definitive conclusions. Weaknesses in the evidence base include the lack of clinical trials, the heterogeneity of the patient populations studied, variability in the surgical procedures performed, and short-term and incomplete follow-up.

The primary goal of the present study was to examine the long-term success of hip adductor surgery in a large group of children with cerebral palsy who had been managed by a small group of surgeons according to standardized protocols. The secondary goal was to investigate the relationship between walking ability, as determined with use of the GMFCS, hip displacement, and the success of adductor surgery.

### Materials and Methods

We performed a retrospective, population-based cohort study of children with cerebral palsy identified with use of the Victorian Cerebral Palsy Register (VCPR), which has a high degree of accuracy and case capture. This study was approved under the clinical audit provisions of our institution’s Human Research Ethics Committee.

Inclusion criteria were (1) a diagnosis of cerebral palsy, bilateral involvement (diplegia or quadriplegia), and registration in a statewide Cerebral Palsy Register; (2) index surgery consisting of bilateral hip adductor releases performed at our tertiary-level pediatric hospital between January 1994 and December 2004; (3) a minimum clinical and radiographic follow-up duration of twenty-four months from the time of the index surgery; and (4) adequate medical records and hip radiographs to determine the outcome. Exclusion criteria were (1) a diagnosis other than cerebral palsy that did not satisfy the requirements for registration in the statewide Cerebral Palsy Register; (2) index surgery on the hip adductors that was performed elsewhere; (3) a diagnosis of monoplegia or hemiplegia and unilateral adductor surgery; and (4) inadequate case records or radiographs.

### Table I: Patient Characteristics According to GMFCS Level at the Time of Adductor Surgery

<table>
<thead>
<tr>
<th>GMFCS Level</th>
<th>No. (%)</th>
<th>Mean Age at Surgery (mo)</th>
<th>Initial Migration Percentage at Surgery†</th>
<th>Mean Duration of Follow-up (mo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>II</td>
<td>33 (10)</td>
<td>41</td>
<td>R: 36 (28-47) L: 34 (21-42)</td>
<td>84</td>
</tr>
<tr>
<td>IV</td>
<td>103 (31)</td>
<td>49</td>
<td>R: 42 (21-60) L: 42 (28-64)</td>
<td>87</td>
</tr>
<tr>
<td>V</td>
<td>139 (42)</td>
<td>55</td>
<td>R: 47 (31-60) L: 48 (28-64)</td>
<td>85</td>
</tr>
<tr>
<td>All</td>
<td>330</td>
<td>50.2</td>
<td>R: 43 (21-64)</td>
<td>85.5</td>
</tr>
</tbody>
</table>

*GMFCS = Gross Motor Function Classification System. †The values are given as the mean percentage, with the range in parentheses.
The management of hip displacement in children with cerebral palsy at our institution includes early detection by means of systematic screening, early preventive surgery, reconstructive surgery when preventive surgery fails, and efforts to avoid salvage surgery. Long-term follow-up is offered to all children with cerebral palsy from the time of diagnosis until the transition to adult services at an age of eighteen to twenty years. Indications for adductor surgery were clinical and radiographic, including an abduction range of <40° in one or both of the hips and a migration percentage of >30% in one or both of the hips. Indications for reconstructive surgery were a persistently high migration percentage (>50%) for more than two years after initial adductor surgery in one or both of the hips. Indications for salvage surgery were severe pain that was refractory to medical and tonic management combined with severe osseous deformity that was considered to not be amenable to reconstructive surgery.

Every patient underwent bilateral adductor longitudinal and gracilis muscle releases. The anterior fibers of the adductor brevis muscle were released in a small number of hips with more severe contractures to achieve abduction of >30° in both hips. Lengthening of the iliopsoas tendon at the lesser trochanter was added in nonambulatory children if the hip flexion contracture was >20°. Phenolization (with use of a 6% aqueous solution) or neurectomy of the anterior branch of the obturator nerve was performed in severely affected (GMFCS level IV or V) patients with preoperative scissoring. In patients with asymmetric hip displacement, the final surgical prescription differed between sides, with the aim being symmetric abduction of >50° in both hips. Specific details of the surgical protocol for adductor release and phenolization can be found in the Appendix and have been previously published elsewhere.

The migration percentage was measured on the initial radiograph made at the time of the index surgery by a method with good reliability. Gross motor function and walking ability were classified with use of the GMFCS, using age-appropriate descriptors. The GMFCS level was determined from hip surveillance records (if the child was ambulatory), gait laboratory assessments (if the child was ambulatory), or standardized assessments by developmental pediatricians and physical therapists.

Surgical "success" was defined as the absence of subsequent hip surgery during the study period and a migration percentage of <50% in both hips at the time of the most recent follow-up. Surgical "failure" was defined as either the need for any subsequent surgery to treat hip displacement or a migration percentage of ≥50% in either hip. The numbers of children who were lost to follow-up, children who were deemed medically unfit for further surgery, parents who were unwilling to consent to further surgery, and hips that subsequently dislocated (migration percentage >100%) and/or needed salvage surgery were also recorded.

### Statistical Methods
Means and standard deviations were used to summarize continuous variables (age at the time of the index surgery and index migration percentage) that were symmetrically distributed. Kaplan-Meier curves for the time to failure according to GMFCS level were used to graphically display surgical success. Cox proportional-hazards regression analysis was used to calculate hazard ratios to compare the failure risk between subgroups of children and with regard to continuous variables. Stata statistical software was used for all analyses (version 10; StataCorp, College Station, Texas).

### Source of Funding
There was no external funding source for this study.

### Results
Between January 1994 and December 2004, 342 children underwent bilateral hip adductor surgery, and 330 were eligible for this study. Four of the twelve children who were...
excluded were lost to follow-up within twenty-four months of surgery, and the other eight had missing or incomplete clinical and radiographic records. The mean duration of follow-up was eighty-five months (standard deviation, twenty-five months; range, twenty-four to 161 months).

Thirty-three (10%) of the children were at GMFCS level II, fifty-five (17%) were at level III, 103 (31%) were at level IV, and 139 (42%) were at level V (Table I). The overall rate of success was 32% (106 of 330), with the remaining 68% (224) of the procedures being classified as “failures” because the children

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Univariate Analysis</th>
<th>Multivariate Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.0</td>
<td>0.8 to 1.3</td>
</tr>
<tr>
<td>Initial MP</td>
<td>1.09†</td>
<td>1.07 to 1.11</td>
</tr>
<tr>
<td>Age in months at index surgery</td>
<td>1.02‡</td>
<td>1.01 to 1.03</td>
</tr>
<tr>
<td>Surgery type§</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3.6</td>
<td>2.1 to 5.3</td>
</tr>
<tr>
<td>3</td>
<td>4.0</td>
<td>2.5 to 6.3</td>
</tr>
<tr>
<td>4</td>
<td>4.5</td>
<td>2.8 to 7.3</td>
</tr>
<tr>
<td>GMFCS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>10.9</td>
<td>2.6 to 45.8</td>
</tr>
<tr>
<td>III</td>
<td>17.0</td>
<td>4.2 to 69.3</td>
</tr>
<tr>
<td>IV</td>
<td>25.9</td>
<td>6.4 to 105.0</td>
</tr>
</tbody>
</table>

*Calculated by Cox proportional-hazards regression analysis of time to failure. HR = hazard ratio, CI = confidence interval, MP = migration percentage, and GMFCS = Gross Motor Function Classification System. †Increase in hazard for a 1% increase in MP. ‡Increase in hazard for a one-month increase in age. §1 = lengthening of adductor longus and gracilis, 2 = type 1 plus lengthening of the iliopsoas at the lesser trochanter, 3 = type 2 plus phenolization of the anterior branch of the obturator nerve, and 4 = type 2 plus anterior obturator neurectomy.

Fig. 1
Kaplan-Meier plot of surgical success (i.e., survival until failure according to the study definition) according to the Gross Motor Function Classification System (GMFCS) level.
either required a subsequent surgical procedure involving the hip or had persistent hip displacement. The success rate was 94% (thirty-one of thirty-three) in children at a GMFCS level of II, 49% (twenty-seven of fifty-five) in children at a level of III, 27% (twenty-eight of 103) in children at a level of IV, and 14% (twenty of 139) in children at a level of V.

Eighty-two children underwent isolated lengthening of the adductor longus and gracilis, and ninety-seven children underwent lengthening of the adductor longus, gracilis, and iliopsoas. An additional ninety-seven patients underwent phenolization of the anterior branch of the obturator nerve and fifty-four patients underwent obturator neurectomy of the anterior branch in addition to the above-mentioned muscle lengthening (Table II).

Of the 106 successes, the mean initial hip migration percentage (and standard deviation) was 21% ± 11% in the right

---

**Fig. 2**

An illustrative case of hip adductor surgical failure. Hip radiographs of a child with spastic quadriplegia cerebral palsy (GMFCS level V) from eleven months to four years and four months of age are shown. In each radiograph, the age in years and months is indicated in the bottom left and the number in the chronological sequence in the top right. Panel 1 (age, eleven months) shows early ossification of the proximal femoral epiphysis and mild acetabular dysplasia in the right hip. The position of the ventriculoperitoneal shunt is also visible. Panel 2 (age, two years and two months) shows hip displacement with a migration percentage of 52% in the right hip and 18% in the left. Panel 3 (age, two years and five months) shows bilateral hip dislocations. Surgery had been delayed because of unstable epilepsy and feeding difficulties. Panel 4 (age, two years and seven months) shows concentric reduction of both hips after bilateral adductor and psoas releases, including phenolization of the anterior obturator nerve. Panel 5 (age, two years and nine months) shows redisplacement of the hips. Panel 6 (age, four years and four months) shows bilateral hip redislocation, which required osseous reconstructive surgery.
hip and 20% ± 10% in the left. In the 224 failures, the mean initial hip migration percentage was 45% ± 8% in the right hip and 46% ± 9% in the left. The mean age at the time of the index surgery was 4.4 years in patients in whom the outcome was classified as a failure and 3.7 years in the patients in whom it was a success. For the 224 failures, the mean age at the time of failure was 8.4 ± 2.2 years and the mean time from surgery to failure was 4.0 ± 2.2 years. An association among higher GMFCS level, increased initial migration percentage, and increased age at the time of the index surgery was noted (Table I).

The majority of failures (161 of 224, 72%) were treated with osseous reconstructive surgery (Table III). In addition, thirty-five of the failures (twenty-three with subluxation [migration percentage of >50%] and twelve with dislocation [migration percentage of >100%]) had not been treated with definitive surgery at the time of the last review; the reasons included poor general health, parental wishes, and lack of symptoms. No abduction contractures occurred after obturator nerve neurectomy; however, two extension contractures occurred after phenolization of the obturator nerve combined with iliopsoas release, and these were managed uneventfully with chair modification and proximal hamstring release.

Nineteen deaths (6%) were recorded in the study cohort; all were in children at a GMFCS level of V, resulting in a death rate of 14% in this group. The cause of death was respiratory failure in thirteen of the patients, complications following epileptic seizures in two, and acute renal failure, a complication of an existing hematological disorder, complications of a fundoplication procedure, and septicemia in one patient each. At the time of death, the index surgery had been classified as a failure in nine (47%) of these patients and was still classified as a success in ten. None of the deaths were recorded within the first two years following the adductor surgery.

The surgical success rate decreased with increasing GMFCS level (Fig. 1). At thirty-six months, the success curve for the GMFCS II group diverged slightly from those of the GMFCS III, IV, and V groups. However, at eighty-four months (seven years) the success curves diverged markedly, with the failure rate in the GMFCS II group remaining stable over time but all other GMFCS groups experiencing increasing failure
rates. Univariate analysis revealed that, compared with the GMFCS III group, the GMFCS IV group had a higher risk of failure (hazard ratio [HR], 1.6; 95% confidence interval [CI], 1.0 to 2.4; p = 0.05). Similarly, the GMFCS V group had a higher risk of failure than the GMFCS IV group (HR, 1.5; 95% CI, 1.1 to 2.0; p = 0.005) (Table IV).

Only the GMFCS level and the initial migration percentage remained important predictors of the failure risk in the multivariate analysis; when adjusted for the GMFCS level and the initial migration percentage, the failure risk was not related to the age at surgery or to the surgery type. Furthermore, when adjusted for the initial migration percentage, the GMFCS III, IV, and V groups had a similar failure risk and the risk in each group was greatly increased compared with the GMFCS II group. (See Figures 2 and 3 for representative examples of success and failure.)

Discussion

Previous studies have investigated the influence of walking ability on the outcome of hip adductor surgery in children with cerebral palsy, but, to our knowledge, this is the first study to analyze adductor surgery outcome according to the GMFCS level. In our study, the success rate of hip adductor surgery decreased with increasing baseline migration percentage once this percentage exceeded a threshold of 50%. After seven years of follow-up, the surgical success rate for children at GMFCS level II was 94% (thirty-one of thirty-three) compared with 14% (twenty of 139) for children at level V. Sex and the type of hip adductor release were not found to have a significant effect on the outcome of the surgery.

Previous studies have shown that the success of adductor surgery may be linked to the migration percentage at the time of the index surgery. In our study, the success of hip adductor surgery decreased with increasing baseline migration percentage (>50%). In a recent systematic review of hip adductor surgery in children with cerebral palsy, a preoperative migration percentage of <40% was associated with a successful outcome in 75% to 90% of hips. Conversely, hips with a migration percentage of >50% had a poorer outcome, with 75% to 77% of hips remaining subluxated or dislocated. Only 5% (eleven of 242) of children in our study had a severe initial migration percentage (260%) at the time of the index surgery, which is similar to the findings of Presedo et al. Whether differences in the initial migration percentage reflect differences in the natural history or merely a different stage in the development of hip displacement is unknown.

The reported percentage of good results of hip adductor release in children with cerebral palsy ranges from 33% to 90%. This variation in the rate of surgical success is due to differences among the series with regard to age at the time of surgery, hip migration percentage, surgical technique, definitions of success and failure, duration of follow-up, and population heterogeneity. Given that preventive surgery, by its nature, is performed for asymptomatic hip displacement in order to prevent both later symptoms and the need for more invasive surgery, it is appropriate to have a stringent definition of failure. In our study, the need for additional hip surgery, including revision of soft-tissue releases, was defined as failure. Patients who demonstrated hip displacement (migration percentage of >50%) or dislocation (migration percentage of >100%) and had not yet undergone secondary procedures were also included in the failure group. Our overall success rate of 32% (106 of 330) for hip adductor surgery was lower than previously reported rates for medium to long-term follow-up. However, in most of the previous studies the result for each hip was reported separately, and better results will be obtained if each hip is reported as a separate entity. We agree with Turker and Lee that a hip that progresses to unilateral subluxation or dislocation and requires repeat surgery would be considered a failure by the patient and family.

The duration of follow-up is intimately related to the surgical success rate. High surgical success rates of approximately 70% have been found in studies with less than five years of follow-up. The number of long-term follow-up studies in the literature is small, and the success rates in these studies are lower than those in the shorter-term studies. Turker and Lee reported eight-year results for forty-five children with quadriplegic cerebral palsy treated with soft-tissue surgery for hip subluxation. They observed a 58% rate of failure, defined as progressive subluxation or dislocation that eventually resulted in the need for revision surgery. In comparison, Presedo et al. reported the results of soft-tissue surgery in sixty-five children with quadriplegic cerebral palsy treated with soft-tissue surgery for hip subluxation. They observed a 63% rate of failure, which is higher than the 80% success rate after shorter-term follow-up reported by Miller et al. Presedo et al. reported an overall success rate of 67% for adductor surgery; however, the success rate was 89% for ambulatory subjects and 60% for nonambulatory subjects. In their study, revision soft-tissue release was not considered a surgical failure; if such revision surgery had been considered a failure, the success rate for nonambulatory subjects would have been 49%, which is lower than the 80% success rate after shorter-term follow-up reported by Miller et al.

In the present study, the seven-year outcome of soft-tissue surgery for the treatment of hip displacement was successful in 32% of children. To compare these results with previous studies, it is necessary to consider differences in GMFCS level and duration of follow-up, which might explain the variability in reported outcomes. The majority of our patient population was at GMFCS level IV or V (242 of 330, 73%) (Table I). Soo et al. demonstrated that patients at a higher GMFCS level have a greater incidence of hip displacement, and our study suggests that hip displacement is both more severe and more refractory to surgery in this patient group. Since our study was population-based, it contained all of the most severely involved children, who would be classified as being at very high risk for hip displacement regardless of the intervention. In the study by Presedo et al., forty-seven (72%) of the sixty-five patients were described as "spastic quadriplegics," although only one patient died during the ten-year follow-up period. During our study, nineteen patients died because of
nonsurgical problems during the seven-year follow-up period. Since there is a strong correlation between the GMFCS level and the incidence and severity of medical comorbidities, this again suggests differences in the severity of cerebral palsy involvement between studies, which provide a potential explanation for the variability in the reported success rate.

The relationship between the success of hip adductor surgery and the GMFCS level in our study corresponds well with recent literature on the relationship of GMFCS level to the prevalence of hip displacement and changes in proximal femoral geometry in children with cerebral palsy. In nonambulatory patients with cerebral palsy (GMFCS level IV or V), spastic muscle imbalance and lack of weight-bearing leads to the development of progressive structural changes around the hip joint, including retained femoral anteversion, coxa valga, posterolateral acetabular dysplasia, and flexion-adduction hip contractures. Likewise, the present study indicated that hips with severe osseous deformity (GMFCS IV and V) are less likely to stabilize following soft-tissue surgery alone.

The differences between GMFCS levels III, IV, and V did not emerge until after approximately thirty-six months postoperatively, and many previous studies with success rates of between 70% to 80% had a duration of follow-up of approximately thirty-six months. Turk and Lee stated that a follow-up duration of at least six years was necessary to determine the outcome of soft-tissue releases. The Kaplan-Meier plot in Figure 1 illustrates both the value of assessing the success rate according to the GMFCS level and the need for extended follow-up.

In our study, age at the time of the index surgery was related to surgical success in the univariate analysis but the migration percentage and the GMFCS level completely explained the surgical success rate in the multivariate analysis. The risk of hip displacement in children with spastic cerebral palsy is considered to be at its greatest between four and twelve years of age. However, previous studies on the importance of age on the outcome of soft-tissue releases in patients with spastic cerebral palsy are contradictory. Three studies found better results when soft-tissue releases were performed in younger children (under the age of five) in a systematic review of soft-tissue surgery for hip subluxation in cerebral palsy, Stott and Piedrahita found eleven studies that analyzed age as a variable. Eight of these studies could not demonstrate a difference related to age at the time of the surgery. An association among increased age at the time of the index surgery, higher GMFCS level, and surgical failure was noted in our study.

The strengths of this study include the large number of children with cerebral palsy who were selected from a statewide Cerebral Palsy Register, their management by a small group of surgeons with use of standardized protocols, and the reason-ably long mean duration of follow-up. The weaknesses of this study include the four different combinations of adductor releases and the incomplete follow-up of some children.

In conclusion, the success of adductor surgery in children with cerebral palsy was significantly influenced by the GMFCS level, in conjunction with the initial migration percentage. Active GMFCS level-II patients achieved a high rate of success from isolated hip adductor surgery, whereas GMFCS level-IV and V patients had higher rates of failure and warrant careful surveillance with long-term follow-up. Classifying children according to GMFCS level prior to hip adductor surgery provides the surgeon with more child-specific information with regard to long-term prognosis and likely surgical outcomes.

On the basis of the results of this study, we now explain to the families of children at GMFCS level IV or V that although hip adductor surgery remains our index procedure, it functions as a temporizing measure and is associated with a higher rate of failure in such children. Lack of awareness of the high failure rate of preventive surgery in children who are at GMFCS level IV or V may lead to an inadequate duration of follow-up, late presentation for reconstructive surgery, and dissatisfaction with preventive surgery.

Appendix
An appendix describing the adductor release surgical protocol is available with the online version of this article as a data supplement at jbjs.org.

References
