

SOFT-TISSUE RELEASES TO TREAT SPASTIC HIP SUBLUXATION IN CHILDREN WITH CEREBRAL PALSY

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Background: Spastic hip subluxation and dislocation are common problems in children with cerebral palsy. Soft-tissue releases have proved to be beneficial in the prevention of spastic hip dislocation. A protocol for treatment based on patient age, hip abduction, and hip migration percentage was established in 1988. The purpose of this study was to assess the outcome in sixty-five children treated according to this protocol and followed for a minimum of eight years.

Methods: The medical records and radiographs of sixty-five children, from an original series of seventy-four patients, who met the inclusion criteria were available for review. Forty-seven children had spastic quadriplegia and were unable to walk; eighteen children had spastic diplegia and were able to walk independently or with assistive devices. The mean age at the time of the surgery was 4.4 years. Open adductor tenotomy and psoas muscle recession or iliopsoas tenotomy were performed on 129 hips, which were followed for a mean of 10.8 years. The mean age at the time of follow-up was fifteen years. Hips were grouped according to the hip migration percentage preoperatively, at one year postoperatively, and at the time of final follow-up. The final outcome for the patient was defined according to the worse hip. An analysis was performed to identify potential factors influencing outcome.

Results: Thirty-two patients (49%) had a good result, eleven (17%) had a fair result, three (4%) had a poor result, and nineteen (30%) had a failure. The mean hip migration percentage was 34% preoperatively and 18% at the time of final follow-up. Nineteen patients required subsequent osseous reconstructive procedures, and eleven required repeat soft-tissue releases. The migration percentage at one year postoperatively was the most predictive of the final outcome ($p = 0.001$). Patients who had been able to walk preoperatively had a better long-term outcome ($p = 0.01$). Neither the preoperative hip migration percentage nor the age at surgery significantly affected the outcome.

Conclusions: Soft-tissue release was effective for long-term prevention of hip dislocation in 67% (forty-three) of sixty-five children with spastic hip subluxation. Two preoperative factors that were related to a favorable outcome were a spastic diplegic pattern of involvement and the ability to walk. The hip migration percentage at one year postoperatively was a good predictor of final outcome.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Spastic hip subluxation and dislocation are common problems in children with cerebral palsy^{1,2}. Progressive hip subluxation and eventual dislocation are believed to result from muscle imbalance causing abnormal hip positioning in flexion, adduction, and internal rotation³. The prevalence of spastic hip subluxation and dislocation is related to the severity of the spasticity. Children who are unable to walk and who have a spastic quadriplegic pattern of involvement have the highest prevalence of hip dislocation, which was reported to be 80% (thirty-five of forty-four) in one series⁴. The secondary effects of spastic subluxation and dislocation include problems with seating, gait, personal hygiene, and pain.

Also, the adducted position of the hip may contribute to the development of pelvic obliquity and subsequent scoliosis^{5,6}.

Different surgical procedures, including soft-tissue releases and osseous surgery, can be used to treat these conditions, depending on the age of the child and the severity of the hip subluxation. Soft-tissue releases (muscle recessions and tenotomies) have proved to be beneficial in the prevention of spastic hip subluxation and dislocation⁷⁻⁹. However, there has been disagreement about the timing and indications for the procedure, the specific muscles to release, and the postoperative management. Miller and Bagg evaluated the impact of age and migration percentage on the risk of

progression of hip subluxation in patients with cerebral palsy¹⁰. They concluded that the risk of a normal hip progressing to subluxation is similar between age groups up to the age of eighteen years, but thereafter there is a very low risk of substantial progressive subluxation. Hips that had reached skeletal maturity and had a migration percentage of $\leq 29\%$ remained stable into adulthood. Hips that were subluxated with a migration percentage of 30% to 60% continued to have an approximate 25% risk (twelve of fifty-three) of further subluxation. All hips with severe subluxation (a migration percentage of $\geq 61\%$) progressed to dislocation regardless of the age of the patient. On the basis of these data, a standard protocol for treatment was established. A series of seventy-four patients was treated by the senior author (F.M.), from 1988 through 1991, according to this protocol. These patients were evaluated after a short duration of follow-up (mean, thirty-nine months), and fifty-five (74%) of them had a satisfactory outcome (a good or fair result)¹¹. The goal of the current study was to evaluate the outcome in this group of patients after a minimum duration of follow-up of eight years and to assess the efficacy of this protocol.

Materials and Methods

The study population consisted of a consecutive series of seventy-four children with cerebral palsy who had undergone open adductor tenotomy and psoas recession or iliopsoas tenotomy, between March 1988 and January 1991, to treat spastic hip subluxation. The hospital's institutional review board gave expedited approval and waived the need to obtain written informed consent. A retrospective review of the results in this group after three years of follow-up was reported in 1997¹¹. To be included in the present study, a patient had to have been followed for a minimum of eight years. Nine children did not meet this criterion: one had died, and the other eight had moved and could not be contacted. The mean duration of follow-up for these nine patients was four years (range, one to six years), and the mean migration percentage at the latest follow-up visit was 20% (range, 0% to 33%). Sixty-five patients (88%) were followed for a minimum of eight years (mean, 10.8 years; range, eight to thirteen years). Forty-seven children had spastic quadriplegia and eighteen had spastic diplegia. All of the spastic quadriplegic children were unable to walk or had a minimal ability to walk ("exercise ambulators"). The spastic diplegic children were at least able to walk with assistive devices; six were able to walk about the community, and twelve were able to walk about the house while using a walker. Thirty-seven patients were boys, and twenty-eight were girls. Sixty-four patients had bilateral surgical correction and one had unilateral surgical correction, for a total of 129 treated hips. The mean age at the time of the surgery was 4.4 years (range, 1.9 to eight years).

A protocol for prevention of spastic hip dislocation, initiated in 1988, was used as a guide to indicate surgical treatment (Table I). According to this protocol, the indications for surgery were based on the age of the patient, the degree of hip abduction in extension, and the hip migration

percentage. Hip abduction was measured with the child supine with the knees and hips fully extended, as recommended by Rang¹². The hip migration percentage was used to determine the degree of hip subluxation radiographically, as described by Reimers^{7,13}. With this method, a vertical line (the Perkins line) is drawn from the lateral edge of the acetabulum perpendicular to a horizontal line connecting both triradiate cartilages of the pelvis (the Hilgenreiner line). The measurement is performed on an anteroposterior radiograph of the pelvis made with the patient supine, the femora in neutral abduction-adduction relative to the pelvis, and the patellae facing anteriorly. The portion of the femoral head lateral to the Perkins line is measured, and this measurement is expressed as a percentage of the entire horizontal width of the femoral head. This is the so-called migration percentage. Reimers noted an intraobserver error of $\pm 10\%$ with this method because the position of the acetabular edge may be difficult to define⁷.

Reimers also attempted to ascertain the normal value for the migration percentage. He found that the femoral head was completely covered by the acetabulum in 90% of hips in children who were three years of age or younger. Thus, 0% was considered to be the normal value for the migration percentage in this age group. In normal children four to sixteen years of age, 5% of the femoral head at most was lateral to the Perkins line. Reimers considered the normal migration percentage to range from 0% to 5% in this age group. He considered a hip in a patient with cerebral palsy to be subluxated if at least one-third of the femoral head was lateral to the Perkins line; therefore, a migration percentage of $< 33\%$ was classified as normal in such a patient. The 33% value is not related to the long-term outcome or a specific risk of progression but apparently was chosen to indicate a clearly abnormal hip.

The surgical procedure consisted of an adductor longus tenotomy, a complete myotomy of the gracilis, and a psoas recession or an iliopsoas tenotomy in all of the patients in our series. If hip abduction was $< 45^\circ$ after release of the adductor longus and the gracilis, a partial myotomy of the adductor brevis was also done until 45° of hip abduction could be achieved. If the migration percentage was $\geq 40\%$ and it seemed unlikely that the patient would ever be capable of functional walking, a neurectomy of the anterior branch of the obturator nerve was also performed. Asymmetric procedures, defined as operations in which the adductor brevis release and/or the neurectomy was performed unilaterally, were done in nine patients. The iliopsoas tendon was completely tenotomized in patients who were incapable of walking. However, in patients with any ambulatory potential, only the psoas musculotendinous junction was transected and all muscle fibers of the iliacus were carefully preserved in order to preserve the hip flexor power of the muscle. The approach to the iliopsoas was through the same incision. The interval between the residual adductor brevis and pectineus was developed down to the femur, the iliopsoas tendon was identified, and the psoas tendon fibers were divided as far proximally as possible. If the popliteal angle was $\geq 45^\circ$ after completion of the adductor tenotomies,

TABLE I Indications for Soft-Tissue Releases in Patients with Cerebral Palsy

Patients ≤ 7 yr of age	Migration percentage of $\geq 25\%$ and abduction of $\leq 30^\circ$ Migration percentage of 25%-50% and abduction of 31° - 45° , if migration percentage increases 10% per year Migration percentage of $\geq 50\%$ and abduction of $\leq 45^\circ$
Indication for a repeat soft-tissue release	Migration percentage of 25%-40% and abduction of $\leq 45^\circ$
Patients ≥ 8 yr of age	If migration percentage $\geq 40\%$, proceed to osseous hip reconstruction

proximal hamstring recessions were also performed.

After the surgery, knee immobilizers were used for eight to twelve hours a day for one month. No other immobilization or orthotic device was used. Physical therapy three times a week for six weeks was prescribed. The parents were taught to position the child prone for at least half of the time that he or she spent in bed and to stretch the adductor muscles at least once a day.

The patients' medical records were reviewed to determine the cerebral palsy pattern, ambulatory status, age at surgery, whether a repeat soft-tissue release or osseous surgery had been performed, and hip range of motion. We did not perform a functional assessment to evaluate the clinical benefits of the procedures in this study. To avoid interrater variability, all of the radiographs were reviewed by the same investigator. The hip migration percentage was recorded from the preoperative, one-year follow-up, and final follow-up radiographs. Preoperatively, a hip was considered to be at-risk if the migration percentage was $\leq 24\%$. The degree of hip subluxation was defined as mild if the migration percentage was between 25% and 39%, moderate if it was between 40% and 59%, and severe if it was $\geq 60\%$. All hips were classified, according to the migration percentage, into one of four surgical outcome groups at the time of the latest follow-up. The outcome for a patient was determined by the worse of the two hip outcomes. The outcome was considered to be good if the migration percentage was $\leq 24\%$, fair if it was 25% to 39%,

poor if it was 40% to 59%, and a failure if it was $\geq 60\%$. All children who required osseous hip reconstruction were considered to have a failure, but we did not consider the index procedure to be a failure if the patient required a repeat soft-tissue procedure.

Statistical Analysis

Two sets of analyses were done. For the first set, the independent variable was the surgical outcome for the hips. We defined a satisfactory result as a good or fair outcome and an unsatisfactory result as a poor outcome or a failure. The dependent variables were the preoperative and one-year postoperative migration percentages. For the second set of analyses, the independent variable was the patient outcome (defined by the worse hip outcome) and the dependent variables were the ambulatory status (ambulatory compared with non-ambulatory) and the age at the time of surgery. The t test was used for the analyses of the migration percentage and the age at surgery, and the chi-square test was used for the analysis of the ambulatory status. The significance level was set at $p \leq 0.05$.

Results

Sixty-five patients with spastic hip subluxation underwent soft-tissue release procedures on a total of 129 hips and were evaluated at a mean of 10.8 years (range, eight to thirteen years) postoperatively. The mean age at the time of follow-up

Fig. 1

Results for the sixty-five patients and 129 hips. A good outcome was a migration percentage of $\leq 24\%$, a fair result was a migration percentage of 25% to 39%, a poor result was a migration percentage of 40% to 59%, and a failure was a migration percentage of $\geq 60\%$.

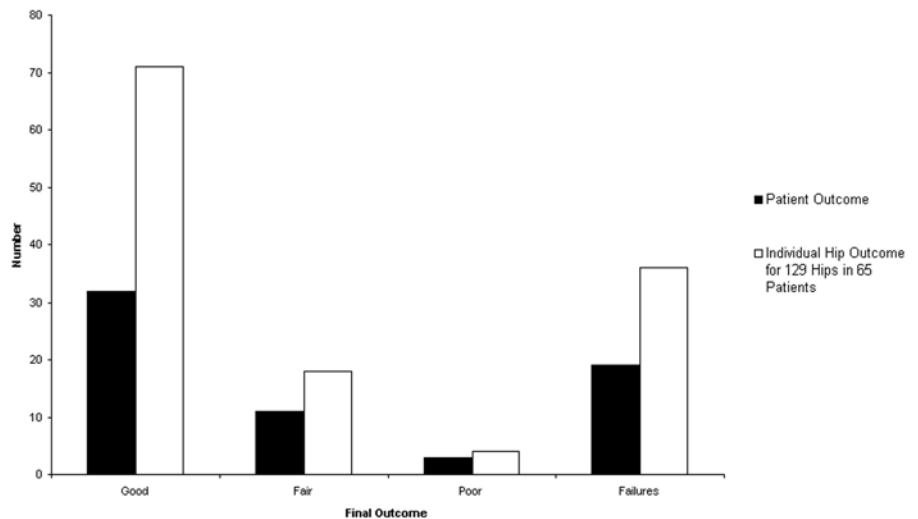


Fig. 2

Results grouped by the severity of the preoperative migration, which ranged from normal, including hips-at-risk, to severe subluxation. The outcome was classified as satisfactory if the migration percentage was $\leq 39\%$ and as unsatisfactory if it was $\geq 40\%$. Although there was a clear trend toward an association between worse preoperative subluxation and a higher rate of unsatisfactory outcomes, it was not significant.

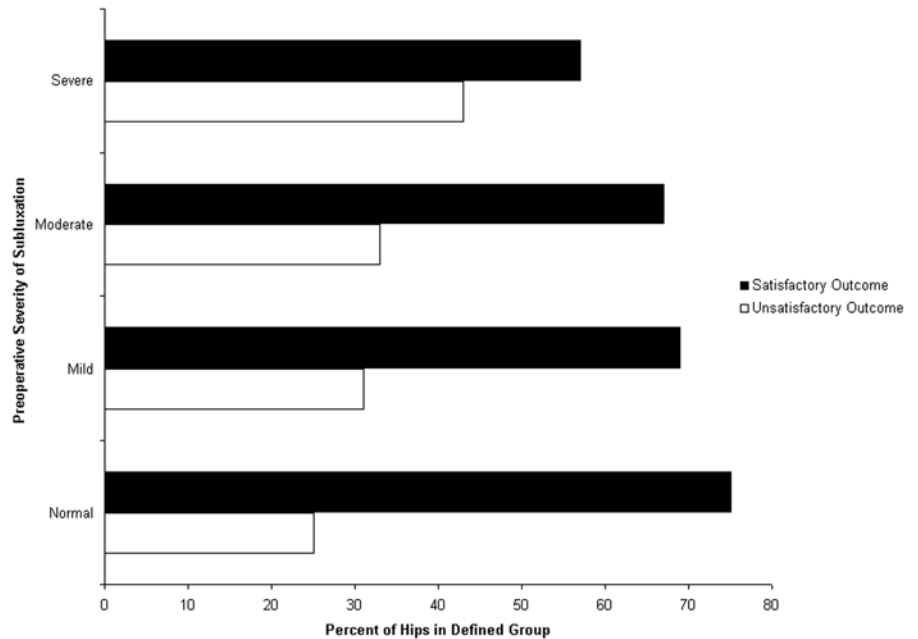
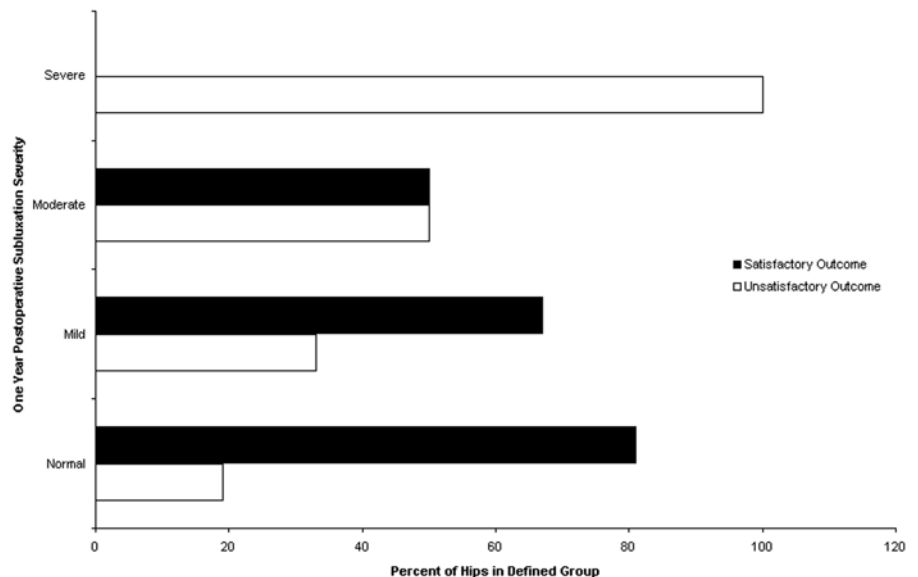


Fig. 3

Results according to the migration percentage at one year postoperatively, which was significantly associated with the final outcome.



was fifteen years (range, twelve to twenty years), and forty-nine patients (75%) were skeletally mature. The sixteen patients who were not skeletally mature at the time of the latest follow-up had a mean age of thirteen years (range, eleven to fourteen years). All patients, except one who had a windblown deformity with an abduction contracture of the right hip, had both hips operated on simultaneously. All children had at least one hip with subluxation, defined as a migration percentage of $\geq 25\%$. Nine of the patients had asymmetric soft-tissue releases. Eleven patients had bilateral repeat soft-tissue release procedures at a mean age of thirteen years (range, five to eighteen years).

Thirty-two patients (49%) had a good result; eleven (17%), a fair result; three (4%), a poor result; and nineteen (30%), a

failure (Fig. 1). No wound infections, sciatic nerve injuries, or other acute problems related to the surgery were recorded in the medical records. There were no fixed extension or abduction contractures, and none of the children who were able to walk had a wide-based gait that impeded walking. The patient who had a windblown deformity and underwent unilateral adductor tenotomies had a good final result. Of the nine patients who had asymmetric soft-tissue releases, three had a good result, one had a fair result, one had a poor result, and four had a failure. A windblown deformity had not developed in any of these patients at the time of the latest follow-up. Of the sixteen patients who were not skeletally mature at the conclusion of the study, twelve had a good result, two had a poor result, and two had a failure.



Fig. 4-A
Radiograph of a five-year-old girl with spastic diplegia who was able to walk about the community. Preoperatively, the migration percentage was 40% bilaterally, and there was acetabular dysplasia with a 30° acetabular index.

Of the 129 hips, seventy-one (55%) had a good result; eighteen (14%), a fair result; four (3%), a poor result; and thirty-six (27%), a failure (Fig. 1). The mean migration percentage was 34% (range, 5% to 80%) preoperatively, 27% (range, 0% to 60%) at one year postoperatively, and 18% (range, 0% to 100%) at the time of final follow-up. Of the eleven children who had repeat soft-tissue releases, ten had a satisfactory final result; the mean preoperative and final follow-up migration percentages in the eleven children were 31%

(range, 18% to 45%) and 18% (range, 0% to 35%), respectively.

There was a trend for better results when the preoperative migration percentage was lower (Fig. 2). The outcome was unsatisfactory in 25% (six) of the twenty-four hips-at-risk, 31% (twenty-two) of the seventy-one hips with mild subluxation, 33% (nine) of the twenty-seven hips with moderate subluxation, and 43% (three) of the seven hips with severe subluxation. However, these differences were not significant. When the migration percentage at one year postoperatively



Fig. 4-B
At one year postoperatively, the migration percentage was 20% in the right hip and 15% in the left hip.



Fig. 4-C

At the time of final follow-up, when the patient was nineteen years of age, there was no deterioration, with a migration percentage of 12% bilaterally and no acetabular dysplasia.

was the dependent variable studied in relation to the final outcome, the differences became significant ($p = 0.001$) (Fig. 3). The mean migration percentage at one year postoperatively was 23% (range, 0% to 40%) for the patients who had a satisfactory outcome compared with 34% (range, 10% to 60%) for the patients with an unsatisfactory outcome. Eighty-one percent (sixty-one) of the seventy-five hips-at-risk (those with a migration percentage of $\leq 24\%$) at one year postoperatively had a good or fair result at the time of final follow-up. Sixty-seven percent (twenty-four) of the thirty-six hips with mild subluxation (a migration percentage of 25% to 39%) at one year postoperatively had a good or fair outcome. Fifty percent (eight) of the sixteen hips that had moderate subluxation (a migration percentage of 40% to 59%) at one year after the surgery had a good or fair outcome. The two hips that were severely subluxated (a migration percentage of $\geq 60\%$) at one year after the surgery required an osseous reconstructive procedure.

Of the eighteen children who had spastic diplegia and were able to walk, eleven had a good result, five had a fair result, one had a poor result, and one had a failure. Of the forty-seven children who had spastic quadriplegia and were unable to walk, twenty-one had a good result, six had a fair result, two had a poor result, and eighteen had a failure. The outcome was satisfactory in 89% (sixteen) of the eighteen patients who were able to walk and in 57% (twenty-seven) of the forty-seven patients who were not. This difference was significant ($p = 0.01$).

To evaluate the impact of age at the time of surgery, the patients were divided into two groups, four years of age or younger (forty-four patients) and five years of age or older (twenty-one patients). The outcome was satisfactory in 68% (thirty) of the patients in the younger group and in 61%

(thirteen) of those in the older group. This difference was not significant.

Discussion

The patients in this series were part of a group of seventy-four children with cerebral palsy and spastic hip subluxation who had been subjects of a previous review, performed at a mean of thirty-nine months (range, eight to sixty-nine months), at which time the result was satisfactory (good or fair) in fifty-five (74%) of the seventy-four patients¹¹. We believed that a longer follow-up period, during which most of the patients reached skeletal maturity, was crucial to demonstrate the effectiveness of the treatment and to validate the protocol that has been used at our institution since 1988. During this longer follow-up period, there was some deterioration in the results, with 67% (forty-three) of the sixty-five patients having a good or fair result compared with 74% (fifty-five) of the seventy-four patients after three years of follow-up. This deterioration was expected on the basis of previous data indicating that spastic hip subluxation does not stabilize until skeletal maturity¹⁰. Although sixteen patients in the present study had not reached skeletal maturity by the time of the latest follow-up, we decided to include them in the analysis of the results because their mean age was thirteen years; the outcome was good in twelve of these patients. Being close to skeletal maturity and having a migration percentage of $< 30\%$ indicates a minimum risk of deterioration in these patients.

The aforementioned protocol, based on Reimers' study in 1980⁷, was designed to decrease hip subluxation and prevent dislocation in children with cerebral palsy. Reimers found that the contracture of the adductor muscles was the primary cause of spastic hip subluxation. He demonstrated that, after the hip becomes subluxated, there is a risk of a 10% increase in the mi-

Fig. 5-A

Radiograph of a three-year-old girl with spastic quadriplegia who was unable to walk. The migration percentage was 23% in the right hip and 30% in the left hip before the performance of gracilis, adductor longus, and iliopsoas tenotomies bilaterally.



Fig. 5-B

A windblown deformity developed when the patient was five years of age. The right hip showed a migration percentage of 40%, and the patient underwent repeat surgery with complete release of the recurrent adductor longus scar mass and the adductor brevis as well as transection of the anterior branch of the obturator nerve on the right.

migration percentage per year⁷. He also stated that spontaneous improvement of a subluxated hip is never expected and thought that, to obtain the best long-term results, bilateral adductor tenotomies should be performed as soon as hip subluxation is noted. The prevalence of hip subluxation in patients with cerebral palsy has varied among series reported in the lit-

erature. Patients with severe involvement have the highest rate, as reported by Howard et al.⁴. Lonstein and Beck¹⁴ reported a prevalence of 11% (eight of seventy-six) in patients classified as "independent ambulators" and of 23% (ten of forty-three) in those classified as "dependent ambulators." Miller and Bagg¹⁰ agreed with Reimers that hip subluxation does not improve



Fig. 5-C

When the patient was eight years of age, the migration percentage was 20% bilaterally. The patient was able to do transfers and walking exercise.



Fig. 5-D

When the patient was fifteen years of age, the hips were well covered, with a 10% migration percentage on the right and a 15% migration percentage on the left.

spontaneously in patients with cerebral palsy and reported that the risk of progression was 23% (twelve of fifty-three) after skeletal maturity if the migration percentage was $\geq 30\%$.

The rates of good results following soft-tissue releases for spastic hip subluxation have ranged from 33% (twelve of thirty-six)⁷ to 90% (ten of eleven)¹⁵ in the literature. This wide range of success rates is due to differences among the series regarding the degree of neurological involvement, age at surgery, hip migration percentage, surgical technique, postoperative care, definitions of success and failure, and duration of follow-

up. In the current series, our protocol prevented hip dislocation or substantial subluxation in 67% (forty-three) of sixty-five patients followed for a mean of ten years. In the study with the longest follow-up in the literature (mean, 8.1 years; minimum, four years), by Turker and Lee⁹, the rate of success was 42% (nineteen of forty-five patients).

There is general agreement in the literature that a higher preoperative migration percentage leads to a less favorable final outcome^{7,9,15}. Reimers recommended that adductor elongation be performed as soon as subluxation, defined by a mi-

gration percentage of $\geq 33\%$, is observed⁷. Onimus et al. reported good results in eleven of twelve patients in whom the surgery had been performed before the age of four years and who had had subluxation of $< 33\%$ preoperatively; however, they included a number of children who had no subluxation at the time of surgery and in whom subluxation may never have developed¹⁵. Turker and Lee reported that patients with a successful outcome had had a lower mean value for preoperative subluxation than had patients who had failure of adductor tenotomies, but they were unable to determine a cutoff value that was predictive of outcome⁹. The present study showed a trend toward better results for patients with a lower preoperative migration percentage, although this observation was not significant. This trend was present in the context of indications for surgery that required mild spastic subluxation at a minimum and precluded severe spastic subluxation and dislocation. It seems very likely that the outcomes of the soft-tissue releases would have been strongly affected by the preoperative migration percentage if our study had had an equal number of children with dislocations, hips-at-risk, and mild, moderate, and severe subluxation. The current treatment protocol was developed with the belief that muscle releases are not indicated if there is no subluxation (defined as a migration percentage of $\leq 24\%$) and are seldom indicated if there is severe subluxation or dislocation (defined as a migration percentage of $\geq 60\%$).

The value of the one-year postoperative migration percentage as a predictor of final outcome has not been previously reported in other series, to our knowledge. This predictive factor is not an absolute indicator for an individual, but it is important to identify those patients with a higher risk of progression who definitely require close follow-up. One year after the surgery, patients with a satisfactory outcome had a mean migration percentage of 23% (range, 0% to 40%), whereas patients with an unsatisfactory result had a mean migration percentage of 34% (range, 10% to 60%). This difference was significant ($p = 0.001$). This result is consistent with the previously reported finding that hips with a migration percentage of $< 30\%$ remain stable into adulthood¹⁰.

Another important factor affecting outcome is the level of neurological involvement in these children. This effect was evaluated by comparing the final outcome groups according to ambulatory status, with the patients who had spastic quadriplegia and the patients who could not walk considered to be identical groups. Children who were able to walk and had a spastic diplegic pattern of involvement had significantly better results (Figs. 4-A, 4-B, and 4-C), a finding that is consistent with those of Reimers⁷ and those of Kalen and Bleck¹⁶.

Reports in the literature have presented inconsistent findings regarding the influence of the patient's age on the final outcome. Reimers⁷ observed a better outcome in patients who were four years of age or less at the time of the surgery. Onimus et al.¹⁵ reported a good result in eleven of twelve patients who had undergone surgery before the age of four years and who had a migration percentage of $< 33\%$. Turker and Lee⁹ found no significant association between outcome and

age. Age was not predictive of outcome in our study either; however, this was in the context of a low mean age at the time of the surgery (4.4 years). The upper age limit for surgery was eight years in the current protocol because it seemed unlikely that adequate acetabular remodeling and hip reduction could occur in older children with mild or moderate subluxation. This decreased ability to remodel in an older child seems to have been confirmed by Reimers' finding that repeat soft-tissue release was less effective than the primary procedure⁷. In the current study, the number of patients who underwent a repeat procedure was too low for us to obtain conclusive results, although the outcome in this group was good (Figs. 5-A through 5-D). Two factors that could have contributed to these satisfactory results were the preoperative migration percentage (mean, 31%) and the percentage of children who were able to walk (34%). In light of these results, we believe that a repeat soft-tissue release may be indicated in patients who are eight years of age or older and have a migration percentage of no greater than 40% and minimal acetabular dysplasia. It seems intuitively clear that hip adductor lengthening, either as a primary or repeat procedure, can be justified only if there is limited hip abduction, usually defined as $< 30^\circ$, although we do not have the data to confirm this.

Another factor that seems to influence outcome is psoas release. Reimers⁷ did not systematically transect the psoas muscle; he performed this procedure only in patients who had a hip flexion contracture. He did not find hip flexor release to have any positive effect on the migration percentage. Kalen and Bleck¹⁶ also performed psoas recession only in patients with hip flexion contracture. Seventy-two percent (thirty-eight) of fifty-three hips treated with psoas recession in their study had a good outcome compared with 64% (twenty-five) of thirty-nine hips that did not have psoas recession. Onimus et al.¹⁵ performed intramuscular psoas recession in all of their patients, and the result was satisfactory in 65% (twenty-six) of forty hips. In our study, psoas release was done in all patients, and the percentage of satisfactory outcomes was comparable with that in the study by Onimus et al.

The rate of unsatisfactory outcomes (twenty of forty-seven; 43%) in our patients with spastic quadriplegia is especially bothersome. Attempts to improve these outcomes might include postoperative abduction bracing, which has been reported to decrease hip subluxation at the expense of increased hip abduction deformities¹⁷. Windblown hip deformity that required hip reconstruction developed in three children in the current series. However, no patient with bilateral hip abduction contracture required treatment or was symptomatic. The association between windblown deformity, pelvic obliquity, scoliosis, and hip dislocation has been the focus of several studies^{6,14,16}. There is agreement that windblown deformity is related to hip dislocation, is difficult to treat, and is prone to switch direction after asymmetric releases^{6,11}. Pelvic obliquity and scoliosis are not so clearly related to hip dislocation. Asymmetric releases are, in general, not recommended since they can cause abduction contracture¹¹. Hypertonicity seems to be responsible for asymmetric contractures, and sur-

gery alone is not a definite treatment for this condition¹¹.

Another option for improving outcome is more aggressive muscle lengthening combined with neurectomy of the anterior branch of the obturator nerve, especially in a child with quadriplegia who is unable to walk. It is, however, difficult to correctly predict which child will become a so-called functional ambulator when the hip subluxation develops before the age of three years. On the basis of this study and previous reports^{7,9,11,15,16}, it seems unlikely that muscle lengthening can correct deformities in all children with spastic hip disease; however, with close follow-up and diligent application of this standardized protocol, the need for osseous surgery should be reduced to a minimum of 5% of patients with hip subluxation who can walk and 45% of patients with spastic hip disease who cannot walk.

In conclusion, on the basis of the results of this long-term follow-up review, we believe that soft-tissue releases can be used effectively to treat hip subluxation and to prevent dislocation in patients with cerebral palsy. The hip migration percentage at one year postoperatively is a good predictor of final outcome. Close follow-up and repeat adductor lengthen-

ing may further improve the outcome and reduce the need for hip reconstruction. ■

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