Extreme Femoral Shortening: An Approach to the Chronically Dislocated Hip in the Nonambulatory Pediatric Population

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Abstract

There are many surgical techniques for treating the chronically dislocated, painful hip in patients with neuromuscular spasticity, but each has significant complication rates.

We conducted a study to examine the outcomes of a novel technique, an extreme varus femoral shortening osteotomy, used in nonambulatory patients with neuromuscular spasticity. Patients who underwent the procedure were identified retrospectively by surgical codes. Medical records were reviewed for range of motion, pain and functional assessment, surgical indications, complications, and results. In addition, preoperative and postoperative radiographs were assessed, and caretaker questionnaires reviewed.

Between 2001 and 2010, 1 surgeon performed 6 femoral shortening osteotomies in 5 nonambulatory patients with neuromuscular spasticity. In all 5 cases, there were improvements in pain, sitting tolerance, ease of hygiene, and ease of transfers at a minimum follow-up of 2 years (mean, 3.4 years). Postoperative complications included asymptomatic heterotopic ossification and recurrent subluxation.

Extreme femoral shortening is a reproducible surgical technique that alleviates pain and makes hygiene easier in nonambulatory children with symptomatic hip dislocations caused by neuromuscular spasticity. Our complication rate was comparable to that of other procedures.

With increasing attention being given to surveillance, fewer children are presenting with chronically dislocated, painful hips. For children who present, however, treatment can be difficult. Hip disorders are common in nonambulatory children, especially those with neuromuscular spasticity.[1] Although their hips are normal at birth, subluxation and eventually dislocation can occur.[2] Absence of normal gait is a predisposing factor; therefore, hip subluxation is more common in spastic quadriplegic cerebral palsy than in spastic diplegic cerebral palsy.[1-3] Excessive femoral anteversion, coxa valga, and muscle imbalance with spasticity from the adductor and iliopsoas muscles also contribute to subluxation.[1,2] Combined, these factors cause the femoral head to subluxate and eventually dislocate, typically in the posterosuperior direction in 25% to 30% of nonambulatory children.[2,3] Children with the most neurologic involvement and children who do not achieve independent sitting usually have the most severe hip pathology.[2] Children who are dependent sitters have a 60% rate of hip subluxation and dislocation, compared with 7% in children who ambulate.[4]

Failure to treat chronic hip dislocations in a spastic, nonambulatory child has several consequences. Pain, the most common, presents in about 70% of these untreated patients. The pain usually develops slowly and gradually over a few years, starting between ages 4 and 12 years.[2,5] It tends to be proportional to the degree of subluxation, with dislocation being the most painful state.[6] Untreated dislocations are also associated with adverse effects on sitting tolerance and hygiene, decubitus ulcerations over the greater trochanters, pathologic fractures of the distal femur, and pelvic obliquity.[2,5,7]

It is well accepted that prevention is the best treatment for hip dislocation in nonambulatory children with neuromuscular spasticity. However, neglect and inadequate treatment lead to advanced pathology and symptoms. Once a hip begins to subluxate in the spastic patient, it seldom improves without intervention.[2] For this reason, the best time for surgery is before the hip begins to subluxate. Failure to intervene leads to dislocation with irreversible damage. Several procedures have been used to treat chronically dislocated hips in the neuromuscular spastic pediatric subpopulation. However, the goals of treatment vary according to functional status. In chronically dislocated hips in the nonambulatory patient population, treatment modalities are often referred to as *salvage procedures*.[2] The primary reasons for performing a salvage procedure in this patient group are to relieve the patient's pain and make transfers and hygiene easier for the caretaker. Bischof and Chirwa[8] found that even activities of daily living, including washing, dressing, and transfers, can cause pain for these patients.

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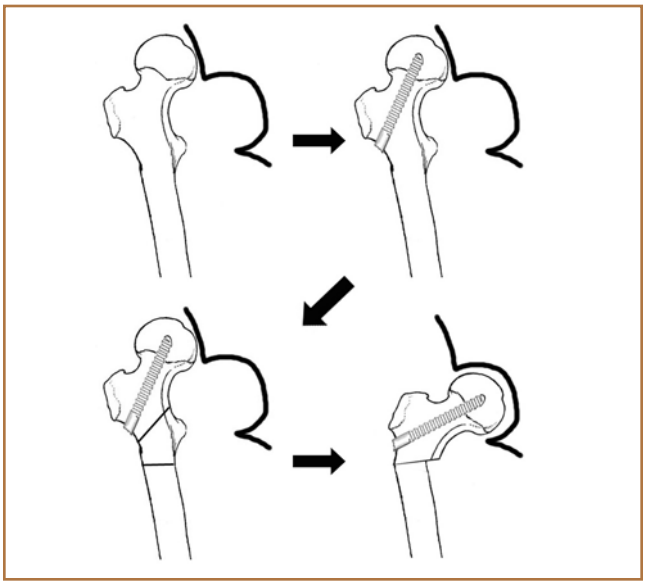

Figure 1. Schematic of series of steps in operative technique.

Compared with nonoperative management of the dislocated hip, orthopedic intervention improves function and quality of life.[9,10] Current surgical options are proximal femoral resection with or without muscle interposition, redirectional proximal femoral osteotomy, combined pelvic and femoral osteotomies, and hip arthrodesis.[4,5,11-18] These procedures have relatively high rates of complications, which include heterotopic ossification, proximal femoral migration, hardware failure, and fracture.[4,5,11-18] Newer techniques include hip arthroplasty and hip resurfacing.[19-25]

Although the trend for ambulatory spastic children is to relocate the femoral head, most salvage procedures create a valgus osteotomy of the proximal femur, leaving the femoral head out of the acetabulum.[2] However, persistent proximal femoral migration can occur, leading to skin breakdown over the hips, caused by a prominent femoral head.

We wanted to develop a surgical alternative that would help relieve pain, ease hygiene care, and improve transfers while preserving the femoral head and minimizing the complication rate. We theorized that marked femoral shortening would decrease spastic tone across the hip, thereby reducing rates of subluxation and skin breakdown. In this article, we present midterm clinical and radiographic results of a varus-producing and femoral shortening osteotomy of 6 chronically dislocated hips in 5 nonambulatory children.

Materials and Methods

We performed this study at Children's Memorial Hospital in Chicago, Illinois. After obtaining institutional review board approval, we used *ICD–9* (*International Classification of Diseases, Ninth Revision*) and *CPT* (*Current Procedural Terminology*) codes as filters to identify the records of patients who had been diagnosed and surgically treated for chronically dislocated hips at the hospital between 2002 and 2010. All patients included were nonambulatory children with neuromuscular spasticity who had presented to clinic with dislocated hips. Only patients treated with an extreme femoral shortening varus osteotomy were included. After a thorough review of all patient matches, it was determined that 6 hips in 5 patients fulfilled the initial search criteria. These patients' medical records and imaging studies were reviewed.

The primary indication for surgery was chronic pain caused by progressive subluxation. Contraindications included preexisting femoral head collapse or avascular necrosis, severe acetabular dysplasia, and infection. The medical records were reviewed before and after surgery for physical examination, including hip range of motion (ROM; primarily hip abduction), pain and functional assessments, surgical indications, complications, and inpatient stay. Preoperative and serial postoperative radiographs were reviewed. The patients' caretakers were given informal surveys 6 and 12 months after surgery and then at annual follow-ups. On the survey, caretakers were asked for their perceptions of patient pain at rest and with transfers and movement, and about sitting tolerance, hygiene and perineal care, and satisfaction with the procedure.

Surgical Technique

The patient was positioned supine on a radiolucent table with a bump placed under the ipsilateral buttock. A standard lateral incision for the proximal femur was made using an 8-cm incision from the level of the greater trochanter and proceeding distally. After division of the skin and subcutaneous tissue, the fascia lata was split in line with the incision. This revealed the proximal femur. The vastus lateralis was then reflected anteriorly and dissected off the intramuscular septum down to the periosteum. Next, the proximal femur was subperiosteally stripped circumferentially from the level of the greater trochanter, making sure not to injure the physis, down to the subtrochanteric region. After that, a guide wire was inserted from the lateral aspect of the femur to the center of the femoral head using fluoroscopy to guide the trajectory. A cannulated reamer was passed over the guide wire, and the lag screw was then inserted. Next, an oscillating saw was used to make an osteotomy parallel to the lag screw (**Figure 1**). Another osteotomy, perpendicular to the diaphysis, was then created on the distal femoral segment about 4 to 5 cm distal from the initial osteotomy site. The varus wedge segment of bone was then cleared of any periosteal attachments and removed. A 4.5-mm hip osteotomy plate (Howmedica; Stryker, Mahwah, New Jersey) was then fitted over the lag screw and tightened down. The femoral shaft was then reduced to the distal aspect of the plate using a Verbrugge clamp. With the hip kept in abduction, the reduction of the hip was then checked using fluoroscopy. During surgery, if the hip remained subluxated, more of the femur was resected until the hip was concentrically reduced. When the hip was reduced, the osteotomy sites were lined up, and the remainder of the diaphyseal screws in the plate were drilled and filled using cortical screws. The wedge of bone that had been removed was morselized and then placed along the anteromedial portion of the osteotomy site as bone graft.

Figure 2. Preoperative radiograph shows right hip dislocation in nonambulatory child with spastic quadriplegic cerebral palsy.

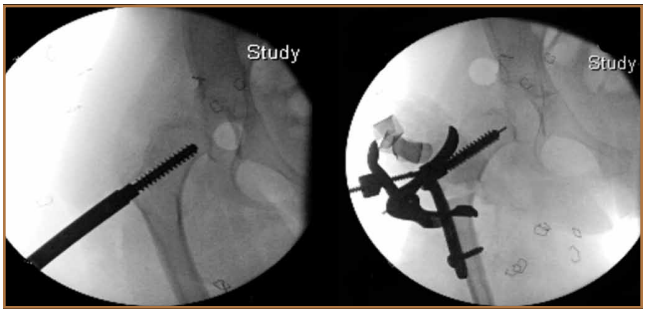

Figure 3. (A) Intraoperative fluoroscopy shows placement of lag screw. (B) Fixation using 4.5-mm hip osteotomy plate with concentric reduction of hip.

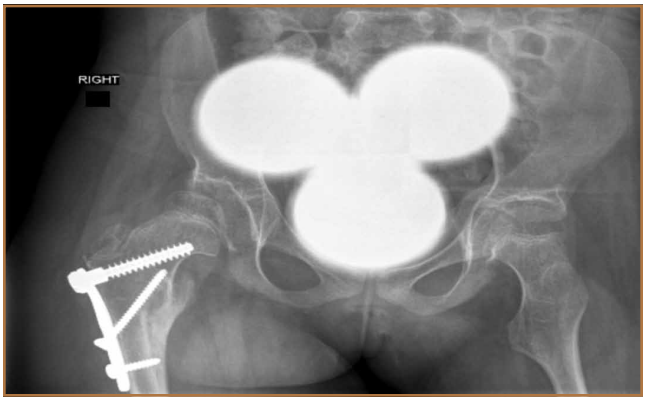

Figure 4. Postoperative radiograph shows concentrically reduced hip with stable hardware.

Under direct and fluoroscopic visualization, the security of the reduction was confirmed. The rotation of the femur was tested, and its adequacy confirmed. The fascia and skin were then closed per routine technique. Before extubation, our physical therapists fashioned a removable total body splint to hold the hips in abduction during the postoperative course.

After surgery, the patients were admitted to the general inpatient floor for pain control, and their caretakers received transfer training from physical therapy. The patients were kept non–weight-bearing during this time. After 2 to 4 days of inpatient stay (mean, 3 days), the patients were discharged home. At follow-up about 10 days after surgery, repeat biplanar radiographs of the hip were obtained. The total body splint was discontinued after 1 month (**Figures 2-4**).

Table I. **Sitting Tolerance**

Pt	Hip	Preoperative	Postoperative	Additional Progress
1	L&R	30 min	2 h	Able to self-transfer; uses stander daily
2	R	20 min	2 h	—
3	R	1 h	2-4 h	—
4	L	1 h	2 h	Better sitting posture
5	L	1 h	2-3 h	Uses stander

Results

We reviewed 6 hips in 5 patients (1 bilateral case) who had been treated with an extreme femoral shortening varus osteotomy at our institution by 1 surgeon, Dr. Sarwark. Mean age of the 5 patients (2 boys, 3 girls) was 10 years (range, 8-13 years). Minimum follow-up was 2 years (range, 2-8 years; mean, 3.4 years). All patients had neuromuscular spasticity. Four had a diagnosis of spastic quadriplegic cerebral palsy, and 1 had a diagnosis of lissencephaly. All patients were nonverbal.

After surgery, hip abduction improved by a mean of 30° (range, 20°-60°). At most recent follow-up, 5 (83%) of 6 hips had preserved abduction. All the caretakers noted an improvement in ease of hygiene secondary to the increased hip abduction. All patients improved their sitting tolerance by at least 1 hour (**Table I**). This was an improvement of 100% over preoperative sitting tolerance. Two patients were able to tolerate stander devices after the surgery; neither could do so beforehand. Unfortunately, 1 patient who was able to sit after surgery lost that ability secondary to lower extremity contractures by most recent follow-up.

All patients had partial to complete pain relief (**Table II**). Because objectively scoring pain relief on a scale was difficult given the patients' cognitive impairment, the caretaker surveys provided much of the data. All caretakers reported subjective pain improvement as soon as 3 months after surgery, as evidenced by patients' crying less at night and with transfers. Three patients had complete relief of pain—no crying at night or with transfers. One other patient seemed to have moderate pain relief—stopped crying at night and cried less with transfers. The last patient had mild to moderate pain relief and continued to cry at night and with transfers, but subjectively

Table II. **Pain**

Pt	Hip	Preoperative	Postoperative
1	L&R	Cried nightly for > 2 y; guarding with hip abduction	No crying at night; less irritation with transfers
2	R	Crying at night; pain with transfers	No crying at night; decreased pain with transfers
3	R	Mild pain	Resolution of pain
4	L	Mild pain	Resolution of pain
5	L	Worsening pain over past 18 mo	Resolution of pain

less so than before surgery.

Also according to the caretaker surveys, all 5 patients and their families seemed to be sleeping better after the surgery. The caretakers all noted improved ease of hygiene and perineal care and improved ease of transfers. Last, all were satisfied with the surgery at most recent follow-up, and all reported they would repeat the surgical procedure if needed.

There were no perioperative complications, such as wound dehiscence, urinary tract infection, deep vein thrombosis, pneumonia, or sepsis. At most recent follow-up, we did not have any hardware failures. None of the patients developed any decubitus ulcers or skin breakdown secondary to prominent hardware. Since the surgery, 1 patient (17%) developed mild hip subluxation. Interestingly, this patient did not seem to be in pain secondary to the subluxation or on physical examination in the clinic. Moreover, 1 patient (17%) developed mild heterotopic ossification around the hip without pain or ROM impairment.

Discussion

Several surgical techniques have been used to treat chronic nonambulatory hip dislocations since the 1800s.[3] Although each technique has had benefits, complications and unique patient scenarios have led to the development of new procedures. We have provided description and evaluation of a femoral shortening technique that preserves and relocates the dislocated femoral head. Castle and Schneider[11] first described proximal femoral resection with or without soft-tissue interposition in 1978. They resected the femoral head distal to the subtrochanteric region and then attached a soft-tissue interposition over the osteotomy site using the rectus femoris and iliopsoas. They noted heterotopic ossification and problems with proximal femoral migration (**Table III**).

The redirectional proximal femoral osteotomy has been described as a salvage technique in nonambulatory patients with chronically dislocated hips. The McHale procedure, which creates a valgus subtrochanteric osteotomy, reliably improves pain and hip ROM.[14] Recently, Van Riet and Moens[18] found a high rate of complications, including heterotopic ossification, residual pain secondary to hardware, fracture, and pulmonary complications with this procedure. Many of their patients required additional surgery, and there was a high rate of failures and complications despite pain relief and improvement in hip motion in some patients. Variant procedures include the Schanz and Hass valgus subtrochanteric osteotomies. Although these redirectional proximal femoral osteotomies decrease pain, several studies have noted a significant complication rate.[3,14,18]

Although osteotomies of the femur and pelvis require more extensive surgery, some surgeons perform them to restore articular congruity. Herold and Daniel[12] described a case series of 32 hips that underwent traction for several weeks followed by open reduction and Chiari osteotomy. The procedure required 2 to 4 weeks of traction and was limited to skeletally immature patients. The authors noted difficulty in bilateral cases as well as complications such as avascular necrosis and sciatic paralysis. Our study incorporated extreme femoral shortening specifically to decrease these 2 complications. As muscle spasticity is a key deforming force causing hip subluxation, femoral shortening is intended in essence to provide a circumferential multitendon lengthening of all the muscles crossing the hip. Studies have shown femoral shortening can decrease the rates of avascular necrosis by relieving the pressure on the femoral head as well, preventing further damage and a source of pain.[26] A varus derotational osteotomy in conjunction with a Dega acetabuloplasty has also been studied in nonambulatory patients with cerebral palsy. However, there are complications of persistent pain in about 10% of patients and acetabular fractures in 10%.[16] Other complications are early physeal closure and need for postoperative casting.[17] Regardless of technique, complications in this patient population occur and must be minimized while optimal clinical and radiographic outcomes are achieved. A potential advantage of our technique is that it does not require an open physis, and thus the procedure can theoretically be performed on patients of any age.

Arthrodesis is another option in the spastic neuromuscular patient population. However, Fucs and colleagues[21] found hip arthrodesis is complicated by the need for revision secondary to delayed union despite improvement in pain relief. They noted that, in a few patients, conversion surgery was needed because of decreased ROM and positioning difficulties. In summary, arthrodesis seems better for patients who have unilateral dislocation and can weight-bear.[20,24]

All these surgeries are extensive and carry medical complications as well. Many nonambulatory patients with neuromuscular spasticity have comorbidities. Complication rates up to 40% to 50% have been reported; these complications include problems with gastrostomy and tracheostomy tubes, urinary tract infection, pneumonia, and other infections.[2]

Our complications parallel some that have been found with other techniques. In 1 (17%) of our 6 hips, heterotopic ossification occurred, seemingly without causing pain or affecting hip motion. We also noted subluxation in 1 hip (17%) at most recent follow-up—seemingly without pain as well. We suspect the subluxation arose from preexisting severe acetabular dysplasia; monitoring for further subluxation will continue. In such patients, adding an acetabuloplasty may be of benefit. Our series did not have any perioperative cardiovascular, pulmonary, infectious, or wound complications. By limiting the

Table III. **Literature Comparison**

Authors	Procedure Type	Major Complications
Kalawadia et al (present study)	Extreme femoral shortening	Resubluxation (17%) Heterotopic ossification, asymptomatic (17%)
Castle & Schneider[11]	Proximal femoral resection	Recurrence of deformity (25%) Persistent pain (25%)
Muthusamy et al[15]	Proximal femoral resection	Heterotopic ossification (41.7%) Proximal femoral migration (19.4%)
Albiñana & Gonzalez-Moran[5]	Proximal femoral resection with external fixator	Proximal femoral migration (38%) Persistent pain (13%) Heterotopic ossification, symptomatic (13%)
McHale et al[14]	Redirectional proximal femoral osteotomy	Persistent pain (33%) Hardware irritation (17%) Heterotopic ossification (17%)
Van Riet & Moens[18]	Redirectional proximal femoral osteotomy	Persistent pain (62%) Heterotopic ossification[a] Fracture[a] Pulmonary issues[a]
Hogan et al[3]	Redirectional proximal femoral osteotomy (Hass subtrochanteric osteotomy)	Postoperative infection (13%) Hardware failure (10%) Persistent pain (6%) Heterotopic ossification, symptomatic (6%) Seroma requiring drainage (6%)
Herold & Daniel[12]	Open reduction, Chiari osteotomy	Avascular necrosis (19%) Sciatic paralysis (3%) Septic hip (3%)
Robb & Brunner[16]	Varus derotational osteotomy, Dega acetabuloplasty	Acetabular fractures (10%) Persistent subluxation (10%) Persistent pain (6%)
de Moraes Barros Fucs et al[20]	Hip arthrodesis	Pseudarthrosis of arthrodesis site (21%) Skin breakdown from casting (7%) Intraoperative femoral vein laceration (7%)
Schroeder et al[25]	Hip arthroplasty	Early aseptic loosening (17%) Dislocation (11%) Infection (8%)

[a]Percentage breakdown not available.

surgery to the femur, we minimized blood loss and operative time, which translated to a mean inpatient stay of only 3 days.

There are a few limitations to our study design. Ideally, we would have had a larger patient sample and a longer follow-up. Fortunately, fewer patients are presenting to clinic with neglected hips that have dislocated in the absence of surveillance. This translates to fewer potential study enrollees. Although our minimum follow-up was 2 years, longer follow-up would have helped to determine if a hip dislocated or became increasingly symptomatic, especially as patients underwent growth spurts. Only 2 patients in our series were followed up through the end of puberty; 1 of the 2 developed hip subluxation. Moreover, though all 6 hips were reduced after surgery, we anticipate that, in a larger series, some patients would have a severely dysplastic anatomy, which would make hip reduction impossible; a pelvic osteotomy and/or femoral head resection may be indicated instead. Furthermore, reduction of a deformed femoral head into the acetabulum may also cause pain in some patients in the long term. Other limitations of our study derive from its being a retrospective case series, with its inherent weaknesses, including selection bias and measurement bias within the caretaker surveys.

Conclusion

A chronically dislocated, painful hip in a neuromuscular spastic child remains a significant problem for the pediatric orthopedist. This study shows that extreme varus femoral shortening clinically and functionally helps patients by decreasing pain, improving sitting tolerance and the ability to progress to use of a stander, and making hygiene easier to manage. Our technique preserves and relocates the femoral head, which serves as a buttress to proximal migration. Other techniques in which the femoral head is resected have been complicated by shaft migration. Furthermore, techniques such as the valgus osteotomy have noted persistent pain, high reoperation rates, and perioperative medical comorbidities, none of which have been an issue with our technique. By the minimum 2-year follow-up, our technique had improved quality of life for both patient

and caretaker, and the complication rate was relatively low. In conclusion, the extreme femoral varus shortening osteotomy is an alternative technique in the armamentarium of pediatric orthopedists trying to help patients with a difficult problem.

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