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Incomplete Transiliac Osteotomy in Skeletally Mature Adolescents with Cerebral Palsy

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Incomplete transiliac osteotomy is commonly used in the surgical treatment of spastic hip disease in children with cerebral palsy. The osteotomy hinges through an intact sciatic notch and an open triradiate cartilage. We asked whether incomplete transiliac osteotomy, combined with varus osteotomy of the femur and soft tissue reconstruction, performed after skeletal maturity could improve hip coverage and acetabular shape and provide pain relief in patients with spastic hip disease. We retrospectively evaluated 27 consecutive adolescent patients (33 hips) with cerebral palsy in whom an incomplete transiliac osteotomy was performed after closure of the triradiate cartilage. The mean age at surgery was 15 years. Five hips were dislocated and 28 hips were subluxated preoperatively. The minimum followup was 2 years (mean, 3.3 years; range, 2 years–7.5 years). The subluxated hips had a minimum Reimers' migration index of 23% (mean, 52%; range, 23–95%), which was reduced to 0% (mean, 7%; range, 0–39%) at followup. The minimum preoperative Sharp's angle was 34° (mean, 52°; range, 34°–70°), which was reduced to 20° (mean, 35°; range, 20°–50°) at followup. A painless hip was achieved in 26 of 33 hips at followup. An incomplete transiliac osteotomy can be performed after skeletal maturity, resulting in a painless and stable hip in the majority of patients.

Level of Evidence: Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

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Hip subluxation or dislocation occurs commonly in children with cerebral palsy and is especially common in patients with spastic quadriplegia.[2,3,10,36] When left untreated, clinically painful osteoarthritis of the hip has been reported in as much as 50% of patients and may cause difficulties with perineal hygiene and sitting tolerance.[1,2,8,12,20] The direct cause of hip subluxation may be the result of the combined effects of spastic muscles and resulting changes in femoral and acetabular morphology.[4] Preventing dislocation by early soft tissue surgery is recommended before the occurrence of substantial subluxation, dislocation, or osseous changes.[5,23,29] For older children in whom acetabular remodeling may not occur after soft tissue lengthenings alone, or in patients in whom severe subluxation or dislocation has occurred, a combined approach of muscle lengthening, femoral osteotomy, and acetabular (pelvic) osteotomy has been advocated.[4,17,23,24,30,32]

The location of the acetabular deficiency in patients with spastic hip disease can be variable but is most marked in the posterior part of the acetabulum.[4,7,19] Pelvic reconstructions for these hips therefore should address this posterior deficiency but be versatile enough to provide comprehensive coverage and stability to hips with a more variable or global deficiency. This has led to considerable interest in the use of periacetabular osteotomies, most notably the incomplete transiliac osteotomy of Dega[9] or one of its variations.[15,18,22–24,30,33]

The hallmark of the Dega osteotomy and its variants is the use of an intact sciatic notch and, in younger patients, an open triradiate cartilage as the hinge points for reshaping the acetabulum. Therefore, numerous authors have stated a closed triradiate is a contraindication to the procedure.[13,22,24,30] We have commonly used an incomplete transiliac osteotomy to treat acquired spastic hip disease in children with cerebral palsy,[23] even in patients whose triradiate cartilage already had closed.

We asked whether an incomplete transiliac osteotomy, combined with varus osteotomy of the femur and soft tissue reconstruction, performed after complete closure of the triradiate cartilage could improve hip coverage and acetabular shape and provide pain relief and improved range of motion (ROM) in patients with acquired spastic hip disease.

MATERIALS AND METHODS

We retrospectively reviewed the medical records and radiographs of 27 consecutive patients (33 hips) with cerebral palsy treated between 1989 and 2000 who underwent surgical reconstruction for acquired spastic hip disease using a variation of the incomplete transiliac osteotomy of Dega despite closure of the triradiate cartilage. Sixteen female and 11 male patients met the inclusion criteria for the study. The minimum age at surgery was 13 years (mean, 15 years; range, 13–20 years). The minimum length of followup was 2 years (mean, 3 years, 3 months; range, 2 years–7 years, 6 months). One patient was ambulatory with hemiplegia, and the remaining 26 patients were nonambulatory with spastic quadriplegia.

We recorded the pattern of neurologic involvement (hemiplegia, diplegia, or quadriplegia), ambulatory status, previous procedures, additional procedures performed at the time of hip reconstruction, and surgical times from the patient's medical record. Preoperative hip motion in flexion and extended abduction was recorded preoperatively and at the latest followup. In all cases, the indications for surgery included a painful subluxated or dislocated hip in which degenerative changes had not yet occurred, decreased sitting tolerance, poor perineal access for provision of hygienic care, and/or a history of failed hip surgery as defined by a Reimers' migration index[27,31] greater than 40% 1 year after muscle releases or persistent symptomatic dysplasia after previous reconstructive hip surgery.

In addition to the incomplete transiliac osteotomy, we performed a femoral varus derotation osteotomy (VDRO) stabilized with a 90° fixed-angle blade plate (Synthes, Inc, Paoli, PA) in all of the 33 hips. All pelvic osteotomies were stabilized with tricortical iliac crest allograft wedges without supplemental skeletal fixation. Of the 27 patients, bilateral pelvic and femoral osteotomies were required in six patients. In the remaining 21 patients, we performed a contralateral femoral VDRO without incomplete transiliac osteotomy in 13 patients to provide symmetric hip motion and to equalize leg lengths.[23,26] In the eight patients who did not require a contralateral femoral VDRO, this procedure already had been performed in six. We performed soft tissue balancing procedures in all 33 hips at the time of hip reconstruction, which typically included adductor, iliopsoas, and hamstring lengthenings. The minimum operative time for the combined procedures was 110 minutes (mean, 174 minutes; range, 110–192 minutes). Nine of the patients also had a history of progressive scoliosis and pelvic obliquity and underwent posterior spinal fusion using unit rod instrumentation at least 6 months before the hip reconstruction.

We performed a combined one-stage surgical procedure that included adductor and iliopsoas release, VDRO stabilized with a fixed-angle blade plate, open reduction of the hip if necessary, and incomplete transiliac osteotomy. Adductor release included, at a minimum, complete release of the adductor longus, adductor brevis, and gracilis muscles to obtain at least 45° hip abduction with the knee fully extended. In patients who were nonambulatory, we also performed an anterior branch obturator neurectomy. Proximal femoral VDRO was performed through a lateral approach to the proximal femur. We completely resected the lesser trochanter during the femoral osteotomy in patients who were nonambulatory to remove the force of the iliopsoas, and femoral shortening (up to 1.5 cm) was performed. We inserted the chisel to achieve a 90° to 100° varus neck shaft angle. Anterior and inferior capsulotomy was required frequently to obtain full seating of the femoral head against the medial wall of the acetabulum. This was performed through the femoral osteotomy site while maintaining control of the femoral head fragment with the inserted blade plate chisel and a bone tenaculum before seating the blade plate device.[23] In long-standing dislocations, fibrofatty tissue and the transverse acetabular ligament could block reduction similar to developmental hip dislocations and was resected if necessary. Once the femoral head was seated against the medial wall of the acetabulum, by fluoroscopy and/or direct finger palpation, we performed the transiliac osteotomy.

An anterior bikini incision was made just distal to the anterosuperior iliac spine. We performed subperiosteal dissection along the outer table of the ilium to expose the superior acetabular ridge from anterior to posterior back to the sciatic notch. It was important to elevate the periosteum far enough posteriorly or the osteotomy fragment would not open a sufficient amount posteriorly to gain adequate coverage. Anteriorly, the interval between the sartorius and the tensor fascia lata was developed down to the anterior inferior iliac spine. We made the initial cut 5 mm superior to the superior acetabular ridge with straight and curved osteotomes under fluoroscopic guidance,[23] except the cut was carried down to the middle of the radiographic teardrop instead of the triradiate cartilage. To facilitate hinging, we made a bicortical cut only in the region just superior to the anterior inferior iliac spine. The cut was unicortical for the remainder of the osteotomy. The fluoroscopic image then was directed toward an iliac oblique orientation to visualize the posterior column and to avoid entrance into the hip. The osteotomy then was directed down the posterior column of bone between the posterior aspect of the acetabulum and the sciatic notch. The osteotomy then could be levered open (using an osteotome or a smooth laminar spreader) and often produced a greenstick fracture in the inferior 33% of the acetabulum below the weightbearing surface. In some cases, the hinging produced propagation of the osteotomy along the lower aspect of the superior pubic ramus. We sized and placed a triangular-shaped tricortical iliac crest allograft as posterior as possible and impacted it into the osteotomy site. Smaller pieces of bone graft were placed anteriorly to hold the osteotomy open where necessary. The bone graft was usually quite stable once impacted and usually did not require fixation. We checked stability by taking the femoral head through a ROM under live fluoroscopic examination. Residual instability usually required more posterior placement of the bone graft or additional femoral shortening. If the stability was satisfactory, we then secured the fixed-angle blade plate to the femur in the desired position. Postoperatively, if the pelvic and femoral osteotomies were stable, immediate mobilization was allowed without the use of postoperative casts (Fig 1).

All charts were reviewed and radiographs were measured by two orthopaedic surgeons (MI, MD) who were not involved in the care of the patients. All radiographs were measured using a fine soft-lead pencil and the same fixed protractor with single-degree markings. These measurements were recorded from standardized anteroposterior and frog lateral supine pelvic radiographs obtained preoperatively, immediately postoperatively, and at the latest followup. Radiographic evaluation included measurements of the Reimers' migration index[27,31] and femoral neck shaft angle[25] to evaluate the improvement in hip coverage and the acetabular angle of Sharp[37] to evaluate the change in acetabular shape achieved by the pelvic osteotomy. The followup radiographs also were assessed for evidence of incorporation of the pelvic allograft, healing of concomitant femoral osteotomies, and the presence of avascular necrosis of the femoral head or acetabular fragment. Heterotopic ossification was graded according to the classification of Brooker et al,[6] with Class I ossification denoting bone islands in the soft tissues about the hip, Class II denoting bone spurs leaving at least 1 cm between opposing bone surfaces, Class III denoting near ankylosis, and Class IV denoting complete ankylosis of the hip.

To evaluate the effect of the surgeries on pain relief and contracture, patients were examined by the operating surgeons (PGG, FM, KD), and caregivers were interviewed with respect to pain in the hips or restriction of hip motion that interfered with sitting, standing, or transfer ability, ambulation (if present), and hygienic care. Pain on physical examination was recorded as none, present with vigorous hip motion but not at rest, or present with any hip motion and at rest. The patient's sitting tolerance was recorded as the number of hours of sitting without requiring repositioning and ranged from being able to sit without limitation throughout the day to unable to sit comfortably as a result of hip pain or contracture. Hip motion was recorded as degrees of hip flexion and abduction with the hip in maximum extension.

Statistical comparison of radiographic and range of motion parameters was performed using the paired-samples t test. Data were checked for normal distribution before all analyses were conducted. The ROM values for one patient (two hips) were considered outliers and were omitted from ROM statistical analyses. Significance was set at $p < 0.05$.

RESULTS

Hip coverage improved ($p < 0.001$) in all patients postoperatively. Of the 33 hips, five hips were completely dislocated preoperatively and 28 hips were subluxated. The mean Reimers' migration index in the subluxated hips was 52% (range, 23–95%). At followup, the mean Reimers' migration index for the entire group was 7% (range, 0–39%). The mean femoral neck shaft angle was 151° (range, 90°–170°) before surgery and 109° (range, 85°–145°) at followup.

Acetabular shape also improved ($p < 0.001$) in all patients postoperatively. The mean preoperative Sharp's

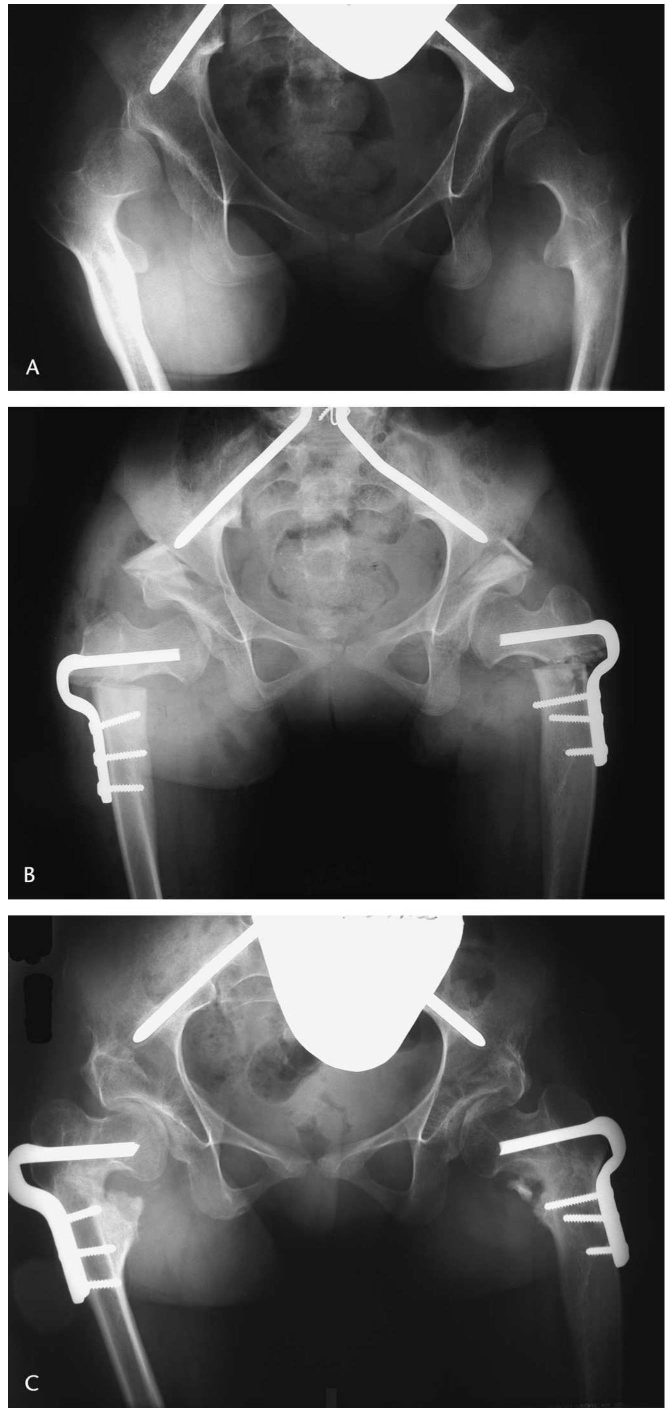

Fig 1A–C. (A) A preoperative anteroposterior radiograph shows the pelvis of a 14-year-old nonambulatory patient (Case 19/20) with painful acquired spastic hip disease. The triradiate cartilage is completely closed. (B) An immediate postoperative anteroposterior radiograph shows bilateral proximal femoral VDROs in conjunction with bilateral incomplete transiliac osteotomies. No internal fixation was necessary to secure the pelvic allograft. (C) A followup anteroposterior radiograph was obtained 7 years postoperatively. Despite moderate limitation of hip motion, the patient remained pain-free and had an excellent overall result with no restriction of sitting tolerance.

angle was 52° (range, 34°–70°), which was reduced to 35° (range, 20°–50°) at followup. The mean improvement in the Sharp's angle was 17° (range, 7°–31°). In one patient who underwent bilateral femoral and pelvic osteotomies (Case 17/18), we noted unilateral extrusion of a pelvic allograft 4 weeks after the surgery, resulting in a Sharp's angle of 50° (improved from 60° preoperatively). Reoperation was recommended by the treating surgeon; however, the family refused.

At the latest followup, a painless hip was achieved in 26 of the 33 hips. Pain with vigorous hip motion, but not at rest, persisted in five hips (Cases 4, 5, 12, 23, 26). Two hips were painful at rest (Cases 8, 14) and were salvaged by a unilateral palliative interposition arthroplasty procedure using a total shoulder prosthesis[11] performed 12 and 20 months, respectively, after the index operation. Twenty-four of the 27 patients had improvement of their sitting tolerance at followup. Sitting tolerance was not limited by hip pain or hip motion in 22 of the patients. In two patients, there was an improvement from no sitting tolerance before hip surgery to up to 2 continuous hours at followup. Three patients were unable to tolerate wheelchair sitting at followup. In two of these three patients, this was attributable to pain (Cases 8, 14). In one patient described subsequently (Case 15/16), painless autofusion of both hips precluded a functional sitting position. This patient was excluded from the ROM analysis.

For the entire group, hip motion improved ($p < 0.01$) after surgery from a mean hip abduction of 19° preoperatively (range, 5°–30°) to 31° at followup (range, 5°–45°). The mean maximum hip flexion was 95° preoperatively (range, 70°–120°) and 101° at followup (range, 70°–120°). Twenty-two of the 33 hips at followup had greater than 30° abduction and greater than 90° flexion. Of these 22 hips, the mean preoperative hip abduction was 22° (range, 10°–30°), the mean preoperative hip flexion was 98° (range, 75°–120°), and the mean preoperative Reimers' index was 53% (range, 23–100%). Eight of the 33 hips at followup had between 15°–30° abduction and 60°–90° flexion. Of these eight hips, the mean preoperative hip abduction was 14° (range, 5°–30°), the mean preoperative hip flexion was 91° (range, 85°–100°), and the mean preoperative Reimers' index was 65% (range, 40–100%). Postoperatively, hip motion had either stayed the same or improved slightly in all eight hips. Severe limitation of hip motion was present in two patients (three hips) at followup. Both of these patients had complications related to deep wound infection (Cases 4, 15/16), and in one (Case 15/16), bilateral Brooker Class IV ossification resulted in autofused hips during a 12-month period after bilateral femoral and pelvic osteotomies.

No intraoperative complications occurred. There were no cases of nonunion or avascular necrosis of the femoral head or acetabular fragment. We observed several complications attributed directly to the blade plate fixation in six hips. Two hips had superficial skin breakdown over the prominent portion of the blade plate, which resolved with local wound care and wheelchair modifications. One hip had deep wound breakdown over the blade plate, and this was treated by exchange plating using a compression screw and sideplate to decrease implant prominence. Deep wound infection at the femoral osteotomy site occurred in three hips (two patients). In one of these patients (Case 4), unilateral infection was managed with intravenous antibiotics, wound débridement, and removal of the blade plate after union of the femoral osteotomy occurred, with a fair overall result. In the other patient (Case 15/16), bilateral deep wound infections occurred secondary to breakdown over the blade plates. The plates were removed, but severe heterotopic ossification occurred, resulting in autofusion of the hips within 12 months of the index procedure and a poor overall result. We observed no chronic osteomyelitis or septic arthritis at followup in any of the patients.

DISCUSSION

The ideal management of spastic hip disease is prevention by early surveillance and appropriate muscle balancing procedures to avoid painful dislocation and to improve sitting tolerance and perineal hygiene.[1,2,8,12,20,29] Ultimately, this treatment approach may not have a positive result in some patients, and we still see a large number of patients in our outpatient cerebral palsy program who present with an established painful dislocation. Many of these patients are already in adolescence, and the opportunity to perform soft tissue surgery alone to relocate the hip has passed. In the absence of radiographic evidence of osteoarthritis, a combined approach of muscle lengthening, femoral osteotomy, and pelvic osteotomy may be performed with satisfactory results.[14,22–24,32,34] We asked whether an incomplete transiliac osteotomy, combined with varus osteotomy of the femur and soft tissue reconstruction, performed after complete closure of the triradiate cartilage could improve hip coverage and acetabular shape and provide pain relief in patients with acquired spastic hip disease.

Our study had major limitations. Although the cohort represents consecutively treated patients, they were studied retrospectively and we reviewed only material in the charts rather than having patients return for a final systematic followup. All clinical examinations were performed by the operating surgeons, introducing the potential for bias. The population studied was universally noncommunicative, and as such, evaluations of pain level were subjective and indirect, such as reliance on grimacing responses elicited with hip motion and caregiver's descriptions of sitting tolerance (which might have been affected by factors other than hip pain, such as back pain, abdominal pain, or a poorly fitted seating device). We did not standardize the radiographs, and therefore the varus we measured reflects only the minimum varus seen on the view available. With a followup ranging from 2 to 7 years, we cannot comment on the long-term outcome of the procedure for either pain relief or sitting function.

In cases of hip dysplasia resulting from neuromuscular disease, acetabular deficiency appears located primarily in the posterolateral acetabulum, although some variability has been reported.[4,7,19] Ideally, pelvic osteotomy in these patients should be able to adequately address this posterolateral deficiency yet have enough versatility to provide comprehensive coverage and stability to hips in which more global or variable deficiency exists. The incomplete transiliac osteotomy of Dega[9] has gained widespread popularity in the treatment of spastic hip disease because of its versatile nature and easy technical execution. The coverage obtained can be modified simply by placement of the allograft wedge more posteriorly, laterally, and/or anteriorly through the same osteotomy site depending on the location of the acetabular deficiency. This versatility makes it more advantageous than other pelvic osteotomies that cannot gain posterior coverage, such as the Pemberton osteotomy[28] and the Salter osteotomy.[35] The Salter osteotomy, and other redirectional osteotomies, may provide coverage in one area at the expense of coverage elsewhere in the acetabulum. Shelf arthroplasty runs the risk of dislocation of the hip posterior to the shelf augmentation, and autofusion of the hip has been reported.[21]

Although multiple variations of the Dega osteotomy have been described,[15,18,22–24,30,33] there is universal agreement that the osteotomy hinges mainly through an intact sciatic notch and the horizontal limb of the triradiate cartilage. Thus, numerous authors have stated a closed triradiate cartilage is a contraindication to an incomplete transiliac osteotomy.[13,22,24,30] In a report on 24 hips having Dega osteotomy for developmental hip dysplasia, Grudziak and Ward[15] recommended the osteotomy be performed before triradiate closure but conceded the osteotomy could be performed after skeletal maturity with other likely points of hinging, such as the sciatic notch, the posterior portion of the inner pelvic cortex, and the pubic symphysis.

In a review of 41 hips treated by incomplete transiliac osteotomy for neuromuscular hip dysplasia, Roposch and Wedge[33] reported on a technique identical to that described by Miller et al.[23] In that report, the authors included seven patients (nine hips) in whom the triradiate was closed at the time of operation. In those patients, the osteotomy was performed "through the former site of the triradiate cartilage." Of the 41 hips at followup, one hip was dislocated, one was unstable, and four were subluxated. However, the authors did not stratify the patients according to whether the triradiate was open or closed at the time of the index procedure, making an assessment of the results in this older group impossible.

Natural history studies suggest spastic hip dislocation, when left untreated, leads to clinically important pain in 50% to 70% of patients.[1,2,8,16,20] In our series of 27 skeletally mature patients (33 hips), incomplete transiliac osteotomy, in combination with femoral osteotomy and soft tissue rebalancing, was successful in achieving a painless hip in 26 of the 33 hips (78%). This is comparable to results reported for combined pelvic and femoral osteotomies in this patient population.[23] Although pain did persist at some level in seven hips, the improvement in sitting tolerance for 24 of the 27 patients (89%) indicates an improvement in preexisting pain, and only two patients had an additional palliative procedure. In 30 of the 33 hips (91%), motion either improved or stayed the same. Severe limitation of motion occurred in only two patients, and these patients were also the only two with deep wound infections. Thus, the goals of relief of pain, increased sitting tolerance, and improved hip motion were achieved in the majority of patients.

The ability to reshape the acetabulum and provide stable coverage of the femoral head using an incomplete transiliac osteotomy despite the absence of an open triradiate cartilage is evidenced by the radiographic improvement in the acetabular angle and Reimers' migration index to means of 35° and 7%, respectively. No hip redislocated, and there were no cases of avascular necrosis.

We believe an incomplete transiliac osteotomy can be performed successfully despite closure of the triradiate cartilage. In skeletally mature adolescents with cerebral palsy and symptomatic spastic hip subluxation or dislocation, the majority of patients can achieve a painless and stable hip when incomplete transiliac osteotomy is performed in conjunction with femoral varus osteotomy and soft tissue surgery.

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