MINI-SYMPOSIUM: CHILDREN—OSTEOTOMIES AROUND THE HIP

(ii) Pelvic osteotomy for the management of hip displacement in neuromuscular disorders

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Summary
Patients with neuromuscular disorders may develop hip displacement and ultimately dislocation as a result of an imbalance of muscle forces acting across the hip joint. Hip displacement can cause pain, mobility and hygiene problems. Management of symptomatic, established hip displacement involves surgical relocation and reconstruction of the abnormal proximal femoral and acetabular anatomy. Several pelvic osteotomies have been described for management of the acetabular abnormalities with the object of preventing recurrent hip displacement. The most common pelvic and periacetabular procedures for management of neuromuscular hip displacement are considered in this article.

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Introduction

Subluxation or dislocation of the hip can occur as a consequence of neuromuscular disorder. Muscle spasticity or flaccidity resulting in imbalance of the muscle groups around the hip can result in gradual migration of the femoral head out of the acetabulum. It has also been proposed that pelvic obliquity secondary to neuromuscular scoliosis is a factor. An awareness of the potential for hip displacement in neuromuscular disorders has led to recommendations for clinical and radiological surveillance.

The hip in neuromuscular disorders

Hip displacement is seen in about 25% of patients with cerebral palsy (CP) and rises to about 75% in those with more severe, total body involvement CP. This suggests that the more severe the neurological impairment, the more likely hip displacement occurs. In CP, the increased tone in the adductors and flexors of the hip shifts the centre of rotation from the femoral head towards the lesser trochanter. In the child with CP, the combination of abnormal muscle force, tone and the malleability of skeletally immature bone results in abnormal development of the acetabulum and proximal femur. Physiological values of femoral anteversion in early childhood do not resolve with normal growth and an increased neck-shaft angle may also persist. Eccentric pressure from the displacing femoral head results in abnormal pressure on the periphery of the developing acetabulum resulting in a predominantly superior acetabular defect. Over a period of some years, therefore, a hip which was normal at birth can dislocate ultimately. Botulinum injections to the adductors, and intrathecal baclofen to reduce abnormal tone or soft tissue surgery to weaken dominant muscle forces may delay eventual dislocation. Once hip subluxation occurs up to 50% of these patients...
develop hip pain. In many, stable seating and access for perineal hygiene are compromised due to the abnormal position of the lower limb on the dislocated side and hip pain. Hip relocation and stabilisation can be very effective in managing these symptoms.

The hip may also dislocate in lower motor neurone disorders such as spina bifida or spinal cord injury. Hip pathology in these patients is influenced by the level of the spinal lesion but is not purely due to the resulting muscle imbalance. High thoracic lesions result in flail hips and such patients often develop hip flexion contractures and a subsequent dislocation. Muscle imbalance at the hip is maximal in a mid-lumbar lesion as the antagonists of the hip flexors and adductors are weak. This results in a slightly higher risk of hip dislocation than at other neurosegmental levels. Loss of abductor power also results in growth retardation of the greater trochanter and progressive coxa valga, which can exaggerate femoral head uncovering.

It remains controversial whether relocation and containment of subluxating hips in spina bifida patients is justifiable. Hip pain is less of a problem than in CP because of the neurological loss. From a functional point of view, reciprocal movement at the hip is usually still possible when the patient sits or when using assistive devices for walking. Pelvic balance and control of joint contracture appear to be more important factors for these patients. Intact quadriceps function, motivation to walk and reasonable cognition are prerequisites when considering hip relocation in these patients. Children with spina bifida who do not have adequate quadriceps strength are unlikely to maintain independent walking in adulthood. When hip reduction is performed, acetabular cover is most commonly enhanced with a periacetabular or Chiari pelvic osteotomy, although triple osteotomy or even shelf procedures have been used. There is, however, a high rate of redislocation despite efforts to improve cover and patients who have had failed surgery may end up worse off.

Hip subluxation is also seen in patients with spinal muscular atrophy and muscular dystrophy but the available evidence suggests that bony surgery is not beneficial for the management of hip subluxation in these patients. Attention should instead be focussed on maintaining spinal alignment and preventing pelvic obliquity.

Despite the controversy surrounding the indications for surgical reduction and containment of the hip in the neuromuscular patient, there is less disagreement about the technical goals once the decision to operate has been taken. Concentric reduction of the hip, soft tissue balancing and correction of both the femoral and acetabular deformities are the objectives. On the femoral side, surgery is aimed at reducing the abnormal neck anteversion to an adult value and often includes femoral shortening and variation to reduce the neck shaft angle to about 120°. A more detailed description of femoral osteotomy is described elsewhere in this symposium. On the acetabular side, the deficiency is usually superior and in many cases postero-superior. The object of acetabular surgery is to improve superior cover and gain increased posterior cover if possible. For this reason, the Salter innominate osteotomy is less suitable for neuromuscular patients as it improves antero-superior cover at the expense of decreasing posterior acetabular cover. The situation is therefore different from that encountered in developmental dysplasia of the hip where the deficiency commonly lies antero-superiorly and is well addressed by Salter’s osteotomy. The osteotomies most commonly used to address acetabular deficiencies will now be considered in more detail.

### Pemberton’s periacetabular osteotomy

Paul Pemberton from Salt Lake City, Utah, originally described his osteotomy in a personal case series published in 1965 for the management of developmental dysplasia of the hip. He described the technique as follows.

The patient is placed supine and the hip approached through an anterior, Smith–Peterson approach. The iliac apophysis is split and the glutei and tensor fascia lata are stripped subperiosteally from the outer wall of the ilium to expose the hip capsule and allow visualisation of the greater sciatic notch. Muscle is also stripped from the medial aspect of the ilium back to the greater sciatic notch. Retractors are placed carefully into the sciatic notch and must remain subperiosteal to reduce the risk of damage to the superior gluteal vessels and sciatic nerve. This approach allows open reduction of the hip at this stage if necessary. An osteotomy is then cut in the outer table of the ilium starting just above the anterior inferior iliac spine and progressing posteriorly remaining approximately 1 cm above the attachment of the joint capsule (Fig. 1). This osteotomy is then completed by curving down posterior to the acetabulum to the level of the ilio-ischial limb of the triradiate cartilage. The osteotomy should not enter the sciatic notch. The position of the osteotomy of the inner table of the ilium then dictates the nature of the acetabular cover achieved. By cutting the osteotomy of the inner wall to conform exactly with the outer osteotomy, the acetabular roof will displace to provide enhanced anterior cover. If the posterior part of the inner table osteotomy is placed more anteriorly and inferiorly, more lateral cover will be gained. After joining the two osteotomies by dividing the intervening cancellous bone, the osteotomy is levered open and held by insertion of a cortico-cancellous wedge taken from the iliac crest. As the

![Figure 1](image)
Pemberton osteotomy leaves the posterior column intact, the bone wedge is held firmly in the osteotomy by the natural recoil of the bone. This negates the need for any fixation. The iliac apophysis is then repaired and the wound closed. A plaster spica is often used for a period of 6–8 weeks post-operatively.

The Pemberton osteotomy therefore enhances anterior and superior acetabular cover. Potential disadvantages are that posterior cover cannot be improved, although it is not sacrificed, as it would be by a redirectional osteotomy like the Salter. Those who do advocate its use in neuromuscular disorders have reported very satisfactory results in patients with cerebral palsy. Other theoretical concern is that by using the triradiate cartilage as the fulcrum for displacing the osteotomy, the growth potential of the triradiate may be damaged. There appears to be little evidence to support this concern.

A variation of the Pemberton osteotomy was described by Perlik et al. and named the Pembersal. This was because it was thought to combine the apparent advantages of both the Pemberton and Salter osteotomies by allowing reshaping and redirection of the acetabulum. This can be achieved by continuing the posterior part of the osteotomy caudally to cross the ilio-ischial limb of the triradiate cartilage and finish in the body of the ischium. It is admitted that a Pembersal may be the inadvertent result of an attempt to perform a Pemberton as the view posterior to the acetabulum is restricted and the end point of the osteotomy often hard to define. There are no reports of the results of the Pembersal osteotomy in neuromuscular hip disorder but the redirectional element might be considered a disadvantage for the same reason as it is with the Salter. Potential for damage to the triradiate cartilage may also be greater.

### Dega’s osteotomies

In 1969, Dega reported the results of what he termed a "transiliac" osteotomy for the management of acetabular dysplasia. There has been some confusion surrounding the exact nature of this osteotomy, which has been put down to the contradictory descriptions originally published by Dega in the Polish and German literature. In effect, he described two different osteotomies. One is a supra-acetabular semicircular osteotomy and the other an incomplete transiliac osteotomy with many similarities to the Pemberton. The latter was originally and erroneously described as a complete transiliac osteotomy but the intention is not to divide the ilium completely.

The semicircular periacetabular osteotomy is fundamentally different from the Pemberton in that it is unicortical (Fig. 2). The hip capsule and outer wall of the ilium are exposed subperiosteally through an anterior approach but the inner wall of the ilium does not need to be stripped of muscle. A gently curved osteotomy is then cut in the outer wall of the ilium superior to the acetabulum from the anterior inferior iliac spine into the greater sciatic notch. Curved osteotomes are then used to cut down between the walls of the ilium towards the triradiate cartilage. The resulting osteotomy can then be opened, hinging on the triradiate cartilage, and due to the intact inner iliac wall can be held open with cortical bone graft without fixation. A bicortical cut may need to be made at the anterior and posterior aspects of the osteotomy to allow adequate opening. A very similar procedure has been described by others including Mubarak who reported a high success rate using this osteotomy in neuromuscular hip disorder. Complications can, however, include inadvertent penetration of the acetabulum and avascular necrosis of the superior acetabular segment, in addition to the other complications common to the other osteotomies described in this article.

A modification of the semicircular osteotomy is to bring the posterior part of the cut down behind the acetabulum and not enter the sciatic notch (Fig. 3). It is believed that this allows increased posterior cover. Robb and Brunner reported good correction of hip migration in CP patients using this technique even after closure of the triradiate cartilage. This showed that an open triradiate cartilage is not a prerequisite for this variation of the Dega procedure.

Grudziak and Ward described the incomplete transiliac osteotomy in detail (Fig. 4). It uses the same surgical...
approach as the Pemberton with soft tissue and femoral procedures still an integral part of the procedure. A curvilinear osteotomy is cut in the outer wall of the ilium from just above the anterior inferior iliac spine to a point superior to the midpoint of the acetabulum. It is then continued posteriorly to end 1–1.5 cm from the greater sciatic notch, which is where it differs from the Pemberton. The osteotomy is then completed to a varying degree from anterior to posterior through the inner wall of the ilium depending on the desired degree of lateral or anterior cover. It is claimed that, when opened, the osteotomy hinges on the intact pelvic cortex of the sciatic notch, the symphysis pubis and to some extent the triradiate cartilage but carries a lesser risk of physeal damage. Radiographic studies have also shown an alteration in the appearance of the obturator foramen indicating some degree of acetabular redirection as well as reshaping. Jozwiak et al.²⁰ have reported the long-term results of using this osteotomy in neuromuscular hip disorders together with soft tissue and femoral procedures. They found that good short-term results gradually deteriorated with 23% of hips redisplacing between 5 and 25 years post surgery.

Chiari osteotomy

Chiari initially described this in 1955 as an alternative to the shelf procedure for the management of hip dysplasia. The osteotomy is transiliac with the intention of improving superior cover by medially displacing the hip with the pubis and ischium (Fig. 5). The resulting increased superior cover is provided by the cancellous bone of the ilium with interposed hip capsule, which then develops a fibrocartilaginous articulation with the femoral head. This is not as desirable as enhancing cover with native hyaline cartilage as achieved with the periacetabular osteotomies.

Figure 3 Photograph of hemipelvis showing line of modified Periacetabular Dega osteotomy (Fig. 1 from Ref.¹⁹).

Figure 4 Diagram showing the Dega incomplete transiliac osteotomy (Figs. 3A and B from Ref.¹⁷).
and is considered to be a salvage procedure when these other techniques are not possible. This is the case in adolescents and young adults in whom the triradiate cartilage has fused and the pubic symphysis has stiffened. The absolute age when a Chiari should be considered in preference to the periacetabular osteotomies is however not clear.

To perform a Chiari osteotomy as originally described requires the patient to be semi-supine and uses an anterior/iliofemoral approach to the hip. As with the Pemberton osteotomy, both tables of the ilium need to be exposed by subperiosteal stripping back to the greater sciatic notch. Care must be taken to ensure that the plane of dissection is subperiosteal at the notch to reduce the risk of inadvertent damage to the sciatic nerve and superior gluteal vessels and allow correct insertion of retractors into the notch. A crucial stage of the procedure is establishment of the correct level for osteotomy of the ilium. Adherent hip capsule should be stripped off the ilium to reveal the true attachment of the capsule and prevent the osteotomy being performed too superiorly where the bone is thin. The groove in the ilium made by the reflected head of rectus femoris is said to be the optimal level for osteotomy. The level should also be checked on image intensifier views. Inadvertent entry into the acetabulum or damage to femoral head by too low a cut must be avoided. The ilium is then divided with osteotomes from lateral to medial with a slight cephalad slope starting at the level of the anterior inferior iliac spine curving over the capsular attachment and exiting into the greater sciatic notch. The osteotomy should not enter the sacroiliac joint. With the ipsilateral leg abducted the lower segment of the pelvis is gently displaced medially but total dissociation of the fragments by excessive displacement should be avoided. Although there is some stability of the ideally displaced fragments derived from interdigitation of the cut surfaces, most authors recommend additional support from a lag screw across the osteotomy. Hip movements need to be checked to ensure that there is no impediment to flexion from a prominent anterior shelf. Postoperative care varies from the use of traction or plaster to immediate mobilisation. As the Chiari is performed in an older age group consideration needs to be given to thromboprophylaxis.

The Kawamura variation of the Chiari osteotomy uses a trans-trochanteric approach and elevation of the abductors. The perceived advantage of this is that it allows direct visualisation of the whole lateral wall of the ilium and better control of the contouring of the osteotomy to conform to the shape of the capsular attachment. The Chiari osteotomy mainly provides superior cover and the Kawamura variant has the potential to improve the deficient posterior cover commonly seen in neurological hip dislocation. Stripping of the medial wall of the ilium is not performed and distal trochanteric transfer can be added to compensate for the relative shortening of abductor length and to reduce the risk of trochanteric impingement. The Kawamura osteotomy is also claimed to have a lower risk of sciatic nerve damage, which is one of the main concerns with the Chiari osteotomy. Additional complications common to both procedures include haemorrhage, acetabular damage, fragment dissociation and non-union and narrowing of the pelvic inlet particularly with bilateral procedures.

When the Chiari osteotomy is used for the management of neuromuscular hip dislocation, it is commonly combined with soft tissue and femoral procedures. The Chiari osteotomy in CP has been found to produce relatively satisfactory results comparable with other techniques. Debnath et al. found most patients continued to benefit from relief of pain and better sitting at an average follow-up of 13 years. Sustained improvement in mobility was less clear but influenced by many other factors. Others have shown, however, that between 15% and 30% of hips can redisplace in the longer term following a Chiari osteotomy, which is much more common than when the osteotomy is carried out for management of developmental hip dysplasia. This reflects the fact that the pathological processes driving hip displacement remain active in cerebral palsy in the long term.

Less satisfactory results have been reported when the Chiari has been used for hip displacement secondary to myelodysplasia with redisplacement in the medium term a common finding. Summary

Successful management of hip displacement due to neuromuscular disorders requires a thorough understanding of the original pathological processes. Clear and realistic goals

Figure 5 Diagram and photo showing the Chiari transiliac osteotomy (Figs. 8.16 and 8.17 from: Malcolm F. Macnicol. Colour atlas and text of osteotomy of the hip. Mosby-Wolfe; 1996, p. 75).
must be established before embarking on major surgery in patients who commonly have many other health problems. In appropriate circumstances, however, pelvic osteotomy as an integral part of hip reduction and stabilisation can result in very satisfactory relief of symptoms for neuromuscular patients. As is often the case, the choice of osteotomy is less important than its appropriate application and the surgeon’s familiarity with the technique.

References