Combined femoral and Chiari osteotomies for reconstruction of the painful subluxation or dislocation of the hip in cerebral palsy

A LONG-TERM OUTCOME STUDY

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In order to treat painful subluxation or dislocation secondary to cerebral palsy, 11 patients (12 hips) underwent combined femoral and Chiari pelvic osteotomies with additional soft-tissue releases at a mean age of 14.1 years (9.1 to 17.8). Relief of pain, improvement in movement of the hip, and in sitting posture, and ease of perineal care were recorded in all, and were maintained at a mean follow-up of 13.1 years (8 to 17.5). The improvement in general mobility was marginal, but those who were able to walk benefited the most.

The radiological measurements made before operation were modified afterwards to use the lateral margin of the neo-acetabulum produced by the pelvic osteotomy. The radiological migration index improved from a mean of 80.6% (61% to 100%) to 13.7% (0% to 33%) ($p < 0.0001$). The mean changes in centre edge angle and Sharp's angle were 72° (56° to 87° ; $p < 0.0001$) and 12.3° (9° to 15.6° ; $p < 0.0001$), respectively. Radiological evidence of progressive arthritic change was seen in one hip, in which only a partial reduction had been achieved, and there was early narrowing of the joint space in another. Painless heterotopic ossification was observed in one patient with athetoid quadriplegia. In seven hips the lateral Kawamura approach, elevating the greater trochanter, provided exposure for both osteotomies and allowed the construction of a dome-shaped iliac osteotomy, while protecting the sciatic nerve.

The prevalence of subluxation or dislocation of the hip in severe cerebral palsy is reported to be between 2.5% and 28%.¹ Between a third and a half of these dislocated hips are believed to cause significant pain,² which, with an abnormal position of the limb, interferes with mobility, perineal care and sitting.³

In its early stages, subluxation can be treated by weakening or removing the responsible abnormal muscle forces, provided that there is no significant anatomical deformity. The results of soft-tissue surgery alone are poor in adolescents, when subluxation is usually severe with secondary bone deformity. Additional bony surgery is required to achieve and maintain reduction.⁴ A varus, external rotational femoral osteotomy, with or without shortening of the proximal femur, reduces the head into the acetabulum and reconstitutes Shenton's line. Superior acetabular augmentation stabilises the reduction. Various corrective pelvic osteotomies have been advocated based on the degree of acetabular dysplasia and the state of the triradiate cartilage. The Chiari pelvic osteotomy^{5,6} is a salvage procedure used after closure of the triradiate cartilage, relying on reduction of the femoral head into the acetabu-

lum and metaplasia of the superior capsule for good results. This extensive procedure carries potential morbidity, such as redislocation, avascular necrosis and injury to the sciatic nerve. Other complications include decubitus ulcers, gastrointestinal upsets and supracondylar fractures. For developmental dysplasia of the hip the Chiari osteotomy may provide radiological benefit for up to 25 years.⁷ We report the long-term results of combined femoral and Chiari osteotomies in a group of adolescents and young adults with cerebral palsy and painful, subluxation or dislocation of the hips.

Materials and Methods

Between 1986 and 1993, 13 hips in 12 patients with cerebral palsy had combined femoral and Chiari osteotomies as part of a single-stage reconstruction for painful subluxation or dislocation of the hip. One patient was lost to follow-up and was excluded from the study. Of the remaining 11 patients (12 hips), six had spastic quadriplegia, three had spastic diplegia, one had spastic hemiplegia and one had athetoid quadriplegia. At the initial presentation, four hips were dislocated, six subluxed more than 50% and two less than 50%.

Fig. 1

Diagram of the pelvis showing the line of the dome osteotomy for Kawamura's modification of the Chiari osteotomy.

The operation included initial radiological evaluation of the hip under general anaesthesia. Through a lateral exposure an intertrochanteric varus external rotation osteotomy was undertaken, with or without shortening. The decision to shorten the femur was based on the radiological findings and the ease of relocation of the femoral head.

All the patients then underwent Chiari osteotomy. In seven hips, which had significant acetabular dysplasia, the Kawamura⁸ modification (Fig. 1) was used to obtain better dome-shaped cover for the femoral head. Through an extension of the same lateral approach, the greater trochanter and abductors are elevated in the extracapsular plane. This exposes and protects the sciatic nerve and ensures that the iliac osteotomy enters the sciatic notch without damaging the sacroiliac joint. The osteotomy was stabilised with screws (Fig. 2) or pins. The three parts of the femur were fixed with a single 90° blade plate, correcting the excessive anteversion and valgus. All patients had a psoas tenotomy through the osteotomy exposure and percutaneous release of the adductor longus. A capsulorrhaphy of the hip was performed in four cases.

In the other five hips a conventional Chiari osteotomy or capsulorrhaphy was performed through an ilioinguinal approach. Either approach allows exposure of the capsule, radiological assessment of stability and further capsulorrhaphy if the capsule is still lax after the femoral osteotomy.

Fig. 2a

Fig. 2b

Fig. 2c

A 12-year-old boy with spastic hemiplegia and painful severe subluxation of the right hip. Figure 2a – Pre-operative appearance. Figure 2b – Four years following modified Chiari osteotomy with varus de-rotational osteotomy (VDRO) on the right, and a more recent VDRO on the left to treat early contralateral subluxation. Figure 2c – After 12 years, there is a well-covered painless right hip. The patient leads a pain-free and almost normal walking life at 28 years of age.

Fig. 3a

Fig. 3b

Fig. 3c

A 17-year-old wheelchair-bound athetoid quadriplegic girl with severely painful subluxation of the right hip. Figure 3a – The pre-operative appearance. Figure 3b – Six years after modified Chiari osteotomy and varus de-rotational osteotomy, showing heterotopic ossification on the superior aspect of the femoral neck. Figure 3c – After 12 years, showing matured ossification. At 33 years of age the patient has an asymptomatic right hip.

After operation the legs were rested on slings and springs for between three and four weeks. Patients who could not walk were transferred to wheelchairs as soon as they were comfortable; the others began gradual mobilisation after four weeks. All the procedures were performed by the senior author (GAE).

Patients were reviewed at three, six and 12 months, and annually thereafter for a minimum of ten years (with the exception of one patient who died at eight years). Most were discharged from hospital between two to three weeks after operation, following excellent progress, but some were followed up in hospital for other problems relating to cerebral palsy, such as severe scoliosis or stiff legged gait. Ethical approval was obtained and the patients were evaluated both clinically and radiologically. Clinical progress was assessed by examination and a questionnaire regarding pain, mobility, comfort when sitting and perineal hygiene. Radiographs were measured for secondary displacement of the femoral head and for acetabular cover using Reimers index,⁹ the centre edge (CE) angle, Sharp's angle and Shenton's line.⁹ Radiographs were also assessed for heterotopic ossification (Fig. 3), evidence of degenerative change and avascular necrosis. Parents and carers provided information if the patients were unable to do so themselves.

Results

The mean age at surgery was 14.1 years (9.1 to 17.8) and the mean follow-up was for 13.1 years (8 to 17.5). The shortest follow-up was of a patient who died after eight years of routine follow-up.

Clinical. All the hips were painful pre-operatively and caused limited endurance of sitting. The pain was severe in six hips, moderate in one and mild in five. All were pain free at the final follow-up. When these results were graded according to Osterkamp, Caillouette and Hoffer,¹⁰ 11 hips had a good outcome, and one a fair outcome because of the radiological appearance (Table I).

Eight patients had improved personal hygiene because of facilitation of nursing care (Table I).

Three patients improved from being cane/rollator users to walking independently. One improved from being wheelchair-bound to walking with a cane. Seven were unchanged, one was an independent walker and six were confined to wheelchairs. In one case walking ability deteriorated.

Pre-operatively, the mean ranges of flexion and abduction were 85° (75° to 90°) and 20° (5° to 15°), respectively. At the most recent follow-up, these ranges were 95° (90° to 105°) and 25° (15° to 25°) respectively (Table I).

All but two patients had improved sitting balance. At long-term review four patients had pelvic obliquity, three of whom had severe scoliosis and two a wind-swept deformity (one patient had scoliosis and a windswept deformity). One with a marked right thoracic scoliosis was treated in a brace and confined to a wheelchair. One patient with spastic quadriplegia and severe scoliosis with rib impingement died eight years after the operation on the hip. Another with spastic quadriplegia and scoliosis had posterior instrumentation, resulting in good sitting balance, relief of pain and independent transfer.

Table I. Clinical outcome of 11 patients (12 hips) with painful cerebral palsy who had Chiari osteotomy and varus de-rotational osteotomy

Patient	Age at operation	Gender	Side	Duration of follow-up (yrs)	Ambulation		Sitting ability		Personal hygiene		Range of movement		Outcome* (Osterkamp et al ¹⁰)
					Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative	
1	9 yrs, 1 mth	F	R	14	Wheelchair	Wheelchair	Sits with support	Sits independently	Manages with difficulty	Manages with difficulty	Flexion < 90°, Abduction > 10°	Flexion > 90°, Abduction > 10°	Good
2	13 yrs, 8 mths	F	L	8	Wheelchair	Wheelchair	Unable to sit	Unable to sit	Unable to manage	Manages with difficulty	Flexion > 90°, Abduction > 10°	Flexion < 90°, Abduction > 10°	Good†
3	17 yrs, 3 mths	F	R	13	Wheelchair	Wheelchair	Unable to sit	Unable to sit	Unable to manage	Manages with difficulty	Flexion < 90°, Abduction < 10°	Flexion < 90°, Abduction < 10°	Fair
4	15 yrs, 8 mths	M	L	17	Wheelchair	Walks with aids	Sits with support	Sits independently	Manages with difficulty	Manages easily	Flexion < 90°, Abduction < 10°	Flexion > 90°, Abduction < 10°	Good
5	12 yrs, 2 mths	F	L	17.5	Walks with aids	Wheelchair	Sits with support	Sits independently	Manages with difficulty	Manages easily	Flexion < 90°, Abduction < 10°	Flexion > 90°, Abduction > 10°	Good
6	12 yrs, 1 mth	M	R	14	Walks with aids	Independent	Sits independently	Sits independently	Manages with difficulty	Manages with difficulty	Fixed flexion adduction deformity	Flexion > 90°, Abduction > 10°	Good
7	16 yrs, 8 mths	F	R	11	Wheelchair	Wheelchair	Sits with support	Sits independently	Manages with difficulty	Manages easily	Flexion < 90°, Abduction < 10°	Flexion > 90°, Abduction > 10°	Good
8	15 yrs, 7 mths	M	R	13	Wheelchair	Wheelchair	Sits with support	Sits independently	Manages with difficulty	Manages easily	Flexion < 90°, Abduction < 10°	Flexion < 90°, Abduction < 10°	Good
9	14 yrs, 4 mths	M	R	17.3	Wheelchair	Wheelchair	Unable to sit	Sits independently	Unable to manage	Manages easily	Flexion < 90°, Abduction < 10°	Flexion < 90°, Abduction < 10°	Good
10	11 yrs, 5 mths	F	L	11	Walks with aids	Independent	Sits with support	Sits independently	Manages easily	Manages easily	Flexion < 90°, Abduction < 10°	Flexion < 90°, Abduction < 10°	Good
	12 yrs, 4 mths	F	R	10	Walks with aids	Independent	Sits with support	Sits independently	Manages with difficulty	Manages easily	Fixed flexion adduction deformity	Flexion < 90°, Abduction < 10°	Good
11	17 yrs, 8 mths	M	R	11.5	Independent	Independent	Sits independently	Sits independently	Manages easily	Manages easily	Flexion < 90°, Abduction < 10°	Flexion > 90°, Abduction > 10°	Good

* good, pain-free and reduced hip; fair, hip subluxed or pre-operative pain persisted, or both

† deceased aged 22 yrs because of severe cardiorespiratory compromise caused by progressive kyphoscoliosis

Table II. Pre- and post-operative radiological measurements

Patient	Hip status		Reimer's index (%)		Sharp's angle (%)		Centre-edge angle (%)	
	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative	Pre-operative	Post-operative
1	< 50% subluxation	Well reduced hip	68	20	58	42	-14	18
2	Dislocated	Well reduced hip	100	0	50	36	-50	30
3	Dislocated	< 50% subluxation	100	30	46	34	-80	10
4	> 50% subluxation	Well reduced hip	68	20	42	38	-22	24
5	> 50% subluxation	Well reduced hip	69	30	50	44	-22	24
6	Dislocated	Well reduced hip	100	0	58	44	-64	36
7	> 50% subluxation	Well reduced hip	82	33	50	36	-40	32
8	< 50% subluxation	Well reduced hip	61	0	54	34	-26	52
9	> 50% subluxation	Well reduced hip	88	22	56	42	-44	32
10	Dislocated	Well reduced hip	100	10	56	52	-90	22
	> 50% subluxation	Well reduced hip	63	0	56	38	-22	56
11	> 50% subluxation	Well reduced hip	68	0	52	40	-16	38

Table III. Results of Chiari osteotomy with varus de-rotational osteotomy in 12 hips

Radiological measurements	Mean change	95% Confidence intervals	p-value
Reimer's index (%)	66.8	53.8 to 79.8	< 0.0001
Sharp's angle (°)	12.3	9 to 15.6	< 0.0001
Centre-edge angle (°)	72	56 to 87	< 0.0001
Neck-shaft angle (°)	18.7	14.5 to 23	< 0.0001

The patient with bilateral involvement had a level pelvis pre-operatively. The proximal part of the right femur was more valgus than the left and required shortening along with derotation. At 11 years after operation she remains pain-free and walks with a stick.

Post-operative complications occurred in one patient with troublesome gastro-oesophageal reflux which was difficult to diagnose because the patient could not communicate verbally, and in another who sustained a supracondylar fracture of the femur ten weeks after operation.

No patient developed avascular necrosis of the femoral head, and at the last review none had recurrent subluxation. There were no wound infections, problems with the sciatic nerve or pressure sores.

Radiological. The radiological measurements used before operation were modified afterwards to use the lateral margin of the neo-acetabulum produced by the osteotomy. Reimers' migration index improved from a mean of 80.6% before operation (61% to 100%) to 13.7% (0% to 33%) at the final follow-up, when only three had a migration index of more than 22% (Table II). No hip re-dislocated. The rate of mean improvement was 81% (mean change in Reimers' index 66.8% (95% CI 53.8 to 79.8); $p < 0.0001$; Table III).

Pre-operatively the mean CE angle and the mean Sharp's angle were -40.8° (-14° to -90°) and 52.3° (42° to 58°), respectively. At final follow-up this had improved to 31.2° (10° to 56°) and 40° (34° to 52°), respectively (Table II). The mean improvement in CE angle was 72° (95% CI 56 to 87) and for Sharp's angle it was 12.3° (95% CI 9 to 15.6; $p < 0.0001$; Table III).

The mean pre-operative neck-shaft angle of 147.4° (138.2° to 156.6°) which reduced to 128.6° (116° to 141°), a mean improvement of 18.7° (14.5° to 23° ; Table III). A standard anteroposterior radiograph does not allow measurement of the true neck-shaft angle because of the error produced by anteversion.

There was some remodelling in five subluxed and two dislocated hips. Late loss of joint space was noted in two patients. One had early changes and one, in whom only a partial reduction had been achieved, progressive osteoarthritis, as yet asymptomatic. A single patient with athetoid quadriplegia developed heterotopic ossification but had a spherical head and was free from pain. Only four of the 12 painful hips had a visible notch, compared to all nine relocated painful hips reported by Cooperman et al.¹¹

Discussion

For a child with cerebral palsy the optimal management of the hip requires an early baseline assessment followed by regular clinical and radiological review during growth in order to identify and treat early lateralisation of the femoral head. However, this study deals with a small group of patients seen at a tertiary referral centre at a late stage in the natural history. They already had pain, which they could either describe themselves or which was observed by parents and carers. In this latter group great care must be taken to exclude other sources of pain, such as gastro-oesophageal reflux. Consistent distress on movement of the hip while being dressed and examined, unrelieved by analgesia, is the indication for operation. Unfortunately, the surgical options are major procedures with a risk of serious complications in the patient with severe involvement and poor airway control and there is uncertainty as to the short- and long-term benefits. This study is relevant to the latter, with our mean follow-up being 13.4 years (8 to 17.5).

The choice of surgical treatment is considerable and includes excision of the proximal femur,^{12,13} Schanz¹⁴ valgus femoral osteotomy with or without excision of the head, and major reconstruction, as described in this study. Currently, we use Dega's pelvic osteotomy¹ for acetabular dysplasia in the presence of an open triradiate cartilage, and the Chiari procedure when the cartilage is closed.

Prolonged subluxation and localised loading of the femoral head on the lateral acetabular margin can cause a deep linear ulceration of the superior articular surface, visible radiologically if the appropriate tangential projection can be achieved. Because of this, when undertaking reconstructive surgery to replace the femoral head into the acetabulum, it was uncertain whether any benefit would last in the long term. All 11 patients in our study had troublesome pain before operation, compared to 69% in Brunner and Baumann's¹⁵ review of combined femoral and pelvic surgery. The pain was eliminated post-operatively in all patients in both studies.

The spastic muscles producing deformity are psoas, the adductors, and occasionally the hamstrings. In our cases, psoas was released either directly or as an effect of femoral shortening by the varus-derotation osteotomy. This osteotomy may also relax the adductors so that they do not require additional lengthening. Osterkamp et al¹⁰ were concerned that over-lengthening of the psoas in sitting patients might cause extension contractures and anterior instability of the hip. Our patients were older, with severe anatomical disturbances, and this problem did not arise.

The perceived advantage of the Chiari osteotomy is the immediate buttressing effect of the pelvic displacement against secondary subluxation. The lateral Kawamura approach does not reflect the abductor muscles distally from the ilium and thereby avoids weakness.⁸ It also exposes the sciatic nerve and reduces the risk of damage to it. This approach allows an accurate osteotomy at the mar-

gin of the attachment of the capsule.⁸ An important technical point is that the dome-shaped cut should not converge as it passes medially through the ilium, otherwise it will not be possible to medialise the distal fragment. The anterior end of the ilium is narrow compared to its central portion, and on displacing the osteotomy there may be a small anteriorly-based wedge of exposed capsule between the fragments. If necessary, this can be covered with cancellous bone from the segment removed at the femoral osteotomy. The number of cases is too small to compare the results of surgery for the conventional and the lateral trochanteric approaches for the Chiari osteotomy, but for severe subluxation the lateral approach facilitates easier exposure of the sciatic notch and safety for the nerve, as well as the dome-shaped cut which avoids possible encroachment into the sacroiliac joint.

The medium-term results of the Chiari osteotomy for painful hip subluxation published by Dietz and Knutson⁹ reported benefit at a mean follow-up of seven years. Of the 24 hips in their study, 71% were painful before operation and the 93% mean migration index was corrected to 19% post-operatively.⁹ Our review showed that all hips remained pain-free, but there was evidence of progressive radiological osteoarthritis in one patient who had not had optimal anatomical correction. There was also early joint space narrowing in one other patient.

Notwithstanding these cases, the combination of release of the psoas and relevant soft-tissue with simultaneous realignment and shortening of the proximal femur and Chiari augmentation of acetabular dysplasia provides continued pain relief and an acceptable functional outcome at a mean of 13 years following surgery. This treatment is helpful for

the adolescent or young adult with painful subluxation, especially one who applies load to the leg for limited walking or to enable transfers.

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