

Hip reconstruction surgery is successful in restoring joint congruity in patients with cerebral palsy: long-term outcome

Frank Braatz · Annette Eidemüller · Matthias C. Klotz ·
Nicholas A. Beckmann · Sebastian I. Wolf ·
Thomas Dreher

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Abstract

Purpose Neurogenic hip dislocation is frequently observed in patients with cerebral palsy (CP). If the hip is not centred but not dislocated, the hip joint can be recentered with minor operative effort. Reconstructive procedures are indicated if the femoral head is subluxated or dislocated. There are no data as to when destruction of the femoral head requires a salvage procedure or whether hip reconstruction surgery is successful in restoring joint congruity in patients with CP. Our aim was to investigate femoral head plasticity after hip reconstruction surgery in a long-term outcome study.

Methods We studied a large cohort of patients with CP and high hip dislocation (Tönnis grade IV) before surgery. Sixty-eight patients were assessed, of whom 23 presented with bilateral high hip dislocation, and 91 complex hip reconstructions were conducted. Standardised radiographic examination was performed before and directly after surgery and at the long-term follow-up examination.

Results Pain was the most frequent reason for complex hip-joint reconstruction (49 patients, 72 %). An impressive improvement in pain was demonstrated postoperatively. Forty-five hip joints presented aspheric incongruity postoperatively, which improved on average 7.7 years after surgery and 59 hip joints showed congruency. Only 15 % of patients experienced

pain at the time of final follow-up, and that was of low intensity.

Conclusions Early conservative treatment for hip dislocation is helpful, and operative reconstruction should also be scheduled early. Continued surveillance is necessary, and Reimers index is useful for monitoring the development of hip centering. In case of hip pain and femoral head deformity, our long-term study indicates that hip reconstruction surgery as a part of multilevel surgery improves pain and function in patients with CP and Tönnis IV hip dislocation, even if the hip joint is incongruent after operation. This incongruity improves over the long-term. If possible, a reconstruction procedure should be performed before the femoral head becomes deformed. High plasticity of the hip joint suggest that even if the femoral head is deformed, hip reconstruction can be recommended.

Keywords Cerebral palsy · Hip reconstruction surgery · Tönnis IV hip dislocation · Neurogenic hip dislocation · Congruity

Introduction

Neurogenic hip displacement is frequently observed in patients with cerebral palsy (CP). Along with gait abnormalities, it constitutes a very common reason for initiating neuro-orthopaedic treatment and is often an indication for surgery. The prevalence of hip dislocation is ~ 35 % [1, 2]. Among other reasons, functional abilities of these patients influence the risk for hip dislocation. Functional status and walking ability are classified according to the Gross Motor Function Classification System (GMFCS), which distinguishes five levels:

Level I – Walks without limitation, uses no assistive devices (such as crutches)

Level II – Walks with limitations but independently

F. Braatz · M. C. Klotz · N. A. Beckmann · S. I. Wolf · T. Dreher
Clinic for Orthopedics and Trauma Surgery, Heidelberg University
Clinics, Heidelberg, Germany

F. Braatz (✉)
Department of Trauma Surgery and Orthopaedics, University
Medical Center, Robert-Koch-Str. 40, 37075 Göttingen, Germany
e-mail: braatz@pfn.de

A. Eidemüller
Deutsche Klinik für Diagnostik DKD, Gastroenterology, Wiesbaden,
Germany

Level III – Walks using a hand-held mobility device, uses assistive mobility devices

Level IV – Self-mobility with limitations; may use powered mobility, severely limited

Level V – Transported in a manual wheelchair [3].

The higher the GMFCS level, the higher the risk for hip dislocation; risk for level 5 is > 60 % [4, 5].

Spasticity leads to neurogenic hip dislocation. The vector of the resulting force in patients with CP is directed laterally, superiorly, and posteriorly. Adductors, iliopsoas and medial hamstrings have a particularly strong dislocating effect [5]. Lateralisation and valgus position of the femoral head causes local pressure through the caput reflexum of the rectus femoris muscle and the lateral portions of the hip-joint capsule. This flattens the femoral head laterally, and it becomes deformed. In addition to hip-joint contractures, pain develops in 65 % of cases, which leads to further loss of function [6]. As a result, important basic functions, such as positioning, patient care, sitting, standing, and transfer, are frequently restricted in these patients [7]. To avoid the destruction of the femoral head and loss of function, surveillance programmes have been developed over the past ten years [8].

The development of contractures and secondary damage to the femoral head and joint socket represent a dynamic process over time. For treatment planning and management, therefore, early detection is especially important. In the early stages, conservative treatment, such as injection of botulinum toxin (BTX) and simple operations such as soft tissue procedures, can positively influence the course of neurogenic hip dislocation. The adductor tenotomy can positively influence the course of neurogenic hip dislocation but has a high risk of recurrence, which also correlates with GMFCS level [9, 10, 17, 29]. Once the femoral head and cartilage are destroyed, retraction procedures represent the only treatment option, and they are associated with poorer results.

A major question is when reconstruction surgery should be performed and which criteria are important for indication. In the literature, treatment algorithms focus on timing and Reimer's index. No data indicate when destruction of the femoral head requires a salvage procedure and whether or not reconstruction surgery is successful in restoring hip-joint congruity in patients with CP. Our aim was therefore to investigate femoral-head plasticity after hip-reconstruction surgery in a long-term outcome study of a large cohort of patients with CP and high hip dislocation (Tönnis grade IV) before surgery.

Materials and methods

Patients suffering from CP as the primary disease and in whom a complex surgical hip reconstruction was performed during single-event, multilevel surgery (SEMLS) between

1990 and 2000 were included in the study. Pre-operatively, study patients presented with a high hip dislocation. According to the classification of Tönnis, hip dislocation was staged as high if the core of the head or the center of the femoral head sat above the acetabular rim, which corresponds to Tönnis grade IV [11] (grade I centre of femoral head medially to the vertical line of Perkins; grade II, centre of femoral head lateral to line of Perkins; grade III, centre of femoral head close to level of superior acetabular rim; grade IV, centre of femoral head above superior acetabular rim).

Of the 96 patients included in the study, follow-up examinations could be conducted in 68 (21 girls, 47 boys) at our specialised outpatient clinic for CP. As part of the follow-up, patients—or their parents or caregivers in cases of severe mental retardation—completed standardised documentation to record medical history and pain development and assess the development of functional capacity and subjective satisfaction with the operation. As pain is difficult to assess in a nonverbal patient, assessment was done for those patients by parents or caregivers. The amount of pain was assessed for the time before the operation and at the follow-up examination. In addition, a standardised clinical examination was performed. Standardised radiographic follow-up examinations (anteroposterior pelvic overview) were conducted before and immediately after surgery and at long-term examination. Sixty patients presented with clinical features of spastic tetraplegia and eight with spastic diplegia; three of the 68 had an athetotic component. According to GMFCS classification, five patients were level IV and 62 level V. Of the 68 patients who were followed up, 23 presented with bilateral high hip dislocation. Hence, 91 complex hip reconstructions were conducted in the context of SEMLS. Hip reconstructive procedures and concomitant bony and soft-tissue procedures carried out during SEMLS are presented in Tables 1 and 2.

Age at time of surgery was between four and 19 (mean 10.9) years. At the time of follow-up, patients were on average 18.6 (range 11.8–28.5) years. Mean time to follow-up was 7.7 (range 2.5–13.4) years. Radiographs at the time immediately after surgery and at a long-term examination were divided in four subgroups: congruity, spherical or aspherical, congruent or incongruent (Fig. 1–2).

Changes in hip-joint morphology and differences in radiological subgroups provided basic information by which to estimate plasticity of hip joints postoperatively. Joint space was measured in postoperative radiographs. The smallest amount of space in the weight-bearing area was measured in millimetres after surgery and at follow-up examination. Despite incongruence or subluxation, this distance value indicated development and plasticity of the articular cartilage.

Table 1 Pelvic osteotomy procedures performed during single-event, multilevel surgery (SEMLS)

Pelvic osteotomy	Number (91)
Salter	54
Chiari	4
Pemberton	12
Triple osteotomy	20
Dega	1
FDO	89
Open repositioning	72

Consent and ethical approval

All patients/parents gave written consent for surgery and inclusion in the study, which was performed in accordance with local the ethics committee and according to the Declaration of Helsinki (World Medical Association).

Statistical analysis

For statistical evaluation, the software SAS 9.0 was used. For statistical analysis, McNemar's test for dependent variables and the rank test were used. The level of significance was defined as $p < 0.05$.

Results

Recurrent hip dislocation and subsequent procedures In the postoperative period, in six of 91 reconstructed hip joints, recurrence was found radiographically. In two cases, recurrent hip dislocation occurred within the first six weeks after initial surgery; both were surgically realigned in a revision procedure. In two other patients, recurrent dislocation occurred within three years and was successfully treated by performing another operative reconstruction procedure. Upon follow-up, we found redislocation in two patients radiologically, and one also presented with severe stretching spasticity in the lower extremities. One patient underwent resection of the femoral

Table 2 Adjuvant soft-tissue operations

	Number
Adductor tenotomy	73
Psoas lengthening	59
Hamstring lengthening	49
Distal rectus femoris transfer	40
Rectus tenotomy	13
Gracilis tenotomy	3
Distal hamstring tenotomy	9
Quadriceps tendon lengthening	1

head to treat painful chondrolysis of the femoral-head epiphysis.

Functional results

Mean joint movement for hip flexion at the long-term follow-up was 94°. All patients could sit in sitting devices at the time of follow-up. Pre-operatively, five patients were unable to sit, 44 (65 %) had severe pain, eight (12 %) had moderate pain and 15 (22 %) had no pain. At the follow-up, only ten patients (15 %) had pain, mostly of low intensity, and 57 (84 %) had no pain. Pre-operative and follow-up data for pain was incomplete or missing in one patient.

Radiological results

Reimers Index

Pre-operatively, all X-rays showed a 100 % migration according to Reimers Index. On the X-rays taken directly after surgery, this value was 5.6 % on average; at long-term examination, migration index averaged 14.0 % (from 0° to 100°). Thus, an average increase of 8.4 % was observed for femoral-head migration in the postoperative period (Fig. 3). Nonetheless, these values were lower than the defined cutoff point of 33 % for a subluxation position. On the X-rays taken directly after surgery, incongruence was observed in 45 hip joints.

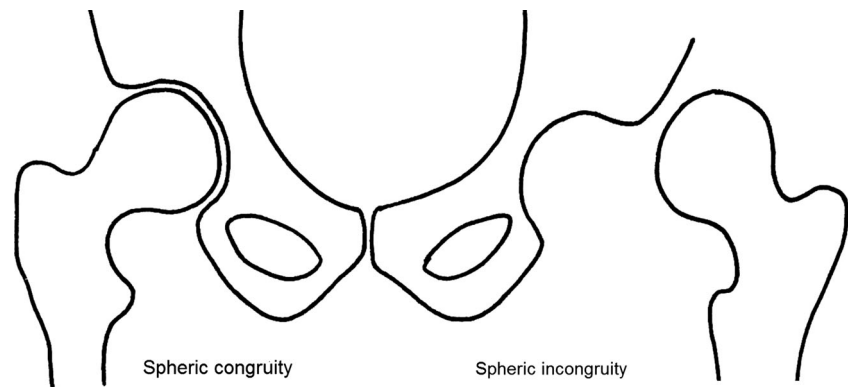
Congruity

X-rays taken directly after surgery showed an improvement in the relationship between femoral head and acetabulum; incongruence was observed in 45 hip joints (Fig. 4).

At the time of follow-up the number of incongruent joints decreased, and a better relationship between femoral head and acetabulum was recorded (Fig. 5).

On radiographs taken immediately after surgery, six femoral head were spheric, and their position to the acetabulum was congruent; 30 hip joints showed aspheric congruity; six showed spheric incongruity; 39 showed aspheric incongruity. At long-term examination, X-rays showed more congruent joints. At the time of follow-up, 25 hip joints were congruent and spheric, 34 femoral heads were not spheric but their position to the acetabulum was congruent, ten showed spheric incongruity, and 12 were aspheric and incongruent. The number of aspheric and incongruent joints decreased from 39 after surgery to 12 at follow-up examination. There was a significant postoperative shift to more physiological hip-joint morphologies ($p < 0.05$). The complete pre-operative, postoperative and follow-up radiographs were not available for ten patients.

Fig. 1 Spheric congruity and incongruity



Joint space

The joint space in the weight-bearing area of the hip joint increased from X-rays taken directly after surgery to the follow-up examination by 0.73 mm. In X-rays taken immediately after surgery, the joint space was 2.84 mm (0–10 mm) and was 3.57 mm (0–8 mm) at the time of follow-up examination; improvement was significant ($p < 0.01$).

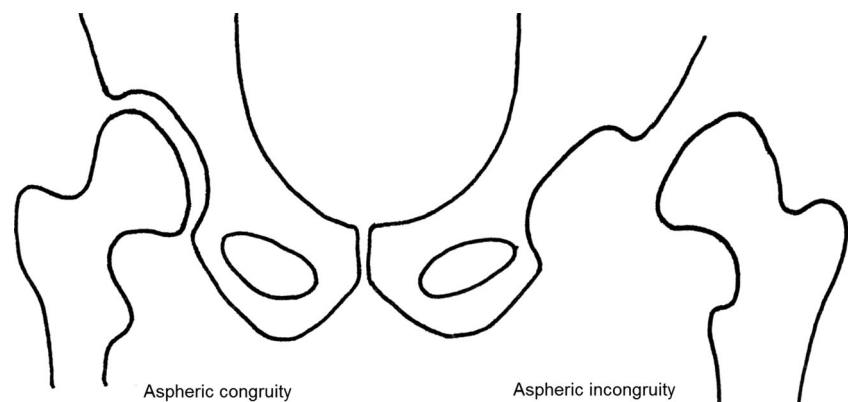
Discussion

Neurogenic hip dislocation is a frequent finding in patients with CP. The more pronounced the primary injury as a result of brain damage that occurred in early childhood, the higher the predisposition to hip decentration. At GMFCS level V, prevalence is 64–90 % [12, 13]. Furthermore, hip dislocation is painful in a high percentage of patients. Hodgkinson et al. reports a 47.2 % rate of adult patients with ICP who cannot walk [14]. Knapp and Cortes cited a 29 % rate for painful dislocation [15]. Painful hip dislocations also occasionally cause severe restrictions in basic functions, including positioning, personal care, sitting and standing (e.g. for transfer) [7]. As a result, many activities of daily life are more difficult or impossible, and this can strongly affect patients' quality of

life. Bolding described that migration and deformity are closely related and described a significant association with hip pain [16]. This association of hip pain with deformity suggests that early reconstruction should be performed. However, early operation is not always possible, and Miller classified surgical procedures as preventive, reconstructive or salvage. The first steps are soft-tissue procedures, the second bony reconstructions and the third angulation osteotomies or resection of the proximal femur. Surveillance procedures developed in recent years to avoid such salvage procedures [8]. Soft-tissue procedures and other conservative treatments influence the migration progression but cannot stop migration of the femoral head [9, 17]. Data reported by Graham et al. [18] do not support recommending the use of BTX combined with bracing for managing spastic hip displacement.

A high hip dislocation is often combined with a large deformity, which leads to destruction of the femoral head and requires a salvage procedure [19]. However, compared with reconstructive surgery, salvage procedures have poor functional results [20]. The question is: Does deformity of the femoral head always necessitate resection, or is there a plasticity of the hip joint after surgery? The outcome of surgical reconstruction depends on deformation of the femoral head and timing of the operation. Data on plasticity and long-term follow-up is poor. Canavese et al. [21] described that recurrence rates following original and contralateral hip

Fig. 2 Aspheric congruity and incongruity



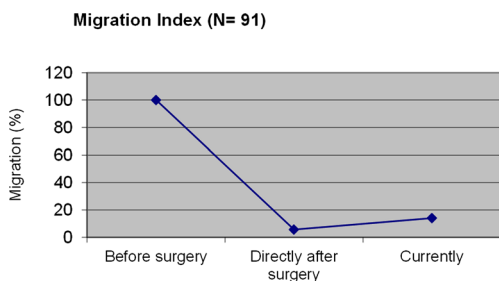


Fig. 3 Postoperative migration index course according to Reimers (N= 91 hip joints)

subluxation and dislocation after unilateral bony surgery in GMFCS III–V patients with CP are higher than those of other, earlier, series.

In this study, patients presented pre-operatively with high hip dislocation according to Tönnis grade IV. Postoperative X-rays, however, showed incongruence in a high proportion of patients: six hip joints presented spheric and 39 aspheric incongruity. This effect improved on average 7.7 years after surgery: 59 hip joints were congruent on long-term follow-up. The redislocation rate at six of 91 patients is in line with data reported in the literature despite the high hip dislocation pre-operatively [22, 23].

The standard technique for pelvic osteotomy in this study was the Salter osteotomy. However, the vector of the resulting force is directed laterally, superiorly and posteriorly, and the

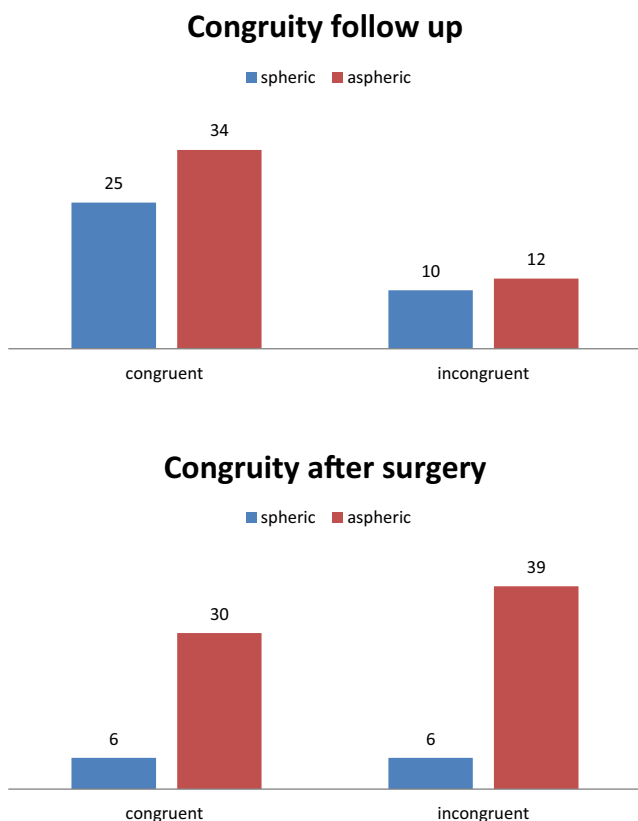


Fig. 4 Congruity after surgery and at follow-up

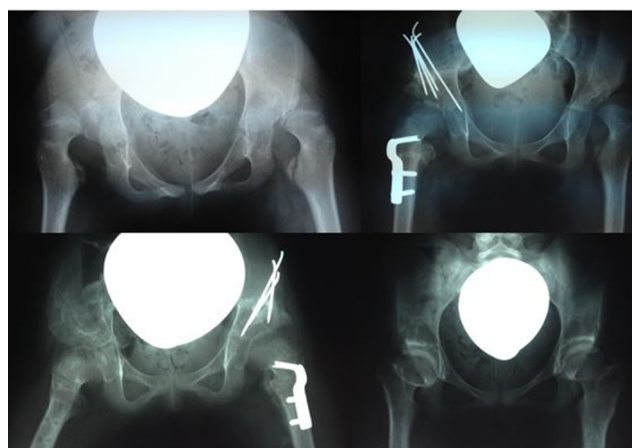


Fig. 5 An 8-year-old patient with cerebral palsy (CP) and Gross Motor Function Classification System (GMFCS) level V at the time of operation, and pre- and postoperative radiographs after FDO and Salter osteotomy (right). Hardware removal and remaining FDO 1 year after the first operation. Long-term radiograph shows a congruent situation for both hip joints 7.5 years after the first operation

acetabular rim defect was, in most cases, in this position. Therefore, the surgical technique in our department is a modified Dega acetabuloplasty, as described by Kim et al. [30], in combination with proximal femoral shortening, varisation and derotation osteotomy of the proximal femur.

hip-joint reconstruction is usually not successful if the femoral head is deformed and incongruence of the reconstructed joint is present postoperatively [16]. In these situations, retraction procedures are recommended, such as proximal femur resection or angulation osteotomy [24, 25]. Prophylactic angulation has been recommended for severe tetraplegia [26] and hip arthroplasty in ambulatory patients with CP [28]; however, caution should be exercised when making this decision and the procedure reserved for patients presenting with deformed femoral head and high displacement. In our study, only patients with high hip dislocation were included, and there was a high rate of postoperative incongruence. Even though there was a shift to congruent joints at long-term follow-up and an unexpectedly high plasticity, this high rate of postoperative incongruence can be avoided by performing early operative reconstruction. A reconstruction procedure should be carried out before the femoral head becomes deformed so that a congruent situation of the reconstructed joint can be achieved in the highest percentage of patients possible. Prevention programmes, such as that described by Hägglund [10], should be initiated so that the neuro-orthopaedic operative treatment plan is not initiated unless pain has already developed. The Migration Index according to Reimers appears to be a reliable tool for pre- and postoperative monitoring [27]. If patients with CP are not followed up in a hip-surveillance programme, neuro-orthopaedic treatment usually starts when they suffer from hip pain during activities of daily living. Hip pain is closely

related to migration and deformity [16]. In our study, pain was the main reason for surgical hip reconstruction; painful hip-joint dislocations were present in 65 % of patients pre-operatively. Indeed, an impressive reduction in pain was demonstrated postoperatively: 45 hip joints presented aspheric incongruity postoperatively, and this improved on average 7.7 years after surgery, when 59 hip joints were congruent.

In the weight-bearing area, the smallest distance between femoral head and acetabulum was measured. The increase in joint space is a positive development, and data suggest there is also articular cartilage plasticity. After 7.7 years, another effect might be growth following the pubertal growth spurt. There are no data available on femoral head deformity and plasticity after reconstructive surgery.

In our study, only 15 % of patients were experiencing pain—and mostly of low intensity—at the time of follow-up. Sitting, standing and walking ability could also be significantly improved. Thus, hip pain was significantly reduced. This effect was also sustained on average 7.5 years after surgery. These findings are very impressive, as the study period involved the important phase of adolescent growth spurt. Patient age at follow-up was a mean of 18.6 years: the growth period was thus completed.

Conclusion

Early initiation of conservative treatment for hip dislocation is helpful, and operative reconstruction should be scheduled early. Hip surveillance is necessary, and Reimers Index is a useful tool by which to monitor the development of hip centring. In case of hip pain and femoral-head deformity, results of our long-term study indicate that hip reconstruction surgery as a part of multilevel surgery improves pain and function in patients with CP and Tönnis IV hip dislocation, even if the hip joint is incongruent after the operation; this incongruity improves on long-term follow-up. If possible, a reconstruction procedure should be carried out before the femoral head becomes deformed. This study on high plasticity of the hip joint suggests that even if the femoral head is deformed, hip reconstruction can be recommended.

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