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Femoral derotation osteotomy in adults with cerebral palsy

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ABSTRACT

Background: Internal rotation gait constitutes a complex gait disorder in bilateral spastic cerebral palsy (BSCP) including static torsional and dynamic components resulting in lever arm dysfunction. Although femoral derotation osteotomy (FDO) is a standard procedure to correct increased femoral anteversion in children, unpredictable outcome has been reported. The effect of FDO when it is done as part of single-event multilevel surgery (SEMLS) in adulthood has not been investigated.

Methods: In this study mid-term data of 63 adults with BSCP and internal rotation gait, undergoing SEMLS including FDO were analyzed pre- and 1.7 years postoperatively by clinical examination and 3D-instrumented gait analysis. All legs were categorized as the more or less involved side to consider asymmetry. The mean hip rotation in stance preoperatively and the intraoperative derotation was correlated with the difference pre- and postoperatively.

Results: The group as a whole experienced the following results postoperatively: improved mean hip rotation in stance ($p = 0.0001$), mean foot progression angle ($p = 0.0001$) and a significant improvement of the clinical parameter: passive internal and external hip rotation, midpoint and anteversion ($p = 0.0001$) for both legs separately. With regard to the less and more involved side, clinical and kinematic parameters showed comparable significant changes ($p = 0.0001$). The anteversion improved significantly in proximal compared to distal FDO ($p = 0.03$).

Conclusion: This study emphasizes an overall good correction of internal rotation gait in adults with bilateral involvement after FDO. However, the results are more predictable in adults compared to studies reporting outcome after FDO in children.

1. Introduction

Cerebral palsy (CP) is a lifelong condition of disability caused by a non-progressive impairment of the central nervous system [1]. The National Institute for Health and Care Excellence emphasizes that the transition of healthcare from child and adolescence with CP to adult is of critical importance [2] and specialized services for adults with CP are limited [3,4]. An emerging research topic in adults with CP implies the progressive decline or the loss of gait function over time and the recurrence of gait disturbances after surgical interventions in childhood [3,5]. A total of 25% of adult patients experience gait decline. Risk factors are age, higher levels of pain and fatigue, less gait independence or bilateral motor impairment [3]. Morgan and McGinley [3] pointed out that the factors of walking decline in adults with CP are uncertain and most studies include self-reported deterioration of gait without specifying the symptoms. Further, objective gait indices or gait parameters based on 3D-gait analysis contribute to a better understanding of complex gait disorders after surgical interventions in short- and longterm outcome in patients with CP [6–9]. Single-event multilevel surgery (SEMLS) in children and adolescents with cerebral palsy has become an established procedure with good short- and longterm outcome [6–14] with the intention to improve energy consumption, kinematic parameters and speed.

Internal rotation gait (IRG) represents a common gait abnormality in patients with cerebral palsy and is seen as a consequence of excessive femoral anteversion, hip flexor tightness, imbalance of hip rotators, and hamstring and adductor tightness [15] or as a result of lever-arm dysfunction. Lower limb torsional profiles mostly involve multiple levels including the combination of an increased internal hip rotation and an external foot progression angle due to an increased tibial torsion [16]. To correct increased femoral anteversion femoral derotation osteotomy is accepted as the gold standard procedure [17–19]. FDO is commonly performed either at the intertrochanteric or supracondylar level and

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indications were specified by various authors in children with CP [10–17].

Long term outcome studies in children with CP already discussed persistent dynamic factors after the pubertal growth leading to recurrence of internal gait [10]. Only 60% of the intraoperative extent of derotation is reflected in the 3D-gait analysis including static torsional (increased femoral anteversion) and dynamic (spasticity) components [20]. Severe deterioration or even complete recurrence of IRG in 15% of the legs [10,18] with an overall deterioration of 5° in the long term outcome is still a focus of debate in children with CP undergoing FDO. Hence, growth must be seen as one factor leading to recurrence after initial good correction. It is therefore a question if rotational treatment should be performed as late as possible or even in adulthood.

Until now there are no studies reporting clinical and dynamic outcome in adults with cerebral palsy who underwent FDO. It is a major question if the initial effects of FDO performed in adults are comparable to those in children and if long-term follow-up shows superior outcome.

The purpose of the present study is to evaluate functional outcome in adults with bilateral spastic cerebral palsy (BSCP) and internal rotation gait following multilevel surgery including FDO and to investigate clinical and kinematic parameters as well as over- and undercorrection after FDO. Furthermore, a subgroup analysis was performed to compare the results of proximal vs. distal FDO.

2. Material and methods

For the present retrospective clinical cohort study, ambulant adult patients aged 17 to 48.6 years with either bilateral or unilateral CP (levels I–III, according to the Gross Motor Function Classification System (GMFCS)) [21] were selected for potential inclusion from a prospectively gathered gait laboratory database of a single center between 1996 and 2014. A total of 103 patients who underwent SEMLS at the age of ≥17 years was eligible to be included in this trial. The minimum follow-up was set one to six years (mean 1.7 years) postoperatively. Overall 40 patients were excluded containing three patients with unilateral CP, three patients in whom preoperative 3D-gait analysis or the surgical intervention was not provided and 34 patients with flexed knee gait or tibial torsional problems (Fig. 1). Previous orthopedic surgical procedures in childhood or adolescence including multilevel musculotendinous lengthening or osteotomies were not excluded. Overall 38 patients had no surgical interventions in childhood, 14 had soft tissue procedures (e.g. calf muscle lengthening) and 11 patients had SEMLS including 5 proximal FDO in 4 patients. The study group consisted of 63 adult patients with BSCP and internal rotation gait who were treated with SEMLS including FDO. All subjects were examined before and at least 1 year after the intervention including clinical and 3D-instrumented gait analysis according to a standardized protocol. Further we assessed if patients walked with or without orthotic devices (e.g. crutches) pre- and postoperatively. The patients gave informed consent and the protocol was approved by the local ethics committee.

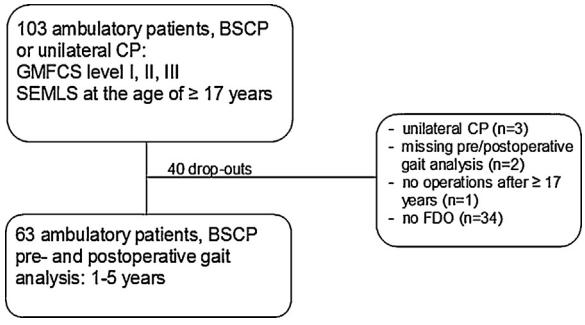

Fig. 1. Outline of in- and exclusion criteria of CP patients (BSCP = bilateral spastic cerebral palsy, GMFCS = Gross Motor Function Classification System, SEMLS = single-event multilevel surgery).

Table 1 summarizes the amount of surgical procedures performed in CP patients aged ≥17 years. All bony and soft-tissue procedures were carried out by three responsible senior orthopedic surgeons (LD, FB, TD). The indication for FDO was: clinical relevant internal rotation gait, increased femoral anteversion, a shift in the mid-point of hip rotation [22] of more than 10° toward internal hip rotation and kinematic parameters representative for IRG, e.g. foot progression angle and hip rotation [10]. We performed an additional supramalleolar derotation osteotomy after FDO in persisting torsional deformities (thigh-foot and foot progression angle) at the level of the shank.

As part of multilevel surgery FDO was either performed proximally as intertrochanteric osteotomy (32 legs) or distally (64 legs) at the supracondylar level. With reference to the study of Dreher et al. [18] the indication for FDO was a functionally and cosmetically compromising internal rotation gait, when passive internal hip rotation exceeded 50° and passive external hip rotation was less than 30°. The anteversion angle was measured radiographically to avoid intraoperative retroversion. Our objective was to correct anteversion to 10° intraoperatively. The amount of derotation was determined intraoperatively with the objective to achieve an equal range of motion of external and internal rotation in hip extension (neutral mid-point [22]) and an anteversion up to 10°. Before we performed the osteotomy, we placed K-wires proximally and distally parallel to the osteotomy. Intraoperatively we measured the angle between the proximal and distal K- wire with a goniometer. Before plate fixation, we checked clinical midpoint in neutral position, remaining of at least 20° of internal rotation and spontaneous external rotation position of both legs. If any of this conditions was not met, the derotation was modified.

Postoperative management included weight-bearing after 6 weeks. If FDO was unilaterally performed, early mobilization with immediate weight-bearing of the contralateral side was initiated. Specialized physiotherapy was done from the first days after surgery at least twice a day and as soon as knee or hip flexion of 90°

Table 1
Outline of surgical procedures.

Surgical procedures	63 patients (n = 126 legs)
Pelvic osteotomy	1
Femoral derotation osteotomy (FDO)	96
Proximal	32
Distal	64
Tibial derotation osteotomy	16
Bony foot stabilization[a]	23
Intramuscular psoas lengthening	4
Rectus femoris surgery[b]	37
Adductor lengthening	10
Internal hip rotator transfer[c]	1
Hamstring lengthening	24
Posterior capsulotomy (knee)	6
Patella tendon shortening	3
Calf muscle lengthening	68
Soft tissue procedures, foot[d]	15

[a] Consisted of calcaneocuboid distraction arthrodesis, triple arthrodesis, Evans (lateral calcaneal lengthening) procedure.
[b] Rectus femoris transfer (n = 28), distal rectus femoris release (n = 9).
[c] Transfer of the the gluteus medius and minimus from the greater trochanter to the anterior part of the femur.
[d] Consisted of split anterior tibial tendon transfer, split posteror tibial tendon transfer, plantar fascia release.