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Factors associated with recurrence after femoral derotation osteotomy in cerebral palsy

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ABSTRACT

Femoral derotation osteotomy (FDO) as gold standard treatment for internal rotation gait in cerebral palsy (CP) leads to satisfying short-term results, whereas rates of recurrence up to 33% are reported in long-term outcome studies. The purpose of this study was therefore to identify factors contributing to recurrence of internal rotation gait in patients with CP who were treated with FDO in childhood.

70 patients (age: 10 (±3.3) years at surgery) with bilateral CP and internal rotation gait were examined pre-, one year and at least five years (mean 8 ± 2 years) postoperatively after distal or proximal FDO, using standardized clinical examination and 3D gait-analysis. 27 patients had a good hip rotation one year postoperatively (between 5° external and 15° internal for both limbs) and were considered for the analysis of factors contributing to recurrence of internal rotation gait.

Regarding all included patients both mean hip rotation and foot progression angle improved significantly ($p < 0.001$) from pre- to postoperative. A significant deterioration in hip rotation (more involved side) ($p < 0.001$) from one year postoperatively to the long-term follow-up can be observed. Younger age, reduced hip joint impulse, increased plantar flexion and internal foot progression angle postoperatively could be identified as factors for recurrence.

FDO on average leads to a satisfactory correction of internal rotation gait. In order to improve the long-term outcome after FDO the time of multilevel surgery should be indicated as late as possible and the different factors leading to potential recurrence should be considered.

1. Introduction

Internal rotation gait is a common gait abnormality in children with bilateral cerebral palsy [1]. The pathogenesis includes both transverse plane deformity of the pelvis, femur, tibia, and/or foot [2,3] and dynamic components such as muscular imbalance, increased muscle tone and spasticity [4]. Children with internal rotation gait have problems with foot clearance with respect to the contralateral leg and therefore tripping.

Femoral derotation osteotomy (FDO) as the gold standard treats increased femoral anteversion, internal rotation gait [3,5–11] and lever-arm dysfunction [12,13]. Corresponding to the variable goals of correction, the degree of derotation is determined differently either statically by anteversion or the mid-point of passive hip rotation [14] or dynamically by hip rotation during gait analysis. The osteotomy can be conducted either at the intertrochanteric level as proximal FDO or at the supracondylar level as distal FDO with equivalent static and functional outcomes [3,7,9,15].

Satisfying short-term results after FDO for the correction of hip rotation and foot progression have been reported by various authors [5,7,15].

However, there are – to our knowledge – only four long-term studies reporting results at least 4 years after FDO in children with cerebral palsy. Rates of recurrence of 0% [3], 10% [16], 15% [8] and 33% [17] are reported. These conflicting long-term results with partially high rates of recurrence rotation gait after FDO. However, no further explanations were found in these past studies why some patients are prone to develop recurrence of internal rotation raise the question for factors associated with recurrence of internal gait.

The purpose of the current long-term outcome study was therefore to identify factors contributing to recurrence of internal

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Table 1
Demographic data.

Parameter	E0				E1				E2			
	"Corrected"		All patients		"Corrected"		All patients		"Corrected"		All patients	
	Sustained	Recurrence	Sustained	Recurrence	Sustained	Recurrence	Sustained	Recurrence	Sustained	Recurrence	Sustained	Recurrence
Number of patients	17	10	53	17	17	10	53	17	17	10	53	17
Time of follow-up (years)	–	–	–	–	1.2 ± 0.4	1.0 ± 0.1	1.1 ± 0.3	1.0 ± 0.2	7.7 ± 2.0	8.7 ± 2.1	8.0 ± 2.2	8.5 ± 2.2
Age (years)	10.7 ± 3.3	7.3 ± 2.2	10.9 ± 3.2	7.6 ± 2.1	11.8 ± 3.1	8.3 ± 2.2	12.0 ± 3.3	8.7 ± 2.1	18.3 ± 4.3	16.2 ± 3.5	18.9 ± 4.5	16.3 ± 3.3
Anteversion (°)	29.6 ± 11.0	32.3 ± 13.0	30.0 ± 10.0	31.9 ± 12.0	24.2 ± 8.9	25.6 ± 8.5	22.6 ± 9.1	25.3 ± 10.4	22.5 ± 8.3	22.5 ± 6.4	20.4 ± 7.5	22.5 ± 9.8
Hip rotation (°)	23.7 ± 8.2	28.1 ± 11.8	24.9 ± 10.7	26.2 ± 12.6	3.4 ± 5.1	2.3 ± 4.6	0.8 ± 11.5	4.1 ± 10.0	2.2 ± 11.6	18.5 ± 12.4	2.9 ± 11.8	21.7 ± 10.2
Derotation angle (°)	24.7 ± 8.1	30.4 ± 5.5	26.7 ± 7.7	27.6 ± 8.5								
GMFCS (no. of patients)												
Level I	3	1	9	1								
Level II	10	4	34	8								
Level III	5	4	10	8								

"Corrected": 27 patients with mean hip rotation one year postoperatively between 5° external and 15° internal
Sustained: patients, who sustained correction in the long-term follow-up.
Recurrence: patients with recurrence of internal rotation gait in the long-term follow-up.
Anteversion of the more involved limb, measured by TPAT [29].
Mid-point of hip rotation of the more involved limb [14].
Hip rotation (gait analysis) of the more involved limb: mean hip rotation during stance phase in gait analysis.

rotation gait in patients with cerebral palsy who were treated with FDO in childhood. Being aware of risk factors for recurrence helps to reduce unsatisfying long-term outcomes after FDO in future and will provide important information on how these factors may be addressed.

2. Patients and methods

For the present cohort study, all ambulatory children with bilateral spastic cerebral palsy (GMFCS level I–III), that received uni- or bilateral FDO to correct internal rotation gait in the context of single-event multilevel surgery were selected retrospectively from the gait laboratory database. Patients with a minimum follow-up of 5 years were selected for this study. 75 children matched these criteria. 5 patients had to be excluded due to additional gait modifying surgery in the follow-up (Table 1).

Femoral derotation osteotomy was performed either distally as supracondylar osteotomy or proximally as intertrochanteric osteotomy in the context of single event multilevel surgery. The aim of FDO was mainly to correct increased femoral anteversion and the amount of derotation was determined intraoperatively achieving a neutral clinical midpoint [14] between passive internal and external rotation. The amount of derotation was measured intra-operatively with a goniometer by using K-wires placed proximally and distally to the osteotomy.

Concomitant procedures are listed in Table 2.

Standardized three-dimensional gait analysis and clinical examination are routinely performed for all ambulatory patients with cerebral palsy before (E0) and one year (1.0 ± 0.3) (E1) after surgery. All included children underwent an additional examination (E2) at least five years postoperatively (8.1 ± 2.2 years).

The long-term outcome in gait analysis kinematics and the rate of recurrence was analyzed for all included patients.

43 patients were over- or undercorrected on at least one limb. 17 limbs on the more and 23 limbs on the less involved side had a hip rotation more than 5° external one year postoperatively. Both

Table 2
Number of surgical procedures performed in single-event multilevel surgery.

Procedures	"Corrected"				All patients			
	Sustained		Recurrence		Sustained		Recurrence	
	More involved	Less involved	More involved	Less involved	More involved	Less involved	More involved	Less involved
Pelvic osteotomy	1	3	2	0	3	3	3	1
FDO (proximal)	6	5	4	3	24	16	7	6
FDO (distal)	10	8	5	4	27	23	12	7
Supramalleolar DO	3	1	1	1	6	1	3	1
Intramuscular psoas lengthening	1	0	3	2	3	3	4	5
Adductor lengthening	0	0	0	0	1	2	1	1
Hamstring lengthening	8	8	7	7	30	29	13	12
Distal rectus femoris transfer	13	13	7	7	40	38	13	12
Patella tendon shortening	2	2	0	0	6	5	0	0
Calf muscle lengthening	10	10	5	4	29	33	11	9
Bony foot stabilization	7	8	3	4	16	17	4	5
Soft tissue procedures, foot	3	2	2	3	11	11	3	5

"Corrected": 27 patients with mean hip rotation one year postoperatively between 5° external and 15° internal.
Sustained: patients, who sustained correction in the long-term follow-up.
Recurrence: patients with recurrence of internal rotation gait in the long-term follow-up.