



The effect of hip reconstruction on gross motor function levels in children with cerebral palsy



Mutlu Cobanoglu ^{a, *}, Emre Cullu ^a, Imran Omurlu ^b

^a Adnan Menderes University, Faculty of Medicine, Department of Orthopedics and Traumatology, Aydın, Turkey

^b Adnan Menderes University, Faculty of Medicine, Department of Biostatistics, Aydın, Turkey

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ABSTRACT

Objective: The aim of this study was to determine whether the hip reconstruction has an effect on gross motor function classification system (GMFCS) levels in patients with hip instability in cerebral palsy (CP). **Methods:** A total of 45 hips of 30 patients (mean age: 8.7 (4–17) years) with CP operated due to hip instability with a minimum of 2 years of follow-up were included into the study. Migration index was used for classification of the severity of hip instability. Clinical evaluation included sitting and walking ability, existence of pressure sores, difficulty in perineal care, and hip pain. The functional gains from the surgery were evaluated with changes in GMFCS levels. Wilcoxon *T* test, chi-square test and Spearman correlation test were used.

Results: Mean follow-up time was 57 (24–132) months. The distribution of preoperative GMFCS was level I in 1 patient, level II in 4 patients, level III in 5 patients, level IV in 9 patients and level V in 11 patients. The complaints resolved in 25 patients, and persisted in 5 postoperatively. There was no correlation between the changes in GMFCS levels and the postoperative complaints ($p = 0.504$). The GMFCS levels did not change in 20 patients, improved in 8, and worsened in 2. There were no significant differences between the preoperative and postoperative GMFCS levels ($p = 0.052$). Positive correlations were found between the preoperative GMFCS-MI, the type of CP-MI respectively ($p = 0.001$, $p = 0.015$). **Conclusion:** There was an improvement in preoperative complaints. GMFCS levels remained stable after surgery. Relief in symptoms was not consistent with the changes in GMFCS in children with cerebral palsy after hip reconstruction.

Level of evidence: Level IV, Therapeutic study.

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Introduction

Hip displacement is one of the most common orthopedic problems in cerebral palsy (CP), and constitutes a management challenge for both orthopedic surgeons and the patients' care-takers. Hip displacement ranges from a silent subluxation to a painful hip dislocation, and when left untreated it negatively affects the quality of life and leads to problems in sitting, standing, and walking.^{1,2} Therefore prompt diagnosis, close follow up, and preventive conservative and surgical management are necessary. Hip displacement is not affected by sex, and its rates may be as high as 75% depending on the level of neurologic involvement and walking

ability. The incidence of hip instability in non-ambulatory patients is higher compared to ambulatory patients.³

Gross motor function in children with cerebral palsy is assessed using Gross Motor Function Classification System (GMFCS). In this system, level I shows the highest function, and level V shows the lowest.⁴ The risk of hip displacement in patients at Level V on GMFCS is 2.5–3 times greater than those patients who are at Levels III–IV. Thus, the risk of hip dislocation increases as motor capacity decreases.^{5,6} It is reported that while GMFCS remains constant during childhood, it may change by interventional methods.^{7,8} On the other hand, when displacement increases in a child who is ambulatory or who can sit without support, a vicious cycle may occur when an increase in hip displacement leads to a decrease in functional capacity. Breaking this cycle may provide a change in the functional capacity. This condition brings to mind how the motor ability will be affected after surgery in patients suffering from the frequently encountered hip displacement. The aim of the study was

* Corresponding author. Adnan Menderes University, Faculty of Medicine, Department of Orthopedics and Traumatology, Kepez Mevkii 09100, Aydın, Turkey. Fax: +90 2562197163.

E-mail address: drmutlu79@hotmail.com (M. Cobanoglu).

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to investigate how the GMFCS would be affected by surgical procedures in patients with CP related hip displacement.

Materials and methods

A retrospective chart review of patients operated between 2003 and 2012 due to CP related hip dislocation or subluxation, was performed. The data were recorded by the same author. The follow-up time was at least 2 years per patient. The patients who continued to the clinical follow had long-term follow-up period. But the last follow-up time of the patients who did not apply for routine examination was accepted as the last visit time.

The patients were evaluated before the operation for sitting and walking ability, pressure sores, difficulty in perineal care, and the presence of hip pain. The pain was evaluated by talking to caretakers or patients having talking ability. The level of pain was assessed with presence of pain or no pain. The improvements in these symptoms after the operation were also assessed. Improvements in seating and walking were evaluated according to whether any walking assistance or wheelchair modifications were needed. Subluxation was defined as the lateral and superior displacement of the femoral head, and dislocation was defined as the lack of relationship between the acetabulum and femoral head. The displacement rate of the hip was assessed with Reimer's migration index (MI).⁹ Hip subluxation was graded according to the magnitude of the migration index in the anteroposterior hip X ray, an index under 24% was accepted as hip under risk, between 25 and 39% as mildly subluxated hip, 40–59% as moderately subluxated hip, more than 60% as severely subluxated hip, and 100% as dislocated hip.¹⁰

Hip surgery consisted of proximal femoral varisation and derotation osteotomy (with or without open reduction), and combined surgery (open reduction proximal femoral osteotomy, Dega osteotomy, and combination of adductor–iliopsoas tenotomies (if required)). If only femoral osteotomies were indicated bilaterally, the osteotomies were performed simultaneously by two surgeons but if combined pelvic and femoral osteotomies were indicated bilaterally, there was at least 3 weeks between surgeries of both sides. A short leg cast with antirotational bar was applied for two weeks after the operation in patients who underwent proximal femoral osteotomy, while a hip spica cast was applied for six weeks in patients who underwent combined surgery. The surgical procedures other than the hip operations were also evaluated. Soft tissue operations, applied simultaneously with hip surgery or afterwards, consisted of soft tissue operations outside the hip (hamstring release, achilloplasty, vulpius).

Functional gains obtained from surgery were assessed by using GMFCS 6–12 years, before and after the operation⁴ (Table 1). Postoperative GMFCS level and complaint status were assessed by a researcher who was identified as an independent observer and not part of the surgical team.

Statistics

Comparison of preoperative and postoperative GMFCS levels was performed with the Wilcoxon *T* test. Comparison of qualitative data was performed with the chi-square test. The relationships

between MI versus preoperative GMFCS and type of CP were evaluated with the Spearman correlation test. Complementary statistics were reported as mean (standard deviation), minimum–maximum values and frequency. A *p* value below 0.05 as considered statistically significant.

Ethics

This retrospective clinical study was approved by the institutional review board (Number: 2015/668).

Results

There were 31 patients who were operated due to CP related hip dislocation or subluxation, one of these patients was excluded due to the death of the patient from an unknown cause. Thirty patients (45 hips) fulfilled the study criteria. There were 16 males and 14 females; mean age was 8.7 (5–18) years. Mean follow up was 57 (24–132) months. Based on the type of CP, 13 patients were children with diplegia, 2 were children with hemiplegia, and 15 were children with quadriplegia. Based on the severity of hip displacement, 7 hips were risky, 13 had mildly severe subluxation, 7 had moderately severe subluxation, 7 had severe subluxation, and 11 hips were dislocated. The demographic data of the patients are shown in Table 2.

Pelvic and femoral osteotomies were performed in 7 of the dislocated hips. In the remaining 4 hips the acetabular coverage was considered adequate and a proximal femoral osteotomy was applied. In subluxated hips, femoral osteotomies alone were performed in 19, pelvic and femoral osteotomies were applied together in 8. In 7 risky hips, only femoral osteotomies were performed. During the early postoperative period, superficial infection developed in four of the operated hips, and they were treated with tissue debridement and antibiotic therapy. During the late period one hip in one patient was reoperated for femoral nonunion, and recurrent dislocation developed in one hip of the another patient who refused to undergo another operation.

The distribution of the patients according to preoperative GMFCS are one patient level I (hemiplegia), four patients (one of hemiplegia, three of diplegia) level II, five patients (diplegia) level III, nine patients level IV (five diplegia, four quadriplegia), 11 patients (quadriplegia) level V.

There was a positive correlation between the preoperative GMFCS and MI ($p = 0.001$, $r = 0.596$). There was also a positive correlation between the type of CP and MI ($p = 0.015$, $r = 0.440$). The GMFCS levels remained constant in 20 of the patients, improved in 8, and deteriorated in 2. The difference between the preoperative and postoperative GMFCS levels was not statistically significant ($p = 0.052$).

Assessment of the relationship between the type of CP and the change in gross motor function levels showed improvement in 1 of the 2 patients with hemiplegia, 4 of the 13 patients with diplegia, and 3 of the 15 patients with quadriplegia. The levels remained constant in 11 of the patients with quadriplegia and 8 of the patients with diplegia. One patient with hemiplegia was at level 1 both before and after the operation.

Table 1
Gross motor function classification system.

Level I	Walks independently. Limitations in advanced gross motor abilities.
Level II	Walks without assistive devices. Experiences limitations when walking in public. Experiences difficulties when walking on uneven surfaces and in the crowd, and is unable to run or jump.
Level III	Walks with an assistive device (orthosis, walker, crutch). Limitations when walking in the crowd. Able to sit without support.
Level IV	Very limited ability to move independently, often carried by another in the public. Able to sit independently.
Level V	Have no means of independent mobility. Often unable to sit without support.

Table 2
Demographic data of the patients.

Case no	Age	Sex	CP type	Preoperative GMFCS	End of follow up GMFCS	Complaints	MI
1	12	M	Quadriplegia	V	V	Improved	100
2	10	F	Diplegia	IV	IV	Improved	44
2 ^a							42
3	13	M	Diplegia	II	I	Improved	33
3 ^a							22
4	10	F	Diplegia	III	IV	Did not improve	37
5	5	M	Quadriplegia	V	IV	Improved	55
5 ^a							80
6	10	M	Quadriplegia	V	IV	Improved	100
6 ^a							100
7	6	F	Diplegia	III	1	Improved	23
7 ^a							26
8	9	F	Quadriplegia	IV	IV	Improved	82
9	7	M	Quadriplegia	V	IV	Did not improve	75
9 ^a							92
10	6	M	Hemiplegia	II	1	Improved	22
11	9	F	Quadriplegia	IV	IV	Improved	35
11 ^a							31
12	8	M	Quadriplegia	IV	V	Improved	20
12 ^a							21
13	6	F	Quadriplegia	IV	IV	Improved	100
14	10	M	Diplegia	IV	III	Improved	34
14 ^a							34
15	6	M	Diplegia	II	II	Improved	31
15 ^a							25
16	9	M	Diplegia	IV	III	Improved	100
17	7	F	Diplegia	II	II	Improved	37
17 ^a							40
18	18	M	Hemiplegia	I	I	Improved	100
19	7	F	Quadriplegia	V	V	Improved	100
20	18	M	Diplegia	III	III	Did not improve	28
20 ^a							21
21	7	F	Quadriplegia	V	V	Improved	96
22	8	F	Quadriplegia	V	V	Improved	83
23	9	F	Diplegia	III	III	Did not improve	23
24	8	F	Quadriplegia	V	V	Improved	52
25	5	M	Diplegia	III	III	Did not improve	32
25 ^a							25
26	7	M	Diplegia	IV	IV	Improved	50
26 ^a							50
27	9	F	Quadriplegia	V	V	Improved	61
28	9	M	Diplegia	IV	IV	Improved	100
28 ^a							100
29	8	M	Quadriplegia	V	V	Improved	100
30	6	F	Quadriplegia	V	V	Improved	100

GMFCS: gross motor functional classification system; F: female; M: male; MI: migration index.
^a Left hips of the bilateral cases.

The complaints during admission included difficulties with sitting in 4 patients, difficulties with gait in 17, difficulties with perineal hygiene in 8 and pain in 1. Gross motor function levels according to the complaints during admission are shown in Table 3.

Before the operation 8 patients had perineal hygiene difficulties and 1 had pain. These problems resolved in all patients after the operation. The preoperative complaints improved in 25 patients, and did not improve in 5. Difficulties with sitting, with perineal hygiene, and pain improved in all patients, whereas 11 of the 17 patients having difficulties with gait showed an improvement. Gross motor function levels remained constant in 17 of the 25

patients whose preoperative complaints improved. Change in gross motor function levels and postoperative complaints were not related ($p = 0.504$). Similarly, there was no relationship between the type of CP and the level of postoperative complaints ($p = 0.158$).

Discussion

Hip instability is one of the most common orthopedic problems in CP, and may lead to subluxation or dislocation before the onset of skeletal maturity. Therefore orthopedic management should be performed according to the age of the patient and the severity of

Table 3
Distribution of GMFCS according to the complaints.

Chief complaint during admission	GMFCS				
	Level I	Level II	Level III	Level IV	Level V
Difficulty in sitting	0	0	0	3	1
Difficulty in walking	1	4	5	5	2
Difficulty in perineal hygiene	0	0	0	1	7
Pain	0	0	0	0	1

GMFCS: gross motor function classification system.

the pathology, as well as the functional and mobilization capacity. Most clinicians prefer surgical treatment in the presence of progressive subluxation. Similar to other published studies, we prefer osteotomy in children older than 4 years.^{11,12} The stability and reliability of GMFCS was studied previously. Wood et al reported that in children between 2 and 12 years of age, GMFCS remained stable over time with a relatively 79% test–retest reliability; Palisano et al reported that it remained stable over time with a rate of 73%. It is also reported that GMFCS may be altered with interventional methods.^{7,8} GMFCS is a classification system that shows the functional capacity of the patients, and it is used widely in scientific studies. Previous studies have reported that GMFCS can be used to assess the postoperative functional capacity.^{13,14} In this study, we evaluated the effect of surgery on gross motor function levels during a minimum period of 2 years in patients with different severities of hip displacement.

Because classifications based on the motor type and topographic involvement in cerebral palsy have low reliability, GMFCS is a valid, reliable, and clinically oriented system which can be used to predict the motor functions of children with cerebral palsy between 2 and 12 years of age.⁷ Although GMFCS is utilized to assess children between 2 and 12 years of age, we evaluated two patients older than 12 years by using this classification system. A study on adult cerebral palsy patients which compared the measurements of the patients with those of professional evaluators reported that this classification system had a proven efficacy. When the levels of the patients at their current ages were compared against the levels at 10–12 years of age, more than half of them had retained their levels.¹⁵ Another study reported that the GMFCS observed around age 12 was highly predictive of adult motor function.¹⁶

In a study that evaluated the relationship between motor type, topography, and gross motor function classification system, it was shown that GMFCS levels were greater in spastic quadriplegia compared to diplegia or hemiplegia, and the spastic group had higher gross motor function classification system levels compared to the dyskinetic-hypotonic group. In children classified as mixed motor type, the motor function classification system level is higher compared to ataxic or spastic types. Spastic hemiplegia is at levels I–II, spastic diplegia is at levels II–III–IV, spastic quadriplegia is levels III–IV–V.¹⁷ In our study the distribution of the gross motor function levels were levels I–II in patients with hemiplegia, II–III–IV in patients with diplegia, and IV–V in patients with quadriplegia.

The current study showed increased dislocation rates in GMFCS IV and V. All patients with severely displaced hips had GMFCS IV and V. These results are similar those of other studies.^{1,18}

In our study, changes in the gross motor function levels before and after surgery were evaluated. After the operations, gross motor function levels did not change in 20 patients, improved in 8, and deteriorated in 2. Presence of a deterioration in gross motor function levels after the operation may be due to inadequate rehabilitation or postoperative complications. The important point is to observe a change at every level by surgery. However this improvement is not correlated with resolution of the symptoms during presentation. These operations need to be performed on larger numbers of patients to reach definite conclusions. Kim et al followed 23 patients with GMFCS III–IV who underwent both single stage femoral and modified Dega osteotomies, for at least 1 year. At the end of follow up, 6 patients with preoperative GMFCS levels V became level IV, and 17 patients had no changes.¹⁹

Classification of our patient group according to GMFCS showed that there was 1 patient in level I, 4 patients in level II, 5 patients in level III, 9 patients in level IV, and 11 patients in group V. After the operation, there were 4 patients in level I, 2 patients in level II, 5 patients in level III, 10 patients in level IV, and 9 patients in level V. Barakat et al used the gross motor function classification system to

evaluate the functional outcomes of 22 cerebral palsy patients with whole body involvement who underwent soft tissue and bone operations due to hip subluxations or dislocations. Before the operation 5 patients were level III, 7 were level IV, 10 were level V, and after the operation 9 were level III, 6 were level IV, and 7 were level 5.²⁰ In the study by Root et al, at the end of a mean follow up period of 7 years, femoral head coverage, painless hip, and improvement of at least one level in walking ability were all attained. This study too did not provide information on the evaluation tool.²¹ It was previously reported that the improvement seen after soft tissue and bone operations in patients with gross motor function levels I–II–III did not differ between the levels, also age (above and below age 10) and surgical technique were not effective factors in postoperative improvement.²² In our study the GMFCS in 24 patients who underwent procedures in addition to hip surgery remained constant in 15, improved in 7, and deteriorated in 2. However, none of the patients who underwent additional procedures showed a decrease in the gross motor function levels.

In our study, postoperative complaints did not show a statistically significant relationship with the severity of the CP type and the changes in GMFCS levels. Therefore it is understood that these two parameters cannot serve as indicators of the patients who will benefit more after the operation. For example, a patient who has intoeing or scissoring gait, walking difficulty, and gross motor function level III (ambulating with a crutch) may show an improvement in walking difficulty after surgery, however the patient will remain in level III. The presence of such a problem, therefore, suggests the question whether the GMFCS is a useful method in the evaluation of postoperative gain. The results of surgery may be affected by intraoperative and postoperative complications, additional operations, and inadequate rehabilitation. In this study a validated questionnaire such as CPCHILD²³ was not used to evaluate the postoperative quality of life. A validated method such as Pediatric Evaluation of Disability Inventory (PEDI) and Gross Motor Function Measure (GMFM) should be performed to reach more information about functional ability and performance.^{24–26} The change in gross motor function level may be positively affected by the severity of patient's neurologic involvement. Therefore studies with greater number of patients and longer follow up periods with a validated questionnaire may be needed.

The clinical outcomes of operations performed for hip instability in CP may be summarized as follows:

1. There is a positive relationship between GMFCS and hip displacement
2. There is a positive relationship between the CP type and severity of hip displacement
3. Hip surgery fails to provide a statistically significant change in GMFCS
4. The postoperative improvement in the patients' complaints after surgery is not related to the CP type
5. The postoperative improvement in the patients' complaints after surgery is not related to the change in GMFCS levels.
6. Relief in symptoms was not consistent with the changes in GMFCS in children with CP after hip reconstruction.

Conflicts of interest

The authors declare that they have no conflict of interest.

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