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ORIGINAL ARTICLE

Reviewing the reliability of revised Melbourne Cerebral Palsy Hip Classification System across different medical specialties

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ABSTRACT

Objectives: The aim of this study was to measure the reliability of the expanded and revised Melbourne Cerebral Palsy Hip Classification System (r-MCPHCS) across different medical specialties.

Patients and methods: Anteroposterior pelvic radiographs of a total of 44 patients (20 males, 24 females; median 16.7 years; range, 12 to 32 years) with cerebral palsy (CP) were analyzed between January 2005 and December 2020. Four medical specialists (an orthopedic surgeon, a pediatric neurologist, a radiologist, and a physical medicine and rehabilitation specialist) were included in the study. The time gap between the first and the second assessment was at least three months. The intra- and inter-observer intraclass correlation coefficient (IntraOb. and InterOb. ICCs) were calculated. An ICC of >0.8 was considered excellent fit.

Results: The median IntraOb. ICC was found to be 0.93 (range, 0.89 to 0.97), the median InterOb. ICC was found to be 0.88 for the first assessment (A) and 0.93 for the second assessment (B). Both results were interpreted as excellent in terms of compatibility.

Conclusion: Our study results suggest that r-MCPHCS is a well-designed, reliable and reproducible scale that is easy to use among different medical specialists.

Keywords: Cerebral palsy, hip, reliability, revised Melbourne Cerebral Palsy Hip Classification System.

Cerebral palsy (CP) is a heterogeneous spectrum of non-progressive diseases which occur in the developing child's brain, permanently affecting motor function and posture.[1-3] In addition to involvement in the musculoskeletal system, mental problems, communication difficulties and behavioral disorders may be observed in children with CP.[4,5] The progressive deterioration of motor functions in children with CP causes many orthopedic problems.[1,2,4,5] The severity of hip dysplasia correlates with neurological involvement and Gross Motor Function Classification System (GMFCS) level. Hip displacement is seen in around 35% of CP children; however, this rate increases to 90% from GMFCS-I to V.[4-7] The degree of displacement in children with CP covers a wide range. There may be different presentations ranging from a hip at risk for dislocation to a fully dislocated hip.[4,5] Degenerative arthritis, pain, difficulty in standing and walking, and hygiene problems are common in these patients.[1,2,4,5,8-11]

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The hip joint often has a normal anatomy at birth in children with CP.[12] The hip begins to subluxate due to excessive spasticity of the adductors, flexors and hamstrings. The natural development and shape of the immature hip joint is disrupted. These forces increase anteversion and neck-shaft angles over time.[2,13]

Different treatment modalities have been proposed in children with CP according to the severity of muscle involvement and the degree of hip displacement. Some studies have suggested the use of sitting orthoses in the early period of hip displacement in CP.[14,15] Several treatment methods are recommended depending on the severity of the displacement such as botulinum toxin injections, muscle relaxation, reconstructive interventions, salvage interventions, and finally, total hip replacement.[11,16-18]

The grading of hip displacement in children with CP was first introduced with the Severin classification in 1941[19] and later with the Melbourne classification in 2009.[20] The drawbacks of the Severin classification based on the measurement of the center-edge angle were revealed by Ward et al.[21] Later, the Melbourne Cerebral Palsy Hip Classification System (MCPHCS) based on the measurement of the migration index was introduced by Robin et al.[20] The Melbourne classification, which initially consisted of six grades, was later revised and re-presented as seven grades.[20,22] The clinical applicability and reproducibility of such classifications are important.

In the present study, we aimed to examine the clinical performance and applicability of the most recent revised Melbourne Cerebral Palsy Hip Classification System (r-MCPHCS) for hip dysplasia in children with CP by measuring the intra- and inter-observer reliability among different clinicians at different time points.

PATIENTS AND METHODS

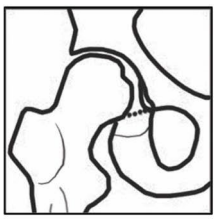
This single-center, prospective study was conducted at Aydın Adnan Menderes University, Faculty of Medicine, Department of Orthopedics and Traumatology between January 2005 and December 2020. Initially, patients aged between 12 and 32 years with CP who had sufficient closure of the triradiate cartilage as assessed by the radiographs obtained from the hospital database were screened. Detailed clinical data and CP type of the patients could not be evaluated and presented due to lack of data. Finally, a total of 44 patients (20 males, 24 females; median 16.7 years; range, 12 to 32 years) with CP were included in the study. Physicians from four different medical specialties (an orthopedic surgeon, a pediatric neurologist, a radiologist, and a physical medicine and rehabilitation specialist) were included in the study for the evaluation of the radiographs. Data of the patients were retrospectively analyzed. A written informed consent was obtained from the patients and parents and/or legal guardians of the patients. The study protocol was approved by the Aydın Adnan Menderes University Faculty of Medicine Ethics Committee (date: 22.02.2022, no: 139117). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Before evaluating the radiographs, all medical specialists included in the study were given a 10-min presentation about the classification to standardize the knowledge about the new classification system. In this presentation, the use of the Reimer migration index was explained in detail. The medical specialists in the study and their year of expertise in their field are as follows: orthopedic surgeon (MD I) 13 years, pediatric neurologist (MD II) 21 years, radiologist (MD III) 15 years, physical medicine and rehabilitation specialist (MD IV) 20 years. All medical specialists, excluding the pediatric neurologist, had no prior experience in pediatric orthopedics. The radiographs were enumerated and anonymized. All specialists were asked to perform the first evaluation, and grade each hip from 1 to 7 according to r-MCPHCS. After three months, the same medical specialists were asked to grade the same cases randomly for a second evaluation.

The results of the first evaluation by the medical specialists were compared with the results of the second evaluation. As there was not a homogenous number of cases in each grade in the cohort, grades were organized in groups for a more accurate statistical analysis. The results obtained were grouped into four groups as Grades 1-2, Grades 3-4, Grades 5-6, and Grade 7. The medical specialists who performed the evaluation were coded as MD-I, MD-II, MD-III, and MD-IV.

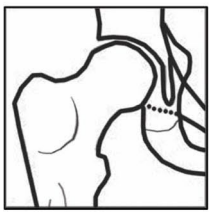
Statistical analysis

Statistical analysis was performed using the IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Descriptive data were expressed in mean ± standard deviation (SD), median (min-max) or number and frequency, where applicable. The chi-square test was used to analyze whether there was a significant difference between categorical




Grade 1. Normal hip-migration percentage <10%

1. Shenton's arch intact
2. Femoral head round (within 2 mm using Mose Circles)
3. Normal acetabular development with a normal horizontal sourcil, an everted lateral margin and normal tear drop development
4. Pelvic obliquity < 5°
5. No degenerative change, no pain



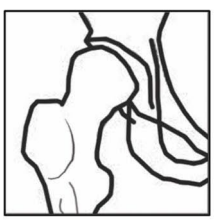

Grade 2. Near normal hip-migration percentage ≥10% ≤15%

1. Shenton's arch intact
2. Femoral head round or almost round
3. Acetabulum-normal or near normal development
4. Pelvic obliquity <5°
5. Low risk of degenerative change, usually pain free




Grade 3. Dysplastic hip-migration percentage >15% ≤30%

1. Shenton's arch intact or broken by ≤5 mm
2. Femoral head round or mildly flattened
3. Acetabulum-normal or mildly dysplastic including blunting of the acetubular margin
4. Pelvic obliquity <10°
5. Low risk of degenerative change, mild pain




Grade 4. Dysplasia with mild subluxation-migration percentage >30% <60%

1. Shenton's arch broken by >5 mm
2. Femoral head some flattening
3. Acetabulum dysplastic
4. Pelvic obliquity variable
5. Risk of degenerative change, pain variable



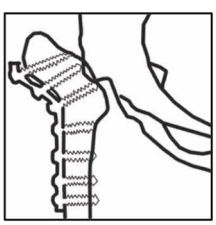

Grade 5. Moderate to severe subluxation-migration percentage ≥60% <100%

1. Shenton's arch broken by >10 mm
2. Femoral head variable deformity
3. Acetabulum variable deformity
4. Pelvic obliquity variable
5. Degenerative change frequent, pain frequent




Grade 6. Dysplasia hip-migration percentage ≥100%

1. Shenton's arch completely disrupted
2. Femoral head variable deformity
3. Acetabulum variable deformity
4. Pelvic obliquity variable
5. Degenerative change frequent, pain frequent




Grade 7. Salvage surgery

1. Valgus osteotomy
2. Arthrodesis
3. Excision arthroplasty ± valgus osteotomy
4. Replacement arthroplasty
5. Pain relief following salvage surgery: variable

FIGURE 1. The revised and expanded Melbourne Cerebral Palsy Hip Classification System (r-MCPHCS).[23]

TABLE I
Details of intra-observer reliability

Rater	ICC	95% CI
MD-I	0.90	0.82 to 0.95
MD-II	0.97	0.94 to 0.98
MD-III	0.96	0.93 to 0.98
MD-IV	0.89	0.79 to 0.94
All	0.93	0.91 to 0.95

MD: Medical specialist; ICC: Intraclass correlation coefficient; CI: Confidence interval.

TABLE II
Details of inter-observer reliability

Rater	ICC	95% CI
All raters		
Reading A	0.88	0.81 to 0.93
Reading B	0.93	0.89 to 0.96

ICC: Intraclass correlation coefficient; CI: Confidence interval.

variables. The Mc-Nemar chi-square test was used to compare categorical variables in dependent groups. The intra- and inter-observer intraclass correlation coefficient (IntraOb. and InterOb. ICCs) were calculated. The ICC was interpreted using established conventions for kappa (κ) where <0 is poor agreement, 0 to 0.2 is slight agreement, 0.2 to 0.4 is fair agreement, 0.4 to 0.6 is moderate agreement, 0.6 to 0.8 is substantial agreement and >0.8 is excellent agreement.[23] A *p* value of <0.05 was considered statistically significant.

RESULTS

Tables I and II show the intra- and inter-observer results. The ICCs were found to be between 0.89 and 0.97, indicating excellent agreement. The ICCs were obtained by evaluating the results between the first evaluation (A) and the second evaluation (B). The agreement between the two evaluations (0.88 and 0.93) was excellent.

In Table III, the reliability of the scoring system was evaluated. A total of 70.8% of those who scored as Grades 1-2 in the first evaluation scored as Grades 1-2 in the second evaluation, 87% of those who scored as Grades 3-4 in the first evaluation scored as Grades 3-4 in the second evaluation, 92.1% of those who scored as Grades 5-6 in the first evaluation scored as Grades 5-6 in the second evaluation, and 100% of those who scored as Grade 7 in the first evaluation scored as Grade 7 in the second evaluation.

In Table IV, the compliance between the pre- and post-assessments was compared among the specialists. Before and after, the MD-I 84.1%, MD-II 93.2%, MD-III 84.1%, MD-IV 83.7% were found to be in compliance and no statistically significant difference was found in terms of compliance among the specialists (p=0.5).

DISCUSSION

The MCPHCS is a classification based on the Reimer migration index. The measurements made with the migration index clearly reveal the grade of the hip.[20] Its main advantages are that it is easy to measure, widely used in the literature, and has no subjective effect.

This classification was originally developed in response to by the deficiencies of the Severin classification in which the center-edge angle was used.[19] The reliability of the classification system defined by Severin[19] and based on the measurement of the central-edge angle was evaluated by Ward et al.[21] Tuğrul et al.[24] reported that the central margin angle increased with age between the ages of 5 and 14 years. Therefore, measurements based on the central-angle may be misleading. Reimer

TABLE III
Assessment of the reliability of the scoring system

	Grade (First assessment)							
	1-2		3-4		5-6		7	
	n	%	n	%	n	%	n	%
Grade (Second assessment)								
1-2	17	**70.8**	6	5.6	0	0	0	0
3-4	6	25	94	**87**	3	7.9	0	0
5-6	1	4.2	8	7.4	35	**92.1**	0	0
7	0	0	0	0	0	0	5	**100**

TABLE IV
Comparison of the agreement between pre- and post-assessments between specialists

	Compliance status				
	Compatible		Not compatible		
	n	%	n	%	*p*
Group					
MD-I	37	84.1	7	15.9	0.500
MD-II	41	93.2	3	6.8	
MD-III	37	84.1	7	15.9	
MD-IV	36	83.7	7	16.3	
Total	151	86.3	24	13.7	

MD: Medical specialist.

migration index shows the quantity of femoral head dislocation away from the acetabulum as a percentage.[21,24] However, the major disadvantage is that the measurement is performed in two-dimensional (2D) environment for posterolateral dislocations.[25]

In the present study, the pelvis and hip radiographs of the patients with CP were presented to senior medical specialists from various disciplines. In the literature, there are reliability studies on the six-graded MCPHCS of Murnaghan et al.[25] However, there are no reliability studies on the r-MCPHCS, which is a revised classification consisting of seven grades.[26] In the study conducted by Murnaghan et al.,[25] the evaluations by an orthopedic surgeon and a physical medicine and rehabilitation specialist were used and the interval between evaluations was determined as one month. Unlike the study by Robin et.al.,[25] in the present study, the r-MCPHCS was used by four different specialists. In addition, the time interval between the first and second evaluation was three months instead of one month, to minimize the bias between the evaluations.

As the number of cases in each group was not equal and not homogenous, the patients were divided into four groups as Grade 1-2, 3-4, 5-6, and 7. Our intraOb. and interOb. ICC results were interpreted as excellent, similar to two previous studies. In our study, the IntraOb. ICC was found to be 0.93. This rate was reported as 0.91 in the study of Murnaghan et al.[25] and 0.88 in the study of Shrader et al.[27] Our InterOb. ICC result was 0.88 in the first evaluation and 0.93 in the second evaluation. These ratios were reported as 0.81 and 0.91 by Murnaghan et al.[25] and reported 0.85 and 0.84 by Shrader et al.[27] Taken together, the second evaluation of all medical specialists were more accurate than their first one (0.88 to 0.93) as a result of the learning effect.[25]

It should be noted that detailed subgroup analyses were not available in other studies in the literature. In the present study, the subgroup analyses were evaluated and attempted to point out the issues between grading the groups. Only 70.8% of the patients who were assessed as Grades 1-2 in the first assessment were assessed as Grades 1-2 in the second assessment. This difference was decreasing in higher grades. In the IntraOb. and InterOb. ICC subgroup analyses according to hip stage, the observers had more difficulties in the diagnosis of early-stage hip dysplasia and less difficulties in the diagnosis of severe stage hip dysplasia.

Interventions varied according to the stage of the hip in CP patients. Botulinum toxin injection, muscle releases, proximal femur osteotomies, bone reconstruction surgeries, salvage procedures, and total hip arthroplasty are some of these interventions.[28] By r-MCPHCS-Grade 4, deformities are observed in the femoral head and neck and complex bone procedures are added to the soft tissue surgeries to be performed.[29] The management of the displaced hip in lower grade is simpler than displaced hip in higher grade. The present study showed that almost 30% of the Grades 1-2 cases were misgraded. This misgrading in early stages would lead to more aggressive interventions for the cases in future.

In the first classification system, patients who had Reimer migration index between 30-100 percentile were defined as Grade 4 and dislocated hips (>100 percentile) were defined as Grade 5. In the revised version, patients who had

a migration index between 30-60 percentile were defined as Grade 4, patients between the 60-100 percentile were defined as Grade 5, and completely dislocated hips (>100 percentile) were defined as Grade 6.[20] Thus, in the revised classification, the 30-100 percentile range was divided into two different categories.[26]

To the best of our knowledge, the present study is the first to review the reliability of the r-MCPHCS across different medical specialties.[30] Being reviewed by four different specialists, keeping the interval between the two evaluations longer than other studies, standardizing the knowledge about the classification for all medical specialties and having cases in each group are the main strengths of the study. On the other hand, the limitations include its retrospective data interpretation, excluding cases whom triradiate cartilage was not closed, performing the evaluation with 2D imaging modality, and not having enough and homogenous cases in all grades.

In conclusion, the revised and expanded MCPHCS classifies hip displacement in more detail than previous classification scale. Our study results suggest that r-MCPHCS is a well-designed, reliable and reproducible scale that is easy to use among different medical specialists. For early-stage low-grade classified hips, special attention needs to be paid.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Made substantial contributions to conception or design of the work: M.G., R.O., E.C.; Involved in drafting the work, approved the final version to be published; and investigated and resolved the agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriate: M.G., R.O., E.C. All authors participated in collecting the data for the work. All authors participated in revising the manuscript.

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