Hip X-rays versus 3-D CT-scans in Patients with Cerebral Palsy

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Evaluación de la radiografía de cadera frente a la tomografía tridimensional en pacientes con parálisis cerebral

Introducción. Se estudiaron 17 pacientes con diagnóstico de parálisis cerebral, para evaluar la utilidad de los rayos X de cadera frente a la tomografía 3D.
Material y método. Se compararon 3 parámetros radiológicos con 4 parámetros tomográficos tridimensionales.
Resultados. Se obtuvieron resultados que correlacionan significativamente a los estudios radiológicos con los tomográficos. El ángulo CE de Wieberg mostró 28 caderas displásicas y 6 normales. El índice de Reimers 29 caderas displásicas y 5 dentro de límites normales. El índice acetabular 4 caderas normales y 30 caderas subluxadas. En los parámetros tomográficos el ángulo cérvico-diafisiario femoral presentó una media de 147,09° con un rango entre 127° y 175°, lo que demuestra un promedio más alto de lo normal. El ángulo de anteversión femoral obtuvo los siguientes resultados: media de la muestra 33,43°, rango superior 50°, rango inferior 9°. Se observa un valor aumentado de la anteversión. El índice acetabular axial mostró un promedio de índice axial acetabular de 120,29°, siendo el valor normal 101,6° para los 9 años de edad, lo que se asocia con aplanamiento del acetábulo. El ángulo de anteversión acetabular presenta una media de 13,11° con un rango entre 24° y 7°, lo que representa una paridad en los resultados.
Conclusiones. La indicación de radiografías está justificada para el diagnóstico y pronóstico de displasia de cadera. La cobertura acetabular y las evaluaciones para cirugías deben estudiarse y programarse con tomografías tridimensionales.

Palabras clave: *parálisis cerebral, cadera, radiología, tomografía computarizada tridimensional.*

Introduction. Seventeen patients diagnosed with cerebral palsy were studied to assess the results of X-rays vs. 3D CT scans of the hip.
Materials and methods. 3 X-ray parameters were compared with 4 3D CT scan parameters.
Results. The results obtained showed a significant correlation between X-rays and CT scans. According to the assessment of the Weinberg Central Edge (CE) angle there were 28 dysplastic hips and 6 normal hips. According to the Reimers index there were 29 dysplastic hips and 5 normal hips. According to the acetabular index there were 30 subluxated hips and 4 normal hips. Using CT scan parameters the mean value of the femoral neck-shaft angle was 147.09° (range: 127°-175°), a higher-than-normal figure. The mean value of the femoral anteversion angle was 33.43° (range 9°-50°), also higher than usual. The mean axial acetabular index was 120.29°, with a normal value of 101.6° at 9 years of age associated with acetabular flattening. The mean acetabular anteversion angle was 13.11° (range 7°-24°), which indicated a parity of results.
Conclusions. X-rays are necessary for the diagnosis and prognosis of hip dysplasia. Acetabular coverage and presurgery assessment and planning must be done based on 3D CT scans.

Key words: *cerebral palsy, hip, X-rays, axial C*

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Cerebral palsy is a name given to a collection of movement disorders caused by a non-progressive lesion of the central nervous system sustained before birth, during childbirth or in the first few years of life. In cerebral palsy, some disorder of a motor function tends to predominate, which tends to be accompanied with more or less frequency or intensity by mental compromise, seizures and perceptive or

character dysfunctions, which makes management of these patients a highly complex task[1].

Hip deformity is the second most frequently observed one in patients with cerebral palsy[2]. It is caused by muscle imbalance, persistence of primitive reflexes, posture disorders, absence of a weight-bearing stimulus in the bone and growth. Congenital anteversion of the femoral neck does not resolve spontaneously and can even get worse and the valgus deformity of the femoral neck increases gradually. Finally the hip may dislocate or subluxate[3].

In patients with cerebral palsy, muscle contractures and muscle spastic activity lead to a dislocation or a subluxation of the hip joint[4], which can cause pain in some patients as well as deformity, balance disorders when standing and during gait, pelvic tilt and difficulties in perineal hygiene[5]. All authors agree that the best treatment for hip dislocation in cerebral palsy is prevention[6,7]. This means that one should be constantly aware of it. In his way, one can prevent dislocation by resorting to the appropriate measures or at least enable early diagnosis so that treatment can be effective[2].

Therefore periodical clinical examinations and imaging studies are needed to make sure that hips do not dislocate or subluxate, or that they do not develop dysplasia. The most practical radiographic method is based on the degree of migration of the femoral head under the lateral rim of the acetabulum; it was described by Beals in 1965, and Reimers called it «migration percentage»[8,9]. Another important reference on the x-rays is femoral head coverage. The coverage notion normally refers to the radiographic relationship between the superolateral wall of the acetabulum and the center of rotation of the femoral head; this is sometimes referred to as Wiberg's CE angle[10].

Such advances as 3D CT-scans have caused a revolution in the evaluation of pathological hips[11] Wenger and Hahn report that 3D images have permitted a better understanding of the morphology of dysplasias and biomechanical anomalies, which enables them to better plan the most appropriate correction method, i.e. either acetabular or proximal femoral osteotomy[12].

Currently, when confronted with a patient with cerebral palsy, we should consider when to request conventional images such as hip radiographs and when to request more comprehensive studies like 3D CT-scans, which often allow us a better understanding of the condition. Are A/P hip x-rays still useful for these patients or have they been outperformed by 3d CT-scans? The purpose of this study is to assess the prevalence of A/P hip x-rays in patients with cerebral palsy in comparison with 3D CT-scans in order to establish criteria for indicating either a radiological or a 3D examination.

MATERIALS AND METHODS

Seventeen patients of both genders were evaluated with a diagnosis of cerebral palsy. Thirty-four hips were studied radiologically with A/P x-rays, patients placed in dorsal decubitus. Subsequently they were subjected to a 3D CT-scan of the hip. The group studied had a mean age of 9 years (range: 4-15 years).

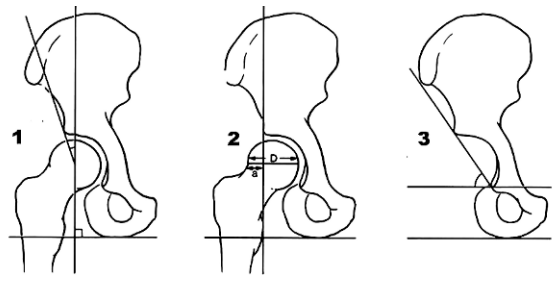

Figure 1. *Main radiological parameters used in the study. C1: Wiberg's CE angle; 2: migration index (Reimers); 3: acetabular index.*

Patients did not have previous surgery; all of them were able to walk unaided, with crutches or in a wheelchair. Patients consulted us because they had: difficulties to walk, difficulties to sit and/or pain. A statistical correlation was made between the radiological and the tridimensional groups using Pearson's correlation. The radiological parameters used were the following (Fig. 1):

1. Wiberg's CE angle[6,10].
2. Migration index (Reimers)[10].
3. Acetabular index[5,10].

The parameters used for the 3D CT evaluation were as follows (Fig. 2):

1. Femoral neck-shaft angle[5].
2. Femoral anteversion[5].
3. Axial acetabular index[13].
4. Acetabular anteversion[14].

RESULTS

Both the x-ray evaluations and the 3D CT study showed signs of hip subluxation. The patients' mean age was 9 years. Table 1 shows the main data in this study.

Radiographic parameters

Wiberg's CE angle

The mean was 22.66° (range: 47°-8°). Taking into consideration that the standard value for a normal hip at the above mentioned age is 28°[6,10,15], it can be said that the mean obtained corresponds to a dysplastic value. The breakdown of the cases gives us 28 dysplastic hips and 6 normal ones.

Migration index (Reimers)

The mean migration index was 22.78 (range: 32.69-4). This index is considered pathological when it exceeds 10°7,

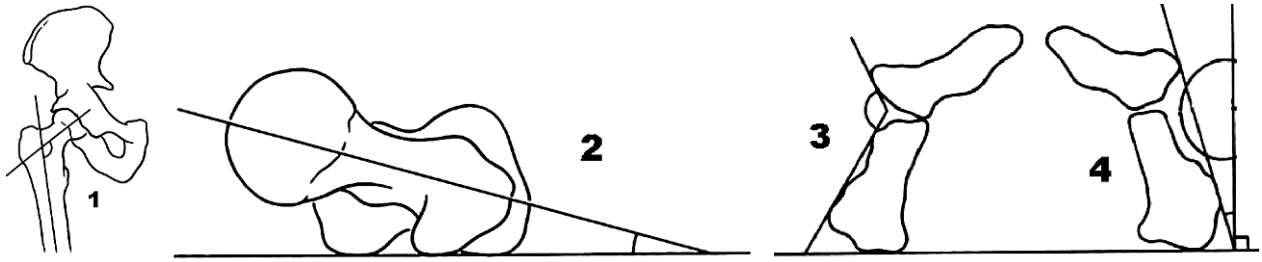

Figure 2. *Main CT parameters in this study.1:Femoral neck-shaft angle; 2:femoral anteversion; 3:axial acetabular index; 4: acetabular anteversion.*

which is precisely our case. Specifically, we had 29 dysplastic hips and 5 hips within normal limits.

Acetabular index

The mean acetabular index was 52.97° (range: 42-67°). Values lower than 45° are considered normal for children between 5 and 12 years[5,15]. The average obtained points to hip subluxation. The breakdown is as follows: 4 normal and 30 subluxated hips. In cases of hips with a closed Y cartilage the acetabular point is taken at the deepest region of the acetabulum, where the cartilage was located.

CT parameters

Femoral neck-shaft angle

The normal value observed for the 9-year age group was 135°[5]. The mean result obtained was 147.09° (range: 127-175°), which points to a higher-than-normal average.

Femoral anteversion angle

The mean of the sample was 33.43° (range: 50°-9°). The normal value for this age group is 20°[5]. An increased anteversion degree is observed.

Axial acetabular index

Mean axial acetabular index: 120.29°. The normal value is 101.6°[13] for patients aged 9, which is associated to a flattened acetabulum. All the values in the sample were higher than normal: 3 hips were between 101 and 110°, 14 were between 111 and 120°, 16 between 121 and 130°, 1 was 131° or more.

Ácetabular anteversion angle

The normal value for the age group between 1 and 15 years was 12.8°[14]. Individuals in this study had a mean of 13.11° (range: 24-7°), which closely matches the normal value. Tables 2-4 show the correlation between the different parameters.

Table 1. Main data in our study

	N	Range	Mean	Standard deviation
Wiberg's CE angle	34	22,66	8-47	7,99
Reimer's Migration index	34	22,78	4-32,69	8,84
Acetabular index (degrees)	34	52,97	42-67	6,22
Femoral Neck-Shaft Angle	34	147,09	127-175	7,35
Femoral Anteversion Angle	34	33,43	9-50	9,43
Axial Acetabular Index	34	120,29	105-133	5,64
Acetabular anteversion angle	34	13,11	7-24	4,28

N: number.

DISCUSSION

Hip dislocation in cerebral palsy does not occur at birth. Rather, it happens as a result of muscular imbalance, persistence of primitive reflexes, posture disorders, absence of a weight-bearing stimulus in the bone and growth[2].

The natural history of the untreated hip in cerebral palsy, especially in seriously affected patients, normally evolves towards dislocation. We tried to avoid dislocation in the following ways[14,16]: a) surgery of deforming soft tissues, which should always be early and bilateral; b) in cases of severe subluxation (preferably femoral) osteotomies are performed and c) if the subluxation is severe or occurs in patients that are older and less able to remodel spontaneously and whose acetabular angle is greater it is necessary to operate both the femur and the acetabulum[4].

Hip evaluations should be accompanied by indices to assess: the dislocation/subluxation diagnosis, the evolution of the hip dysplasia (migration), the direction of the dislocation, the femoral neck anteversion, the acetabular coverage, the regularity of the femoral head and the degree of acetabular flattening.

A simple A/P hip x-ray does not provide information on the anterior or posterior coverage of the femoral head, which is a problem that must be taken into account when considering an acetabular osteotomy to increase coverage[10]. Femoral head and acetabular images are projected on the x-

Table 2. Correlation between Wiber's angle and other parameters

Correlation	r	P
Wiberg vs. neck-shaft angle	–0.33	0.05
Wiberg vs. femoral anteversion	–0.08	0.65
Wiberg vs. acetabular index	–0.48	0.003
Wiberg vs. acetabular anteversion	–0.07	0.70

Table 3. Correlation between migration and other parameters

Correlation	r	P
Migration vs. neck-shaft angle	0.09	0.61
Migration vs. femoral anteversion	0.23	0.18
Migration vs. Acetabular index	0.57	0.04
Migration vs. Acetabular anteversion	–0.10	0.05

ray on the coronal plane, but the anterior or posterior displacement of the head cannot be determined[15].

Another complication of radiological evaluations is that caused by pelvic tilt. At the Congress of the American Academy for Cerebral Palsy held in Toronto on 21 October 2000, Dr. Rang M. stated: «One may observe a variation of up to 20% in the results of A/P x-rays if they are not performed with hip flexion, resting the hollow of the knee on a higher plane (eg. on a pillow).»

From the correlation of Wiberg's CE angle and the parameters evaluated in the CT-scans we can observe significant results for the neck-shaft angle and the acetabular index ($p < 0.05$); however, these two do not show a statistically relationship between each other ($r < 0.5$).

Assessing the results of the correlation between Reimer's migration index and the CT parameters, we observe values that are significant and related to each other for the acetabular index ($r > 0.5$), which indicates a relationship between the radiological and CT evaluations; this confirms the reliability of the radiological parameter. Significant values were also obtained for the acetabular anteversion angle, although these are not related.

Lastly, if we correlate the radiological acetabular angle with the 3D scan parameters, we obtain values that are significant and related to one another between the acetabular angle and acetabular anteversion ($r > 0.5$), which again confirms the relatedness of radiological and CT findings. We obtained significant values for the neck-shaft angle and for the acetabular index, although these are not related ($r < 0,5$).

These results allow us to affirm that the parameters used in hip radiological evaluations in cases of cerebral palsy bear a statistically significant relationship with 3D CT parameters. We should add to this discussion that x-rays are relatively inexpensive; technological advanced imaging is normally more expensive, which means that the patient has to face higher costs.

Tabla 4. Correlation between acetabular angle and other parameters

Correlation	r	P
Acetabular angle vs. Neck-shaft angle	0.25	0.02
Acetabular angle vs. Femoral anteversion	0.22	0.21
Acetabular angle vs. acetabular index	0.14	0.04
Acetabular angle vs. Acetabular anteversion	0.66	0.03

In conclusion, in spite of the fact that hip x-rays (in patients with cerebral palsy) offer only limited planes and do not provide an accurate description of acetabular coverage, their indication is justified in diagnostic cases or as a reference in the evolution of hip dysplasia in patients with cerebral palsy given their simplicity, the reliability of their parameters and their inexpensiveness. Although for a sound operative plan, as regards the relationship between a dysplastic acetabulum and femoral head, a 3D CT examination should be requested.

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