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Radiographic and MRI findings associated with early degenerative joint disease of the hip in patients with Legg-Calvé-Perthes disease

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SUMMARY

Objective: To identify a pattern of radiographic outcomes and Magnetic Resonance Imaging (MRI) findings in patients with the late sequelae of Legg-Calvé-Perthes disease (LCPD) leading to degenerative arthritis. **Methods:** 78 patients (88 hips) were classified into 3 groups according to the radiographic outcome at skeletal maturity: Group 1- Spherical congruency (n = 8), Group 2- Non-spherical congruency (n = 76) and Group 3- Incongruency (n = 4). MRI were obtained in 24 patients in Group 2, the presence of a labral injury was considered. We used the Tönnis scale to determine the presence of early degenerative arthritis at a minimum 10 year follow up. The Mann-Whitney U and Wilcoxon tests were used for statistical analysis. **Results:** Of the 8 hips in Group 1, 6 were considered Tönnis type 0 and 2 as type I (mean = 0.25). Of the 76 hips in Group 2, 4 were considered Tönnis type 0, 14 type I, 13 type II, 25 type III and 18 type IV (mean = 2.9). All 4 hips in Group 3 were considered Tönnis type IV. Of the 24 cases where an MRI was obtained in Group 2, 18 cases were found to have a labral tear, of these 18 hips, 6 were considered Tönnis type III and 12 as type IV. Univariate analysis demonstrated that joint incongruity and the presence of a labral tear were associated with signs of degenerative arthritis. **Conclusion:** The classification of hips in patients with LCPD into 3 Groups at skeletal maturity: 1. Spherical congruency, 2. Aspherical congruency and 3. Incongruency and the finding of a labral tear identifies patients at a higher risk of developing degenerative joint disease. **Significance:** The early radiographic and MRI patterns observed will allow surgeons to make better decisions in counselling their patients with LCPD.
Evidence level: III (Pronóstico, serie de casos)

RESUMEN

Objetivo: Identificar un patrón de resultados radiográficos y hallazgos de imagen de resonancia magnética (RM) en pacientes con las secuelas tardías de la enfermedad de Legg-Calvé-Perthes (ELCP) que conduce a la artritis degenerativa. **Métodos:** 78 pacientes (88 caderas) se clasificaron en 3 grupos de acuerdo con el resultado radiográfico de madurez esquelética: grupo 1- Congruencia esférica (n = 8), grupo 2- Congruencia no esférica (n = 76) y grupo 3- Incongruencia (n = 4). Se hicieron resonancias magnéticas en 24 pacientes del grupo 2, se consideró la presencia de desgarre en el labrum. Se utilizó la escala de Tönnis para determinar la presencia de artritis degenerativa temprana a un mínimo de 10 años de seguimiento. Para el análisis estadístico se utilizaron las pruebas de Mann-Whitney y Wilcoxon. **Resultados:** De las ocho caderas en el grupo 1, 6 fueron consideradas Tönnis tipo 0 y 2 como tipo I (media = 0.25). De las 76 caderas en el grupo 2, 4 fueron considerados Tönnis tipo 0, 14 tipo I, 13 tipo II, 25 de tipo III y 18 tipo IV (media = 2.9). Las 4 caderas en el grupo 3 se consideraron Tönnis tipo IV. De los 24 casos del grupo 2 en los que se obtuvo una resonancia magnética, se encontró que 18 casos tenían un desgarre en el labrum, de estas 18 caderas, 6 fueron consideradas Tönnis tipo III y 12 como tipo IV. El análisis univariante mostró que la incongruencia articular y la presencia de un desgarre del labrum se asociaron con signos de artritis degenerativa. **Conclusión:** La clasificación de las caderas en pacientes con ELCP en 3 grupos de madurez esquelética: 1. Congruencia esférica, 2. Congruencia asférica y 3. Incongruencia y el hallazgo de un desgarro del labrum identifica a los pacientes con mayor riesgo de desarrollar la enfermedad degenerativa de las articulaciones. **Significado:** El estudio radiográfico temprano y los patrones observados por resonancia magnética, permiten a los cirujanos tomar mejores decisiones para asesorar a sus pacientes con ELCP.
Nivel de evidencia: III (Pronostic, case series)

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Key words: Legg-Calvé-Perthes disease, prognosis, osteoarthritis, magnetic resonance imaging MRI.
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Palabras clave: Enfermedad de Legg-Calvé-Perthes, pronóstico, osteoartritis, imágenes de resonancia magnética IRM.
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BACKGROUND

It has been over 100 years since Legg, Calvé and Perthes independently described a condition affecting the proximal femoral epiphysis characterized by avascular necrosis of the femoral head in children, now known as Legg-Calvé-Perthes Disease (LCPD). Although the optimal treatment remains elusive the goal of treatment has been the same: to restore spherical congruency to the femoral head and avoid early degenerative joint disease.

Many attempts to determine the prognosis of the disease based on initial findings have been undertaken, Catterall[1] suggested that most patients improve with time, a preliminary follow-up of 36 patients (at a mean age of 45 years) found that 86% of the hips were still functioning and only 3 out of their 36 patients (8%) had undergone an arthroplasty;[2] However 13 years later the same 36 patients were again followed-up, finding that 40% of them had undergone an arthroplasty, and only 40% had maintained a good level of function, this means that 60% of the hips had bad results.[3]

Others have found similar results with most cases being mild in the short or mid term but worsening with time.[4]

A relationship between minor deformity of the proximal femur and the subsequent development of osteoarthritis has been well documented.[5-18]

The Stulberg classification has been widely applied for prognostic purposes in patients with LCPD who have reached skeletal maturity. This classification considers 5 types of hip: Type I is a normal hip, which is spherical, congruent and of the same size as the contralateral (unaffected) hip; Type II is coxa magna, where the head is larger than normal but remains spherical and congruent, the diameter of the head measures the same on the anteroposterior and lateral views; Type III is a deformed head which loses sphericity, the diameter is greater on the anteroposterior than the lateral view, giving it an ovoid or mushroom shape, however it is congruent in the acetabulum which also undergoes changes; Type IV is coxa plana where the femoral head is flattened but the acetabulum is also flattened providing congruency and Type V is joint in-congruency with a severely deformed head.

Studies have shown that patients with LCPD who have Stulberg Type I hips have a normal survival rate compared to normal hips, Stulberg type II, III and IV tend to develop degenerative joint disease in the fourth or fifth decades of life and Stulberg Type V hips develop early degenerative joint disease within the second or third decades of life. While this classification is widely used its inter and intraobserver reliability has been brought into question and the fact that almost no patients end up as Type I, or completely normal hips drove us to seek a better prognostic test at skeletal maturity.

Magnetic resonance imaging (MRI) is the imaging modality that is most widely used to evaluate the soft tissues and the integrity of joints, and although Magnetic Resonance Arthrograms can increase the sensitivity for detecting labral tears in the hip it has been shown that simple MRI is effective for diagnosing clinically relevant lesions.

We sought to identify a radiographic pattern associated with the development of early degenerative joint disease, complemented by magnetic resonance imaging (MRI) to evaluate the status of the labrum and chondro-labral junction which have been shown to be associated with osteoarthritis when they are abnormal. Our objective was to identify radiographic and MRI findings which were associated with early degenerative joint disease in patients with the sequelae of LCPD.

METHODS

78 patients (88 hips) with sequelae of LCPD were evaluated at a minimum of 10 years after they had reached skeletal maturity and the degree of degenerative joint disease was evaluated with the Tönnis scale *(Table I)*, since this scale considers the shape of the femoral head considering loss of sphericity, we considered the change in the shape between the last available radiograph (at skeletal maturity) and the final follow-up. All images were evaluated by 3 different investigators on two occasions and consensus was met for 83 of the hips. In the cases where consensus was not met the most agreed upon classification was used.

Patients were then divided into three groups according to the sphericity of the femoral head and

the joint congruency at the time of skeletal maturity: Group I was «Spherical congruency» (n = 8), considered when the diameter of the femoral head was measured to be the same size on two orthogonal views of the proximal femur, meaning that the diameter was no greater than 2 mm on the anteroposterior or lateral view, and congruency was determined the use of Mose's concentric circles and it was deemed congruent when the femoral head was less that 2 deviations from the acetabular circumference *(Figure 1)*. Group II was «Non-spherical congruency» (n = 76), and was considered when the diameter of the femoral head was greater on one of the two orthogonal views but the sphericity was less than two deviations from the acetabular circumference *(Figure 2)*. Group III, «Incongruency» (n = 4) was considered when the sphericity of the femoral head was less than two deviations from the acetabular circumference *(Figure 3)*.

Additionally Magnetic Resonance Imaging studies were obtained in 24 cases in Group II and the presence of a labral tear was considered as a qualifier for this subgroup.

Table I. Tönnis grade of osteoarthritis.

Grade	
0	No degenerative joint disease
1	Subchondral sclerosis, minimal reduction of the joint space, minimal loss of sphericity of the femoral head
2	Small cysts, moderate reduction of the joint space, moderate loss of sphericity of the femoral head
3	Large cysts, total loss of the joint space, severe deformity of the femoral head

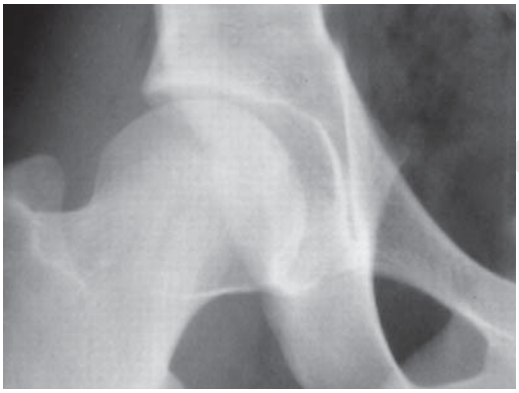


Figure 1. *Spherical congruency.*

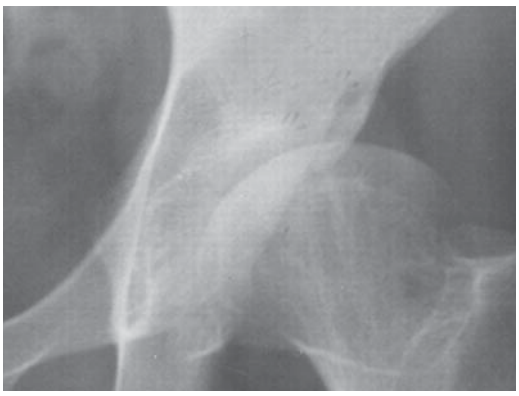


Figure 2. *Aspherical congruency.*

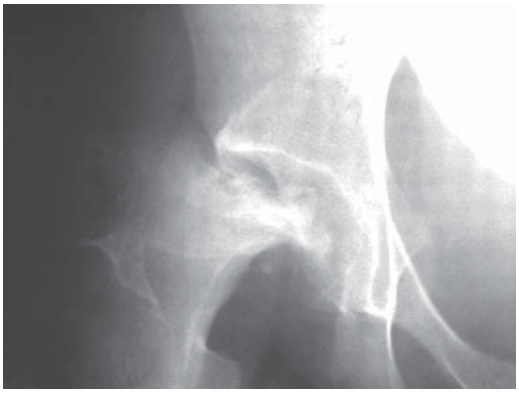


Figure 3. *Incongruency.*

The Mann-Whitney U test was used to compare differences between two independent groups when the dependent variable is ordinal, but not normally distributed; and the Wilcoxon signed-rank test was used as a non-parametric statistical hypothesis test to compare 2 related samples and to assess whether their population mean ranks differ.

RESULTS

Radiographic and clinical follow-up was obtained at a minimum of 10 years after the patients had reached skeletal maturity, (mean = 11.3) they had a mean age at the time of final follow up of 27.4 years (range 26.1 to 34.2).

At the time of skeletal maturity 8 hips were considered to have spherical congruency and thus were assigned to be in Group 1, of these 6 were considered Tönnis type 0 and 2 as Tönnis type I (mean = 0.25) *(Figure 4)*. These hips were not all considered Stulberg I at the time of skeletal maturity, only 1 was consid-

ered a truly «normal» hip with the diameter of the head measuring the same on the anteroposterior and frog-leg lateral views *(Table II)*.

At skeletal maturity, 76 hips were considered to have non-spherical congruency and thus were assigned to Group 2; of these only 4 were considered Tönnis type 0, 14 as type I, 13 as type II, 25 as type III and 18 as type IV (mean = 2.9). We were able to obtain MRI studies in 24 patients in Group 2 at the time of skeletal maturity, the indication for the MRI was groin pain and of these 24 patients 18 were found to have a labral tear and 6 did not. Of the patients with a labral tear, 8 underwent arthroscopic repair and 10 underwent arthroscopic debridement, at the time of final follow up 6 were considered Tönnis type III and 12 as Tönnis type IV (mean = 3.6), of the 6 patients without a labral tear on MRI 2 were considered Tönnis type II and 4 as Tönnis type III (mean = 2.6). These hips would have been considered Stulberg type III and IV and we did not observe a difference in the incidence of labral pathology between these types *(Figure 5)*.

There were 4 hips considered to be incongruent at the time of skeletal maturity, thus assigned to Group 3 and all 4 were considered Tönnis IV (mean = 4.0). All of these hips would have been considered Stulberg type IV *(Table III)*.

Univariate analysis demonstrated that joint incongruity and the presence of a labral tear were associated with signs of degenerative arthritis *(Figures 6 to 8)*.

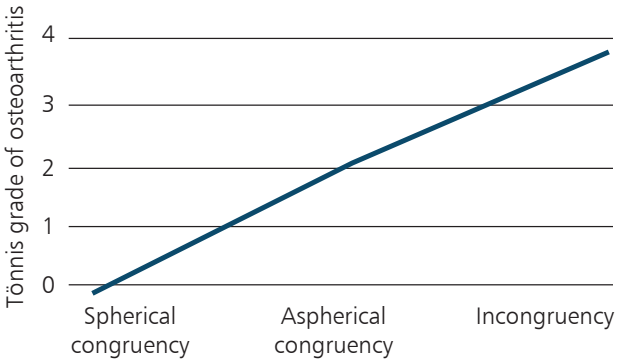


Figure 4. *Relationship between morphology and Tönnis grade of osteoarthritis.*

Table II. Results, according to morphologic group.

Classification	Mean Tönnis grade of OA
Spherical congruency (n = 8)	0.25
Aspherical congruency (n = 76)	2.25
Incongruency (n = 4)	4

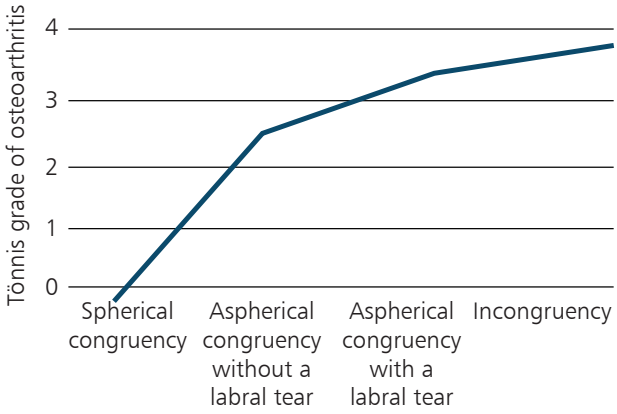


Figure 5. *Relationship between morphology and Tönnis grade of osteoarthritis (including MRI qualifier of a labral tear).*

Table III. Results with the qualifier of a labral tear as seen on MRI.

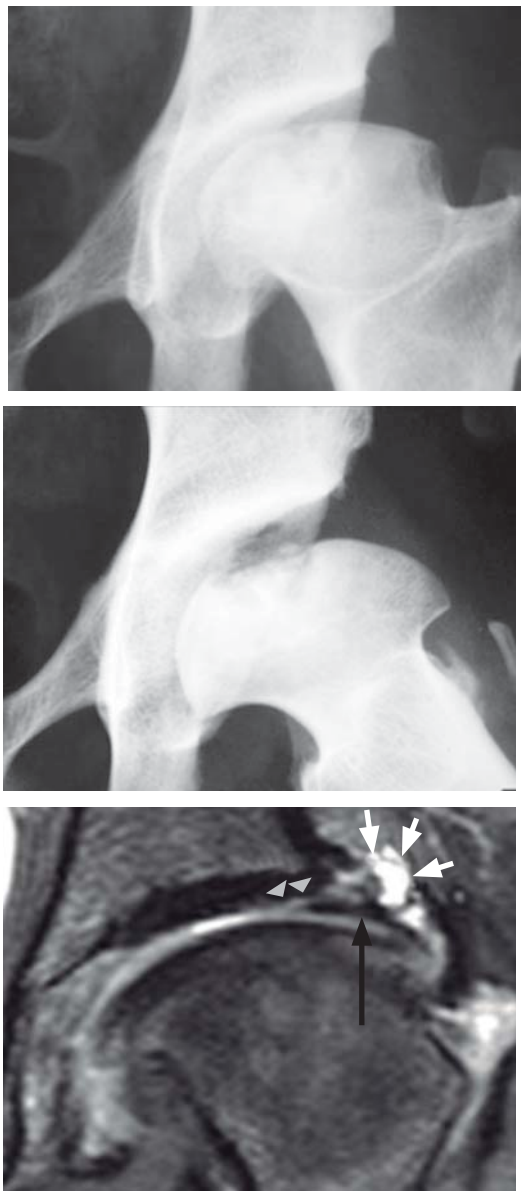
Classification	Mean Tönnis grade of OA
Spherical congruency (n = 8)	0.25
Aspherical congruency (n = 76)	2.25
Without labral tear (n = 6)	2.83
With labral tear (n = 18)	3.66
Incongruency (n = 4)	4

CONCLUSIONS

When faced with having to provide a long term prognosis for patients with the sequelae of LCPD, the classification of hips into 3 Groups at skeletal maturity: 1. Spherical congruency, 2. Aspherical congruency and 3. Incongruency and the finding of a labral tear identifies patients at a higher risk of developing degenerative joint disease.

Every attempt should be made during the early course of LCPD to ensure that the final outcome of the morphology of the hip is as close to normal as possible. We do not pretend to look into treatments or outcomes of this cohort, merely to report on the natural history of the sequelae of the disease and the effect minor abnormalities may have on the long term results.

This study has limitations, including a short follow-up period of just 10 years, compared to others (Weinstein and Ippolito), but the trend is quite evident that with greater loss of sphericity the potential for normal hip function is decreased significantly. It is also limited



Figures 6 to 8. Aspherical congruency seen on an AP and lateral views, a coronal MRI shows a tear of the labrum (black arrow), cartilage delamination (gray arrowhead) and a perilabral cyst (white arrows).

by the non-standardization of radiographs and the possibility of inter and intraobserver variability, however, the simplification of the classification into 3 possible outcome groups and a single qualifier reduced variability significantly and we believe that by unifying this criteria better long-term studies can be performed. Another limitation is that this classification is of no use in prognosticating at the beginning of the disease, this is the subject of many other studies concluding that the lateral pillar classification described by Herring is probably the best available at this time[19,20] however recent feasibility studies have shown that perfusion MRI hold great potential in identifying the patterns associated with differing severity of the disease.[21]

MRI seems to be the best method for evaluating articular morphology, able to provide imaging of the different components from bone to cartilage and soft tissue. The availability of new more sophisticated MRI techniques such as fat suppression, intravenous contrast administration, and gadolinium enhances MRI, showed multiple cartilaginous vascular structure of the growing skeleton,[22] parallel imaging that can enhance the depiction abnormalities, and increased speed of imaging and improves overall quality of the study.[23] Recently, diffusion-weighted imaging applied in conjunction with balanced steady state free precession sequences in the assessment of cartilage repair such as autologous chondrocyte have had good sensitivity. Delayed gadolinium-enhanced MRI of cartilage is based on the observation that ions within the interstitial fluid in hyaline cartilage are distributed in relation to the concentration of negatively charged glycosaminoglycan molecules, which in turn are related to the amount. The term delayed in delayed gadolinium-enhanced MRI of cartilage reflects the time needed to allow the penetration of Gd-DTPA2 through the full cartilage thickness. The majority of the studies about this new technique have been correlated to the articular cartilage surface. Very few studies have been published until now about the growth cartilage and LCPD.

The appearance of the growing structures changed after injection as the gadolinium diffused through the cartilage and marrow. Enhancement was greatly influenced by the skeleton maturation. It seems very important to have more studies using the new MRI techniques in LCPD to increase our knowledge and to improve our chances to reach a reliable classification to obtain best results in the treatments.

The early radiographic and MRI patterns observed will allow surgeons to make better decisions in counselling their patients with LCPD.

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