

Head-at-risk signs in Legg-Calvé-Perthes disease

Poor inter- and intra-observer reliability

Mark C Forster¹, Senthil Kumar¹, Rohan A Rajan¹, W Guy Atherton¹,
Rajan Asirvatham¹ and Vallipuram R Thava²

Departments of ¹Orthopaedic and ²Radiology, Lincoln County Hospital, Greetwell Road, Lincoln LN2 5QY, UK.
Correspondence MF: mcforster@doctors.org.uk
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Background The head-at-risk signs are used as prognostic indicators in Legg-Calvé-Perthes disease. These signs have been assessed only once regarding inter-observer reliability, however. Intra-observer reliability seems not to have been studied to date.

Method 76 anteroposterior pelvic radiographs of unilateral Legg-Calvé-Perthes disease were assessed by 5 observers on 2 occasions, in order to assess the inter- and intra-observer reliability in identifying head-at-risk signs. The observers included 1 consultant paediatric orthopaedic surgeon, 1 consultant radiologist, 2 specialist registrars and 1 senior house officer. Inter- and intra-observer reliabilities were assessed using the kappa coefficient.

Results The intra-observer reliability was good for lateral subluxation and metaphyseal cystic changes, moderate for lateral calcification, and fair for Gage's sign and horizontal growth plate. The inter-observer reliability was moderate for lateral subluxation, fair for lateral calcification and metaphyseal cystic changes, and slight for Gage's sign and horizontal growth plate.

Interpretation There was considerable variation in the diagnosis of the head-at-risk signs between observers. This makes the classification difficult to use in clinical practice.

head-at-risk signs, Gage's (1933) sign, calcification lateral to the epiphysis, lateral subluxation of the femoral head, and the presence of a horizontal growth plate. Smith et al. (1982) later added a fifth by confirming metaphyseal cystic changes to be a poor prognostic indicator. We assessed the inter- and intra-observer reliability of these head-at-risk signs.

Material and methods

76 anteroposterior pelvic radiographs of patients with unilateral Legg-Calvé-Perthes disease were assessed by 5 observers on 2 occasions. There was at least 1 month between the first and second observations. The observers included 1 consultant paediatric orthopaedic surgeon, 1 consultant radiologist, 2 specialist registrars, and 1 post-fellowship senior house officer. Inter- and intra-observer reliabilities were assessed using the kappa coefficient (Landis and Koch 1977) (Table 1). Kappa coef-

Table 1. Kappa coefficients and reliability (Landis and Koch 1977)

Kappa	Reliability
0.81–1.0	Almost perfect
0.61–0.80	Good
0.41–0.60	Moderate
0.21–0.40	Fair
0–0.20	Slight
< 0	Poor

Since the seminal paper of Catterall (1971), the radiographs of patients with Legg-Calvé-Perthes disease have been assessed for the head-at-risk signs in order to assess the prognosis and to plan treatment accordingly. Catterall originally described 4



Figure 1. Is this Gage's sign?

ficents for each inter- and intra-observer pairing were calculated. The mean kappa coefficient and standard deviation was calculated for the inter- and intra-observer reliability of each sign. The 95% confidence intervals were calculated by using ± 2 standard deviations from the mean. All calculations were performed using SPSS version 13. Prior to data collection, each of the observers were sent copies of the original articles describing each radiographic sign or measuring method (Gage 1933, Catterall 1971, Dickens and Menelaus 1978, Green et al. 1981, Smith et al. 1982, Mirkopoulos et al. 1988, Song et al. 1998).

Gage's sign (Gage 1933)

Gage described a convexity of the upper border of the proximal femoral neck. Its presence or absence was noted by the observers (Figure 1).

Lateral calcification (Catterall 1971)

Catterall described calcification just lateral to the epiphysis. Its presence or absence was noted by the observers (Figure 2).

Metaphyseal cystic change (Smith et al. 1982)

Smith et al. (1982) described the cysts as round radiotranslucent areas with a well-defined edge. The presence or absence of these cysts was noted by the observers (Figure 2).

Lateral subluxation

This was measured using the following 3 previously described methods:



Figure 2. Lateral calcification and metaphyseal cysts.

Method 1. Green et al. (1981) described epiphyseal extrusion as a measure of lateral subluxation. It is calculated as follows: Hilgenreiner's line is first drawn through both triradiate cartilages. Perkin's line is then drawn from the bony edge of the acetabulum perpendicular to Hilgenreiner's line. The length of the epiphysis lateral to Perkin's line is recorded. The length of the epiphysis on the normal side is recorded. Epiphyseal extrusion (%) is defined as:

$$\left(\frac{\text{Length of the epiphysis lateral to Perkin's line on the affected side}}{\text{length of the normal epiphysis}} \right) \times 100.$$

Extrusion of more than 20% of the epiphysis has been shown to lead to a poorer prognosis (Gage 1933). The observers calculated the amount of extrusion and the radiographs were then graded in terms of good or poor prognosis.

Method 2. Song et al. (1998) used the medial joint space as an index of lateral subluxation of the femoral head. This was calculated by measuring the distance between the lateral bony margin of the teardrop and the medial and proximal margin of the metaphysis of the femoral neck. A hip was considered subluxated if there was more than 2 mm difference between the 2 sides. The hip was then graded as being subluxated or not.

Method 3. Dickens and Menelaus (1978) measured lateral subluxation by measuring the distance from the teardrop to the femoral epiphysis. A hip was considered to be subluxated if there was more than 2 mm difference between the 2 sides. The hip was then graded as being subluxated or not.

Table 2. Mean frequency (95% CI) of radiographic signs (maximum 76)

Sign	First occasion	Second occasion
Gage's sign	23 (4.8–42)	28 (3.7–52)
Lateral calcification	24 (2.5–45)	22 (1.6–43)
Metaphyseal cystic change	41 (26–47)	38 (20–56)
Lateral subluxation 1	19 (14–24)	20 (14–27)
Lateral subluxation 2	46 (43–49)	40 (30–50)
Lateral subluxation 3	39 (34–42)	36 (31–41)
Horizontal growth plate	4 (0.5–7)	6 (3–10)

Horizontal growth plate

This technique was originally used by Mirkopoulos et al. (1988) in relation to slipped upper femoral epiphysis. Since then, it has also been used in Legg-Calvé-Perthes disease (Loder et al. 1995). The presence of a horizontal growth plate was determined by measuring the angle between the femoral shaft and physis. The physal axis is defined by locating 2 points on the straight portion of the physis and connecting them. The femoral shaft axis is defined by bisecting the femoral shaft at 2 points and connecting these points. The angle between these 2 lines is the physal angle. The larger the angle, the more horizontal the growth plate. The “normal” range in unaffected hips is 61–73° (Loder et al. 1995). Any growth plate with a physal angle > 73° was considered horizontal.

Results (Table 3)

The frequency with which each head-at-risk sign was diagnosed varied greatly between observers (Table 2). For example, the incidence of Gage's

sign ranged from 8% to 89% depending on the observer. Overall, the intra-observer reliability was good for lateral subluxation (all 3 methods) and metaphyseal cystic changes, moderate for lateral calcification, and fair for Gage's sign and horizontal growth plate. The more experienced observers did not have consistently better intra-observer reliability. The inter-observer reliability was moderate for lateral subluxation (all 3 methods), fair for lateral calcification and metaphyseal cystic changes, and slight for Gage's sign and horizontal growth plate.

Discussion

For a radiographic sign to be of prognostic value, it must also be possible to diagnose the sign reliably. Methods of assessing the prognosis of Legg-Calvé-Perthes disease from radiographs include the Herring classification, the Salter-Thompson classification, the Catterall classification, and the head-at-risk signs (Catterall 1971, Salter and Thompson 1984, Herring et al. 1992). The Herring classification, Salter-Thompson classification and Catterall classification have all been validated independently and have also all been assessed for reliability (Dickens and Menelaus 1978, Simmons et al. 1990, Ritterbusch et al. 1993, Farsetti et al. 1995, Ismail and Macnicol 1998, DeBilly et al. 2002). The simpler Herring and Salter-Thompson classifications generally have better inter-observer reliability when compared to the Catterall classification.

The head-at-risk signs have, however, been assessed for inter-observer reliability only once to our knowledge (DeBilly et al. 2002). Intra-observer reliability has not been studied previously. Interest-

Table 3. Intra- and inter-observer reliability of the head-at-risk signs expressed by kappa coefficients (95% CI)

Sign	Intra-observer	Inter-observer
Gage's sign	0.36 (0.21–0.50)	0.13 (0.05–0.22)
Lateral calcification	0.53 (0.38–0.68)	0.28 (0.13–0.42)
Metaphyseal cystic change	0.62 (0.49–0.75)	0.35 (0.23–0.47)
Lateral subluxation 1	0.62 (0.50–0.75)	0.47 (0.40–0.54)
Lateral subluxation 2	0.62 (0.53–0.71)	0.53 (0.46–0.59)
Lateral subluxation 3	0.64 (0.53–0.75)	0.55 (0.48–0.62)
Horizontal growth plate	0.23 (0.08–0.39)	0.16 (0.06–0.26)

ingly, the study of DeBilly et al. (2002) had markedly different results from our study. The observers in our study showed great variation in the frequency of diagnosing the head-at-risk signs, and this led to the inter-observer reliability being unacceptable for some of the signs. DeBilly et al. (2002) found that lateral subluxation was the only head-at-risk sign to have a poor inter-observer reliability. They attributed this to the assortment of methods available for deciding whether lateral subluxation is present. They had not specified to their observers which method to use, adding another dimension to the possible inter-observer variation. In our study, lateral subluxation was the only sign to have moderate or better reliability for both inter- and intra-observer reliability. All 3 measuring methods tested had a moderate or better reliability for both inter- and intra-observer reliability, with method 3 having the best inter- and intra-observer reliability. Lateral subluxation is an important head-at-risk sign, as it correlates with outcome (Dickens and Meneleus 1978, Green et al. 1981, Ippolito et al. 1987), whereas there has been some doubt raised over some of the other head-at-risk signs (Dickens and Meneleus 1978, Ippolito et al. 1987, Loder et al. 1995).

Gage's sign and horizontalization of the growth plate had the poorest inter- and intra-observer reliability. There are many different definitions of Gage's sign, and this may account for the fair amount of inter-observer error (Gage 1933, Catterall 1971, DeBilly et al. 2002). In order to minimize these problems, the original paper was sent to each observer (Gage 1933)—but there is a different description in Catterall's paper (1971), which may have led to some confusion. Gage's sign and horizontalization of the growth plate have been shown not to be well correlated with long-term outcome (Dickens and Meneleus 1978, Ippolito et al. 1987, Loder et al. 1995) and their usefulness in prognosis may be limited. Lateral calcification has been shown to correlate with outcome (Dickens and Meneleus 1978), but some authors dispute this (Ippolito et al. 1987).

Overall, there was considerable variation in the diagnosis of the head-at-risk signs between the observers in this study. This makes the classification unreliable and difficult to use in clinical practice. This, combined with the knowledge that some

of the signs are not—or may not be—prognostic indicators makes classification of head-at-risk signs of doubtful clinical value.

Contributions of authors

All authors were involved in the study design. All authors except MCF analyzed the radiographs. Statistical analysis was performed by MCF and RAJ. The article was mainly written by MCF with contributions from all authors.

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