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Validation of Catterall Classification in the Management of Legg-Calve-Perthes Disease

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Abstract

Introduction: Despite the advancement in the recent times, there is still no consensus about the ideal classification that could grade the patient with Perthes disease preoperatively and prognosticate its outcome on follow-up. Although principal dictum in the management of Perthes disease is to contain the femoral head in the acetabular socket to prevent deformation of the femoral head, method of containment and candidate selection for surgery depends on the stage of presentation of the disease where classification system plays a major role. The aim of our study to is validate the role of Catterall classification in grading the disease preoperatively and prognosticating its outcome and categorising the post op outcome by Catterall postoperative scale.

Materials & methods: This is a prospective study done from 2014-2018 where 72 children with Perthes disease were categorised and managed based on the Catterall classification and outcome was analysed. Surgical containment by varus derotation osteotomy was done in all patients presenting late and with severe disease and in patients with head at risk signs.

Results: Mean age of presentation was 7.4 years and out of 72 children, 26 belonged to grade 2 and 32, 14 belonged to grade 3 and 4 respectively. Surgical containment was done in 68 patients and in all patients containment was maintained till last follow-up. At a mean follow up of 2.4 years, good results were obtained in 49, fair in 21 and poor in 3 children using Catterall's postoperative classification. Radiological evaluation was done using Caput Index and Epiphyseal Quotient to assess the regenerative potential of the femoral head. Statistical analysis revealed significant results on follow up, with earlier grades having significantly better outcome compared to the late stage of disease.

Conclusion: We concluded from our study that Catterall classification was consistent in prognosticating better outcome in patients presenting with low grade at early age and ideally selecting patients for surgical containment for advanced disease. Our study suggests that varus derotation osteotomy is an effective and easy surgical containment method for children with advanced disease that significantly altered the natural history of this self-limiting pathology.

Keywords: Legg Calve Perthes Disease, Classification, Catterall

Introduction

Classifications established for Legg-Calve-Perthes disease (LCPD) may be divided into three categories: Those defining the stage of the disease, those attempting to prognosticate outcome, and those defining outcome. Although Arthur Legg [1], Calve [2], and Georg Perthes[3] share credit for their descriptions of the disease published between 1909 and 1910, according to Wenger and Pandya, Henning Waldenstrom of Norway published on LCPD, in 1909, mistaking it for tuberculosis of the hip [4]. Although Waldenstrom's name does not appear in the disease eponym, he is credited with the development of the first classification of the disease, in 1922, which recognized four stages of radiographic progression: Initiation, fragmentation, reossification, and healed [5]. Outcome classifications also are based on radiographic characteristics. The classification of Stulberg et al. groups mature hips by shape of the femoral head and congruency in the joint and is the mostly used for outcome measure [6,7]. Several prognostic classification systems for use at disease onset have been proposed. Catterall [8] was the first to publish a widely accepted prognostic classification, in 1971. This system described four categories based on the location of involvement of the femoral head as viewed on AP and lateral radiographs. In 1984, Salter and Thompson [9] proposed a two-category system based on a review of 1057 children with 1264 involved hips. They determined that subchondral fracture was predictive of eventual degree of involvement of the femoral head and also believed that a two-category classification could increase reliability. This system has been criticized as difficult for less experienced surgeons to use as the subchondral fracture line can be quite subtle and not always present [10]. Later, Herring et al. [11] followed a group of 86 patients (93 hips) longitudinally and correlated their presenting radiographs to their Stulberg classification and found that the height of the

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Table 1: The Catterall Grading of Legg-Calve-Perthes disease and its prognosis [8, 13]		
Grade	Description	Prognosis
Grade I	Very anterior involvement of epiphysis	Excellent prognosis without treatment at any age
	No metaphyseal involvement	
Grade II	Anterior involvement < 50%	<4 years:Good prognosis
	Possible metaphyseal involvement	>4 years: 50% of good prognosis without treatment
Grade III	Anterior involvement >50%	Poor prognosis
	Frequent metaphyseal involvement	
Grade IV	Total epiphyseal involvement	Poor or bad prognosis
	Metaphyseal involvement	

lateral column on AP radiographs was predictive of the final outcome of the disease. Most cases are unilateral, but some may be bilateral. For some children, outcomes may be excellent with no intervention, while others may require surgery to maintain range of movement and prevent early-onset arthritis. The prognosis is dependent on age at disease onset, with younger patients generally faring better than older patients [11,12]. An ideal classification system should predict functional outcomes and prescribe treatment, enabling the surgeon to distinguish operative from non-operative cases. A practical classification system must be reproducible, relying on landmarks that are only minimally affected by the disease process. It must accurately group similar hips so that treatment outcomes may be compared. Catterall system of classification of LCPD is one such classification system which categorizes, prognosticates, and dictates the management for various stages of the disease.

Factors in prognosis

Age

Most authors agree on the importance of age in prognosis. The later the age at which the patient presents with the disease the lesser is the time available for remodeling of the deformed head, and moreover, the relatively elder patients always present with late stage of the disease which might be a reason why most of the patients of higher age have worse prognosis compared to the ones of the younger ages.

Table 2:The Catterall post-operative classification for Legg-Calve-Perthes disease	
Group	**Characteristics**
Good	Hip causes no symptoms
	Full range of motion intact
	Radiographically head is round and well contained within the acetabulum
	Some loss of epiphyseal height is accepted provided the head is round
Fair	Hip causes no symptoms
	Movements are slightly restricted
	Head is round but broadened and not fully contained within the acetabulum, up to one-fifth being uncovered
	Loss of epiphyseal height is always present
Poor	Hip may not be completely free from symptoms
	Hip always shows restriction of movement

Stage of the disease at diagnosis

The stage of the disease at diagnosis has always been regarded as important, as treatment in early disease is more likely to be effective in preventing deterioration in the shape of the femoral head. Conversely, once flattening has occurred treatment should be considered only if it will reverse the change. Arthrography will confirm head shape in established disease and should be used to show head shape and congruity if treatment is being considered in advanced disease [13].

Head at-risk signs

Catterall noted that if the factors given below are associated with femoral head flattening, then they would be associated with fair or poor result. Such cases may be considered "at risk" and would have the following signs: [13]

a. Calcification lateral to the epiphysis
b. Gage's sign
c. Lateral subluxation
d. Diffuse metaphyseal reaction
e. A horizontal growth plate.

The presence of two or more of these signs should be regarded with suspicion and bias the clinician in favor of advising treatment [8, 13]. Definitive treatment would be indicated by Catterall in the following cases: (a) All "at risk" cases, (b) Groups 2 and 3 over 7 years not at risk, and (c) Group 4 when femoral head shape change has not occurred. The further separation of the cases in Groups 2 and 3 by age is made as experience suggests that over the age of 7 years all these cases will ultimately become at risk. In Group 4 cases, early head shape change is usual, and if treatment is

Table 3: The relevance of Catterall pre-operative grading and its post-operative outcome with age and stage at presentation as the criteria determining the outcome									
Age (years)	Catterall post-operative classification								
	Catterall Pre-operative Grade 2			Catterall Pre-operative Grade 3			Catterall Pre-operative Grade 4		
	Good	Fair	Poor	Good	Fair	Poor	Good	Fair	Poor
<10	16	3	-	11	6	-	8	2	-
>10	5	2	-	7	3	1	1	5	2

Table 4: The epiphyseal quotient distribution in the study population						
EQ						
Age (years)	Good		Fair		Poor	
	Mean EQ	Total cases	Mean EQ	Total cases	Mean EQ	Total cases
<10	0.68	36	0.54	11	0.33	1
>10	0.64	13	0.47	8	0.31	3
EQ: Epiphyseal quotient						

Table 5: The caput index change between the pre-operative and final follow-up				
CI				
Group	***n***	**Mean change in CI**	**SD**	***P* value**
Normal hip	72	1.73	2.42	0.564
Affected hip	72	27.52	15.21	0.001
CI: Caput index				

Figure 1: showing the outcome of VDRO in a Catterall Grade 3 disease with complete regain of the sphericity of the femur at last follow up.

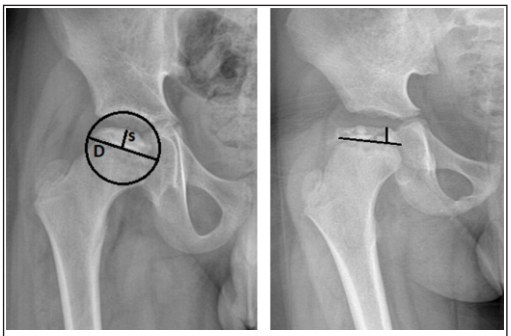

Figure 2: showing the Caput Index and Epiphyseal Quotient calculation where s is the minimum radius and D is the maximum diameter of the femoral head.

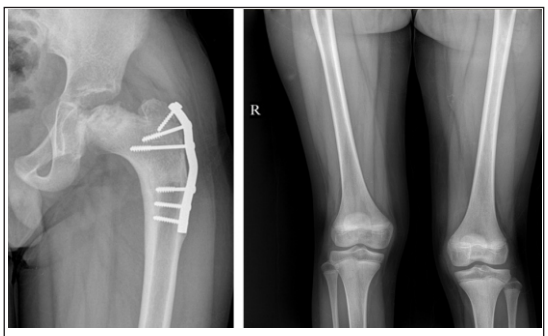

Figure 3: Figure 3 showing the trochanteric ephiphysiodesis done to prevent trochanteric hypertrophy and shortening arising as a complication of varus derotation osteotomy.

considered, it must be shown by arthrogram that the head is still round. Between the two sets of indications lie a few cases needing symptomatic treatment such as short courses of traction for"irritable hip syndrome" and adductor tenotomy plus 4weeks in an abduction plaster to correct adduction deformity. Published reports on the treatment of Perthes disease suggest two major principles of treatment: Containment of the femoral head within the mold of the acetabulum and relief of weight. To these, two principles should be added a further important one: Prevention of injury. Combining these principles produces several treatment regimens. Particularly when containment splints are used, injuryis easily prevented but with surgical or no treatment regimens care must be taken to prevent injury by restricting sports and related activities [13].

Material & Methods

This is a prospective study conducted in Institute of Child Health, Egmore, after getting approval from the Institutional Ethical Committee. All children who presented with Perthes disease were included in the study after getting proper consent to involve in the study. They are categorized with Catterall grading and based on the age and stage of the disease treatment is instituted, and they were followed up both radiologically and clinically and categorized into appropriate post-operative group,and the prognosticating power of the classification system along with the significance of change in the natural course of the disease is analyzed. Radiologically, we reviewed the anteroposterior (AP)and lateral X-ray of both the hips of the patient. All the measurements were carried out on pre-operative and post-operative X-rays after 3-yearfollow-up. In an ideal situation, the femoral head is round. The anatomical center of the femoral head was found out by accommodating the femoral head within an optimal sphere in both AP and lateral X-rays. The maximum diameter of the femoral head is D. The minimum radius (s) is measured from middle of D to the surface of the femoral head. The D and s are an average of respective values in both the views. The sphericity of the femoral head was measured using caput index (CI) = ([s × 2]/D) [14]. The epiphyseal quotient (EQ) is calculated from the X-rays. It is the ratio of the epiphyseal index of the involved head with that of the uninvolved head. The epiphyseal index is calculated by the greatest height of the epiphysis divided by its width. The EQ was graded as good (>60%), fair (40–60%),and poor (≤40%) [15]. The clinical and radiological parameters of the affected hip were compared with the contralateral normal hip.

Statistics

We used IBM SPSS (Version 25.0, Armonk, NY: IBM Corp, USA) Statistics software for analysis of our results. Fischer's exact test for subject distribution, Student's unpaired t-test for change in CI, and Fischer's exact test for results in terms of EQ were used. The statistical significance value (P) was set to 0.05.

Result

A total of 72 patients were enrolled in the study with a sex ratio of M:F of 3.2:1 was involvement of the right to left hip ratio was 5.4:1. The mean age at presentation was 7.4 years (range 5–12 years).24 patients (33.3%) were of >10 years of age at presentation. All patients had the limitation of abduction and internal rotation at presentation. 38 patients (52.7%) had pain at the hip and 51 patients (70.83%)had limp at presentation. The mean period of the union of osteotomy site was 2 months(range 1.5–3 months). Mean follow-up period in the study is 2.4 years (range 1.2–3.7 years).

Radiological parameters

After complete follow-up, the final CI of the affected and the normal hip was evaluated, and change in CI of the normal hip was compared to change in CI of the affected hip after surgery. It was found that there was a significant change in the CI on the final follow-up which showed the remodeling of the

femoral head on containment by surgical method as dictated by the Catterall classification. The mean value of EQ at diagnosis and EQ at final follow-up was calculated, and it also showed a significant improvement after Varus derotation osteotomy which shows the regain of the sphericity of the femoral head on treatment.

Clinical parameters

Clinically,7 patients (9.72%) complained of limping. Five had purely Trendelenburg gait while two patients had a short limb gait. Children with post-operative trochanteric overgrowth were the ones associated with Trendelenburg gait in the hip. Anticipating this complication trochanteric epiphysiodesis was attempted in the index surgery in many cases. 86.6% of the patients could sit cross-legged and were able to squat. Two patients had the restriction of terminal abduction and internal rotation. No one had fixed deformity of the hip. Limb length discrepancy was seen in 12 patients. The mean shortening was 1.3 cm (range: 0.8–1.5).There was no instance of non-union of the osteotomy site. 27 patients who were categorized into Grade 2 in which 22 (81.48%) exhibited good post-operative outcome while five showed fair outcome. Of 28 patients who were categorized preoperatively into Grade 3 exhibited good outcome in 18 (64.28%) patients while nine showed fair and one showed poor outcome. In Grade 4,of 18 patients only 9 (50%) showed good outcome while seven showed fair and two showed poor outcome. This analysis clearly showed that the classification of the disease at presentation was significantly associated ($P< 0.05$) with the outcome. Age of the patient at the time of diagnosis was also found to have a significant bearing on the functional outcome of the disease. In Grade 2 category, seven patients presented above 10 years of age and in which only 5/7 (71.42%) patients showed good outcome, whereas in age <10 category 17/20 (85%) showed good outcome and as the age progresses and grade increased outcome was better in younger patients compared to the patients more than 10 years of age. This shows as statistically significant variable in predicting the outcome of the management as dictated in the Catterall classification.

Discussion

Lots of studies had been done on Perthes disease over the century, yet it still continues to be an idiopathic disease with variable natural history and unpredictable outcomes. The disease has been classified in various ways to quantify the severity. We validated Catterall classification in our study in terms of its pre-operative categorization in relation to the post-operative outcome of the patient both radiologically and clinically. This classification is based on the stages of evolution of the disease. Joseph et al. [16]have assessed the classification system and found the system to be prognostically useful. Various authors have used Moses index[17]in their studies. However, it is not possible to measure some femoral heads using Moses index which is not circular enough to fit the outline of the Moses ring as quoted by Dickens et al. In their study, they found it difficult to fit Moses rings to every femoral head. Fore sighting this problem, we avoided Moses rings [12, 16]. Hence, we used CI and the EQ as a measure of the sphericity in our study. Shigeno and Evans [18] stated that femoral head deformation was more significant in AP radiograph than lateral in fragmentation stage. However, Cho et al.[19] put forward that in children the femoral head is deformed both in the sagittal and coronal plane. Herring et al. [11],Fredensborg [20],Heyman and Herndon [21], and Mose [17] used AP radiographs only. In our study, we took into account both the AP and lateral radiographs. The mean age at onset in our study is 7.4 years (range 5–12 years). In the study by Joseph et al.[22], the age at onset was 8.14 years, and by Saini et al.[14], it was 9.2 years. In this study, we performed trochanteric epiphysiodesis to prevent trochanteric overgrowth. However, two patients still had a trochanteric overgrowth and associated Trendelenburg gait with complaints of limping. Langenskiöld [23] and Matan et al.[24] have recommended trochanteric epiphysiodesis to prevent trochanteric overgrowth. Both shortening and Trendelenburg gait have been reported with VDRO. However, both improve with time as the osteotomy site remodels and skeletal maturity is attained [25]. The most important independent prognostic factors in Perthes disease are the extent of involvement and the age at presentation. Patients presenting with a higher grade of involvement (Catterall 3,4) tend to have a greater collapse of the femoral head, more pronounced deformities of the femoral head and neck, with greater limitation of hip range of motion and a poor prognosis [8,9,12]. Most authors agree that patients younger than 6 years of age have a good prognosis, and outcome usually does not vary despite treatment [11, 19, 20, 21]. Children between 6and 9 years of age are considered to have a variable prognosis, and they usually benefit from surgical containment [9,10,11].Patients who are older than 9 years at onset are considered to have a poor prognosis regardless of the extent of the disease [8, 13,16]. This may be ascribed to lesser time available for the deformed femoral head to remodel. Literature is quite confusing regarding the best treatment protocol for such patients as there are contradictory studies about the additional benefit of operative containment in such patients [16,17]. There are reports in the literature which support the fact that Varus derotation osteotomy provides improved results in children older than 9 years of age as compared to the natural history or

non-containment methods [15]. In consensus with this, we also favor the surgical containment inthe form of Varus derotation osteotomy at our institution for all patientsolder than 6 years of age with Catterall Grade 3 or 4. Our study had the limitation of short duration of follow-up, and there is no comparison group taken to account for validating the study with the natural history of the disease.

Conclusions

From our study, we conclude that Catterall classification of LCPD both preoperatively and postoperatively has a significant impact on the outcome and natural history of the disease. Irrespective of classification systems, the treatment aims to restore the sphericity, the epiphyseal height, and the congruity of the joint in the long term which is main prognostic factor along with the age and the severity of presentation as detailed above. Studies to quantify the morphology of femoral head and the acetabulum continue to develop to give a better understanding of the disease.

References

1. Legg AT. An obscure affection of the hip joint. 1910. ClinOrthopRelat Res 2006;451:11-3.

2. Calve J. On a particular form of pseudo-coxalgia associated with a characteristic deformity of the upper end of the femur. 1910. ClinOrthopRelat Res 2006;451:14-6.

3. Perthes G. The classic: On juvenile arthritis deformans. 1910. ClinOrthopRelat Res 2012;470:2349-68.

4. Wenger DR, Pandya NK. A brief history of Legg-calve-Perthes disease. J PediatrOrthop 2011;31 2 Supp l:S130-6.

5. Kim HK, Herring JA. Pathophysiology, classifications, and natural history of Perthes disease. OrthopClin North Am 2011;42:285-295, v.

6. Kuo KN, Wu KW, Smith PA, Shih SF, Altiok H. Classification of Legg-calve-Perthes disease. J PediatrOrthop 2011;31 2 Supp l:S168-73.

7. Stulberg SD, Cooperman DR, Wallensten R. The natural history of Legg-calve-Perthes disease. J Bone Joint Surg Am 1981;63:1095-108.

8. Catterall A. The natural history of Perthes' disease. J Bone Joint Surg Br 1971;53:37-53.

9. Salter RB, Thompson GH. Legg-calve-perthes disease: The prognostic significance of the subchondral fracture and a two-group classification of the femoral head involvement. J Bone Joint Surg Am 1984;66:479-89.

10. Mahadeva D, Chong M, Langton DJ, Turner AM. Reliability and reproducibility of classification systems for Legg-Calve-Perthes disease: A systematic review of the literature. ActaOrthopBelg 2010;76:48-57.

11. Herring JA, Neustadt JB, Williams JJ, Early JS, Browne RH. The lateral pillar classification of Legg-Calvé-Perthes disease. J PediatrOrthop 1992;12:143-50.

12. Farsetti P, Tudisco C, Caterini R, Potenza V, Ippolito E. The herring lateral pillar classification for prognosis in perthes disease: Late results in 49 patients treated conservatively. J Bone Joint Surg Br 1995;77:739-42.

13. Kim HK. Legg-Calve-Perthes disease. J Am AcadOrthopSurg 2010;18:676-86.

14. Saini R, Goyal T, Dhillon MS, Gill SS, Sudesh P, Mootha A. Outcome of varusderotation closed wedge osteotomy in Perthes disease. ActaOrthopBelg 2009;75:334-9.

15. Noonan KJ, Price CT, Kupiszewski SJ. Results of femoral varus osteotomy in children older than 9 years of age with Perthes disease. J PediatrOrthop 2001;21:198-204.

16. Dickens DR, Menelaus MB. The assessment of prognosis in Perthes' disease. J Bone Joint Surg Br 1978;60-B:189-94.

17. Mose K. Methods of measuring in Legg-Calvé-Perthes disease with special regard to the prognosis. ClinOrthopRelat Res 1980;150:103-9.

18. Shigeno Y, Evans GA. Revised arthrographic index of deformity for Perthes' disease. J PediatrOrthop B 1996;5:44-7.

19. Cho TJ, Lee SH, Choi IH, Chung CY, Yoo WJ, Kim SJ. Femoral head deformity in Catterall groups III and IV Legg-Calvé- Perthes disease: Magnetic resonance image analysis in coronal and sagittal planes. J PediatrOrthop 2002;22:601-6.

20. Fredensborg N. The spherical index. A measure of the roundness of the femoral head. ActaRadiolDiagn (Stockh) 1977;18:685-8.

21. Heyman CH, Herndon CH. Legg-Perthes disease: A method for the measurement of the roentgenographic result. J Bone Joint Surg Am 1950;32 A:767-78.

22. Joseph B, Srinivas G, Thomas R. Management of Perthes disease of late onset in Southern India. The evaluation of a surgical method. J Bone Joint Surg Br 1996;78:625-30.

23. Langenskiöld A. Changes in the capital growth plate and the proximal femoral metaphysis in Legg-Calvé-Perthes disease. ClinOrthopRelat Res 1980;150:110-4.

24. Matan AJ, Stevens PM, Smith JT, Santora SD. Combination trochanteric arrest and intertrochanteric osteotomy for Perthes' disease. J PediatrOrthop 1996;16:10-4.

25. Skaggs DL, Tolo VT. Legg-Calve-Perthes disease. J Am AcadOrthopSurg 1996;4:9-16.

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