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Reliability of a New Radiographic Classification System for Developmental Dysplasia of the Hip

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Abstract

The Tonnis radiographic classification for developmental dysplasia of the hip (DDH) has been widely used for grading the severity of the disease. By definition, this method requires the presence of an ossification centre, which can be delayed in appearance and eccentric in location at times. The International Hip Dysplasia Institute (IHDI) classification, a new classification system recently developed by the IHDI, answers the scenario unanswered by the Tonnis classification. This study aimed to validate its reliability in evaluating DDH with an ossification center and to compare the 2 classifications in evaluating all DDH hips. In total, the pelvic radiographs of 92 DDH patients (115 hips) between the ages of 6 and 48 months between 2014 and 2017 were assessed by 3 observers retrospectively using the 2 classifications. Intraobserver and interobserver variations were evaluated using Cohen's kappa method and graded with Munro's correlation strength categories. Both classifications showed excellent intraobserver and interobserver reliability. However, the IHDI demonstrated more interobserver reliability, especially for evaluating DDH without an ossification center. The IHDI classification exhibited good practicability in classifying the radiographic severity of DDH compared to the Tonnis classification, particularly in hips without an ossification center. Therefore, the IHDI classification seems to be the expanded version of the Tonnis classification and can be used as a reliable tool in the management of the early stages of DDH to stage the disease and plan treatment accordingly.

Keywords: Tonnis classification, IHDI classification, DDH

Introduction

Developmental dysplasia of the hip (DDH) is a very common disorder in the paediatric population, with an incidence of approximately 3 or 4/ per 1000 live births[1]. Physical examinations is arevital for diagnosing DDH in its early stages. However, clinical examination cannot detect all cases of DDH by itself. Imaging examinations include ultrasonography and radiography, both of which are popular for screening or confirming the diagnosis and the severity classification of DDH[2]. Quantifying the severity of displacement in DDH is important for its diagnosis and treatment. Anteroposterior (AP) pelvic radiographs have replaced the less accurate ultrasonography for screening and imaging in older infants[3]. However, AP pelvic radiographic assessments may be suboptimal or misleading when the ossification of the femoral head of the hips is absent, delayed, or eccentric, as in DDH. In 1978, Tonnis described a pelvic radiographic classification of DDH depending on the ossification of the femoral head of the hips[4]. Unlike the center-edge angle of Weiberg and the acetabular index angle of Hilgenreiner, the Tonnis classification covers the full spectrum of DDH severity using plain radiographs, as the Graf subtypes are well established for ultrasounds[4, 5, 6, 7]. The Tonnis classification has previously been shown to be predictive of treatment success and the need for secondary surgery[8,9]. However, this method relies on the relative position of the ossific nucleus to Perkin's line (P-line) and Hilgenreiner's line (H-line); therefore, it has limitations in that it relies on the presence of an ossific nucleus, which may not be apparent or may be eccentric, and about whose centricity assumptions must be made. Therefore, this limitation can make the application of the Tonnis classification without the presence of an ossification center quite difficult and potentially unreliable. Recently, the International Hip Dysplasia Institute (IHDI) proposed an alternative classification system with a wider application than the Tonnis classification. The IHDI classification uses the midpoint of proximal femoral metaphysis as a landmark reference and can, therefore, be applied to all ages of the pediatric population[10]. The purposes of this study is to validate the IHDI classification and compare the reliability of the Tonnis classification with the IHDI classification for evaluating DDH patients at a single institution with three observers.

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Methods

Our study was done at Institute of Child Health, Egmore, approved by the Institutional Ethical Committee. All the children's legal guardians gave written and informed consent. All the pediatric patients who presented with DDH between January 2014 and December 2017 were retrospectively

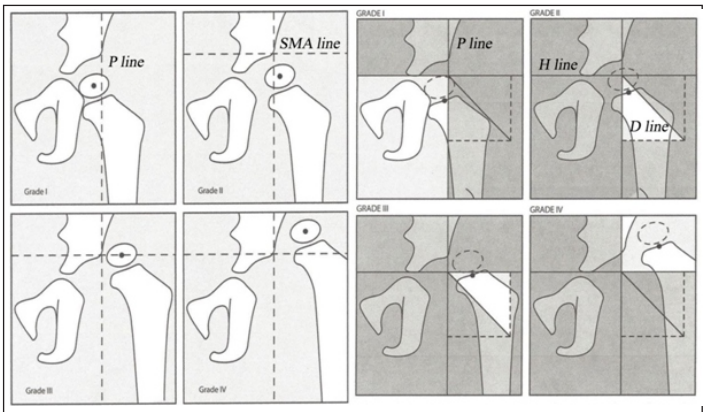

Figure 1: The comparison of Tonnis classification versus IHDI classification where the Tonnis classification uses the Perkin's line and SMA-line drawn the superolateral margin of acetabulum bilaterally to assess the relative position of the femoral ossific nucleus while the IHDI classification uses the Perkin's line and H-line drawn through the top of the triradiate cartilage bilaterally to assess the relative position of midpoint of superior surface of proximal femoral metaphysis. The IHDI classification also uses a D-line drawn 45°from junction of H-line P-line to differentiate between Grade II and Grade III.

reviewed. Patients without clear X-rays were excluded from the study. The obtained medical data of the pediatric patients included their sex, age, the side of the suffering hip, and AP pelvic radiographs. All the hip X-ray examination was done on the admission of the patient for treatment. We identified 92 patients with diagnoses of idiopathic DDH who received treatment between the ages of 6 and 48 months. All hips were included to analyze the reliability of the Tonnis classification compared to that of the IHDI classification. In total, 115 hips were treated by closed reduction, open reduction, or pelvic osteotomy, including combined pelvic and femoral osteotomy. [11,12]. All patients had a minimum of a 12-month follow-up and complete clinical records. The correlation of the 2 radiographic classifications in terms of treatment selection was also assessed. The Tonnis classification was assessed according to the relative position of the femoral proximal ossific nucleus to Perkin's line (P-line) and the superolateral margin of the acetabulum line (SMA-line). The P-line is a perpendicular line from the superolateral margin of the acetabulum SMA, and the SMA-line is a single line drawn through the superolateral margin of the acetabulum SAM bilaterally.

The Tonnis classification was utilized according to these definitions as follows:. .

- Grade I: The capital femoral ossification center is medial to the P-line.
- Grade II: The ossification center is lateral to the P-line but below the SMA-line.
- Grade III: The ossification center is near or level with the SMA-line.
- Grade IV: The ossification center is above the SMA-line. [4].

This measurement relies on the appearance of an ossification center, which is often eccentric or delayed in DDH hips. The IHDI classification uses the H-point as a landmark referance to determine the location of the hip, which is defined as the mid point of the superior margin of proximal femoral metaphysis that replaces the ossific nucleus as shown in the (Fig. 1). As in the Tonnis classification, the H-line is drawn bilaterally through the top of the tri radiate cartilage in the IHDI classification. The standard P-line is then drawn perpendicular at the superolateral margin of the acetabulum SAM. However, unlike in the Tonnis classification, an additional diagonal line (D-line) is then drawn 45° degrees from the junction of Hilgenreiner's line (H-line) and the P-line. The H-line is a single line drawn through the top of the tri radiate cartilage bilaterally. The relation of the H-point to these 3 lines determines the IHDI grade. In an IHDI Grade I hip, the H-point is at or medial to the P-line. In an IHDI Grade II hip, the H-point is lateral to the P-line andat or medial to the D-line. In an IHDI Grade III hip, the H-point islateral to the D-line and at or inferior to the H-line. In an IHDI Grade IV hip, the H-point is superior to the H-line. Three observers were asked to classify each pre operative radiograph independently with both the Tonnis classification and the IHDI classification and repeated this classification 2 weeks later. The 3observers included 2residents pediatric orthopaedic surgeon and 1 experienced professor.They were blind to one another's assessments and to the identities of the patients. All statistical analyses were performed using the SPSS (V version 25)software. The statistical analyses included the use of Cohen's kappa values to compare the correlation and agreement of the Tonnis classification with that of the IHDI classification between three independent observers where a value between 0.0 and 1.0 is obtained where 1.0 represents perfect agreement or concordance. [14]. Although there are no definitive values that clearly differentiate between acceptable and unacceptable agreement, for the purpose of this study, we adopted Munro's correlation strength categories where 0.90 - –1.0 = very high; 0.70 - –0.89= high; 0.50-–0.69= moderate; 0.26 - –0.49= low; and 0.00 - –0.25= little, if any.

Table 1: The statistical significance of agreement between three observers between Tonnisclassification and IHDI classification in patients with ossific nucleus

Hips with ossific nucleus (n =103)	Tonnis classification	IHDI classification	P value
Interobserver correlation			
Observer 1 versusobserver 2	0.913	0.928	P <0.001
Observer 1 versusobserver 3	0.943	0.927	P <0.001
Observer 2 versusobserver 3	0.914	0.971	P <0.001
Intraobserver agreement			
Observer 1	0.914		P <0.001
Observer 2	0.927		P <0.001
Observer 3	0.927		P <0.001

Table 2: The statistical significance of agreement between three observers in the IHDI classification without ossific nucleus

Hips without ossification nucleus(n =12)	IHDI classification	P value
Interobserver correlation		
Observer 1 versusobserver 2	0.889	P <0.001
Observer 1 versusobserver 3	0.889	P <0.001
Observer 2 versusobserver 3	0.782	P <0.001

Results

In total, 115 hips (92 DDH patients) were available for the classification measurement, all of which were classifiable by the 3observers using the Tonnis and IHDI classifications. In total, 12 patients with inadequate or unavailable radiographs or mis-diagnosis in the course of clinical treatment were excluded from the study. The weighted kappa values of all 103 hips using both the Tonnis and IHDI classifications are presented in Tables 1 and 2, respectively. The weighted kappa values demonstrated very high intraobserver agreement for both classifications; the kappa values of the 2 observers for the Tonnis and IHDI classifications were 0.914 and 0.927. The weighted kappa values also demonstrated good interobserver agreement for both the classifications, but the IHDI showed very high agreement (0.928compared to 0.913). The Tonnis classification cannot account for the classification of 12 cases where ossification center is absent where IHDI classification played an upper hand in classifying the disease stage and aided in planning the management. High agreement was noted between the observers in classifying such cases with statistical significance.

Discussion

The original intention of the IHDI classification was to remedy the limitations of the Tonnis classification in cases with the disappearance or the eccentric location of the ossific nucleus, as the Tonnis classification depends on the relation of the ossific nucleus to the P-line and the H-line[10]. The IHDI and Tonnis classifications are both practical in the radiographic evaluation of DDH; however, the former classification shows better stability, particularly in evaluating DDH with the disappearance or eccentric location of the ossific nucleus. The IHDI classification can be applied for evaluating DDH regardless of the appearance or disappearance of the ossific nucleus. Therefore, the IHDI classification seems to be the upgraded version of the Tonnisclassification[15]. There are 3 three possible reasons for the better stability of the IHDI classification of DDH compared to the Tonnisclassification. First, the IHDI classification judges the superior margin of proximal femoral metaphysis as a line, but the Tonnis classification judges the proximal femoral ossific nucleus as a circle or quasi-circle. The latter encounters difficulty when an edge is vague or irregular, especially in imagined edge situations. Second, the H-point is the midpoint in a metaphysis margin line, but the Tonnis classification determines a circle's center. It is much easier to judge a line and midpoint than a circle's boundary and center, especially in DDH without an ossific nucleus, which implies an imagined circle. Third, the IHDI classification has more accuracy in evaluating IHDI Grade II and III hips because the lower outer quadrant is divided into two precisely equal parts by the D-line. It is possible that the proximal femoral ossific nucleus becomes clearer and easier to judge with increasing age; however, the H-point is always prone to identification[17,18]. Owing to the different locations of the proximal femoral ossific nucleus and the H-point, there is some disparity between the two classifications. Both classifications used the same P-line to distinguish IHDI Grade I and grade II hips. Since the H-point is usually on the outside of the proximal femoral ossific nucleus, the IHDI grade Grade II hip is easier reach than the Tonnis Grade II hip. The IHDI classification showed an advantage in accuracy in differentiating the classification of Grade II and grade III hips because the D-line quantified the lower outer quadrant. The IHDI and Tonnis classifications use the H-line and the SMA-line,respectively, and the distance between the H-line and the SMA line usually greater than the longitudinal distance between the H-point and the proximal femoral ossific nucleus; thus, IHDI Grade IV hips are easier to reach than Tonnis Grade IV hips. This study has several limitations. First, it is a retrospective observational study. Second, the data of this study were from the single institute. Third, we have not classified the pelvic radiographs at the endpoint of the follow-up which received the treatment. Comparing to the Tonnis classification, the IHDI may also have some limitation such as requiring a more stringent radiographic position. The H-point is located on the distal side of femoral proximal ossific nucleus, but the femoral proximal ossific nucleus near or located in the center of femoral head, which is similar to the relationship between a circle's center and boundary. When the children thigh is in abduction or adduction position during examination, the displacement of H-point will be significantly greater than ossific nucleus which will be leading to obvious misjudgement by the IHDI classification.

Conclusions

The IHDI classification is subjectively easier to use, more accurate, and has favourable interobserver agreement for classifying DDH radiographically. The main reason is that the H-point and the D-line make it much easier to determine the severity of DDH accurately. IHDI classification should be considered as a good alternative to the Tonnis classification when considering DDH treatment, especially in patients without ossific nucleus.

References

1. Dezateux C, Rosendahl K. Developmental dysplasia of the hip. Lancet 2007;369:1541-52.

2. Orak MM, Onay T, Çağırmaz T, Elibol C, Elibol FD, Centel T, et al. The reliability of ultrasonography in developmental dysplasia of the hip: How reliable is it in different hands? Indian J Orthop 2015;49:610-4.

3. Atalar H, Dogruel H, Selek H, Tasbas BA, Bicimoglu A, Gunay C, et al. A comparison of ultrasonography and radiography in the management of infants with suspected developmental dysplasia of the hip. Acta Orthop Belg 2013;79:524-9.

4. Tönnis D. Indications and time planning for operative interventions in hip dysplasia in child and adulthood. Z Orthop Ihre Grenzgeb 1985;123:458-61.

5. Boniforti FG, Fujii G, Angliss RD, Benson MK. The reliability of measurements of pelvic radiographs in infants. J Bone Joint Surg Br 1997;79:570-5.

6. Upasani VV, Bomar JD, Parikh G, Hosalkar H. Reliability of plain radiographic parameters for developmental dysplasia of the hip in children. J Child Orthop 2012;6:173-6.

7. William TT, John BT. Classic. Translation: Hilgenreiner on congenital hip dislocation. J Pediatr Orthop 1986;6:202-14.

8. Rosen A, Gamble JG, Vallier H, Bloch D, Smith L, Rinsky LA, et al. Analysis of radiographic measurements as prognostic indicators of treatment success in patients with developmental dysplasia of the hip. J Pediatr Orthop B 1999;8:118-21.

9. Bolland BJ, Wahed A, Al-Hallao S, Culliford DJ, Clarke NM. Late reduction in congenital dislocation of the hip and the need for secondary surgery: Radiologic predictors and confounding variables. J Pediatr Orthop 2010;30:676-82.

10. Narayanan U, Mulpuri K, Sankar WN, Clarke NM, Hosalkar H, Price CT, et al. Reliability of a new radiographic classification for developmental dysplasia of the hip. J Pediatr Orthop 2015;35:478-84.

11. Judd J, Clarke NM. Treatment and prevention of hip dysplasia in infants and young children. Early Hum Dev 2014;90:731-4.

12. Alsaleem M, Set KK, Saadeh L. Developmental dysplasia of hip: A review. Clin Pediatr (Phila) 2015;54:921-8.

13. Ramo BA, De La Rocha A, Sucato DJ, Jo CH. A new radiographic classification system for developmental hip dysplasia is reliable and predictive of successful closed reduction and late pelvic osteotomy. J Pediatr Orthop 2018;38:16-21.

14. Viera AJ, Garett JM. Understanding interobserver agreement: The Kappa statistic. Fam Med 2005;27:360-3.

15. Kotlarsky P, Haber R, Bialik V, Eidelman M. Developmental dysplasia of the hip: What has changed in the last 20 years? World J Orthop 2015;6:886-901.

16. Murphy RF, Kim YJ. Surgical management of pediatric developmental dysplasia of the hip. J Am Acad Orthop Surg 2016;24:615-24.

17. Roposch A, Odeh O, Doria AS, Wedge JH. The presence of an ossific nucleus does not protect against osteonecrosis after treatment of developmental dysplasia of the hip. Clin Orthop Relat Res 2011;469:2838-45.

18. Roposch A, Wedge JH, Krahn MD. The role of the ossific nucleus in the treatment of established hip dislocation. Clin Orthop Relat Res 2006;449:295-302.

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