Int J Med Invest 2024; Volume 13; Number 4; 169-176 http://intjmi.com

Original Research

Evaluation of the Predictive Value of the Vertical Distance of the Greater Trochanter Tip from the Teardrop Line Compared to the Junction of the Femoral Head and Neck in Crowe Classification for Patients with Developmental Hip Dislocation

Alireza Sadeghpour[1], Ali Aghajani[2], Reza Noktesanj[3], Shahriyar Khoshbakht[4*]

1. Professor, Department of Orthopedics, Faulty of Medicine, Tabriz University of Medical Sciences, Tabriz, Iran. **Orcid:** 0000-0003-0585-4470

2. Orthopedic Surgeon of Ardebil University of Medical Science, Ardabil, Iran. **Orcid:** 0009-0007-7007-3829

3. Department of Surgery and Orthopedics, Ardabil University of Medical Sciences, Ardabil, Iran. **Orcid:** 0000-0001-9008-4487

4. Assistant Professor, Department of Orthopedic, Faculty of medicine, Ardebil University of Medical Sciences, Ardebil, Iran. **Orcid:** 0000-0002-7178-5934

***Corresponding Author: Shahriyar Khoshbakht,** Assistant professor, Department of orthopedic, Faculty of medicine, Ardebil University of Medical Sciences, Ardebil, Iran. **Email:** shahriyar_021 @yahoo.com.

Abstract

Background: Total hip arthroplasty (THA) in patients with developmental dysplasia of the hip (DDH) is challenging due to the severity of deformity and bone defects. This study aimed to evaluate the predictive value of using the tip of the greater trochanter as an alternative landmark in the Crowe classification to indicate femoral osteotomy in patients with developmental dysplasia of the hip.

Methods: This retrospective study examined 39 patients with developmental dysplasia of the hip who underwent total hip arthroplasty from 2018 to 2023. Based on radiographic assessments and surgical reports, five out of the six patients classified as Crowe type IV underwent femoral osteotomy. In addition, among the eight patients classified as Crowe type III, four underwent osteotomy. Based on the criterion of a greater trochanter height above 130%, nine out of nine patients required femoral osteotomy. The p-value for the greater trochanter height and all four Crowe classification types was calculated.

Results: All patients classified as Crowe types I and II had a GT score below 130%. Crowe type III patients with GT scores above 130% underwent osteotomy, while those with GT scores below 130% did not. In Crowe type IV patients, those with a GT score above 130% underwent osteotomy; only one patient in this group did not require osteotomy, and this patient had a GT score below 130%. There was a significant correlation between the GT score and each of the Crowe classification types.

Conclusion: Based on the results, the height of the greater trochanter can be used to predict whether femoral osteotomies should be performed during total hip arthroplasty in patients with developmental dysplasia of the hip.

Keywords: Developmental Hip Dislocation, Crowe Classification, Total Hip Arthroplasty.

Submitted: 11 Sep 2024 Revised: 8 Oct 2024 Accepted: 16 Nov 2024

Introduction

Developmental dysplasia of the hip (DDH) is a spectrum of hip developmental disorders that present at different ages. In most cases, this condition is caused by excessive laxity of the hip joint capsule, which makes it difficult to keep the femoral head within the acetabulum. The examiner usually detects subluxation (partial displacement) or dislocation of the femoral head from the acetabulum in infants with this syndrome. As the femoral head dislocates over time, there is no repositioning when the femoral head position changes. Children and adolescents with this syndrome experience a dislocated hip. Adults with this syndrome have a dysplastic hip characterized by inadequate acetabular coverage. The condition of Developmental Dysplasia of the Hip (DDH) is frequently associated with secondary osteoarthritis that eventually leads to Total Hip Arthroplasty (THA) in an adult (1). An arthroplasty is often necessary for patients with Crowe type IV DDH who have been unsuccessfully treated or neglected. THA in these patients is challenging due to changes in the acetabulum and proximal femur anatomy, as well as limb length discrepancies (2). Since DDH patients have anterolateral bone defects and severe deformities, total hip arthroplasty is technically challenging and challenging (3). A higher complication rate and lower patient satisfaction are associated with THA in the treatment of DDH patients compared to patients with primary degenerative osteoarthritis (4).

From a biomechanical perspective, it is preferable to place the acetabular component in its anatomical location, which potentially necessitates femoral shortening to prevent sciatic nerve injury by avoiding excessive femoral lengthening (2). Several techniques for femoral shortening in Crowe type IV hips have been described, including greater trochanteric osteotomy with or without distal advancement, step-cut subtrochanteric osteotomy, oblique subtrochanteric osteotomy, v-shaped osteotomy, transverse subtrochanteric osteotomy, and distal femoral osteotomy (5). However, some researchers have proposed alternative surgical methods for Crowe type IV patients to avoid femoral shortening. These alternatives include intraoperative injection of muscle relaxants, more extensive release of tightened soft tissues, preoperative iliofemoral leverage, and distraction, which can result in good clinical outcomes with acceptable complications (6-8). Morphological differences in the proximal femur, leading to the placement of the head-neck junction in various locations, have been emphasized in studies. In a 2020 study, Jin Yang Sun and colleagues (9) from Nankai University in China evaluated the predictive value of greater trochanter height as a criterion for hip dislocation height to determine the use of subtrochanteric osteotomy in THA for Crowe type IV DDH patients. In another study, Cheng and colleagues (10) from Shanghai Jiao Tong University in China in 2019 investigated the relationship between the Crowe classification and the three-dimensional displacement of the femoral head in DDH patients. In yet another study, Zhou and colleagues (11) reported that the morphology of the proximal femur varies in the presence and absence of a false acetabulum and that implants with different geometric specifications should be used for reconstruction in such cases.

The objective of the present study was to measure the distance between the teardrops on anteroposterior pelvic radiographs and classify them based on the Crowe classification based on the importance of the subject. A correlation was found between the vertical distances of the greater trochanter tip and the head-neck junction in the Crowe classification. This study examined to what extent the greater trochanter tip might be used as an alternative landmark in the Crowe classification to predict whether a patient with developmental dysplasia of the hip (DDH) needs a femoral osteotomy.

Materials and Methods

This cross-sectional analytical study was conducted jointly in the Orthopedics Department of the Medical School at Ardabil University of Medical Sciences and the Orthopedics Department of the Medical School at Tabriz University of Medical Sciences. A retrospective review of 334 total hip arthroplasty procedures performed at Shohada Hospital in Tabriz by our orthopedic team between early 2018 and early 2023 was conducted after ethical approval was obtained. In 194 cases, severe degenerative arthritis in older age was the cause, 71 cases were trauma-related, 18 cases were caused by avascular necrosis (AVN), and six cases had previous corrective surgery for DDH during childhood. These cases were excluded from the study. The exclusion criteria were patients with fractures due to trauma, degenerative arthritis in older age, avascular necrosis, inadequate preoperative radiographs, and DDH patients with a history of corrective surgery during childhood. Ultimately, 39 patients (42 hips) were included in the study. The sample size was initially estimated to be around 50 patients. According to the prevalence of developmental dysplasia of the hip in the population, which is approximately 3% based on previous studies, the minimum required sample size was calculated using the Cochran formula as follows:

N=Z2PQ/d2

In which, P represents the prevalence of the variable in the population, Q equals 1−P1 - P1−P, d is the margin of error, typically set at 0.05, and Z is a constant number, which equals 1.96 at a significance level of 0.05. By substituting the values into the above formula, the required sample size is calculated to be 45 individuals. However, considering the potential dropouts, the sample size was increased by 10%, resulting in a target of 50 individuals.

Data Collection

Demographic data, including age, gender, and surgical details, were collected from hospital records. Radiographic evaluations included standard digital anteroposterior pelvic radiographs taken before and after the surgery, as well as full-length femoral radiographs used for assessing femoral osteotomy. From the preoperative radiographs, we measured the height of the femoral head (HH), the vertical height of the head-neck junction (HNH), and the vertical height of the greater trochanter tip (GTH). In cases where the height of the femoral head could not be calculated, 20% of the total pelvic height was used as a substitute measure. We employed two methods to measure the preoperative dislocation height of the femoral head. The first method measured the height of the head-neck junction according to the Crowe classification. In contrast, the second method measured the height of the greater trochanter, using the greater trochanter tip as a reference, vertically drawing a line to the Inter-teardrop line. First, we measured the height of the head-neck junction on the preoperative anteroposterior radiograph and classified the patients into four groups according to the Crowe classification. Then, the height of the greater trochanter from the Inter-teardrop line was measured in all patients, and the ratio of the obtained measurement to the femoral head height (HH) was expressed as a percentage, termed the GT Score.

Next, we reviewed the surgical reports from the patient's medical records to determine the need for femoral shortening (osteotomy), and this information was entered into the statistical table. We then analyzed the correlation between the Crowe classification groups and the GT Score in patients who underwent osteotomy. Since, in most cases, osteotomy was performed when GT Score > 130%, this was considered the criterion for performing osteotomy based on the height of the greater trochanter. Before starting the study, all observers agreed on the measurement criteria. The measurements were conducted independently by two observers, who were not involved in the surgeries, after removing all identifiable markers.

The position of the head-neck junction can change due to varying neck-shaft angles. Due to the complex morphology of the femoral head, measuring the location of the head-neck junction can sometimes be challenging, especially in cases with severe wear or absence of the femoral head.

Statistical Analysis

The data were analyzed using IBM SPSS software version 24. Qualitative data were presented as numbers (percentages), while quantitative data with a normal distribution were reported as mean ± standard deviation. Differences between the two groups were assessed using the independent t-test or the Mann-Whitney test when necessary. Analysis of Covariance (ANCOVA) was conducted to compare differences between groups at the end of the study, adjusting for baseline values and disease duration. Demographic information was presented using descriptive charts and tables. A p-value of less than 0.05 was considered significant.

Ethical Considerations

The ethical considerations observed in this thesis were based on the 26 codes approved by the National Committee of Ethics in Biomedical Research, which include the following:

- Obtaining ethical approval with the identifier IR.ARUMS.MEDICINE.REC.1400.031 from the Ethics Committee of Ardabil University of Medical Sciences.
- Ensuring that the priority of societal benefit or scientific progress does not justify exposing subjects to unreasonable harm or restricting their autonomy.
- Ensuring that the material and moral rights of all relevant parties, including the subject, researcher, research team, and associated organizations, were respected in all productions and reports.
- Listing the names of the research team members.

Results

A total of 334 cases of total hip arthroplasty (THA) were performed by the orthopedic team at Shohada Hospital in Tabriz, Iran, in 2018-2023. This retrospective study included only 39 patients who met the study's inclusion criteria, resulting in a total of 42 hips (three patients had bilateral DDH) (Table 1).

In the 42 cases studied, 10 cases had distal femoral osteotomies, whereas 32 cases did not. Table 2 shows no statistically significant differences between the groups in terms of demographics ($p > 0.05$). As against the osteotomy group, the non-osteotomy group had a greater trochanter height of 46.31 mm (range: 16.85–81.06 mm), whereas the osteotomy group had a greater trochanter height of 70.84 mm (range: 60.28–125.59 mm). Table 3 shows that the height of the head-neck junction (HJ) was 31.19 mm in the non-osteotomy group (range: 7.55–42.44 mm) and 48.99 mm in the osteotomy group (range: 35.61–99.53 mm).

All patients classified as Crowe Type I and II had a GT Score below 130%. One patient classified as Crowe Type II underwent osteotomy despite having a GT Score below 130%. In Crowe Type III patients, those with a GT Score above 130% underwent osteotomy, whereas those with a GT Score below 130% did not require osteotomy. In Crowe Type IV patients, those with a GT Score above 130% underwent osteotomy. One patient in this group did not require osteotomy, and this patient also had a GT Score below 130% (Tables 4 and 5).

Discussion

According to the Crowe classification, it is generally assumed that anatomical abnormalities increase with higher femoral subluxation (2). Subtrochanteric osteotomy is likely performed in non-reducible Crowe type III and IV hips during THA. However, current studies have reported similar outcomes from THA with or without femoral shortening in these patients (12). We hypothesized that not all Crowe type III and IV hips would equally predict the need for femoral shortening and that osteotomy might be specifically suitable for certain cases. To our knowledge, this is the second study evaluating dislocation height to predict the use of subtrochanteric osteotomy. The results showed that both HGT and HJ were stronger indicators.

Based on our data, both HGT and HJ were equally effective in predicting the need for femoral shortening, which could be useful in predicting the use of distal femoral osteotomy before surgery. These two indicators may provide more assistance in clinical practice due to the easy availability of plain radiography. Before starting this study, we assumed that HJ would be less effective than HGT. On the one hand, the position of the head-neck junction can change due to varying neck-shaft angles among Crowe type IV hips. On the other hand, the greater trochanter, as the insertion point of the abductor muscles, may have its height more closely related to muscle contraction and shortening. Unexpectedly, they performed equally well in terms of predictive value. However, given the complex morphology of the femoral head, measuring HJ is often difficult, particularly in cases involving slipped epiphysis, severe iliofemoral osteoarthritis, or even resorbed femoral heads. Although the greater trochanter is a more stable reference point, its characteristics can vary between individuals, partially explaining the relatively lower specificity of HGT.

In the study by Jin Yang Sun and colleagues (9), they also concluded that the use of greater trochanter height as an indicator of dislocation height is beneficial in predicting the use of subtrochanteric osteotomy during THA for Crowe type IV hip dysplasia. Cheng and colleagues (10) examined the relationship between the Crowe classification and the three-dimensional displacement of the femoral head in DDH patients. The severity of DDH, according to the Crowe classification, was associated with the degree of superior-inferior displacement rather than medial-lateral or anterior-posterior displacement.

In the study conducted by Zhou et al. (11), the morphological differences in developmental hip dislocation types were investigated. They found that the morphology of the proximal femur varies in the presence or absence of a false acetabulum, necessitating the use of implants with different geometric specifications for reconstruction. In another study by Hartofilakidis and colleagues (13), the outcomes of joint reconstruction in patients with developmental hip dislocation across different subtypes were examined. In this study, joints classified as type 1C were more frequently reconstructed. There was no significant difference in pain, function, and mobility between these two types. However, type 1C joints exhibited greater lengthening. The authors concluded that morphological differences in joints with developmental hip dislocation lead to varying reconstruction outcomes in these patients.

Wells and colleagues (14) investigated the three-dimensional imaging of the femoral head and neck and associated deformities in patients with developmental hip dislocation. According to their findings, cam-type deformities are common in these patients. However, the morphology of the proximal femur covers a wide range, potentially impacting the results of joint reconstruction surgery. Additionally, it should be acknowledged that several other factors may influence the decision to perform femoral osteotomy, such as proximal femoral deformity, secondary medullary obstruction due to pyogenic arthritis, and instrument impingement during surgery, which necessitates osteotomy (15-16).

Study Limitations

This study has several limitations. First, it is a retrospective study. We relied on radiographs with minimal recall bias. Second, multiple confounding factors influencing the surgeon's decision to perform osteotomy must be excluded. Therefore, a comprehensive and multivariate analysis may be necessary in the future. Furthermore, this study was designed as a diagnostic test and did not consider the outcomes of THA with and without osteotomy. Lastly, this was a single-center, single-surgeon study, limiting its external validity. Nevertheless, the accurate prediction of the greater trochanter in indicating osteotomy in hip arthroplasty is noteworthy.

Conclusion

This study demonstrates that HGT is a stronger predictor than HJ in predicting the need for femoral osteotomy during THA for Crowe type III and IV patients.

Acknowledgment

None

Funding

None

Authors Contributions

The author contributed to the data analysis. Drafting, revising and approving the article, responsible for all aspects of this work.

Ethical Consideration

None

References

1.Kosuge D, Yamada N, Azegami S, et al. Management of developmental dysplasia of the hip in young adults: current concepts. Bone Joint J. 2013;95-B(6):732–737. doi:10.1302/0301-620x.95b6.31286

2. Greber EM, Pelt CE, Gililland JM, et al. Challenges in total hip arthroplasty in the setting of developmental dysplasia of the hip. J Arthroplasty. 2017;32(9):S38–S44. doi:10.1016/j.arth.2017.02.024

3. Meermans G, Doorn JV, Kats JJ. Restoration of the center of rotation in primary total hip arthroplasty. Bone Joint J. 2016;98-B(12):1597–603.

4.Jasty M, Anderson MJ, Harris WH. Total hip replacement for developmental dysplasia of the hip. Clin Orthop Relat Res. 1995;311:40–5.

2016.11.005.

5. Yang S, Cui Q. Total hip arthroplasty in developmental dysplasia of the hip: a review of anatomy, techniques, and outcomes. World J Orthop. 2012;3(5):42–48. doi:10.5312/wjo.v3.i5.42.

6. Yan F, Chen G, Yang L, et al. A reduction technique of arthroplasty without subtrochanteric femoral shortening osteotomy for the treatment of developmental high dislocation of the hip: a case series of 28 hips. J Arthroplasty. 2014;29(12):2289–2293. doi:10.1016/j.arth. 2013.11.016.
7. Binazzi R. Two-stage progressive femoral lowering followed by cementless total hip arthroplasty for treating Crowe IV-hartofilakidis type 3 developmental dysplasia of the hip. J Arthroplasty. 2015;30 (5):790–796. doi:10.1016/j.arth.2014.12.019.
8. Yixin Zhou. et al,Primary total hip arthroplasty ,Deijing jishuitan hospital.Beijing china.2022 ;83-84
9 . Jingyang Sun,et al. Dislocation Height Performs Well in Predicting the Use of Subtrochanteric Osteotomy in Crowe Type IV Hips. Therapeutics and Clinical Risk Management 2020:16 989–997
10. Cheng et al. Relations between the Crowe classification and the 3D femoral head displacement in patients with developmental dysplasia of the hip. BMC Musculoskeletal Disorders (2019) 20:530
11. Xu H, Zhou Y, Liu Q, Tang Q, Yin J. Femoral morphologic differences in subtypes of high developmental dislocation of the hip. Clin Orthop Relat Res. 2010;468(12):3371–6.
12. BJERKREIM I, ÅRSETH PH, Palmén K. Congenital dislocation of the hip in Norway late diagnosis CDH in the years 1970 to 1974. Acta Pædiatrica. 2012;67(3):329–32.
13. Hartofilakidis G, Babis GC, Lampropoulou-Adamidou K, Vlamis J. Results of total hip arthroplasty differ in subtypes of high dislocation. Clin Orthop Relat Res. 2013;471(9):2972–9.
14. Wells J, Nepple JJ, Crook K, Ross JR, Bedi A, Schoenecker P, et al. Femoral morphology in the dysplastic hip: three-dimensional characterizations with CT. Clin Orthop Relat Res. 2017;475(4):1045–54.
15. Perry KI, Berry DJ. Femoral considerations for total hip replacement in hip dysplasia. Orthop Clin North Am. 2012;43(3):377–386. doi:10.1016/j.ocl.2012.05.010
16. Rosenstein AD, Diaz RJ. Challenges and solutions for total hip arthroplasty in treatment of patients with symptomatic sequelae of dev elopmental dysplasia of the hip. Am J Orthop. 2011;40(2):87–91.

Tables

Table 1. Frequency of variables

		Frequency	Percent
Sex	Male	9	21.4
	Female	33	78.6
Crowe Type	Crowe type 1	24	57.1
	Crowe type 2	4	9.5
	Crowe type 3	8	19.0
	Crowe type 4	6	14.3
GT Score	under 130%	33	78.6
	above 130%	9	21.4
Osteotomy	No osteotomy	32	76.2
	Osteotomy	10	23.8

Table 2. Average (standard deviation) of demographic information

	Osteotomy		**P-Value**
	No osteotomy	Osteotomy	
Age	45.02 (10.03)	44.80 (9.46)	0.937
Sex			0.058
Male	9 (100.0%)	0 (0.0%)	
Female	23 (69.7%)	10 (30.3%)	

Table 3. Average HNJ and average GTH

	HNG Average	
	No osteotomy	**Osteotomy**
Crowe type 1	14.20(7.55-22.86)	0
Crowe type 2	28.3(22.93-34.63)	35.61
Crowe type 3	39.83(36.88-41.92)	42(39.95-45.03)
Crowe type 4	69.37(40.70-99.53)	42.44
		GTH Average
Crowe type 1	34.91(16.85-50.24)	0
Crowe type 2	33.64(27.37-38.93)	62.31
Crowe type 3	63.91(53.80-81.06)	66.11(62.43-68.30)
Crowe type 4	52.80	84.10(60.28-125-59)

Table 4. Standard deviation in four types of Crow and GT score

		Osteotomy performance		P-Value
		No osteotomy	Osteotomy	
Crowe Type	Crowe type 1	24 (100.0%)	0 (0.0%)	<0.001
	Crowe type 2	3 (75.0%)	1 (25.0%)	
	Crowe type 3	4 (50.0%)	4 (50.0%)	
	Crowe type 4	1 (16.7%)	5 (83.3%)	
GT Score	under 130%	32 (97.0%)	1 (3.0%)	<0.001
	above 130%	0 (0.0%)	9 (100.0%)	

Table 5. Standard deviation in four types of Crow compared to GT score

	GT Score	Osteotomy performance		P-Value
		No osteotomy	Osteotomy	
Crowe type 1	Under 130%	24 (100%)	0(0%)	
	Above 130%	0(0%)	0(0%)	
Crowe type 2	Under 130%	3 (75%)	1 (25%)	
	Above 130%	0(0%)	0(0%)	
Crowe type 3	Under 130%	4 (100%)	0(0%)	0.005
	Above 130%	0(0%)	4 (100%)	
Crowe type 4	Under 130%	1 (100%)	0(0%)	0.014
	Above 130%	0(0%)	5 (100%)	