ACTA
ORTHOPAEDICA
et
TRAUMATOLOGICA
TURCICA

Author s translation
Acta Orthop Traumatol Turc 2007;41 Suppl 1:14-18

Evidence-based current concepts in the radiological diagnosis and follow-up of developmental dysplasia of the hip

Gelişimsel kalça displazisinin radyolojik tanı ve izleminde kanıta dayalı yeni görüşler

Hakan OMEROGLU, Alper KAYA, Berk GUCLU

Ufuk University Faculty of Medicine, Department of Orthopaedics and Traumatology

Bu derlemede gelişimsel kalça displazisinin (GKD) radyolojik tanı ve izleminde son beş yılda ortaya konan kanıta dayalı bazı yeni görüşler özetlenmiştir. Graf yöntemiyle kalça ultrasonografisinde standart plan elde etme oranının 1-6 yaşlar arasında %66 ile %93 arasında değiştiği ve bu oranın özellikle 1-3 yaş arasında %90'ın üzerinde olduğu belirtilmiştir. Gerek Sharp'ın asetabuler açısının gerekse merkez-kenar açısının ölçümlerinde asetabulum tavanının en dış noktası yerine asetabuler subkondral sklerozun en dış noktasının ölçüm noktası olarak kullanılmasının kalça eklemindeki patolojiyi daha doğru tanımlayabileceği bildirilmiştir. Patolojiyi daha etkin biçimde tanımlayabilmek amacıyla, asetabulum ve femur başı merkezleri arasındaki uyumu değerlendirmede MZ uzaklığını ölçmek için iki alternatif yöntem geliştirilmiştir. Bugüne kadar yalnızca bilgisayarlı tomografide ölçülebilen asetabuler anteversiyon için standart ön-arka pelvis grafisinde asetabuler anteversiyon açısı ölçümü tanımlanmıştır. Bu açının düz grafide tanımlanan ön ve arka asetabuler duvar çizgileri arasında ölçüldüğü ve bilgisayarlı tomografi ile elde edilene son derece yakın değerler verdiği ortaya konmuştur. Diğer yöntemde, proksimal femurun değerlendirilmesinde femur başı merkezi ile büyük trokanterin üst ucunun birbirlerine göre konum ve uzaklıklarının milimetre cinsiden ölçüldüğü merkez-trokanter uzaklığı tanımlanmıştır. Gelişimsel kalça displazisi sağaltım sonuçlarının radyografik değerlendirmesinde Severin sınıflamasının yetersiz kalması üzerine, asetabulumun eğimi, proksimal femurun şekli ve asetabulum-proksimal femur ilişkisinin sayısal olarak değerlendirildiği yeni bir radyografik değerlendirme ve skorlama sistemi geliştirilmiştir. Kanıta dayalı bu yeni görüşler klinik uygulamada kullanılabilir nitelikte bulunmuştur.

This review summarizes some new concepts introduced in the past five years for the radiological diagnosis and follow-up of developmental dysplasia of the hip (DDH). It has been found that the rates of obtaining a standard plain in hip ultrasonography using the Graf method range from 66% to 93% between 1 and 6 years, being greater than 90% between 1 and 3 years. It has been reported that taking the lateral point of acetabular subchondral sclerosis as the measuring point, instead of the lateral point of the acetabular roof, while measuring both the Sharp's angle and the center-edge angle could better define the global hip pathology. To define the pathology more accurately, two alternative methods have been developed to measure the MZ distance that delineates the congruency between the centers of the acetabulum and the femoral head. Measurement of the acetabular anteversion angle on standard anteroposterior pelvis radiography have been defined, that would otherwise be measured only on computed tomography. This angle is measured between the anterior and posterior acetabular wall lines on a plain radiograph, yielding very close values to those obtained by computed tomography. The other method measures the center-trochanter distance in millimeters between the center of the femoral head and the uppermost point of the greater trochanter to evaluate the proximal femur. As the Severin classification proved to be insufficient for the radiographic evaluation of the treatment results in DDH, a new radiographic classification and scoring system has been developed, that numerically evaluates acetabular inclination, shape of the proximal femur, and the relation between the acetabulum and the proximal femur. These evidence based new concepts are considered useful in the clinical practice.

Correspondence to: Dr. Hakan Omeroglu. Ufuk University Faculty of Medicine, Department of Orthopaedics and Traumatology, 06520 Ankara-Turkey.
Phone:+90312 - 204 41 26 Fax: +90312 - 287 23 90 e-mail: homeroglu@superonline.com

Several imaging techniques are used in both diagnosis and the follow-up of developmental dysplasia of the hip (DDH). Accepted golden standard for diagnosis is hip ultrasonography for the first 4-6 months of life and anteroposterior pelvis radiography for the rest of the life. Anteroposterior pelvic plain radiography has still been accepted as the golden standard during the follow-up after treatment. Computerized tomography (CT) and magnetic resonance imaging (MRI) are not referred as primary methods since they both require sedation and the first one a doze of radiation and the latter is economically costly. However, MRI is used specifically for the diagnosis and follow-up of redislocation or complications like avascular necrosis of the femoral head after treatment and as an additional imaging method to plain radiography for the evaluation of joint cartilage. Together with the classical information, medical science advances in the light of new concepts and inventions. In this review, some evidence based new concepts on radiological diagnosis and follow-up of DDH introduced within the last five years will be discussed.

Uppermost age limit for hip ultrasonography by the graf's method

Graf and Wilson[1] reported that uppermost age limit age for their method is one year and after that the method is not useful since femoral head ossification center may obscure the definition of lower edge of ilium (deep point) which is crucial for standard plan hip ultrasonography. However, if only bone edge and cartilage frame require to be evaluated, this method can be used instead of more invasive methods such as arthrography.[1] Özçelik et al.[2] in a clinic study found the standard plan obtaining ratio in hip ultrasonography by the Graf method as 93% between 13-24 months, 91% between 25-36 months, 84% between 37-48 months, 79% between 49-60 months and 66% between 61-72 months. It was also reported that hip ultrasonography by Graf method might be used in addition to plain radiography which was the golden standard between 1 and 5 years of age for the evaluation of both bone and cartilage frames of the hip joint if a standard plan could be obtained. Besides the availability of Graf method over one year of age, Terjesen[3] method can be used effectively in older children. We evaluate bone and cartilage frame using hip ultrasonography specifically in children between 1 year and 3 years of age among anteroposterior plain pelvic radiography that we use in daily clinical practice in DDH diagnosis and follow-up of older children.

Measurement of acetabular slope in the frontal plane on a plain radiograph (acetabular angle of Sharp)

Acetabular angle of Sharp[4] that has been defined for the measurement of acetabular slope on a standard anteroposterior pelvis roentgenogram is one of the two frequently used methods. It has been described classically on anteroposterior pelvis graphy as the angle between the line combining both lower edges of the teardrops and the line drawn between the outermost point of acetabulum and the lower edge of the teardrop. Ağuş et al. [5] described a modified acetabular angle measurement method and proposed to use the lateral point of subchondral sclerosis in acetabulum instead of the most lateral point of acetabular bony roof as the index point. They reported that both measurements done by classical and newly defined method were effective in determining the inclination of acetabulum in the frontal plane. However measurements done by classical methods on dysplastic hips may introduce more optimistic results whereas measurements by newly defined methods can reveal acetabular inclination in the frontal plan more correctly because it has been reported that acetabulum which is distant to its lateral point (type 4 acetabulum)[6] and of which subchondral sclerosis is deformed has insufficiency in middle-superior and posterior walls in the transverse plane. It has also been reported that there is approximately 2 degrees of error margin in measurements done by newly defined method so reliability of this method is sufficient.[5] Moreover, Özçelik et al.[7] reported that Turkish people's upper limit for the Sharp's acetabular angle by the classical method was 2-3 degrees higher than the ones of other races, so this must be considered during evaluation. In our daily clinical practice we measure Sharp's acetabular angle by both methods, but also bear in mind the newly defined method especially for hips with insufficient bony roof.

Measurement of the lateral coverage of the femoral head in the frontal plane by plain radiography (Center-edge angle)

Center-edge angle described by Wiberg[8] is one of the most frequently used angular evaluation method in DDH. Center-edge angle is recommended for 5 years old and older people and is described as the angle between a line drawn parallel to body midline (sacrum) and a line between the femoral head center (C point) and the most lateral point of acetabulum (E point). However, Ogata et al.[9] defined a new measurement method taking the lateral point of subchondral sclerosis in acetabulum as the E point. Ömeroğlu et al. compared classic and modified measurement methods of center-edge angle and suggested that specifically classical method center-edge angle measurements of type 4 acetabulum defined by Ogata et al.[9] might yield optimistic results. They reported that measurement error in classical method is approximately 3-4 degrees whereas 4-5 degrees in newly defined method but were satisfied by the reliability of both methods. In Turkish population classical center-edge angle normal minimum values are 15 degrees between 5-10 years, 19 degrees between 11-15 years, 20 degrees between 16-55 years and 24 degrees for over 55 years of age.[10] In our daily clinical practice, we use both methods, nevertheless we consider using newly defined method particularly in dysplastic hips.

Determining the acetabulum and femoral head relationship on plain radiography

MZ distance defined by Tönnis is the measurement of vectorial distance between the acetabular centre (M) and the femoral head centre (Z), on an anteroposterior pelvis graphy in millimeters. (Figure 1) The MZ distance showing consistency or inconsistency between femoral head and acetabular centers has not received much acceptance except the German School. Özçelik and Ömeroğlu[12] developed two new methods to measure MZ distance and argued them to be more useful than the classical one. In the first described method vectorial distance was a "+" value if Z point was on the medial side of M point and "-" value if on the lateral. Thus, it was possible to do an exact determination of positions and distance of M and Z points with respect to each other. In the second described method; distance between the lines parallel to body middle line crossing M and Z points were measured in millimeters and this value described as "+" and "-" according to their position on the medial or lateral respectively. It was reported that with this method it was possible to do an exact determination of positions and distance of M and Z points with respect to each other on the x-axis. With this study, it was determined that MZ distance no matter measured by the new or classical method was in relation with the widely used center-edge angle. Mean error margin was about 1-2 mm in both methods.[12] In our daily clinical practice we use MZ distance rarely but believe that it is a highly useful measurement and evaluation method when lateralization should be numerically proven with respect to femoral head acetabulum.

Acetabular anteversion measurement on a plain radiography

Computerized tomography seems to be the most effective method to measure acetabular anteversion.[11] However, a simpler, cheaper and less time-consuming method with less radiation exposure to the patient with effective and reliable acetabular anteversion measurement on plain graphy has not been defined for many years. Özçelik et al.[13] suggested that the method they described could measure acetabular anteversion on standard anteroposterior pelvis graphy as reliable and effective as computerized tomography (Figure 2). In

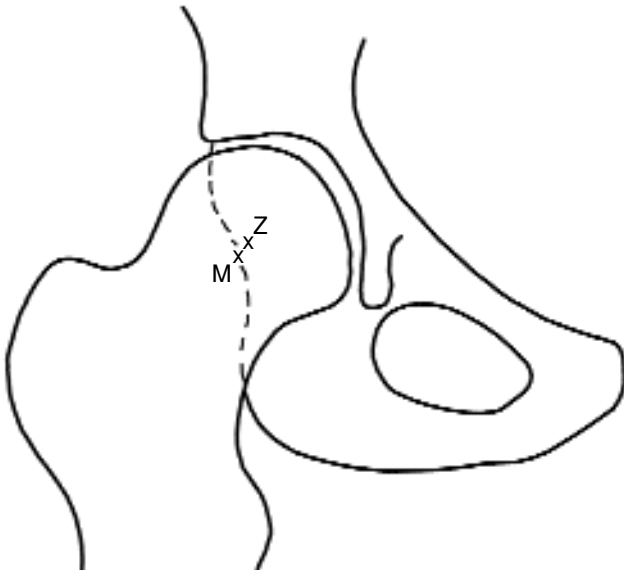

Figure 1. Measurement of MZ distance by classical method.[11] M: Acetabulum center (middle point of the line between upper and bottom lateral acetabular edge.); Z: Femoral head center

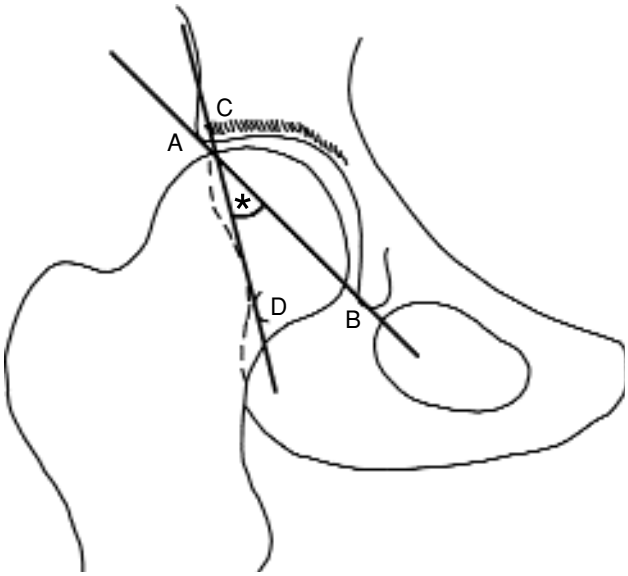

Figure 2. Measurement of acetabular anteversion angle (*) on plain anteroposterior radiography.[13] Measurement of acetabular anteversion angle (*) on plain anteroposterior radiography.[13] It is the angle between AB line (anterior wall line) and CD line (posterior wall line). A: lateral edge of acetabulum (outermost anterolateral edge of bony roof).[5] B: Bottom edge of the curve joining inner and outer edges of the teardrop (anterior semicylindric cortex of acetabular notch). [14] C: Outermost edge of subchondral sclerosis (lateral point of acetabular posterior bony roof) [6] D: A little lucent crescent in the bottom part of acetabulum; posterior lunate surface sclerosis (the bottom point where the acetabulum reaches to acetabular notch, posteriorly).[11]

their study performed on thirty-nine volunteers, acetabulum anteversion was measured in the same individuals by both CT and plain graphy and it was found that there was 2.5 degrees difference between the two methods, moreover plain graphy and CT had a strong positive correlation. They also reported that their method had approximately 1.5 degree measurement error.[13] All measurement points used in this method were anatomically defined beforehand.[6, 11, 14] In our clinical practice when acetabular anteversion measurement is necessary we prefer to use this method since it is cheaper, simpler and less harmful to the patient.

Evaluation of proximal femur on plain graphy (Center-trochanter distance)

A variety of methods are being used for the radiological evaluation of proximal femur. Most commonly used methods are plain graphy for head-neck-diaphysis angle, articulotrocanteric distance measurements[11], and CT for femoral head anteversion measurement.[15] Ömeroğlu et al. proposed a new measurement method called center-trochanter distance (CTD) on standard anteroposterior pelvis graphy and described it as the distance between two parallel lines crossing femoral head center (C) and upper edge of greater trochanter (T) in millimeters. They pointed out if M point was over T point, the obtained value should be defined as "+" and if vice versa the value was defined as "-". They also reported that while using CTD values according to different age groups, this method had a measurement error approximately 1-2 mm. It has been emphasized that in clinical practice a significant increase in CTD may depend on increased head-neck-diaphysis angle and/or femoral head anteversion whereas significant decrease may be resultant of decreased head-neck-diaphysis angle or a relative growth of greater trochanter with shortening of femoral neck.[16] In our daily clinical practice we pre-

Table 1. New radiographic evaluation system available for 5 years old and older cases in developmental dysplasia of th hip[21]

Radiographic parameters	2 Points	1 Point	0 Points
Center-edge (CE) angle (°)	≥15*	0-14*	<0*
	≥20**	5-19**	<5**
Sharp's angle (°)	≤49*	50-55*	>55*
	≤43**	44-49**	>49**
Center-trochanter distance(mm)	between0+10*	between -1-5 and +11+15	<–5 and >+15*
	between-11and+1**	between-12-17 and +2+7**	<–17 and>+7**

*Hips with incomplete skeletal maturity (one or more of the Y cartilage, proximal femoral growth cartilage or greater trochanter growth cartilage is open); ** Hips with completed skeletal maturity (all of the Y cartilage, proximal femoral growth cartilage or greater trochanter growth cartilage are closed).

Corrections (-1 point each)

1) Existence of type 4 acetabulum according to Ogata et al.[6] ; 2)Secondary operation(s) (closed reduction, soft tissue or bone surgery); 3) Early redislocation or resubluxation.

Total score: 6 Points: Excellent; 5 Points: Good; 4 Points: Fair+; 3 Points: Fair-; <3 Points: Poor; 5-6 points: Satisfactory result; <5 Point(s): Unsatisfactory result.

fer to use CTD for plain radiographic evaluation of proximal femur since it is simple, harmless, reliable and not time consuming.

Radiographic evaluation of treatment results (A new and objective classification system)

Radiographic assessment system described by Severin[17] is still used as the golden standard. However, in two separate studies questioning the reliability of this classification; limited objectivity, inclusion of subjective concepts and poor reliability of the classification were emphasized.[18,19] Moreover, the opinion that measurements done by using only one radiological parameter could not correctly evaluate pathologic anatomy of the entire hip especially in subluxated and dislocated hips, was emphasized.[20] Radiographical evaluation system developed by Ömeroğlu et al.[21] consisted of the evaluation of three different parameters objectively assessing acetabular inclination, type of proximal femur and acetabulum-proximal femur relationship[4, 8, 16] and resultant scoring system after corrections were done (Table 1). It was reported that not only observational reliability of the system was satisfactory but also it assessed whether or not initial treatment was successful. It was suggested that Severin classification yields more optimistic results than the new system and in evaluations performed by both systems, the evaluation done before the skeletal maturity was more optimistic than the one after the skeletal maturity.[21] We use new evaluation system in our daily clinical practice.

References

1. Graf R, Wilson B. Sonography of the infant hip and its therapeutic implications. Weinheim: Chapman & Hall; 1995.
2. Ozcelik A, Akcar N, Inan U, Omeroglu H. Assessment of the use of hip ultrasonography by Graf's method between 1 and 6 years of age. J Pediatr Orthop B 2005;14:97-100.
3. Tegnander A, Terjesen T. Reliability of ultrasonography in the follow-up of hip dysplasia in children above 2 years of age. Acta Radiol 1999;40:619-24.
4. Sharp IK. Acetabular dysplasia: the acetabular angle. J Bone Joint Surg [Br] 1961;43-B:268-72.
5. Agus H, Bicimoglu A, Omeroglu H, Tumer Y. How should the acetabular angle of Sharp be measured on a pelvic radiograph? J Pediatr Orthop 2002;22:228-31.
6. Ogata S, Moriya H, Tsuchiya K, Akita T, Kamegaya M, Someya M. Acetabular cover in congenital dislocation of the hip. J Bone Joint Surg [Br] 1990;72:190-6.
7. Ozcelik A, Omeroglu H, Inan U, Ozyurt B, Seber S. Normal values of several acetabular angles on hip radiographs obtained from individuals living in the Eskisehir region. [Article in Turkish] Acta Orthop Traumatol Turc 2002;36:100-5.
8. Wiberg G. Studies on dysplastic acetabula and congenital subluxation of the hip joint: with special reference to the complication of osteoarthritis. Acta Chir Scand 1939; 83(Suppl 58):1-135.
9. Omeroglu H, Bicimoglu A, Agus H, Tumer Y. Measurement of center-edge angle in developmental dysplasia of the hip: a comparison of two methods in patients under 20 years of age. Skeletal Radiol 2002;31:25-9.
10. Ozcelik A, Omeroglu H, Inan U, Seber S. Center-edge angle values in normal hips of children and adults in Turkish population [Article in Turkish]. J Arthroplasty Arthroscopic Surg 2001;12:115-9.
11. Tonnis D. Congenital dysplasia and dislocation of the hip in children and adults. Berlin: Springer Verlag; 1987.
12. Ozcelik A, Omeroglu H. Two alternative methods for the measurement of MZ distance on a hip radiograph. Arch Orthop Trauma Surg 2003;123:215-8.
13. Ozcelik A, Calisir C, Akalin Y, Seber S, Omeroglu H. Measurement of acetabular anteversion on a plain radiograph. SICOT/SIROT 2005 XXIII. World Congress Abstract Book; 2-9 September 2005; Istanbul, Turkey. Istanbul; 2005. p. 232.
14. Tachdjian MO. Pediatric orthopedics. Vol. 1, 2nd ed. Philadelphia: W. B. Saunders Company; 1990. p. 317-22.
15. Edgren W. Coxa plana. A clinical and radiological investigation with particular reference to the importance of the metaphyseal changes for the final shape of the proximal part of the femur. Acta Orthop Scand Suppl 1965;Suppl 84:1-129.
16. Omeroglu H, Ucar DH, Tumer Y. A new measurement method for the radiographic assessment of the proximal femur: the center-trochanter distance. [Article in Turkish] Acta Orthop Traumatol Turc 2004;38:261-4.
17. Severin E. Contribution to the knowledge of congenital dislocation of the hip joint. Late results of closed reduction and arthrographic studies of recent cases. Acta Chir Scan 1941; 84[Suppl 63];1-142.
18. Ali AM, Angliss R, Fujii G, Smith DM, Benson MK. Reliability of the Severin classification in the assessment of developmental dysplasia of the hip. J Pediatr Orthop B 2001; 10:293-7.
19. Ward WT, Vogt M, Grudziak JS, Tumer Y, Cook PC, Fitch RD. Severin classification system for evaluation of the results of operative treatment of congenital dislocation of the hip. A study of intraobserver and interobserver reliability. J Bone Joint Surg [Am] 1997;79:656-63.
20. Omeroglu H, Ozcelik A, Inan U, Seber S. Assessment of the correlation between commonly used radiographic parameters in normal, subluxated and dislocated hips. J Pediatr Orthop B 2006;15:172-7.
21. Omeroglu H, Hakan Ucar D, Tumer Y. A new, objective radiographic classification system for the assessment of treatment results in developmental dysplasia of the hip. J Pediatr Orthop B 2006;15:77-82.