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SUMMARY OF RESEARCH

Name, and surname of the researcher: Balamani Venkatakrishnan

Topic of the work: Evaluating pelvic rotation on X-ray in patients who have undergone screening for hip dysplasia.

Goal of research – To evaluate effect of pelvic rotation on newborns X-rays.

Objectives (3-4)
1. Measuring the pelvic rotation on plain x-rays
2. Measuring the alfa angles, ischial bone thickness, pubofemoric distance on both hips
3. Measuring the correlation of pelvic rotation and other indices such as alfa angles, ischial bone thickness, pubofemoric distance

Selection and mode of data collection: Plain x-rays images and data of 97 patients (age, gender) are collected who have undergone screening for hip dysplasia.

Methodology: We measured pelvic rotation and other indices such as alfa angles, ischial bone thickness, pubofemoric distance on x-rays of 97 infants. Of them, 45 are boys and 52 are girls. Patients radiographs are collected without considering whether it is normal or abnormal.

Research results: The correlation of pelvic rotation and other indices such as alfa angles, ischial bone thickness, and pubofemoric distance is measured and the correlation we got wasn't significant. So these infants are continued having the same follow-up.

Ensuring of the respondents’ confidentiality:
The confidentiality of respondents is ensured because the research is anonymous and the names, surnames and other personal data of the respondents are not collected. Only the generalized research results will be published.

Assessment of possible risk and damage to the patients:
There will be no risk and damage to the patients because these radiograph images are taken only for clinical purposes. Our research doesn't change the treatment and outcomes of patients with hip dysplasia. This research is solely for having better diagnostic results for hip dysplasia.
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I would like to thank Saulius Rutkauskas MD PhD for his help in collecting the patient data and clarified my doubts whatever I had.

CONFLICT OF INTEREST

The author reports no conflicts of interest.

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ABBREVIATIONS

Alfa Angle (AA)

Hilgenreiner's Line (HL)

Ischial Thickness (IT)

PuboFemoric Distance (PFD)

Pubic Shadow (PS)

Ischiopubic Ratio (IPR)

Patient's Rotation (PR)

Developmental Dysplasia of the Hip (DDH)
INTRODUCTION

DDH is the most common hip pathology noted in infants. It includes a wide spectrum of abnormal relationships between femoral head and acetabulum. Most studies report an incidence of 1 to 34 cases per 1,000 live births and differences could be due to different diagnostic methods and timing of evaluation. Late diagnosis may lead to early development of secondary osteoarthritis in hip, in addition to abnormal/painful gait. DDH is traditionally detected on physical examination but there are false positive and false negative cases appear when doing physical examination alone resulting in either over treatment or under treatment respectively. So either ultrasound or radiography is used as an adjunct to physical examination depending on the infant's age. Radiographically infants are determined normal or abnormal by acetabular angle. Other indices also exist. But the most commonly used one is acetabular angle. But radiographs are unreliable since it can be used only after the ossification centre is developed most often after 4 months of age. Acetabular angle changes with age from 30° (+/- 5°) at at birth to 20° (+/- 5°) at 5 years. Tonnis reported that values falling two standard deviations above the mean were definitely pathological, but that a grey area existed between one and two standard deviations. He concluded that all these above a single standard deviation should be treated as only 25% become normal without treatment over time. So for which infants the hip normalises over time is an unanswered question because there are no other indices exist to determine that. As with all radiographic measures inaccuracies are common if positioning of the child allows postural artifacts to occur.

The centre edge angle of Wiberg is notoriously difficult to measure in the under 5’s, as it is difficult to pinpoint the centre of the femoral head. For this reason there are no meaningful data of normal values and it is therefore of very limited clinical value at this age. It does, however, offer an indication of femoral head lateralization. Tonnis described the lower limit of normal, in other words one standard deviation below the mean to increase from 19 in 5 year olds, to 25 in 10 year olds. Wiberg considered the adult normal range to be 20 to 40.

Although it is difficult to attach numerical values to Shenton’s line this is one of the most useful radiological findings in DDH. A break in Shenton’s line may best be considered a binary event, and denotes proximal or lateral migration of the femoral head. The Severin radiographic classification (1941) is popular with authors, although debate exists where the cut-off between each of the four groups (six in the modified classification) lies. The radiographic findings in DDH are problematic in that there are no sharp distinctions between pathology and normality. This subtle spectrum is the core of the problem for the management of DDH.

So to counter this disadvantage, our aim is to evaluate effects of patient rotation on other indices such as alfa angles, ischial thickness, and pubofemoric distance radiographically for better diagnosis of DDH.
AIM AND OBJECTIVE OF THE THESIS

DDH is a condition which affects the infants. It results from abnormal relationship between femoral head and acetabulum. It is suspected by having the risk factors such as first born status, female sex, positive family history, breech presentation and oligohydramnios. The suspicion also arises from abnormal physical examination findings. The abnormal physical signs include clicking in barlow and ortolani tests, abnormal thigh folds, leg length discrepancy, shorting of the femur with hips and knees flexed (Galeazzi sign) and swaddling. Ultrasound and radiography act as an adjunct to physical examination depending on the infant's age. Radiography is performed once the child reaches 4 months of age after the ossification centre is developed. Radiography is evaluated by many indices but one of the most common indices which is used is acetabular angle. Acetabular angle changes over time with the highest range being 30°. Tonnis concluded that all these above a single standard deviation should be treated as only 25% become normal without treatment over time. But which infants need subsequent treatment depending on the infant's age remains still controversial. Many false positive cases also occur. The radiographic findings in DDH are problematic in that there are no sharp distinctions between pathology and normality. This subtle spectrum is the core of the problem for the management of DDH. So our goal is to evaluate effects of pelvic rotation on other indices such as alfa angles, ischial thickness, PF distance.

This goal is achieved by objectives:
1. Measuring the pelvic rotation on plain x-rays
2. Measuring the alfa angles, ischial thickness, PF distance on both hips
3. Measuring the correlation of pelvic rotation and other indices such as alfa angles, ischial thickness, PF distance.
LITERATURE REVIEW

Developmental dysplasia of the hip (DDH) is a spectrum of anatomical abnormalities of the hip joint in which the femoral head has an abnormal relationship with the acetabulum. Most studies report an incidence of 1 to 34 cases per 1,000 live births and differences could be due to different diagnostic methods and timing of evaluation. Risk factors include first born status, female sex, positive family history, breech presentation and oligohydramnios. Clinical presentations of DDH depend on the age of the child. Newborns present with hip instability, infants have limited hip abduction on examination, and older children and adolescents present with limping, joint pain, and/or osteoarthritis. Repeated, careful examination of all infants from birth and throughout the first year of life until the child begins walking is important to prevent late cases. Provocative testing includes the Barlow and Ortolani maneuvers. Other signs, such as shorting of the femur with hips and knees flexed (Galeazzi sign), asymmetry of the thigh or gluteal folds, and discrepancy of leg lengths are potential clues. Treatment depends on age at presentation and outcomes are much better when the child is treated early, particularly during the first six months of life.[1]

The exact incidence of DDH is difficult to determine because of a discrepancy in definition of the condition, type of examination used and different levels of skills of clinicians. The incidence ranges from as low as 1 per 1,000 to as high as 34 per 1,000. Higher incidences are reported when ultrasonography is also used in addition to clinical examination. Risk factors include first born status, female sex, positive family history, breech presentation and oligohydramnios. Carter and Wilkinson reported an overall incidence of one per 1,000 live births, with one in 600 girls and one in 4,000 boys having the disorder. Other associated factors include ethnic background (e.g. native Americans who use swaddling that forces the hips into extension and adduction), torticollis and lower limb deformity[1].

Presentation

A patients’ presentation can broadly be categorized into early or late. Arbitrarily, six months of age is often used as a cut-off between the two groups, although it may again be considered a spectrum. Early presenting patients may arrive in the hip clinic as a result of findings on baby checks, as detected by screening of at risk babies, or because of parental concern. Parents often report clicking in a baby’s hip when handling the child, particularly when changing nappies. This reported sign is a notoriously poor predictor of hip pathology as it often arises from the knee, the iliopsoas tendon moving over the femoral head or the fascia lata moving over the greater trochanter. Abnormality of soft tissue creases also corresponds poorly with DDH, despite being an often quoted finding in textbooks. Leg length discrepancy as assessed by Galeazzi’s test may not pick up more subtle differences, and is obviously absent in bilateral dislocations. We along with many authors have found a limitation of hip abduction and obvious tightness in the adductor longus tendon to be the most sensitive examination to detect a dislocated hip. Very infrequently does a child with a dislocation have full, symmetrical abduction. Late presenting hips often present at the time of walking. There is a weak association between delayed walkers and DDH. A Trendelenberg gait may be noted, although in toddlers this may be difficult to appreciate even to the experienced. Leg length discrepancy is a common reason to present but children never present with pain. The first referral may be as a result of symptomatic OA in the young adult[2].
Screening

There is little debate that an early diagnosis in DDH is beneficial to patient outcome. The subject of how patients are detected however is more contentious.

A meta-analysis by Lehmann found the incidence of DDH revealed from examination by a paediatrician to be 8.6/1000, from examination by an orthopaedic surgeon to be 11.5/1000 and from ultrasound examination to be 25/1000.

In the UK, neonates have their hips examined for stability and range of movement by a member of the paediatric team, often a junior member. Jones recognized this as an issue in his 1998 JBJS editorial and called for surgeons to be more involved with screening or, as he preferred to call it, surveillance of DDH and with education of other healthcare professionals[2].

Even normal hips can sometimes be damaged by physical tests

Performing a reductive test (Ortolani) or a provocative test (Barlow) is not a completely benign process. The hip may theoretically be damaged by direct means as the head is pushed over the acetabulum, disrupting the labrum or potentially the iliac or ischial secondary growth plates. Multiple examinations by inexperienced examiners or when findings are equivocal are said to increase the likelihood of iatrogenic damage. Even in experienced hands, it has been postulated that a disruption of the negative intra-articular pressure within the hip joint can lead to dysplasia in an otherwise healthy joint.

Positioning a hip to take a forced, frog lateral X-ray is enough to disrupt the labral seal containing the negative intra-articular pressure as evidenced when an air arthrogram is inadvertently created[2].

Controversies on 'who needs treatment?'

Some authors would argue that screening all births by examination and ultrasound leads to parental anxiety. But Schoenecker points out that this is “a fallacious reason not to screen, as with any healthcare issue in infancy in which early detection can lead to a simple and definitive treatment of a potentially pathological condition”.

Barlow demonstrated hip instability in 1 in 60 of newborns. Untreated, 60% will stabilise in the 1st week, 88% by 2 months. As it is not possible to predict which of the unstable hips will normalize, the consequences of not treating an unstable hip are severe and the risks associated with early treatment relatively low, most authors recommend that all unstable hips should be treated. However, follow up with regular ultrasound and delaying treatment until four to six weeks of age is probably safest[2].

The goal is early detection

There is general consensus that early detection improves outcome. When detected early the soft tissues are lax. A dislocated hip may be reduced by closed means during the clinical examination. Dynamic flexion-abduction splints such as the Pavlik harness or static splints such as the Von Rosen splint or the Graf splint may stabilise the hip until the soft tissues tighten[3].
With a stable contained hip acetabular dysplasia may subsequently normalise due to the excellent remodelling capacity in the infant. With later detection (over six months), soft tissue contractures and bony deformity on the acetabular or femoral side result in fixed deformities. Closed reduction is less likely to succeed without concomitant soft tissue surgery, usually an adductor tenotomy with or without a psoas tenotomy, and an open surgical reduction may be required. The older the child is at presentation, the more likely it is that an open reduction will be required with the addition of femoral and/or acetabular osteotomies to stabilise the reduction. The outcome of late open reduction is significantly worse in terms of long-term hip function and future risk of osteoarthritis. There is no clear definition as to what constitutes a late diagnosis; however, the success rate of simple conservative treatment falls significantly after seven weeks[3].

Radiography

Early in life the largely cartilaginous infant hip joint with its unossified femoral head leave radiography as an insensitive, unsatisfactory and unsatisfying examination with the tradeoff of direct gonadal exposure leading to very unreliable diagnostic information. Images are generally exposed with the hips in the neutral and in the flexed-abducted (frog-leg) views and may not capture the hip joint in displacement. After 4 to 6 months of age, radiography becomes more useful, for the nucleus of the femoral head ossifies at approximately 4 months (50th percentile) with a normal range of 2 to 8 months. An anteroposterior view of the hips in neutral position is routinely used in the screening for DDH. Evaluating the relationship of the radiolucent femoral head and bony metaphysis to the acetabulum is important. The lines of Hilgenreiner, Perkins and Shenton serve as useful visual guides to recognize an abnormal relationship, particularly when the femoral head is still unossified. The acetabular angle is an often used objective measurement in the diagnosis and follow-up of DDH. Normally, it measures less than 30° in newborns and continues to decrease with age. This measurement, however, is not as precise as might be expected. The reported 95% tolerance interval for intraobserver variability is 8.35° with interobserver variability exceeding this number, which casts doubt on the reliability of this angle based on a single reading. In a small series of 7 children (14 nonoperated hips with DDH) with a mean age of 7.3 years (range 3.3–10.5 years) the acetabular index was measured on radiography and compared with MRI with a significant correlation Spearman correlation coefficient of 0.88 (95% confidence interval, 0.61–0.96; p<0.001) and a mean difference between the 2 measures of 0.36 ± 6.5°. In addition, the osseous and cartilaginous acetabular indexes as measured by MRI had a significant correlation with a Spearman correlation coefficient of 0.88 (95% confidence interval, 0.80–0.98; p<0.001). Based on these results the authors suggest that plain radiography is still an appropriate tool for follow-up of the nonoperated hip with DDH and may be a good indicator of hip cartilaginous development. In the older child, two other measurements can be assessed, the coverage of the ossified femoral head by the bony acetabulum can be quantified, and the center-edge angle (C-E angle) can be measured[4].

Radiography and its disadvantages

The term acetabular index (AI) was introduced by Klienberg and Lieberman in 1936 to denote the angle formed between the roof of the iliac portion of the acetabulum and a horizontal line passing through the triradiate cartilage. An angle more than 30 degrees was proposed to be suggestive of dysplasia. The value of AI in diagnosis of DDH has been further supported by the works of Koven (1949), Martin (1951), Pray (1952) and Colonna (1953). At birth, the femoral head and acetabulum are primarily cartilaginous and cannot be accurately defined by radiographs[5].
A radiograph at 3–4 months, measuring the acetabular index is considered by many the gold standard for diagnosis of DDH. But diagnosis after 3–4 months is considered ‘late’, and is associated with a higher likelihood of subsequent surgery and motor disability. Tonnis in 1976 published normal values of the hip joint for the evaluation of X-rays in children and adults. He proposed mean values for all ages and demonstrated that the upper standard deviation of normal comprised the borderline to a critical zone where extreme values of normal and pathological hips were found together. Above the double standard deviation only severe dysplasias were present. It is based on his work that radiologists took an AI of 30 degrees at 6 months of age as the upper limit of normal[5].

**Pelvic position and its importance**

Standard pelvic radiographs are routinely used in studies related to hip joints. Conditions such as hip dysplasia and osteoarthritis of the hip and controls after hip arthroplasty are routinely studied by examining sequential radiographs of the same pelvis. Measurements made on one radiograph are typically compared with corresponding measurements on another. Such measurements are important in evaluating the position of acetabular components in hip arthroplasty, in analyzing polyethylene wear in acetabular components, and in evaluating acetabular coverage[6].

In radiography, a three-dimensional object is projected into a two-dimensional image. The spatial orientation of the object and the position of the central beam, the radiographic focusing, affect this image formation. Differences between corresponding measurements may consequently be caused by the imaging process itself rather than changes in clinical settings[6].

Incorrect positioning of the acetabular cup is associated with dislocation, impingement, and increased amount of polyethylene wear. For some patients, pelvic tilt alters when moving from the supine to the erect position. Cup alignment should be optimal when the patient is in an erect position. Hip surgery is performed in the supine position. However, a possible change in pelvic tilt should preferably be quantified preoperatively and used peroperatively to ensure optimal acetabular cup positioning[6].

Usually, radiographs for the assessment of developmental dysplasia of the hip (DDH) or femoroacetabular impingement are made in the supine position. Several authors suggest positioning (moving from supine to weightbearing) has no effect on pelvic tilt, while another reports pelvic tilt differs notably by 5° between the two positions for both genders[7].

Further, several studies report an effect of pelvic tilt on radiographically interpreting acetabular version. These investigators recommended neutral pelvic positioning when interpreting acetabular deformities and one group suggested limits for defining neutral pelvic positioning. The distance from the symphysis to the sacrococcygeal joint correlated with the pelvic tilt in a subsequent study. However, AP radiographic parameters of DDH do not seem affected beyond inherent measuring errors unless the image is severely distorted[7].

The effect of pelvic positioning on apparent translation of the femoral head has not, to our knowledge, been reported although several authors suggest lateral or “shearing” femoroacetabular impingement results from DDH. In this view, increased lateral translation or subluxation of the femoral head in the widened and steep dysplastic acetabulum causes repeated microtrauma to the anterolateral portion of the labrum during activity. However, the actual occurrence of lateral hypertranslation of the femoral head in DDH has yet to be documented[7].
Three-dimensional objects are transformed into two-dimensional pictures when radiographed, and the transformations are affected by spatial object orientation relative to the radiographic film and radiographic focusing. Sequential standard anteroposterior (AP) supine pelvic radiographs are routinely used in the evaluation of hip joint diseases such as osteoarthritis, dysplasia, and femoroacetabular impingement. Radiographic measurements may change due to the conditions themselves or as a result of surgery. Effects caused by altered radiographic settings may be misinterpreted as changes in clinical settings, since both influence corresponding measurements. In total hip arthroplasty, the orientation of the acetabular prosthesis is described by inclination and version, and correct orientation is important in order to obtain optimal mechanical stability. For some patients, pelvic inclination varies between an erect and supine posture and this could make the positioning of acetabular prosthetic components unsatisfactory. Total hip replacement is performed with patients in a supine position, but cup orientation should be optimal in an erect position, i.e., where the mechanical load on the hip joint is largest. Rotations around the transversal axes influence the apparent prosthetic cup version. Possible pelvic rotations should therefore be acknowledged when examining sequential postoperative radiographs after total hip replacement[8].

Two-dimensional pelvic radiographs are the standard imaging method for the evaluation of hip pathologies and cup position following total hip arthroplasty (THA). Despite their inferior accuracy in comparison to three-dimensional techniques based on magnetic resonance imaging or computed tomography, plain radiographs are widely used for the initial detection of acetabular rim pathomorphologies and for postoperative determination of prosthetic cup orientation, largely due to the simplicity, availability, and minimal expense associated with acquiring these images. While plain pelvic radiographs are easily obtained, their accurate interpretation is complicated by the wide variability in individual pelvic position relative to the X-ray plate. In THA, increased pelvic tilt results in a significant decrease in apparent prosthetic cup anteversion and vice versa. These position variations affect the accuracy of studies correlating cup position to instability, wear, and osteolysis. Furthermore, in native hips without pathomorphological abnormalities, plain pelvic radiographs obtained with the pelvis tilted excessively can lead to the false appearance of a retroverted acetabulum. This can significantly influence the accurate diagnosis of femoro-acetabular impingement (FAI) and affect potential surgical treatment recommendations such as surgical hip dislocation or periacetabular osteotomy[9].

Pelvic tilt around the transverse axis is difficult to correct for and can vary widely between individuals and between pelvic radiographs taken from the same patient at different times.

An understanding of the effect of pelvic tilt on the relationship between the acetabulum and the femoral head is important, particularly in the analysis of plain pelvic radiographs in young adults presenting with hip pain. Subtle changes in the appearance of the acetabulum may influence the determination as to whether there is evidence of pincer impingement or not. The same applies to intraoperative radiographic analysis where changes are made to acetabular orientation, and compensation for pelvic tilt may be required to ensure optimal correction of the position and orientation of the acetabulum[10].

It is now also well recognised that the post-operative appearance of the orientation of acetabular prostheses may be markedly influenced by changes in pelvic tilt, and this may have significant implications in terms of component impingement and bearing surface performance[10].
A number of studies have looked at the influence of pelvic position on the spatial orientation of the acetabulum. Babisch et al used computer navigation to measure pelvic tilt in the sagittal plane, and they produced nomograms for use as a reference for reporting acetabular implant orientation with correction for pelvic tilt. Siebenrock et al reported that pelvic tilt affected the appearance of the crossover sign in subjects with acetabular retroversion. Using supine and standing plain radiographs, pelvic tilt has also been shown to affect acetabular cover of the femoral head[10].

Radiographic diagnosis of DDH or followup studies traditionally are performed by measuring the acetabular index (AI), defined as the angle of inclination of the ossified acetabular roof measured on radiographs. A commonly used method to measure AI is Hilgenreiner’s method. In this method, the AI is defined as the angle between Hilgenreiner’s line and the line joining the superolateral margin of the ossified acetabulum to the superolateral margin of the triradiate cartilage. Hilgenreiner’s line is a straight line between the Y-shaped triradiate cartilage. If the AI values exceed 30 for neonates up to 4 months and 25 for children up to 24 months, DDH is suspected.

The difficulty in consistent AI measurement is precise orientation of the pelvis during radiographic imaging because different orientations of the pelvis will lead to different AI measurements. To obtain a reliable AI measurement using Hilgenreiner’s method, the pelvis must be well positioned during acquisition of the radiograph. This is challenging, especially in young children[11].

**Ultrasonography**

In 1980, Graf introduced ultrasound as a method for screening babies for DDH. This allowed visualisation of non-osseous structures, in a non-invasive, painless, and repeatable manner that did not involve ionising radiation. Therefore, dysplasia could be quantified and treated according to the clinical and radiological findings. Many European countries hence have screening programmes involving universal clinical and ultrasound examination for all newborns. The United States Preventive Services Task Force has not recommended ultrasound screening at present due to its perceived oversensitivity and propensity for over-treatment of DDH. This recommendation by the task force is thought to be controversial as it combines many different ultrasound techniques and does not give a true reflection on the use of a single standardised method as practised in Europe. In the United Kingdom, many units including ours have adopted a policy of selective ultrasound screening for those with risk factors and or a positive finding on clinical examination. To date, a huge body of literature describes US imaging as a useful and accurate diagnostic tool for DDH, but fails to provide clear evidence, either for or against its use in screening new born infants[5].

Roovers et al. examined over 5000 neonates with ultrasound at 1, 2 and 3 months, and reported a sensitivity of 88.5%. This was significantly higher than that of clinical examination alone (76.4%). In the study of Anand Pillai et al, there were few true positive cases identified and therefore sensitivity of US was low. This is probably not a true reflection of the sensitivity of ultrasound for diagnosing DDH and is reflective of the small number of cases of DDH they found in the study population. This is supported by findings on the high accuracy of ultrasound compared to the 6 month radiograph (94–97%). DDH is a dynamic condition, with some babies who had initial abnormal scans (Graf 2b/3) tending to normalise with subsequent scans and having normal X-rays at 6 months. Also having an abnormal scan at an older age increases the likelihood of having an abnormal X-ray at 6 months. Anand pillai’s data show the accuracy of US is lowest before 6 weeks of age and highest for the 3 month scan[5].
Selective versus universal US screening

Two randomised control trials have compared selective to universal ultrasound screening. Holen et al. randomised 15,529 infants to either clinical screening and ultrasound examination of all hips or clinical screening of all hips and ultrasound examination only of those at risk. One late-detected hip dysplasia was seen in the universal group (rate 0.13 per 1,000 babies) compared with six (0.65 per 1,000 babies) in the selective group — a difference that was not statistically significant (p=0.22)[3].

They emphasised the importance of clinical screening performed by well trained examiners but felt they could not justify universal screening on statistical grounds. Using similar methodology, a study of 11,925 infants by Rosendahl et al. found no statistically significant difference in the incidence of late presenting DDH (including acetabular dysplasia and dislocation) between those managed by clinical examination and those who had an additional ultrasound examination. Again, the clinical screening was performed by highly trained examiners. In many countries clinical screening is performed by relatively inexperienced examiners. The results in the Holen et al. and Rosendahl et al. studies might have been different had poorly-trained examiners performed the clinical screening, as the advantage offered by ultrasound only becomes evident when such screening is compared with clinical screening by non-trained examiners[3].

Management

Younger infant

Aims: The ideal treatment involves early diagnosis (before secondary hip changes develop). The objectives are to:

- obtain and maintain concentric hip reduction
- allow normal development of the joints
- avoiding complications (particularly avascular necrosis of the femoral head).

Treatment choice depends upon age of the child and the reducibility of the affected hip.

Classification: Neonatal hips can be classified after clinical examination and imaging.

Normal – further treatment is not required.

Unstable (dislocatable or subluxatable) – most neonatal hips that are habitually reduced but subluxatable at birth stabilize spontaneously over the first 2–3 weeks; clinical reassessment and ultrasound are indicated. If the hip has stabilized, the child should be reviewed to ensure reduction is maintained and the acetabulum is developing normally; a period of splintage is required if the hip has not stabilized.

Dislocated but reducible – abduction splintage is indicated. Concentric reduction of the joint must be confirmed by ultrasound and rechecked at regular intervals. The commonest bracing device used to treat DDH in the younger child is the flexible Pavlik harness, which maintains the hips in flexion and abduction, while restricting extension and adduction.
**Dislocated and irreducible hips** are rare in neonates. Most surgeons attempt to reduce the hip in a harness for two weeks; treatment is discontinued if this fails. At 3–6 months, the dislocated hip is reassessed with an arthrogram and examination under anaesthesia. The position is maintained with a hip spica (as with treatment of older infants) if the hip can be reduced under anaesthesia. If the hip fails to reduce, open reduction is delayed until the ossific nucleus has appeared because the risk of developing avascular necrosis may be reduced at this time.

**Stable hip with acetabular dysplasia** – a proportion of children have clinically stable hips with varying degrees of acetabular dysplasia (as evaluated on ultrasound or radiographs); they should be monitored regularly to ensure satisfactory acetabular development. Flexible abduction splintage is used to encourage normal development if acetabular dysplasia persists in a child aged <8 months[12].

**Older infant**

The displaced hip may not be reducible after the first few months. Traction was often used to reduce the hip, but this is now less common. An arthrogram and examination under anaesthesia is usually required to assess the joint fully.

**Hip arthrography** may reveal the abnormalities discussed below. Dislocated or subluxated with no block to reduction – the hip may reduce completely with gentle manipulation in flexion and abduction. Providing there are no blocks to reduction, a hip spica cast from waist to ankle may be used, maintaining the reduction in a safe position (Figure 5). The safest position for holding the reduction is the ‘human position’, with the hip flexed 90–100° and abducted 40–60° (which should be about 30° less than the maximum range). Splinting the hip in a more abducted (‘frog’) position may provide a more stable reduction, but greatly increases the risk of developing avascular necrosis in the femoral head. A percutaneous adductor tenotomy increases the safe range of movement and may reduce pressure on the femoral head.

**Dislocated or subluxated with block to reduction** – if the femoral head cannot be reduced into the acetabulum, surgery is indicated to remove the obstruction and allow hip reduction. Some surgeons proceed immediately; others leave the hip until the ossific nucleus has appeared in the femoral head. An anterior or medial surgical approach to the hip may be used depending on the mechanical block and surgical preference. Great care must be taken during surgery to avoid damaging the femoral circumflex and capsular vessels to reduce the risk of avascular necrosis. Hip reduction is maintained using a spica extending from waist to ankle postoperatively[12].

**Older childhood**

Treatment becomes more challenging as a child ages:
- the displaced hip is more difficult to reduce
- dysplasia is more marked
- the capacity to remodel is diminished (particularly after the age of 3 years).
Despite these problems, the underlying principles of treatment remain i.e. to obtain and maintain concentric joint reduction and avoid complications.

Surgery is invariably required in children aged >2 years. Extensive soft tissue and ligamentous releases may be done to allow the femoral head to drop back down into the acetabulum. If the hip displacement has been significant, an osteotomy may be required to shorten the femur to reduce pressure on the femoral head. Severe acetabular dysplasia usually requires a pelvic osteotomy to realign or reshape the acetabulum; this helps to provide cover and stability for the femoral head, improving the likelihood of more normal development[12].

**Problems managing DDH in developing world**

The treatment of DDH is age-related and the goal is to achieve and maintain concentric reduction of the femoral head into the acetabulum. The best outcome can be expected only if the treatment is started very early. This has been achieved in the developed world through improved awareness and training, increased surveillance (use of ultrasonography), and quicker access to pediatric orthopedic surgeons. It must be noted that there are very few specialized pediatric orthopedic surgeons in the developing world, and fellowship programs for pediatric orthopedic surgery should be initiated to cater for this requirement, in addition to the myriad of other pediatric orthopedic conditions[1].
RESEARCH METHODOLOGY AND METHODS

We measured pelvic rotation and other indices such as alfa angles, ischial bone thickness, pubofemoric distance on x-rays of 97 infants. Of them, 45 are boys and 52 are girls. Patients radiographs are collected without considering whether it is normal or abnormal. These radiographs are taken in Pediatrics Department, Kaunas Clinics, Kaunas. This research is carried out in Kaunas Clinics, Kaunas. Patients are aged from 7 days old till 253 days old. The mean age of the sample is 110 days. All radiographs are taken as AP view. These radiographs are taken in the year 2015 and 2016 respectively. These radiographs are taken for screening of DDH. These radiographs are taken for screening of DDH. These are determined either normal or abnormal by alfa angles. But the disadvantage of radiography is it can be used only after an infant gets to 4 months old because the ossification centre has to be developed. That's why ultrasonography is being used for infants who are under 4 months of age both for screening and diagnosis. Moreover ultrasonography doesn't expose infants to ionizing radiation whereas radiography exposes the infant to ionizing radiation. So our aim is to evaluate new pelvic rotation on x-rays for better diagnosis of DDH.

We have drawn the landmarks and measured angles and distances. The angles are measured in whole degrees and distances are measured in centimetres. The correlation of patient rotation and other indices such as alfa angle, ischial thickness, PF distance are analysed.

The alfa angle is determined by first drawing the Hilgenreiner (or Y-Y) line, which is a horizontal line between the 2 triradite or Y-Y cartilages, and then drawing a second line connecting the superolateral and inferomedial margins of the acetabular roof (Figure 1). The higher limit of normal acetabular angle is approximately 30°. The angle decreases gradually with age as a result of modeling of the acetabulum by the femoral head and of the maturation of developing bone along the superolateral acetabular roof. The acetabular angle is often increased in DDH because maturation and ossification of the acetabulum are abnormal and delayed.

Hilgenreiner (or Y-Y) line, which is a horizontal line between the 2 triradite or Y-Y cartilages.

Ischial thickness is a line which measures the thickness of the ischium. It is drawn perpendicular to the longitudinal axis of the ischium. It is measured in centimetres.

Pubofemoric distance is a line which measures the distance between pubis and femur. This line is drawn connecting the femur head and pubis. It is measured in centimetres.

Pubic shadow is considered to be either medial or lateral depending on whether the shadow of the pubis is seen medial or lateral to the longitudinal axis of the ischium. If the shadow of pubis ends at the longitudinal axis of the ischium, it is considered to be medial.

Ischiopubic ratio is assessed by the pubic shadow and it is assigned either 1 for medial or 2 for lateral in relation to the longitudinal axis of the ischium.

Pelvic rotation is determined by drawing a line which is longitudinal axis of the spine and a line which lies in between the ischium bones. These two lines which are drawn should be parallel. If these two lines aren't going in the same axis parallelly, then the patient is rotated either left or right which is determined by mid ischial line which lies either left or right in relation to the axis of the spine. The distances are measured in centimetres.

From our data, we have calculated the correlation coefficient of right alfa angles-age in days and left alfa angles-age in days. The correlation coefficient of pelvic rotation and other indices such as alfa angles, ischial thickness, PF distance is measured.
Figure 1- The above given picture depicts the indices which we measured. This is a plain x-ray of an infant who underwent screening for DDH. This infant wasn't found to have dysplastic hips. There is a small rotation to the left. AA - alfa angles, IT – ischialthickness, PFD  pubofemoric distances, PT - patient rotation
**Figure 2** - Here is another patient who also underwent screening for DDH but found to have normal hips and without rotation. AA - alfa angles, IT - ischialthickness, PFD - pubofemoric distances, PT - patient rotation
Figure 3- Here is a patient who is suspected to have dysplasia of the right hip as the alfa angle was found 37° in this case. However, the patient present with obvious rotation to the left, which confusing the final diagnosis.
RESULTS AND THEIR DISCUSSION

We have assessed 97 patients totally. Of them 52 females, and 45 males. Most of the infants are normal. 18 infants are suspected to have dysplastic hips. Our aim is to find the effects of patient rotation in infants who had undergone screening for DDH. Of the 97 patients, 21 patients rotated right and 35 patients rotated left. We have found the correlation of age of the infants and alfa angles on both hips. The correlation of age and right alfa is -0.31 and correlation of age and left alfa is -0.23. The correlation of patients who rotated right and other indices which we measured are alfa angle, ischial thickness, and PF distance respectively. Alfa angle, ischial thickness, and PF distance are measured on both left and right hips.

Average of all alfa angles – 23.59 +/- 4.44
Average of both left and right ischial thickness – 1.09 +/-0.11
Average of both left and right PF distance – 0.87 +/-0.19

Correlation of age and left alfa – -0.23
Correlation of age and right alfa – -0.31

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Correlation is found between pelvic rotation and other indices which we measured on the radiographs of patients who underwent screening process. The correlation is found in order to find the effects of pelvic rotation on the indices such as alfa angles, ischial thickness, pubofemoric distance. There isn’t significant effect of pelvic rotation on the indices. There is evidence that there is highly significant effect of rotation and inclination on the CE angle, Sharp’s angle, the acetabular depth ratio and, to a lesser extent, on Goodman’s Cartesian coordinate system. The CE angle is the most commonly used parameter of hip dysplasia, and it is the most vulnerable to varying rotation of the pelvis but these studies didn’t measure the same indices which we measured for our research.
Graph 1: Correlation of left alfa and left rotation

Graph 2: Correlation of right IT and right rotation
Graph 3: Correlation of left IT and left rotation

Graph 4: Correlation of right rotation and right alfa
As the correlation coefficient values of patient rotation and other indices are not significant, our research shows that there is no significant impact of patient rotation and other indices which we measured on the patients who underwent screening for DDH.

Jacobsen at al. found a highly significant effect of rotation and inclination on the CE angle, Sharp’s angle, the acetabular depth ratio and, to a lesser extent, on Goodman’s Cartesian coordinate system. FHEI was not significantly affected by rotation within a total arc of 42°. The CE angle is the most commonly used parameter of hip dysplasia, and it is the most vulnerable to varying rotation of the pelvis. They recommend that only pelvic radiographs with a foramen obturator index within 0.7–1.8 be used for assessment of acetabular dysplasia in adults.

The pelvic rotation method which we used doesn't have significant impact on the other indices which we measured on pelvic radiographs. In clinical practice, altered pelvic position together with altered radiographic focusing might occur in radiographic sequences. However, we believe that standardized radiographic focusing is easier to achieve than standard pelvic positioning, and that altered pelvic orientation is therefore the most important factor.

Pelvic inclination is naturally integrated into the patient’s general posture and is difficult to correct at the radiographic examination. However, they have found that such examinations should be standardized in all other possible respects to ensure a neutral starting point and reproducible readings; especially in epidemiological and clinical studies, and when performing preoperative planning and follow-up of patients. Actualized by the now popular use of redirecting pelvic osteotomies to prevent secondary coxarthrosis in young patients (e.g. Ganz’ osteotomy), there is a growing interest in hip dysplasia and procedures for correction (Ganz et al. 1988, Azuma and Taneda 1989, Murphy et al. 1999, Siebenrock et al. 2001, Sanchez-Sotelo et al. 2002, Tomlinson and Cook 2002). First referral and first preoperative planning is often founded solely on AP pelvis radiographs. Although some orthopedic surgeons usually wish to supplement radiographs with computerized tomography of the pelvis, knowledge of the variations of radiographic parameters in hip dysplasia due to malrotation is indispensable for decision-making regarding indication and surgical procedure.

Susanne Fuchs et al found that AC angle, CE angle, and minimum joint space width differed between the radiographs taken in the supine and standing positions at followup, whereas the OA grading according to Kellgren and Lawrence and the ACM angle did not. They observed no correlation of the three angles and radiographic signs of OA. Tonnis proposed normal values for the AC, ACM, and CE angles. In their study, patients who had an AC angle of less than 15° had a lower OA grading than patients with an AC angle of more than 15°. Distinguishing ACM and CE angles as normal or abnormal did not predict radiographic OA.

M. J. van der Bom et al believe pelvic rotation and tilt should be considered simultaneously during diagnosis of DDH using Hilgenreiner’s method. Changing pelvic orientation by inducing rotation and tilt simultaneously can cause systematic errors in the AI that are larger than when only rotation or tilt is considered.
CONCLUSION

Our data don't show any significant correlation of patient rotation and other indices such as alfa angles, ischial thickness, pubofemoric distance which we thought would be helpful in diagnosing DDH.

So we recommend the same diagnostic principles which is being used universally. That is clinical examination followed by imaging modality as an adjunct depending on the patient's age either US or radiography.

US screening is done either to all infants or to infants who are at risk. Both has its own advantages and limitations.

There are many radiographical indices which exist in diagnosing DDH. But the most common one is acetabular angle. If the kid is older, wiberg's CE angle is used.

Early diagnosis is the key in avoiding late complications.
REFERENCES

[1] Shahryar Noordin, Masood Umer, Kamran Hafeez, Haq Nawaz Section of Orthopedics, Dept. of Surgery, Aga Khan University, Karachi, Pakistan Orthopedic Reviews 2010; volume 2:e19


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