

## Symposium



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## Can We Predict The Need For Secondary Procedures In Walking Ddh?

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### Abstract

In developmental dysplasia of the hip (DDH) diagnosed after walking age, primary intervention in the form of open reduction with or without femoral and innominate osteotomy is the mainstay of treatment. Even in those where the primary reduction has been successful, many will require Further Corrective Surgery (FCS) at a later date. This review article discusses the factors which are important in predicting the need for FCS.

**Keywords:** DDH; Hip joint arthritis; Hip impingement; Hip dysplasia; Osteotomies in hip dysplasia.

### Introduction

Good outcomes from surgical management of DDH are to be expected from methods that permit anatomic reduction without impairing blood supply to the developing femoral head. After walking age, altered biomechanics of the hip joint in DDH leads to overloading of the articular cartilage resulting in early osteoarthritis. DDH is an important aetiological factor among young individuals undergoing total hip arthroplasty (about 21% to 29%) [1]. The incidence of secondary procedures after closed or open reduction of the hip in DDH varies from 38% to 80% in long-term studies [2-8].

In developing countries where there is no provision of neonates for early detection of hip dysplasia, children usually present at walking age. The most common treatment for children with DDH after walking age is a one-stage combined operation, composing of open reduction with pelvic and femoral osteotomies [9]. Even with optimal surgical management, a subset of walking-age children requires FCS. The need for such procedures can be understood in terms of advanced DDH pathology, inadequate acetabular or femoral remodelling and the adverse effects of lateral loading of the hip in a walking child with an already dysplastic acetabulum. Advancement of imaging techniques and research has led us to better understand and correct the underlying pathology. The most important factors while predicting the need for FCS in DDH are - age of the patient, acetabular index, femoral and acetabular version, head shape, avascular necrosis of head of femur and the quality of reduction achieved during the primary surgery.

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### Age of the Patient

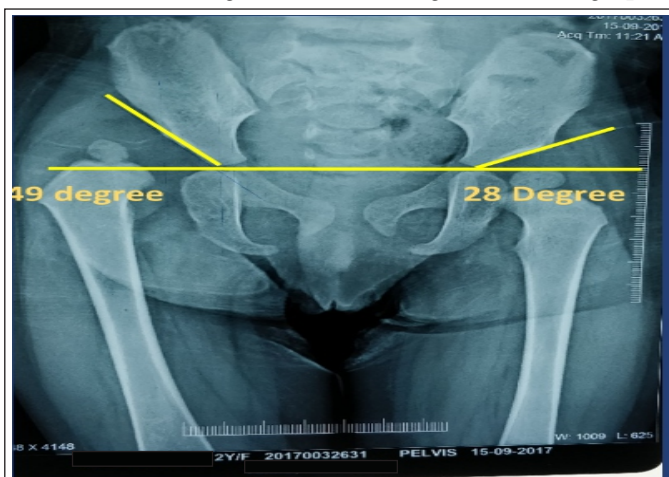
There is a well-established correlation between age of the child and severity of acetabular dysplasia. Age of the patient at primary intervention is therefore directly related to the need of FCS. Ideally, all patients should be identified and treated in infancy. If not, treatment should be instituted as soon as possible, preferably before 4 years of age [10, 11]. The outer limit for surgical correction is probably eight years of age, beyond which complications from treatment may lead to an outcome no better than the untreated clinical course [9, 12, 13]. In unilateral cases, this threshold is higher as the natural history of unreduced unilateral DDH is poorer when compared to bilateral cases. The outcome of bilateral DDH correction is worse compared to unilateral cases due to the difficulty in obtaining a perfectly symmetrical result in bilateral DDH [14]. The goals of treatment in older children with persistent acetabular dysplasia are to delay or prevent the development of osteoarthritis and to obviate the need for arthroplasty at a relatively younger age.

### Acetabular dysplasia

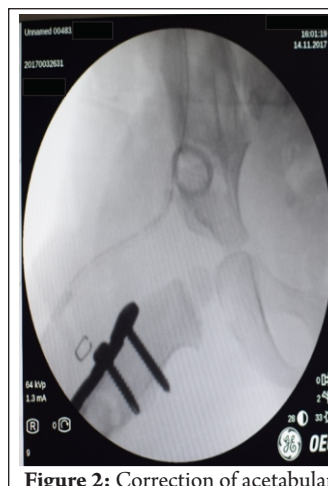
Development of the acetabular cavity is determined by the presence of a concentrically reduced femoral head. The lower limit for acetabular remodelling has been shown to be 18 months, whereas the upper limit is considered to be 11 years [15-17]. Albinana et al found maximum acetabular remodelling in the first 4 years after reduction in Severin grade III/IV hips and 6 years in Severin grade I/II hips [18]. Acetabular dysplasia is one of the major causes of residual subluxation after open reduction. In radiographs, acetabular dysplasia is quantified through the Acetabular Index (AI) and Center Edge Angle (CEA). AI, also called acetabular roof angle or Tönnis angle is a radiographic

measurement of femoral head coverage by the bony acetabulum (Fig. 1). CEA is an angle formed by Perkin's line and a line from the centre of the femoral head to the lateral edge of the acetabulum.

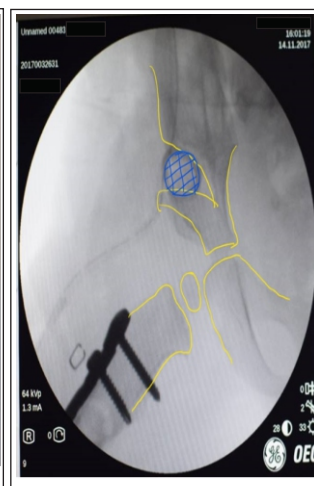
Kitoh et al. studied acetabular dysplasia in hips reduced by overhead traction. They reported that AI four years post reduction and CEA five years post reduction were the earliest predictors of the final outcome at skeletal maturity [19]. The need for an acetabular procedure at the time of open reduction in a child between the ages of 18 months and 3 years of age with acetabular dysplasia is controversial. Spence et al. compared acetabular development after femoral varus derotational osteotomy and an innominate osteotomy in patients from 15 months to 4 years of age. They concluded that acetabular remodelling after open hip reduction and innominate osteotomy was more effective for reversing acetabular dysplasia and maintaining hip stability than open reduction combined with a femoral varus derotation osteotomy [20]. In the child older than 3 years, acetabular osteotomy is performed routinely because of the unpredictable remodelling potential of the acetabulum beyond this age [21]. Wakabayashi et al in their series studied the presence of high signal intensity area (HSIA) in weight bearing zone portion of the acetabular cartilage on T2 weighted MRI in cases with residual subluxation. In all patients who underwent FCS and having HSIA before surgery, it disappeared or decreased after surgery. In patients who did not undergo corrective surgery, HSIA-positive cases showed poor acetabular growth. These authors conclude that the presence of HSIA on MRI is a significant decision making tool for undertaking FCS [22]. Pelvic osteotomy is indicated for persistence of acetabular dysplasia (Fig. 2, Fig. 3).



**Figure 1:** Showing increased Acetabular Index on right side.



**Figure 2:** Correction of acetabular deficiency by Dega osteotomy (preop in fig 1)



**Figure 3:** Schematic representation of Fig 2

### Femoral and Acetabular Version

Rotational misalignment or residual axial plane deformities usually may not cause redislocation, but on review of literature there is close correlation between the painful hip pathologies, osteoarthritis and acetabular and/or femoral neck anteversion changes as it leads to biomechanical problems in the hip or knee joints [23, 24]. The normal range of acetabular anteversion is reported to be between  $6^{\circ}$  and  $24^{\circ}$  (Fig 4) and femoral anteversion is reported to be between  $7^{\circ}$  and  $43^{\circ}$  at 6 years of age.



**Figure 4:** Axial CT image showing increased acetabular version on left side

Isolated increased femoral anteversion, remodelling is expected until maturity [25]. Acetabular anteversion of normal hips shows less variation than femoral anteversion during childhood [25-27]. There is less potential for remodelling of acetabular anteversion in cases where subtrochanteric osteotomy or excessive correction of femoral anteversion had been performed [26]. Mootha et al. on MRI evaluation observed that as the severity of DDH increases the acetabular anteversion (AAV) also increases, but on the other hand femoral anteversion (FAV) remains constant. They found strong positive correlation between AAV and AI, which is considered to be a good predictor of the severity of the disease, while there was no correlation with FAV. They concluded that majority of the abnormalities in early walking age patients with DDH are on the acetabular side and changes on the femoral side in older children seem to be secondary to pressure effects on the femoral head from the acetabulum or ilium due to the persistent dislocation and recommended pre-operative MRI evaluation [28]. Gunal et al. concluded that preoperative tomographic evaluation can help decide the type of innominate osteotomy and magnitude of correction required, especially for inexperienced surgeons [29]. Intraoperative stability test alone for planning osteotomies may result in excessive correction of femoral

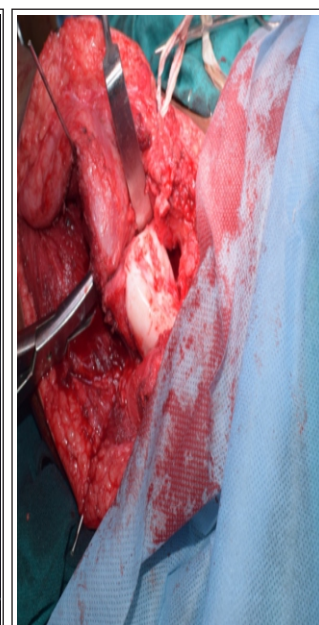
and acetabular anteversions and may lead to unsuitable femoral head coverage in the axial plane. Tonnis et al. observed that change in the anteversion of the acetabulum is frequently offset by a compensatory change on the opposite side of the joint [30]. In contrast to this finding, hips which had undergone additional femoral derotational osteotomies were associated with significantly more pronounced acetabular retroversion [31]. So, pre-operative CT scan and MRI evaluation of femoral and acetabular version are necessary for appropriate correction. Performance of excessive anteversion correction just on basis of intraoperative stability has adverse effects on future remodelling of acetabular anteversion.

### Shape of the femoral head

Acetabular changes and dysplasia in DDH are well recognized and documented but prediction of femoral head shape in treated and untreated cases is not very well researched. Only few authors have investigated changes in morphology of the femoral head [32, 33]. Sankar et al studied femoral head shape in untreated DDH and found that children with DDH have variably shaped femoral heads and these differences in femoral head sphericity explains differences in outcome following the same surgical procedure (Fig. 5, 6). With increasing age, asphericity did not increase due to decreased plasticity of the ossifying femoral head [33].



**Figure 5:** Showing abnormal femoral head shape on both sides



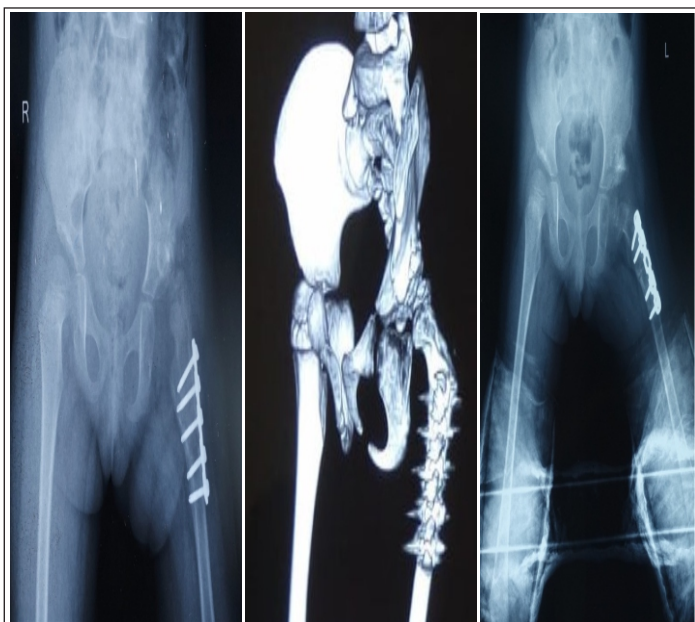
**Figure 6:** Showing abnormal femoral head shape intra-operatively (Xray shown in Fig 5)



### Primary surgery

Prediction of the need for FCS depends on proper execution of the primary surgery. After walking age, primary open reduction with concurrent pelvic and femoral osteotomy has gained acceptance. This lowers the risk of residual subluxation or dislocation and minimizes the need for FCS. However, some residual correction is expected to occur from remodelling and normalization of hip mechanics [34]. Gholve et al found that low threshold to perform femoral osteotomy at primary open reduction may reduce the requirement of a secondary procedure. In their series, 73% of patients who did not have concurrent femoral osteotomy at index surgery required a secondary procedure later [34].

Two components of the femoral osteotomy require discussion while predicting the need for FCS namely shortening and derotation. Femoral shortening has been shown to decrease the complications associated with open reduction, particularly re-dislocation and avascular necrosis (AVN) [35]. Superior displacement of the femur more than 30% of the width of the pelvis and age above 36 months are strong predictors of the need for a femoral shortening osteotomy during the open treatment of DDH but the final decision to perform a femoral shortening osteotomy should be dictated by the intraoperative findings [36].



**Figure 7a:** Redislocation left side, 4 months following index surgery for DDH.

**Figure 7b:** CT assessment showing posterior uncoverage, intraoperatively femoral retroversion following primary surgery also noted.

**Figure 7c:** Revision surgery following proper planning with correction of femoral version and reverse Dega resulted in a successful outcome

The role of derotation is more debatable. Fixsen et al stated that the most common causes for recurrent dislocation are poor capsulorrhaphy and under/over correction of FAV [37]. It has also been reported that combining femoral derotation osteotomy with Salter osteotomy predisposes towards posterior dislocation. Mootha et al studied the requirement for femoral derotation osteotomy in DDH of early walking age group. They concluded that exaggerated femoral anteversion does not occur in early walking age as shown by their MRI analysis and questioned the need for routine femoral derotation in this group [36].

It is recognised that Salter and Triple pelvic osteotomy for DDH might lead to retroversion of the acetabulum. Dora et al found that acetabular retroversion is likely to cause symptoms depending on individual dynamics such as the position of the pelvis during a particular activity [24].

Intraoperative instability should not be the only criterion for judging the amount of femoral anteversion correction and shortening. Appropriate imaging in form of MRI and CT scan is recommended especially in older children, to prevent over-correction during primary DDH surgery.

### Avascular Necrosis of the femoral head

The risk of AVN is related to excessive abduction of the hip, forceful closed reduction when obstacles for reduction are present, maintaining a dislocated hip within the harness or spica cast and surgical open reduction [12]. Low AVN rates have been reported with combined one-stage procedures with good functional results [23]. The incidence of AVN is reported to be between 3% and 60% after open or closed reduction of DDH [9, 38-40]. This wide variation may be explained by age-related factors and differences in classification systems, criteria for identification of AVN and surgical approaches during open reduction. Roposch et al found that patients with AVN had some limitation in hip function at a mean age of 14 years [41]. AVN following primary DDH surgery appears to be an independent risk factor for FCS.

### Recommendations

Requirement for FCS in walking-age children with DDH can be multifactorial. Thorough evaluation of the patho-anatomy is necessary in every case. Age of the patient at the time of surgery has direct influence over the future of the hip joint; all efforts should be made to diagnose DDH at the earliest possible instance.

In walking age, appropriate pre-operative investigations in the form of adequate radiographs, CT scan with 3D

reconstruction and MRI of the hip joint are recommended to fully appreciate the extent of acetabular dysplasia, acetabular and femoral version and head shape. Axial plane deformities also need consideration as they might not cause dislocation post-surgery but can lead to pain in particular activities, restriction of movement and increased chances of osteoarthritis in the future. There should be lower threshold for performing femoral

shortening osteotomy whenever required as it reduces the chances of re-dislocation and AVN. Derotation osteotomy should be planned on the basis of pre-operative evaluation of femoral anteversion rather than intra operative stability, since excessive femoral derotation reduces the chances of acetabular version remodelling. While performing pelvic osteotomies, special care should be taken to prevent overcorrection and retroversion of acetabulum.

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