THE RELATIONSHIP BETWEEN THE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP AND AVASCULAR NECROSIS

Mehmet S. Binnet, MD, Güngör S. Çakırgil MD, Sinan Adıyaman, MD, Yalım Aleş, MD

ABSTRACT

The most important complication following the treatment of congenital dislocation of the hip is avascular necrosis. The potential se-quelae that may arise after the onset of avascular necrosis are worse than if the hip remained dislocated. We evaluated 38 hips in which avascular necrosis developed after re-duction. The average patient age at the time of reduc- tion was 4.3 years, with a follow up of 6 to 15 years. Twelve hips had closed reduction and 26 had open reduction. Following reduction, 8 hips had Type 1, 6 had Type II, 9 had Type III, and 15 had Type IV avascular necrosis. In this article, we evaluate our cases and review current literature on the subject. Close follow up and timely interven-tions can reduce potential sequelae to a minimum.

The purpose in the treatment of congenital dislocation of the hip is to treat patients as early as possible. If treatment of a congenitally dislocated hip starts in the newborn period, the potential exists for complete anatomic and physiologic restoration of the hip joint.

There has been an increased emphasis on the detection of congenital dislocation of the hip (CDH) in the newborn period, but it is not always possible to make the diagnosis shortly after birth.[1-3] Therefore, patients are seen by orthopedic surgeons for the first time at an age when treatment is more difficult. In many countries, early exa- mination of newborns is difficult due to harsh environmental conditions and the lack of primary health care in rural areas. As a result, we see patients at a later period.[1,4] For these reasons, the incidence of CDH does not decrease.[1]

Zionts and MacEwen3 advocated that the goal of treatment of CDH in the older child is to establish a relationship between the femoral head and the acetabulum that is as dose to normal as possible to delay the onset of arthritis.

The treatment of CDH has shown improve-ment with time. Most of the treatments deal with acetabular dysplasia and problems that arise due to this dysplasia, such as dislocation of the fernoral head, but do not deal with avascular problems that may appear during treatment.[2,3,5-10] Controversies are continuing about the factors that affect the development of vascular necrosis. Although the literature includes some positive approaches to dealing with avascular necrosis, there is no mention of a clear cut etiologic theory on the subject.[5-7,11-15]

Different methods used in the treatment of CDII have revealed different results. The differences in these results arise from the fact that the authors have used different criteria in assessing their results. The rate of avascular necrosis has been reported in the range of 0% to 73% by these authors.[7,17] Avascular necrosis of the femoral head is a worse problem than if the hip remains dislocated.

In the treatment of CDH care must be taken not to cause vascular embarrassment. Only this can reduce the ratio of avascular necrosis seen per CDH treated. In this retrospective review of CDH treatment in different age groups the different treatment modalities have been evaluated throughout many years. The factors that arc thought to

be effective in producing the results are described according to our experience. These different factors and their relationship with avascular necrosis are evaluated. Those cases with a poor prognosis in the beginning turn out to have good outcomes with long-term follow up with appropriate precautions.

MATERIALS AND METHODS

This study was done in Ankara University Medical Faculty, Department of Orthopedics and Traumatology during the years 1972 to 1988. We retrospectively reviewed 38 hips (32 patients) in which avascular necrosis of the femoral head had developed after treatment for CDH. [10,19,20] Patients with teratologic, paralytic, septic, or secondary dislocation and those with CDH normal. results were excluded from the study Patients who received treatment at a different clinic were also excluded.

There were 32 patients: 23 girls (71.8%) and nine boys (28.1%). There were 14 unilateral (43.7%) and 18 bilateral (56.4%) hips for a total of 38 hips. The average age at the time of reduction was 4.3 years (range: 5 months to 13 years).

Tonnis described a classification system for defining the severity of dislocation based on the relationship between the ossific nucleus of the femoral head and the superolateral margin of the acetabulum[3] (Fig 1). General distribution of our patients according to Tonnis classification as modified by Zionts[3] are:

- Grade 1: 8 (21%) hips;
- Grade 11:11(28.9%) hips;
- Grade 111:19 (50%) hips.

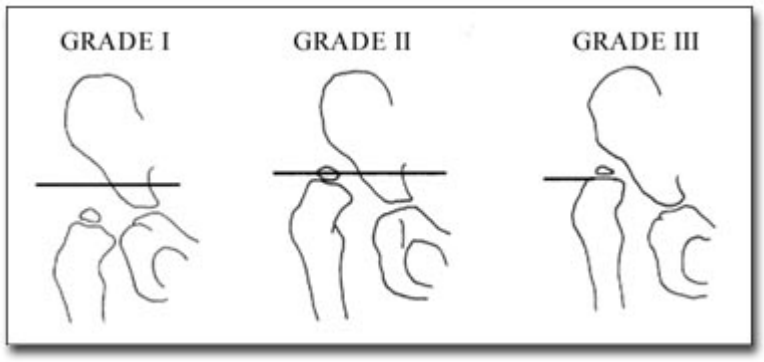


Fig 1: Classification of the degrees of dislocation: Grade I-the ossification center of the femoral head is laterally displaced but still inferior to the superolateral corner of the true acetabulum; Grade II-the ossification center of the femoral head is at the level of the superolateral corner of the true acetabulum; Grade III-The ossification center is superior to the superolateral margin of the true acetabulum. (From Zionts LE, MacEwen GD.[3]

The method of treatment was closed reduction in 12 (31.5%) and open reduction in 26 (68.5%) hips. These patients were followed for an average of 8 years and 3 months (range: 6 to 15 years). Avascular necrosis was determined using the total avascular necrosis criteria of Salter et al[17] Avascular necrosis developed in 26 patients (81.2%) unilaterally and in six patients (18.7%) bilaterally

The degree of avascular necrosis was determined by using the serial radiographs taken routinely 2 years following reduction. The severity of avascular necrosis was determined by using the Kalamchi-MacEwen classification,[7] which classifies AVN according to the degree of deformation of the physis, epiphysis, and meta-physis but is independent of the treatment method used (Fig 2).

General distribution of our patients according to the degree of avascular necrosis present was:

· Type I: 8 (21% hips);
· Type II: 6 (15% hips);
· Type III: 9 (23.6% hips);
· Type IV: 15 (39.4% hips).

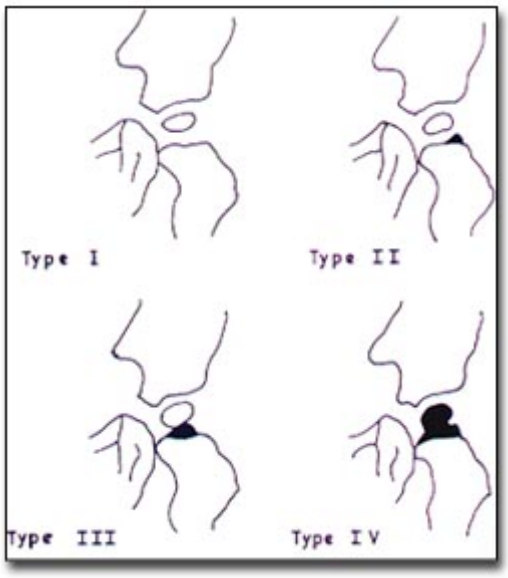
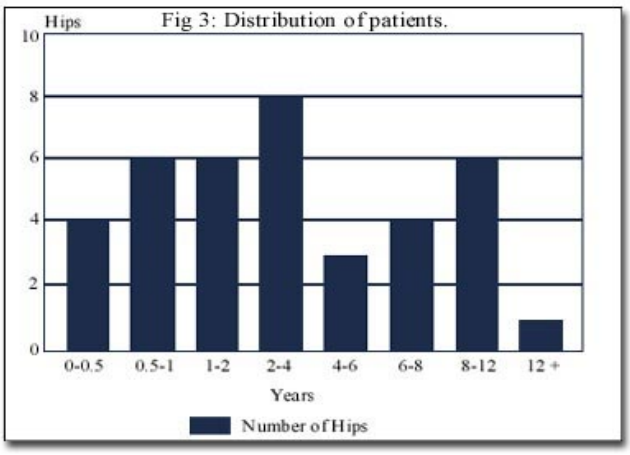


Fig 2: Classification of the degrees of avascular necrosis:
Type I-changes affecting the ossific nucleus;
Type II-lateral physial damage;
Type II I-central physial damage;
Type IV-total dam-age to the head and the physis. (From Kalamchi A, MacEwen

The factors that we think are effective in causing avascular necrosis, (age, type of reduction used, type and amount of immobilization, preoperative traction, and secondary operations) are analyzed in our patient groups. Age. In the beginning of treatment the youngest patient was 5 months and the oldest was 13 years old. A detailed distribution of the patients is shown in Figure 3.



Classification of avascular necrosis according to the age in which the reduction was done is shown in Table1.

Method of Reduction. Twelve hips (31.5%) were treated by closed reduction under general anesthesia, while 26 hips (68.5%) required an open reduction.

Of the 12 hips in which closed reduction was used, five resulted in insufficient concentric reduction in which a secondary procedure was performed. Several factors in the need for secondary procedures after closed reduction were evaluated, including the patient's age at reduction, the degree of dislocation, and the acetabular index prior to reduction. Secondary procedures were done at an average of 2 years after a closed reduction.

Table 1 Classification of avascular necrosis		
Type	Number of Rips	Average Age (Range) at Reduction

I	8(21%)	1.2years(0.5-2years)
II	6(15.7%)	2 years(1.2-3years)
III	9 (23.6%)	4.5 years (2-9 years)
IV	15 (39.4%)	5.7 yeans (0.7-13 years)

Three hips (11.5%) were treated by open reduction without a secondary femoral or acetabular procedure. The open reductions were accompanied by adductor tenotomy, iliopsoas tenotomy, ligamentum Teres excision, and capsulotomy The approaches were the medial approach of Ferguson in two hips and the Smith-Peterson approach in one hip.

Open reduction was combined with proximal femoral varus derotation osteotomy for a concentric reduction in one hip (3.8%). Open reduction is a method that allows the correction of secondary deformities in the soft tissue and bone of a dislocated hip in one radical procedure.[10,19,21] After the adductor tenotomy, a latero-longitudinal approach is used to release the iliopsoas, perform a capsuloplasty, excise the ligamentum Teres, and release the inferior capsule with proximal femoral varization derotation; shortening osteotomy is combined with the appropriate intervention for acetabular dysplasia with different acetabuloplasties according to their indications. The types of acetabuloplasties applied to the patients are listed in Figure 4.

Distribution of patients according to the degree of avascular necrosis is seen in Figure 5.

The cases in which avascular necrosis developed after treatment are shown in Figure 6. For comparison, the degree of dislocation before treatment and the amount of avascular necrosis that developed is compared to the method of Tonnis as modified by Zionts[3] in Figure 6.

Traction Before Reduction. Preliminary traction is used to bring the femoral head down to a level distal to Hilgenreiner's line so there is an ease of reduction.[13] Traction was applied as skin traction or skeletal traction according to the general condition of the patient (age, weight, etc) and the hips.

In the cases in which closed reduction was done, an average of 11 days of skin traction was considered sufficient. With weekly radiologic follow up, skin traction was continued until the femoral head came to +1 level as Gage and Winter suggested.[13] Reduction by traction was not planned in our series as we felt that only the release of soft tissue contractures was necessary.

Only three hips (7.8%) were treated with skeletal traction before open reduction. The initial traction weight was 1.5 kg. Radiographs were made at weekly intervals to assess the position of the femoral head. The average duration of skeletal traction was 2 weeks. Those hips that had skeletal traction developed Type IV avascular necrosis. This finding did not affect our overall result.

Since our patients' average age at reduction is higher than those in the literature, our views of preliminary traction and reduction are different.[10,19,21] In our open reductions-since we apply a varus derotational osteotorny with shortening of the femur-we do not consider preliminary traction necessary Some authors also regard this approach as appropriate.[3,21,22]

In a prospective trial made in our clinic there was no statistical difference between patients undergoing reduction and femoral osteotomy who had preliminary traction and those who did not.[10]

Immobilization and its Duration. Nine hips treated primarily by closed reduction were immobilized in Lorenz I (frogleg) position for an average of 2.9 months (range: 1.5 to 4), and after that the Lange (Lorenz II) position for an average of 2.8 months (range: 1.5 to 3.9). Continuity of reduction was maintained by Dennis-Brown abduction braces for an average of 2.5 months (range: .5 to 5).

Distribution of patients treated with closed reduction and the degree of avascular necrosis are:

· Type 1:1 hip (2.6%);
· Type II: 3 hips (7.8%);
· Type III: I hip (2.6%);
· Type IV: 4 hips (10.5%).

After closed reduction, three hips were treated in the "human position" and immobilized for 3 months in this position. Avascular necrosis developed in two hips-one Type I and one Type II.

Hips treated primarily by open reduction were immobilized in the "human position" for 3 months (two hips) or hip spica for 6 weeks (24 hips). Continuity of reduction in the ones immobilized in the "human position" was sustained by a 900 abduction brace. Those treated by hip spica were stabilized with Dennis-Brown brace (6 weeks all day and night followed by 6 weeks only nights).

Secondary Procedures. In 13 cases a surgical procedure was performed after the appearance of avascular necrosis.

Two hips in the Type I avascular necrosis group who had persistent acetabular dysplasia after closed reduction required Salter innorninate osteotomy Avascular necrosis was present in these hips before the innominate osteotomy and continued after surgery.

Three hips in the Type II avascular necrosis group needed secondary procedures. These procedures included proximal femoral varus derotation osteotomy combined with Salter innorninate osteotomy in two cases and one Dega procedure.

Two hips in the Type III avascular necrosis group required Chiari procedures to augment lateral coverage. Three hips in the same group who had relative decrease of articulotrochanteric distance required distal transplantation of the greater trochanter at the time of skeletal maturity.[23] We could obtain trochanter-to-trochanter distance in only one of these. Also a hip in the Type III group required a femoral lengthening osteotomy due to leg length discrepancy.

Two hips in the Type IV avascular necrosis group were treated with valgus osteotomy for progressive varus deformity. One of them was combined with trochanteric epiphysiodesis. Also, the other hip required a femoral lengthening operation.

RESULTS

Avascular necrosis criteria were not considered in our evaluation, because different treatment methods were used and many factors with different results were obtained.

Therefore, common clinical results were determined by using a modification of McKay's criteria, and radiographic results were classified according to the criteria established by Severin (Tables 2-3).[3,24,25] Our clinical results are listed in Table 4. Our radiographic results are shown in Table 5.

Table 2 Criteria for Clinical Evaluation

Rating	Criteria
Excellent	Stable rainless hip; no limp; negative Trendelenburg sign; full range of moion
Good	Stable painless hip; slight limp; slight decrease in range of motion
Fair	Stable painless hip; limp, positive Titndelenhurg sign and limited range of motion or a combination of these
Poor	Unstable or painful hip or both; positive Trendelenburg sign

Table 3 Classification of Radiographic Results

Classification	Criteria
Group I (excellent)	Normal hip; center-edge angle $>25^0$
Group II (good)	Moderate deformity of head, neck or acetabulurn, concentric reduction; center edge angle $>25^0$
Group III (fair)	Dysplastic hip, no subluxation; center edge angle $<20^0$
Groups IV & V (poor)	Subluxation and articulation in false acetahulum

Table 4 Clinical Results

Results (No. or Hips)				
Type	**Excellent**	**Good**	**Fair**	**Poor**
I	6	2	0	0
II	3	3	0	0
III	0	2	6	1
IV	0	1	7	7
Total	9(23.6%)	8 (21%)	13 (34.2%)	8 (21%)

Table 5 Radiographic Results

Results (No. or Hips)				
Type	**Excellent**	**Good**	**Fair**	**Poor**
I	5	3	0	0
II	0	5	1	0
III	0	2	5	2
IV	0	1	9	5
Total	5 (13.1%)	11(28.9%)	15 (39.4%)	7 (11.4%)

DISCUSSION

The treatment instituted currently is centered around the importance of correcting the soft tissue and osseous pathologies of the hip joint, and does not take into account the vascular problems that may arise. No matter what kind of treatment has been instituted the goal is to decrease the chance of avascular necrosis. For this reason the pathologies that may cause avascular necrosis must be relieved by the treatment instituted. With the institution of therapy, factors that may result in avascular necrosis must be dealt with by the surgeon.

In the first 12 months of life the femoral head is made up of cartilaginous material and is very sensitive to ischemic insults that may arise. This sensitivity has been shown by Salter et al,[17] Bulcholz and Ogden,[5] and Ogden.[26] The ischemic insult on the femoral head can cause a variety of changes from a simple transient change on the physis to a complete destruction and a long standing deformity. [5,7]

As Harris et a1[22] have defined, the first step in the treatment of CDH is a concentric reduction of the femoral head in the acetabulum; only in this way can there be enough stimulus to help in the development of the acetabulum. In the first 6 months of life CDH is treated by placing the legs in abduction so that the femoral head is centralized in the acetabulum. Stabilization of the reduction is made by braces and bandages that hold the legs in abduction. Forceful and rigid reduction of the hips by braces is reported to cause avascular necrosis.[27] So far we have not seen any patient in this age group with avascular necrosis. We think that this is due mainly to the use of Pavlik bandages that do not cause forceful reduction but resist activity that results in dislocation of the hip.[28] The application of the Pavlik Harness without complications depends on the cooperation between the parents, the orthopedic surgeon, and the orthotist.[29]

After the seventh month of life, the dislocated femoral head slips laterally and superiorly, and with this the hip adductors first gain some tension, which results in contracture. The negative effect of the strained adductors on the circulation of the hip joint had been demonstrated in the postmortem angiographic evaluation by Nicholson et al.'[5] For this reason, in whichever procedure we choose, we see adductor tenotomy as an essential part of the treatment. A preoperative evaluation of the adductors and indications for recession should be considered in every case where appropriate. Since adductor tenotomy is a routine part of the treatment protocol in our clinic, we could not evaluate it as a prognostic factor in the formation of avascular necrosis.

Another early intervention is closed reduction. In past years, closed reduction was used more widely in children up to 2 or 3 years of age, but as our knowledge of avascular necrosis increased our indications for closed reduction decreased. Zionts3 states that closed reduction in children between ages 1 to 3 is a controversial issue. With an older age the secondary deformities that develop due to the degree of dislocation make a closed reduction harder to obtain, and if will compromise the local circulation. Gage and Winter[13] stated that if the first attempt at closed reduction fails any reduction obtained after this will increase the chances of avascular necrosis. In our series, Type IV avascular necrosis was seen in four of 12 closed reductions. In the retrospective survey, it was found that these patients were older than 2 years of age; reduction was attained with forceful manipulation after several attempts; and the continuity of the reduction was maintained in a Lorenz type cast. It is also stated that the changes that occur on the proximal end of the femur are multifactorial, and those hips that may have had an easy reduction may end up with these severe deformities.[13] For this reason, we cannot find a single factor for avascular necrosis.

For example, in four of the hips the appearance of signs of avascular necrosis a short time after the surgical procedure made us think that this may be related to the closed reduction applied first. For this reason, in children up to 1 year of age, a gentle reduction under general anesthesia with immobilization in the 'human position" following a period of traction will decrease the incidence of avascular necrosis seen after closed reduction. Salter et a1[17] stated that immobilization in the human position is only effective after other components of closed reduction that we have mentioned have been met.

It is an accepted idea that the position of immobilization after reduction is one of the factors that causes avascular necrosis. Gage and Allen saw avascular necrosis in normal hips following immobilization during the treatment of the contralateral congenitally dislocated hip.[3,17] The pathologies that resulted from prolonged immobilization have been evaluated in retrospective reviews of CDH patients, in animal models, and in infant cadavers.[5,11-15,18] Salter et al'[7] said that in forceful immobilization the strained adductors act as a lever that increases the force by which the femoral head is pulled into the acetabulum and this resulted in narrowing or clogging of the intercartilaginous canals of the femoral epiphysis. The latest reviews on the subject were defined by Ogden, who stated that forceful immobilization placed pressure on the extracapsular arteries and that this was the primary reason for avascular necrosis.[16,26]

In the current literature and as part of our findings we found that the Lorenz I and the Lange position (Lorenz II) increased the risk of avascular necrosis to a maximum.[5,7,11-13,17,30] In our series of CDH patients, if a forceful immobilization is done after a gentle reduction, the chance of obtaining avaseular necrosis is high. In those patients who were immobilized in the Lorenz position and in whom severe deformities of the head developed, they also had other factors affecting the outcome, such as age, the status of the dislocation, and other unfavorable factors. This also proves that the etiology of avascular necrosis is multifactorial.

There are some variations in the development of avascular necrosis. Even though many patients receive the same treatment, different degrees of avascular necrosis develop because of the continuum of avascular necrosis and the differences of compensatory collateral circulation. For this reason, Type I and Type II avascular necrosis develops depending on the revascularization potential of the hip.

Salter et al'[7] has stated that the appearance of irregular ossifications was due to the reaction to the stimulus placed on the hip by reduction which is due to quickening of physial ossification. Type I avascular necrosis is thought by some authors to be due to partial vascular embarrassment.[6,26,30]

Temporal irregular ossifications of Salter or Type I avascular necrosis results in minimal deformity such as coxa magna, which does not Inecessitate any additional intervention.[7,17,30] Interventions made for the treatment of CDH after Type I avascular necrosis has begun do not change the expected outcome. In Type II avascular necrosis there is a tendency to valgus deformity due to the early closure of the lateral physeal plate. This might turn out to lead to incongruency of the hip joint which will cause lateral subluxation of the head.[7]

For these hips, to satisfy a headacetabulum congruency, a proximal femoral varus osteotomy is needed. The interventions made on the acetabulum after a Type II avascular necrosis were done mainly to correct the residual acetabular dysplasia left from closed reduction, and did

not correlate directly with the degree of avascular necrosis. The treatment for Type II avascular necrosis was mainly a varus osteotomy made approximately 4 years after reduction.

The rate of avascular necrosis following an open reduction is generally lower. The reason for this is that the elements that make the process of closed reduction more difficult are inspected directly and the elements that interfere with a concentric reduction like the iliopsoas tendon, the narrowing of the capsule on the isthmus, the limbus, and the hypertrophic ligamentum Teres, are surgically corrected.[10,19-21]

In children up to the age of 16 months the medial approach of Fergusson is used as a open reduction method that removes the soft tissue pathologies seen in CDH during reduction.[20,31,32] In a study made in our clinic we also found that in experienced hands this reduction method has the least associated avascular necrosis.[20]

We set the upper age limit of 16 to 18 months for open reduction without any additional procedure. This age limit is due to the fact that the acetabulum continues developing as Salter and Dubas stated.9 In cases when there is concentric reduction of the hip, the acetabulum has a potential to develop up to 8 years of age as defined by some authors.[10,9,20,22,33] In older patients, to attain a concentric reduction osteotomies must be made under direct vision on the proximal part of the femur and on the dysplastic acetabulum. In addition to these the capsular narrowing can be released, the inferior capsular ligament excised, and following these a capsuloplasty can be done to stabilize the hip joint and decrease the duration of immobilization. [19]

Those who advise open reduction state that even though closed reduction is a far less aggressive intervention, long periods of traction and immobilization are needed which may increase the risk of osteoporosis and have the risk of residual subluxation and insufficient acetabuJar development.3 In avascular necrosis that develops after closed or open reduction, the outcome seems to favor closed reduction. This is due mainly to the range of motion and the centeredge angle. In avascular necrosis that develops after open reduction, the outcome is usually worse than that of closed reduction and includes Type III and IV avascular necrosis.

Salter and Dubas,[9] and Bos and Sloof[34] stated that an unsuccessful open reduction would complicate the surgical treatment that might follow. In hips that redi4ocate, any secondary avascular necrosis is added to the problem. For this reason we believe that all the pathologies of CDH must be treated with one radical approach.

The success in the surgical treatment of CDH depends on the experience of the surgeon. Since the hospital in which this study was done is a teaching hospital, different surgeons did these operations and chances of technical mistakes were higher, because every component of the open reduction has a significant meaning. For example, while doing the iliopsoas tenotomy, if the medial circumflex artery is injured, the whole outcome of the operation might change.

Another factor that affects the development of avascular necrosis is the age at which treatment is begun. Many authors have stated the importance of this and also have stressed that the severity of avascular necrosis increases with age.[5,12,13,16] Unfortunately, in countries where routine examinations of children are not done, CDH is diagnosed after the child starts to walk. For this reason, our age in which treatment is started is higher than in the literature.[1]

The potential sequelae of Type III and TV avascular necrosis are acetabular dysplasia and increasing subluxation of the hip.[7] After the development of a deformity in the femoral head and neck, the concentric stimulation on the acetabulum is lost, resulting in dysplasia as a potential deformity of avascular necrosis. This opens the way for persistent subluxation' of the hip. To relieve this discrepancy, interventions on the proximal femur and/or acetabulum are considered appropriate choices.[7,35]

Since the femoral head has deformed, there is no indication for an innominate osteotomy[9] The best choice for these hips is a Chiari osteotomy in which the lateral acetabular roof covers the femoral head.[30,35] As a result, in Type III avascular necrosis acetabuloplasties are considered the methods of choice since Type III avascular necrosis results primarily in coxa magna on the femoral side.

In Type IV avascular necrosis, the primary deformity is angulation toward varus, and the severe ischemic damage affects the whole physis.[7] The primary intervention during this early period is a valgus osteotomy to centralize the head that is going toward varus. Only in this way can sufficient stimulus be given to the acetabulum for its development.

After Type III and IV avascular necrosis, a relative overgrowth on the trochanteric region appears with severe deforruity of the head and neck.[5,7] To prevent this deformity; trochanteric epiphysiolysis and later the transfer of the trochanter have been performed.[23] These procedures have been performed on our patients during follow up when deemed necessary In those patients in whom the treatment was begun at a later age, we lost the chance of epiphysiolysis, but trochanter transfers were used instead.

Coopermann et al'[2] followed 30 hips in 25 patients for an average of 39 years and found that in 80% of the patients early degenerative changes had formed. In our series, since we were only able to follow for an average of 8 years, it was too early to draw any conclusions. We saw that in those patients who visited our clinic regularly we could manage the problems of avascular necrosis as they appeared, but could not obtain very successful results in patients who came only when they had complaints. Severin[25] reported an increase in the subjective complaints of these patients following heavy labor; pregnancy, etc.

CONCLUSION

The treatment of CDH without avascular necrosis is our goal. After a concentric reduction, the growth of the child will help in the' normal growth of the hip. But the sole purpose of treatment is not to put the head in the acetabulum and make it stay there; rather; it is to avoid the problem of avascular necrosis during treatment and present the patients with a functionally and radiologically normal hip that will last their lifetime.

Since the blood supply of the femoral head changes with growth periods, complications of the vascular insult also change. In the first 12 months of life, the femoral head is very sensitive to vascular insults, and if reduction and maintenance is accomplished through force during this period the most severe form of the deformity will develop.

When applying open reduction, all the factors that may cause vascular insult must be dealt with carefully and then osteotomies on the proximal femur and acetabulum should be done under direct vision for a concentric reduction. In those unfortunate cases in which avascular necrosis develops, interventions for the preservation of femoral head and acetabular contact,

congruency and containment should be instituted. We believe that with the appropriate indications and an experienced surgical team, the incidence of avascular necrosis can be brought to a minimum. By instituting close follow up and with early awareness, the potential sequelae of avascular necrosis can be decreased.

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Section Editor: Robert Chuinard, MD