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The effects of arthrographically detected femoral head lateralization and soft tissue interposition during closed reduction of developmental dislocation of the hip on mid-term r esults

Gelişimsel kalça çıkığının kapalı redüksiyonunda artrografi ile saptanan yumuşak doku interpozisyonu ve lateralizasyonun orta dönem sonuçlar üzerine etkisi

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Amaç: Bu prospektif randomize olmayan çalışmada, 18 ay ve altı yaşlarda, gelişimsel kalça çıkığı nedeniyle genel anestezi altında eklem kapsülü açılmadan yapılan redüksiyon sırasında artrografik olarak saptanan asetabüler labrum altında femur başı lateralizasyonu ve yumuşak doku interpozisyonunun orta dönem radyografik sonuçlar üzerine etkisi incelendi.

Çalışma planı: Çalışmaya ortalama yaşı 12 ay (dağılım 4-18 ay) olan 21 çocuğun 31 instabil kalçası alındı. Medial girişimle iliopsoas ve adduktor longus tendonları kesildikten sonra artrografi yapıldı. Tüm olgularda Tönnis grade 2 artrografik redüksiyon saptandı; ancak eklem kapsülü açılmadı. Ortalama izlem süresi 6.5 yıl (dağılım 3-9.5 yıl) idi.

Sonuçlar: Femur başı avasküler nekrozu (AVN), yeniden çıkık ve ikinci ameliyat oranları sırasıyla %42, %19 ve %29 bulundu. Femur başı avasküler nekrozu saptanan kalçaların yaklaşık yarısında büyüme plağı tutulumu da vardı. Bir yaşın altında ameliyat edilen kalçalarda daha az oranda AVN görüldü. Artrografide birden fazla eklem içi yumuşak doku engeli saptanan kalçalarda komplikasyon daha fazla görüldü. Artrografide 7 mm üzerinde göllenme görülen kalçalarda AVN ve yeniden çıkık oranları, 3-7 mm arasında göllenme olan kalçalara oranla daha yüksek bulundu.

Çıkarımlar: Orta dönemli komplikasyon oranları, eklem açılmadan yapılan redüksiyon sonrası artrografide femur başı lateralizasyonu, yumuşak doku interpozisyonu ve medialde kontrast madde göllenmesi saptandığında, eklemin açılması ve redüksiyona engel olan yapılar ortadan kaldırılarak anatomik redüksiyonun sağlanması gerektiğini göstermektedir.

Anahtar sözcükler: Artrografi; femur başı nekrozu/etiyoloji/komplikasyon; kalça çıkığı, doğuştan/cerrahi/komplikasyon/radyografi; kalça eklemi/radyografi; bebek; ameliyat sonra-

Objectives: In a prospective, non-randomized evaluation of patients who underwent surgery under general anesthesia for developmental dislocation of the hip (DDH) at or below 18 months of age, we assessed the mid-term effects of arthrographically documented femoral head lateralization and soft tissue interposition under the acetabular labrum during reduction without opening the hip joint capsule.

Methods: The study included 31 unstable hips of 21 children (mean age 12 months; range 4 to 18 months). After the iliopsoas and adductor longus tendons were sectioned by a medial approach, hip joint arthrography was performed. According to the criteria of Tönnis, all the patients had grade 2 arthrographic reduction and the hip joint capsule was left intact. The mean follow-up was 6.5 years (range 3 to 9.5 years).

Results: Avascular necrosis of the femoral head (AVN), redislocation, and secondary operation were seen in 42%, 19%, and 29%, respectively. The physeal plate was involved in nearly half of the hips with AVN. The occurrence of AVN was less in hips treated at the age of below one year. Complications were more frequent in cases in which more than one intraarticular soft tissue obstacles had been documented by arthrography. Avascular necrosis and redislocation were more commonly encountered in hips in which the medial pool size of contrast material exceeded 7 mm than those with sizes between 3 to 7 mm.

Conclusion: Our mid-term complication rates suggest that the hip joint capsule be opened in order to achieve an anatomical reduction through eliminating intraarticular obstacles when arthrography shows lateralization of the femoral head, soft tissue interposition, and medial pooling of the contrast material following closed reduction of DDH.

Key words: Arthrography; femur head necrosis/etiology/complications;hipdislocation,congenital/surgery/complications/radiography; hip joint/radiography; infant; postoperative complications.

This study has been presented in the EPOSCongress (April 14-17, 1999, Göteborg, Sweden), the POSNA 2001 Congress, (May 1-5, 2001 Cancun, Mexico) and the 1st National Pediatric Orthopedics Congress (September 15-19, 2002, Antalya, Turkey).

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Closed reduction under general anesthesia is a widely accepted treatment option for patients younger than 18 months and with developmental dysplasia of the hip (DDH). In most instances, the procedure is combined with an adductor tenotomy. During the procedure arthrography is usually required to determine the degree of reduction.[1-4] However, in cases where the joint capsule is preserved intact, the presence of two different classical theories make the term 'adequate reduction' controversial. One theory is in favor of concentric anatomic reduction,[4] while the other theory indicates that, when the hip is immobilized in a stable and nonextreme position, soft tissue interposition between the femoral head and the inner wall of the acetabulum or loss of contact between the femoral head and the inner wall of the acetabulum when the head opposes the triradiate cartilage, would not adversely influence the outcome.[1]

The aim of this retrospective, nonrandomized study is to evaluate the effects of arthrographically documented soft tissue interposition and femoral head lateralization under acetabular labrum on the mid-term radiological outcome after closed reduction and immobilization in nonextreme positions in patients younger than 18 months.

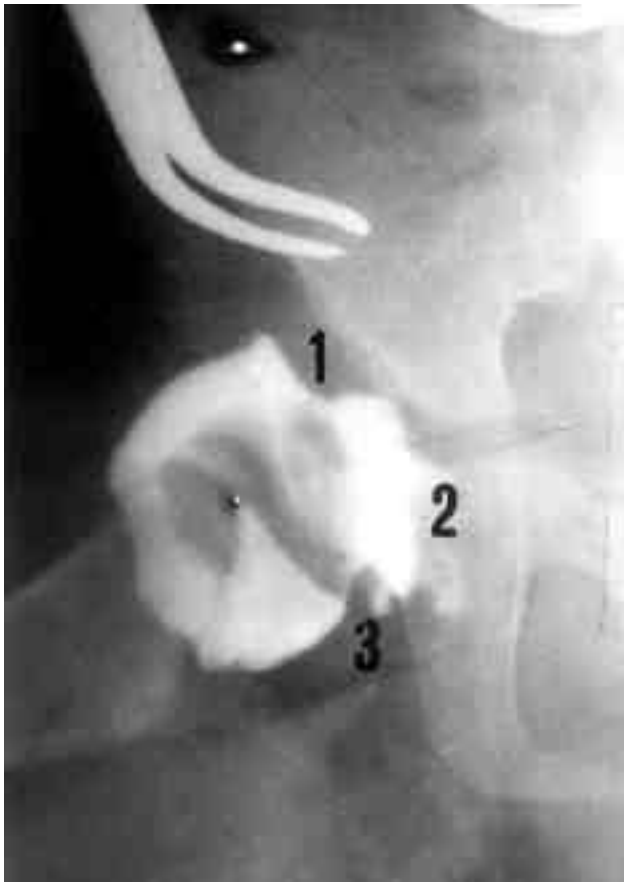
Patients and method

Among 275 patients operated by the authors for DDH and followed-up since 1993, 33 hips of 23 patients with arthrographically documented soft tissue interposition between the femoral head and acutabular inner wall and femoral head lateralization under acetabular labrum after closed reduction under general anesthesia (Tönnis grade 2 arthrographic reduction[3]) (Figure 1) were documented. 31 hips of 21 patients (18 girls, 3 boys) were included in the study since they had completed at least three years of follow-up. Mean age at time of reduction was 12±4 months (range 4-18 months). Involvement was unilateral in 13 patients (5 right hips, 8 left hips) and bilateral in 9 patients. According to the Tönnis classification[3], 20 hips had grade 2, four hips grade 3, seven hips grade 4 dislocations.

The only patient under 6 months of age had previously been unsuccessfully treated with a Pavlik harness. None of the other patients older than 6 months were treated otherwise. Traction was not applied to any of the patients before the procedure.

Surgical technique

Following a skin incision of 4-5 cm starting from the inguinal crease along the posterior edge of the adductor longus muscle, the fascia parallel to this incision is also sectioned. The adductor longus tendon is identified and sectioned. The lesser trochanter is accessed by blunt dissection from between the adductor brevis and adductor magnus muscles, and the iliopsoas muscle is sectioned at its origin. The femoral head is gently reduced without forceful movements and arthography is performed when the hip is in 90°-100° flexion and 50°-60° abduction. For the hips included in the study, the procedure was terminated after Tönnis grade 2 arthographic reduction, without incising the joint capsule, followed by cast immobilization in the 'human' position[2]. After reduction, a safe zone of at least 20 degrees was



Şekil 1. Arthrogram of a 16 month-old girl obtained during the operation. Following iliopsoas and adductor longus tenotomies , a Tönnis grade 2 arthrographic reduction is achieved. Intraarticular soft tissue obstacles: 1) Inverted labrum, 2) Central filling defect; 3) Inferior filling defect.

Table 1. Classification of avascular necrosis of the femoral head[7]

Classification	Result
Type 1Changes are limited to the ossification center	Generally heals without sequelae.
Type 2Damage to the lateral physis together with type 1	Femoral head displaced laterally to valgus position
Type 3Damage to central physis together with type 1	Relative trochanteric overgrowth together with short femoral neck
Type 4Complete damage to the head and physis	Thickened, shortened femoral neck with varus angulation and trochanteric overgrowth.

observed in all hips. Following the procedure, computed tomography or magnetic resonance imaging was not performed. After cast immobilization for three months, an abduction-flexion orthesis was applied for an additional three months. Control arthrography was not performed during follow-up visits. Radiological follow-up consisted of standard AP radiographs.

Evaluation of arthrographic findings

Intraarticular obstacles for achieving anatomic reduction may be divided into three groups: inverted labrum in the superior wall of the acetabulum (İL), the 'central filling defect' including the hypertrophic ligamentum teres (CFD), the inferior filling defect (IFD) in the inferior portion of the acetabulum, which includes the tight inferiomedial capsule and/or the thickened transverse acetabular ligament (Figure 1). In the arthrogram, the distance between the innermost aspect of the femoral head and the outermost part of the acetabular wall, the so-called the 'medial dye pool', was measured in milimeters: Reduction was considered 'good' when this pool was 0-2 mm, 'moderate' between 3-7 mm, and 'bad' over 7 mm.[5]

Avascular necrosis of the femoral head (AVN) was evaluated according to the Kalamchi and McEwen classification system[6] (Table 1).

Mean follow-up period for the 31 hips included in the study was 6.5±2 years (range 3-9.5 years).

Statistical analysis involved Fisher's exact chi-square test for comparing the complication rates between the groups and p values smaller than 0.005 were considered significant.

Results

AVN was encountered in 13 hips (%42). The incidence was less frequent in the ≤12 months age group as compared to 13-18 months group (Table 2). In 7 of these hips, physeal involvement was present and all hips with this disorder had been treated between 13-18 months of age (Table 2).

Redislocation occured in 6 hips (%19). No significant difference existed between different age groups (Table 2).

In nine hips (%29), a second procedure was either performed or planned. In 6 redislocated hips, a total of five soft tissue interventions (anterior or medial open reduction), two bony interventions (open reduction with Salter osteotomy and proximal femoral

Table 2. The incidence of avascular necrosis of the femoral head and complications according to age groups.

	≤12 months(n=11)		13-18 months(n=20)		
	Number	Percent	Number	Percent	p
Avascular necrosis of the femoral head	2	18	11	55	0.066
Type 1	2	18	4	20	
Type 2	–		2	10	
Type 3	–		1	5	
Type 4	–		4	20	
Redislocation	3	27	3	15	0.638

Tablo 2. The rate of complication according to the width of medial dye pool.

	3-7 mm (n=26)		>7 mm (n=5)		
	Number	Percent	Number	Percent	*p*
Avascular necrosis of the femoral head	9	35	4	80	0.134
Type 1	5	19	1	20	
Type 2	2	8	–		
Type 3	–		1	20	
Type 4	2	8	2	40	
Redislocation	4	15	2	40	0.241

osteotomies) had to be performed in order to achieve reduction. One of these 6 hips also had type 4 AVN. Proximal femoral valgus and trochanteric advancement osteotomies were planned in this hip and also in another hip with type 4 AVN. For the remaining two hips with type 4 AVN, trochanteric apophysiodesis was combined with proximal femoral valgus osteotomy. A total of three hips with type 2 and 3 AVN are still under follow-up.

In the intraoperative arthrographies, the mean width of medial dye pool was 6±2 mm (range 3-10 mm). The rate of AVN and redislocation was lower but not statistically significant in those hips which had a medial dye pool width of 3-7 mm in their initial arthrograms, as compared to those where the width was over 7 mm (Table 3). Interestingly, AVN involving the physis was observed in three of the five hips where the medial dye pool was over 7 mm. In most of the complicated hips, more than one type of intraarticular soft tissue obstacles were noted arthrographically (Table 4). In five of the six redislocated hips and 10 of the 13 AVN hips, there were more than one type of intraarticular soft tissue interpositions (Table 4).

Discussion

There are not many studies concerning the effect of femoral head lateralization due to soft tissue interposition initially in dysplastic hips which were treated with closed reduction. Some authors indicate that a certain amount of femoral head lateralization and soft tissue interposition between the femoral head and acetabulum may be acceptable after closed reduction in DDH, and that this situation does not necessitate open anatomic reduction since the soft tissue obstacle would gradually be reduced when the hip is immobilized in a stable and nonextreme position and that this interposition also does not influence the clinical and radiological outcomes adversely [7-11] Taking these ideas into consideration, in the initial phases of the study, closed reduction was evaluated to be adequate and open reduction was not considered when the femoral head was contained under the acetabular labrum after reduction was acquired through nonextreme manipulation with an adequate safety zone, despite arthrographically documented soft tisue interposition and femoral head lateralization. However, an AVN rate of 42%, a redislocation rate of 19% and reoperation rate of

Table 4. The relationship between complications and arthrographic findings

Arthrographic finding	Number of hips	Avascular necrosis of the femoral head		Redislocation	
		Yes	No	Yes	No
IL	3	2 (Type 4)	1	–	3
CFD	–	–	–	–	–
IFD	3	1 (Type 1)	2	1	2
IL + CFD	4	1 (Type 1)	3	–	4
IL+ IFD	1	–	1	–	1
CFD+ IFD	5	3 (Type 1: 2) (Type 3: 1)	2	1	4
IL+CFD+ IFD	15	6 (Type 1: 3) (Type 2: 2) (Type 4: 1)	9	4	11
Total of hips	31	13	18	6	2I

IL: Inverted labrum; CFD: Central filling defect; IFD: Inferior filling defekt.

29% have proved that this surgical algorythm was in fact in need of reevaluation. For the last six years, all hips with Tönnis grade 2 arthrographic reduction following ilipsoas and adducton longus tenotomies received open reduction with excision of the ligamentum teres and transverse acetabular ligament and anatomical reduction acquired was exactly similar to those seen in hips where the femoral head can never be contained in the acetabulum (Tönnis grade 3 reduction). Since the beginning of the study, the joint capsule is not surgically manipulated in hips where Tönnis grade 1 anatomical reduction is possible. The aim of this limited surgical intervention is to acquire a radiographically anatomical reduction with a clinically large safety zone.

What are the reasons for such high complication rates in this study? Liu et al[11] reported that arthrographical noncontainment of the femoral head under the acetabulum was an indication for immediate open reduction and recommended waiting in all other circumstances. Hattori et al[12] reported that the prominent soft tissue interposition which was initially present would gradually be reduced in 17% of the cases and that long-term follow-up results of these hips were almost similar to those in whom arthrographical anatomic reduction was initially acquired. The high complication rate documented in this study prevents us from supporting the ideas indicated above.

Hattori el al[12] reported that there was no correlation between AVN and the type of arthrographic reduction in the long-term follow-up. However, in our study, initially untreated femoral head lateralization and soft tissue interposition were shown to cause ischaemic changes. We believe that the most common cause for AVN observed in almost half of our patients was the increase in intraarticaluar soft tissue tension (including the articular capsule) together with increased intraarticular pressure following reduction. This factor was the only unaltered cause of AVN. Extraarticular obstacles which could hinder reduction and also cause avascular necrosis of the femoral head, have been eliminated routinely before reduction, reduction was performed with nonextreme manipulation and immobilization was provided in a physiological position. According to the findings of this study, the risk of both AVN and redislocation increase in hips with more than one type of arthrographically demonstrated soft tissue interposition and which are planned to undergo closed reduction.

Another result of the study is that the amount of arthrographic dye pool is predictory for possible complications. Race and Herring[5] defined 'good' reduction as that reduction without any soft tissue interposition and with a medial dye pool of 2 mm and less and 'bad' reduction as that where soft tissue interposition and a medial dye pool of more than 7 mm are present. They have reported discouraging radiological results in two thirds of their patients. In our study, initial arthrograms demonstrated a medial dye pool of more than 2 mm, and in five hips the pool was over 7 mm. Redislocation was encountered in two and AVN with physeal damage in three of these five hips. Although no statistical significance could be demonstrated due to the small patient group, an initial medial dye pool of especially 7 mm and more constitutes a significant risk factor for AVN and redislocation. A medial dye pool of 3-7 mm needs to be considered as a risk factor for AVN and redislocation. Our results obtained from a limited number of cases, support the hypothesis by Race ve Herring[5], indicating that a dye pool of more than 2 mm should not be considered as good reduction and that a pool of 7 mm and more should be evaluated as bad reduction.

In this study, a close correlation has been found between the age at operation and radiological results and complications. A higher incidence of severe forms of AVN (types 2, 3 and 4) in patients who were treated when they were 13-18 months old, infers that walking and erect posture may have detrimental effects on the end results.

Classically, the iliopsoas and adductor tendons are classified as the most important extraarticular obstacles to reduction in DDH.[1-3,13] We believe that the most significant extraarticular obstacle in DDH is the iliopsoas tendon and that it should be excised before reduction. The adductor longus tendon should also be excised. Malvitz and Weinstein[14] reported 46% successful radiological results and 60% growth disturbances in the proximal femur, in the long-term follow-up of patients who have initially been treated with closed reduction. Koizumi et al[15] also reported a high rate of unsuccessful radiological results and AVN in the long-term follow-up of cases who have undergone open reduction through an anterior approach, sparing the iliopsoas

tendon. A common feature to both studies is preserving the most common extraarticular obstacle, the iliopsoas tendon, while performing reduction through either an open or a closed approach. The high rate of failure in both of these long-term studies strengthens our belief in the necessity to excise the iliopsoas tendon before any reduction is attempted. However, excising obstacles which hinder reduction alone is also not adequate to improve success, since the complication rate is high due to the presence of intraarticular obstacles after eliminating extraarticular ones. If anatomic reduction can still not be achieved despite elimination of important intraarticular obstacles, intraarticular obstacles (like tight inferomedial capsule, hypertrophic ligamentum teres, thickened transverse acetabular ligament, etc) must be overcome. We believe that routine closed reduction should only be carried out in hips with or without adductor tenotomy, which can be reduced spontaneously in flexion and abduction, without the need for forceful manipulation through relaxation provided by anesthesia. Clinical and radiological documentation of reduction is mandatory. Under any other circumstances, following adductor longus and iliopsoas tenotomies, arthrography should be used to decide whether open reduction would be necessary. Contrary to our belief, Aksoy et al[16] treated 200 patients aged 2-13 months using the classical closed reduction technique and obtained 76% satisfactory radiological results and only 15% AVNs at mid-term follow-up examinations. Prospective randomized clinical studies and their long-term follow-up evaluations are needed to better understand whether the iliopsoas tendon has to be excised before closed reduction is performed. However, depending on our personal experience, we believe that excision of the iliopsoas tendon is not an unnecessary procedure and it should be considered as a measure taken to treat an extraarticular obstacle which plays a role in the pathophysiology of DDH. There are no comprehensive studies indicating that the long- or short-term clinical results are adversely affected by this iliopsoas tenotomy.

There are three major drawbacks to the current study. The first one is the inadequate number of cases to provide sound statistical evaluation, since the method was reevaluated after high complication rates were found. The second drawback is the relatively short mean follow-up period. Better results are evidently obtained in DDH patients after skeletal maturation is completed.[17] We therefore believe that mid-term follow-up findings of unsatisfactory results obtained from such a study should be reported. The last drawback may be the inadequacy to detect the true incidence of type 2 AVN, since lateral physeal growth plate involvement would become prominent between 4-14 years of age. [18] Moreover, using the arthrographic grading system described by Tönnis may also be discussed since it was originally developed for hips where the iliopsoas tendon is left intact.

In conclusion, DDH patients younger than 18 months who did not respond to conservative treatment, should receive an attempt for closed reduction under general anesthesia, and during the procedure if arthrographically documented soft tissue interposition is present between the inner acetabular wall and the femoral head despite containment under acetabular labrum is obtained, detection of a medial dye pool should be considered ‘inadequate’ reduction and open anatomic reduction should then be performed. Hips with a medial dye pool of 7 mm and more are especially prone to increased risk of serious complications. When open reduction is not considered, the risk of AVN over the age of 12 months and redislocation without age limits are expected to be very high.

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