

Clinical And Radiological Results of Ludloff Medial Open Reduction Technique in Patients With Developmental Hip Dysplasia

Ludloff Medial Açık Redüksiyon Uygulanan Gelişimsel Kalça Displazili Hastaların Klinik Ve Radyolojik Sonuçları

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ABSTRACT

Aim: The aim of this study was to evaluate the clinical and radiological results of Ludloff medial open reduction surgery in patients with the developmental of hip dysplasia, younger than 18 months old.

Methods: The radiological and clinical results of 35 patients (49 hips), younger than 18 months of age treated with Ludloff medial approach due to DDH between the years 2013 and 2020 were retrospectively evaluated. Preoperative, final control acetabular index angles and medial apertures were measured according to the McCay criteria, Tönnis classification, Kalamchi-MacEwen classification, IHDI classification and Severin classification were analysed.

Results: At the last control, the youngest age was 27 months, the oldest was 88 months and the mean age was 43.90 ± 14.17 months. The follow-up period was performed at a minimum age of 12 months, a maximum age of 72 months, and the mean follow-up period was 24.81 ± 17.17 months. According to the Tönnis classification, 40 hips were Tönnis classification type 1 (81.63%), 4 hips were Type 2 (8.16%), 3 hips were Type 3 (6.12%) and 2 hips were Type 4 (4.08%) in the follow-up visit. According to McCay clinical evaluation criteria, 38 hips (79.59%) were grade 1 which equates to excellent results. Grade 0 (no necrosis) was detected in 38 (77.55%) of 49 hips according to the Kalamchi and MacEwen AVN clinical evaluation criteria. According to the Severin classification, type 1 results were observed in 32 (65.31%) of 49 hips, type 2 in 9 hips (18.37%), type 3 in 1 hip (2.04%) and type 4 in 7 hips (14.29%). The mean CE angle was found to be 18.56 ± 9.93 . Additional surgical intervention was required in 8 hips of 6 patients.

Conclusion: Clinically and radiologically satisfactory results were obtained in DDH patients with Ludloff medial open reduction technique, below the age of 18 months.

Key words: Developmental hip dysplasia, open reduction and avascular necrosis.

ÖZ

Amaç: Bu çalışmanın amacı, 18 aylıktan küçük, gelişimsel kalça displazisi olan hastalarda Ludloff medial açık redüksiyon cerrahisinin klinik ve radyolojik sonuçlarını değerlendirmektir.

Yöntem: 2013-2020 yılları arasında GKD nedeniyle Ludloff medial yaklaşımı ile tedavi edilen 18 aylıktan küçük 35 hastanın (49 kalça) radyolojik ve klinik sonuçları retrospektif olarak değerlendirildi. Ameliyat öncesi, son kontrol asetabular indeks açıları ve medial açıklıklar McCay kriterlerine göre ölçüldü, Tönnis sınıflaması, Kalamchi-MacEwen sınıflaması, IHDI sınıflaması ve Severin sınıflaması analiz edildi.

Bulgular: Son kontrolde en genç 27 ay, en yaşlı 88 ay ve ortalama yaş 43.90 ± 14.17 ay idi. Takip süresi minimum 12 ay, maksimum yaş 72 ay ve ortalama takip süresi 24.81 ± 17.17 ay idi. Tönnis sınıflamasına göre 40 kalça Tönnis sınıflama tip 1 (%81,63), 4 kalça Tip 2 (%8,16), 3 kalça Tip 3 (%6,12) ve 2 kalça Tip 4 (%4,08) idi. McCay klinik değerlendirme kriterlerine göre 38 kalça (%79,59) derece 1 idi ve bu da mükemmel sonuçlara tekabül ediyordu. Kalamchi ve MacEwen AVN klinik değerlendirme kriterlerine göre 49 kalçanın 38'inde (%77,55) derece 0 (nekroz yok) saptandı. Severin sınıflamasına göre; 49 kalçanın 32'sinde (%65,31) tip 1, 9 kalçada tip 2 (%18,37), 1 kalçada tip 3 (%2,04) ve 7 kalçada tip 4 (%14,29) tespit edildi. Ortalama CE açısı $18,56 \pm 9,93$ olarak bulundu. 6 hastanın 8 kalçasına ek cerrahi müdahale gerekti.

Sonuç: Ludloff medial açık redüksiyon tekniği ile 18 aydan küçük GKD hastalarında klinik ve radyolojik olarak tatmin edici sonuçlar elde edildi.

Anahtar kelimeler: Gelişimsel kalça displazisi, açık redüksiyon ve avasküler nekroz.

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Introduction

Developmental hip dysplasia (DDH) is a vigorous disease in which the structures that compose the hip joint, which are normal during their intrauterine formation, subsequently and for various reasons show structural deterioration [1]. The main goal in DDH treatment is to ensure the concentric reduction of the hip joint as soon as possible and to provide interaction between the proximal femur and the acetabulum [2]. It has been reported that the acetabulum has the ability to develop over many years when appropriate contact is provided between the femoral head and acetabulum [3].

Treatment steps to be applied to the patient includes a process starting from dynamic (Pavlik bandage) or static (such as abduction orthosis, Frejka pillow, etc.) orthoses, to closed reduction, medial or anterior open reduction and pelvic or femoral osteotomy. The age and clinical condition of the patients and the experience of the clinician should be taken into consideration, before selecting treatment options.

Medial open reduction for DDH was described by Ludloff in 1908. The medial approach with the Ludloff technique requires minimal soft tissue dissection, low blood loss and provides direct access to all inferomedial structures that prevent reduction. However, the Ludloff technique requires precision and focus due to the risk of injury to the medial circumflex artery and restricted the hip joint vision [4].

As the diagnosis is delayed, the joint remodelling ability and treatment success decreases, causing complications, and the risk of developing degenerative joint disease increases. The significance of providing the patient with a lifelong, painless and functional hip joint is early diagnosis and treatment [2].

In this study, we aimed to evaluate the clinical and radiological results of the Ludloff medial open reduction surgery in patients with developmental hip dysplasia younger than 18 months old.

Patients and methods

The radiological and clinical results of the patients who underwent open reduction surgery

using the Ludloff medial approach technique due to DDH, between 2013 - 2020 in the Harran University, Faculty of Medicine, Orthopedics and Traumatology Clinic, were retrospectively evaluated.

Patient files were scanned and those who underwent medical open reduction surgery at the age of 18 months and younger, were included in the study. Patients who were older than 18 months at the time of surgery, had teratological dislocation and did not show up for regular follow-ups, were excluded.

Radiographic evaluation of the patients were done with preoperative and final visit, direct pelvic radiographs. Acetabular index angles and medial apertures were measured on the radiographs. The Tönnis and IHDI classifications were used for radiological staging. Additionally, acetabular coverage was evaluated with the Severin classification and the requirements for secondary acetabular intervention were determined. Pain and range of motion were evaluated using the Mc Cay clinical evaluation criteria. Kalamchi-MacEwen classification was used to evaluate patients according to a radiologic avascular necrosis, during the final visit.

Tönnis Classification System: The Tönnis classification was used for arthrographic staging preoperatively and during surgery. The hips are classified according to Tönnis's Rating: accordingly, grade 1 defines acetabular shallowness, grade 2 subluxation, grade 3 dislocation and grade 4 defines high dislocation [5,6].

IHDI classification: A new radiographic classification system has been developed by the International Hip Dysplasia Institute (IHDI), which uses the centrum of the proximal femoral metaphysis as a reference point. Grade 1 represents the mildest hip dislocation, whilst Grade 4 refers to the worst hip dislocation. The IHDI classification gives more effective and accurate results than the Tönnis classification in patients without femoral head ossification [7].

The clinical results of our patients were analyzed according to the McCay clinical evaluation criteria [8]. As for the Kalamchi-MacEwen classification, it divides AVN cases into four groups, thereby

focusing on growth plate involvement [9].

Severin evaluation system: This test is an evaluation system based on the CE angle. The CE angle is normally between 15-25°. This angle is less than 15° in acetabular dysplasia [10]. This angle is considered to be 19° and above between the ages of 6-13, and 25° and above in patients older than 14 years of age [11]. The head center cannot be evaluated completely in children younger than 5 years, therefore although the diagnostic value of CE angle is higher at the age of 5 years and older [12]. However, some studies used the Severin radiological evaluation criteria in patients under 5 years of age [13,14]. Severin's radiological evaluation criteria were used in this study, with reference to the studies in the literature.

Surgical technique: Patients were positioned in supine position. Arthrography was performed under fluoroscopy and the femoral head-acetabulum relationship and capsule were evaluated. According to the arthrography results, 4 cm incision was made parallel and 1 cm distal to the groin crease, starting from the adhesion site of the adductor longus tendon in patients who could not achieve stable concentric reduction with closed methods. Thereafter, tenotomy was performed, 2 cm distal to the insertion of the adductor longus with electrocautery. Consequently, an iliopsoas tenotomy was performed using the cleavage between the adductor longus-pectineus (in superior of the adductor longus) to find the iliopsoas. Subsequently iliopsoas tenotomy, the capsule was exposed and opened in a T shape. Ligamentum teres and transverse acetabular ligament were excised, and the intra-articular pulvinar was removed. The hip was shortened without suturing the capsule. At the end of the operation, the incision was sutured in layers. Wound dressings were applied. The patient was taken to the plaster table with his reduction preserved. A pelvipedal cast was applied in the human position (Figure 1.) [15].

Results

Forty-nine hips of thirty-five patients were included in this study. The youngest age at the last visit was 27 months and the oldest was 88 months old. The mean age was 43.90 ± 14.17

months. The follow-up period was minimum 12, maximum 72 months, and the mean follow-up period was 24.81 ± 17.17 months. The youngest age at time of operation was 5 months, the oldest was 18 months and the mean age at the time of operation was 13.61 ± 2.80 months. The rate of using the Pavlik bandage was found in only 1 (0.35%) patients. It was observed that two (0.7%) of the patients had previously undergone closed reduction. No infection was found in any of the patients. One patient (2.85%) had a femur fracture during pelvipedal casting. Twenty-six (74.28%) of the patients used postoperative abduction devices, while nine (25.72%) did not (Table 1).

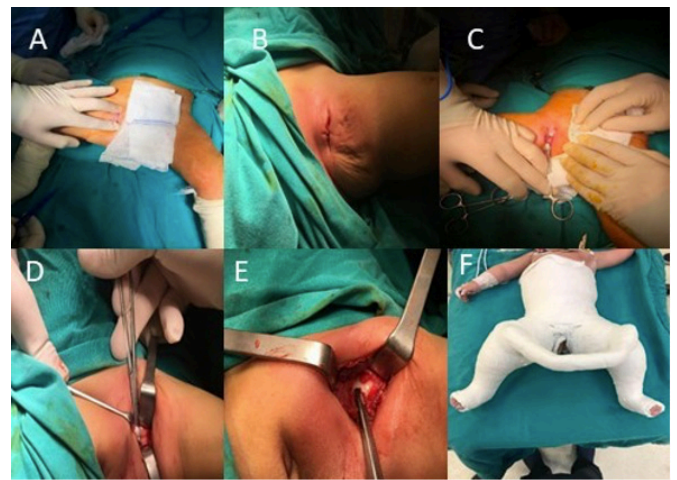


Figure 1. Surgical incision (A, B) Adductor longus view after the fascia is opened (C) Iliopsoas musculotendinous junction (D) Opening the joint capsule in "T" shape, view of acetabulum and femoral head after excision of ligamentum teres and pulvinar (E) Pelvipedal cast (F)

Table 1. Demographics of the patients

		Mean±Std	Min-Max
Age at last follow-up (month)	Female (n:30)	43,43±14,79	27-88
	Male (n:5)	44,22±10,98	29-55
	Total (n:35)	43,90±14,17	27-88
Age at operation (month)	Female (n:30)	13,58±2,55	5-18,00
	Male (n:5)	14,96±1,07	9-16,13
	Total (n:35)	13,61±2,80	5-18,00
Follow-up duration	Female (n:30)	24,75±17,61	12-40
	Male (n:5)	23,61±12,03	12-72
	Total (n:35)	24,81±17,17	12-72

The mean preoperative Acetabular Index angle of 35 patients was found to be 37.19 ± 4.23 . The mean Acetabular Index angle at the last controls was 25.84 ± 6.42 , and the repeated angular values over these periods showed a statistically significant change ($t: 4.967$; $p: 0.013$). The mean

preoperative medial aperture (mm) of 35 patients (49 hips) was 8.56 ± 2.69 , while the mean medial aperture (mm) of 35 patients (49 hips) in the last controls was 0.97 ± 0.76 , and the repeated angular values over these periods, statistically showed significant change ($t = 3,871$; $p: 0,006$).

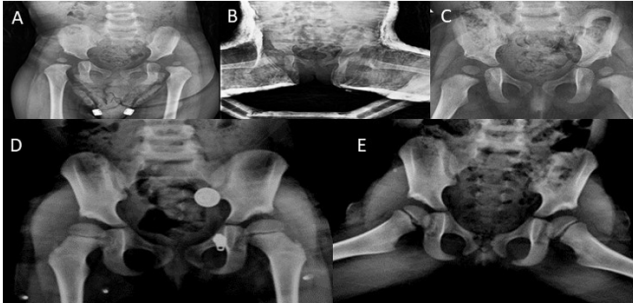


Figure 2. 16 month old female patient preoperative AP radiography (A) Postoperative AP radiography after bilateral Ludloff medial approach technique (B) Postoperative 3rd month AP radiography (C) Postoperative 28 month AP (D) and frog leg (E) radiography

The preoperative radiologic evaluation according to the Tönnis classification revealed 4 hips were type 2 (8.16%), 25 hips were type 3 (51.02%) and 20 hips were type 4 (40.82%) DDH. At the final follow-up, 40 hips were type 1 (81.63%), 4 hips were type 2 (8.16%), 3 hips were type 3 (6.12%) and 2 hips were type 4 (4.08%). A statistically significant difference was established between the preoperative Tönnis classification and the last visit according to the chi-square analysis ($\chi^2: 9.119$ $p: 0.035$) (Table 2.).

Table 2. Tönnis classification

	Tönnis classification	n	%	Chi-square (χ^2)	P value
Preoperative	Type 2	4	8,16	9,119	0,035**
	Type 3	25	51,02		
	Type 4	20	40,82		
Final follow-up	Type 1	40	81,63		
	Type 2	4	8,16		
	Type 3	3	6,12		
	Type 4	2	4,08		

Preoperative radiologic evaluation according to the IHDI classification revealed 3 hips were type 2 (%6.12), 30 hips were type 3 (%61.22), 16 hips were type 4 (%32.65). At the final follow-up, 40 hips were type 1 (%81.63), 6 hips were type 2 (%12.24), 3 hips were type 3 (%6.12) (Table 3). A statistically significant deviation was found between the preoperative IHDI classification and

the last control IHDI classification according to the chi-square analysis ($\chi^2: 8,478$ $p: 0.018$).

Table 3. IHDI classification

	IHDI	n	%	Chi-square (χ^2)	P value
Preoperative	Type 2	3	6,12	8,478	0,018**
	Type 3	30	61,22		
	Type 4	16	32,65		
Final follow-up	Type 1	40	81,63		
	Type 2	6	12,24		
	Type 3	3	6,12		

According to the McCay clinical evaluation criteria of the patients in the study, 38 hips (79.59%) were Grade 1 (excellent), 3 hips (%6.12) were grade 2 (good), 2 hips (4.08%) were grade 3 (moderate) and 6 hips (%12.24) were Grade 4 (poor) (Table 4).

Table 4. McCay classification

	n	%
Grade 1 (excellent)	38	79,59
Grade 2 (good)	3	6,12
Grade 3 (moderate)	2	4,08
Grade 4 (poor)	6	12,24

The rates of AVN in our cases were evaluated according to the Kalamchi-MacEwen classification. According to the Kalamchi-MacEwen AVN clinical evaluation criteria, 38 (77.55%) of the hips were grade 0 (no necrosis), 9 hips (18.37%) were grade 1, 1 hip (2.04%) was grade 2 and 1 hip (2.04%) was grade 3 (Table 5).

Table 5. Kalamchi-MacEwen classification

	n	%
Grade 0	38	77,55
Grade 1	9	18,37
Grade 2	1	2,04
Grade 3	1	2,04

The patients were also evaluated according to the Severin classification: 32 hips (65.31%) were type 1, 9 hips (18.37%) were type 2, 1 hip was type 3 (2.04%) and 7 hips (14.29%) were Type 4. The mean CE angle was found 18.56 ± 9.93 . Additional surgery was required in 8 hips of 6 patients in the study, 2 patients rejected further treatment (3 hips), a Pemberton osteotomy was performed

on 4 patients (4 hips) and Salter osteotomy was performed on 1 patient (1 hip).

Discussion

In this study, low AVN rate, high functional scores and successful radiological results were obtained in the early period with the Ludloff open reduction method in DDH patients younger than 18 months. Faresetti et al. retrospectively analyzed 71 hips that they treated with medial open reduction and reported excellent results in 44 hips (76%), good results in 24 hips (17%), and moderate results in 3 hips (7%) according to the McKay criteria after a mean follow-up of 22 years [16]. Okano et al. used the Ludloff method for 43 patients (45 hips) and reported excellent results in 35 hips (77%), good result in 1 hip (2.2%), moderate results in 3 hips (6.6%) and poor results in 4 hips (8.8%) according to the McKay criteria after a mean follow-up of 16.4 years [17].

In the present study, in accordance with the literature, grade 1 excellent results were observed in 38 hips (79.59%) according to the McCay classification. In addition, grade 2 good results were observed in 3 hips (6.12%), grade 3 moderate results in 2 hips (4.08%) and grade 4 poor results in 6 hips (12.24%). We surmise that the reason we observed a similar success rate with long-term follow-up studies in the literature is that the Ludloff method requires minimal soft tissue dissection, as well as a low AVN rate over a long term period.

AVN is the most serious complication in the long term after DDH treatment. Its frequency rates have been reported in a wide range of 0-73% in different series [3]. In a study conducted by Biçimoğlu et al., 185 hips of 143 patients were reduced with posteromedial limited open intervention and they reported that AVN was observed in 19.5% of patients who were followed up retrospectively, at an average of 7.5 years [18]. Koizumi et al. analysed the results of surgical treatment to 35 hips of 33 patients with DDH using the Ludloff's medial open approach and reported an AVN rate of 42.9% after an average follow-up of 19.4 years [19].

In the present study, AVN rates were evaluated according to the Kalamchi-MacEwen classification.

Accordingly, 38 (77.55%) of the hips were grade 0 (no necrosis), 9 hips (18.37%) were grade 1, 1 hip (2.04%) was grade 2 and 1 hip (2.04%) was grade 3. AVN rates with the Ludloff method in the early period were satisfactory in the present study. However, the reason for the low AVN rate reported in this study may be the shorter follow-up period compared to other studies in the literature.

Isiklar et al. found an affiliation between the age of the child at the time of surgery and secondary surgeries they performed later in patients younger than 18 months in DDH patients, operated with the medial approach [20]. Zamzam et al. found that residual acetabular dysplasia in the patients they treated increased in children older than 12 months [21]. The most controversial age group in hip dysplasia treatment is between 15-18 months. Tümer et al. emphasized the importance of early concentric reduction and recommended monitoring of spontaneous healing in patients before early secondary bone procedures [3]. As a result, it has been seen that residual acetabular dysplasia rates can be reduced at a young age, low grade (Tönnis), low acetabular index angle before reduction, and stable concentric reduction after treatment. In our study, the mean age of patients requiring secondary surgery (10-18 months, mean: 15.7) was higher than the general average age (5-18 months, mean: 13.6). The preoperative mean acetabular index was also found to be 39 ° and Tönnis tapering average was 3.

In light of all this literature, we may infer that residual acetabular dysplasia rates can be reduced at a younger age, low grade (Tönnis), low acetabular index angle before reduction, and stable concentric reduction after treatment. Before performing such surgical interventions, planning should be made according to the Tönnis degree, acetabular index angle and the surgeon's experience and preference [22].

K. Yamada et al., reported the results of 103 patients who underwent open reduction with Ludloff's medial approach, where 115 hip joints were observed over a long-term beyond the age of maturity. According to Severin's classification, 69 hips (60.0%) considered to represent acceptable results were classified as group I or II. A total of 39 hips (33.9%) were group III and the remaining 7

hips (6.1%) were group IV. As for reoperation, 20 of 21 patients who underwent surgical reduction after the age of 12 months required additional corrective surgery during the growth period, as the hip joint tended to subluxate gradually [23].

We evaluated the patients according to the Severin classification: 32 (65.31%) of 49 hips were type 1, 9 hips (18.37%) were type 2, 1 hip (2.04%) type 3 and 7 hips (14.29%) were Type IV. Mean CE angle was 18.56 ± 9.93 . Additional surgery was required for 8 hips of 6 patients in the study. 2 patients underwent treatment rejection (3 hips), 4 patients Pemberton osteotomy (4 hips), 1 patient salter osteotomy (1 hip). Consistent with the findings in the literature, we observed that residual acetabular dysplasia rates and the need for secondary intervention increased as the age and acetabular index rate at the time of operation increased.

The limitation of the present study are the limited number of patients and a short follow-up period. With long follow-up periods, the rate of AVN, secondary acetabular dysplasia and the number of patients requiring secondary surgeries may change.

Conclusion

The Ludloff medial open reduction technique is a reliable method with low AVN rate and satisfactory clinical results, in patients with DDH younger than 18 months of age.

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Literature search. **EV (0000-0001-6048-368X):** Materials, Data collection, Editing. **MO (0000-0002-7944-3124):** Materials, Data collection, Critical Review. **MAA (0000-0001-9164-6090):** Concept, Critical Review, Supervision.

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