Effect of Age and Surgical Procedure on Clinical and Radiological Outcomes in Children with Developmental Dysplasia of the Hip: A Comparative Study

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ABSTRACT

Objective: We investigated the effect of age and surgery procedure on clinical and radiological outcomes in children with developmental dysplasia of the hip (DDH) who were treated before or after 18 months of age.

Methods: Between January 1997 and December 2010, 46 hips of 35 patients were included in this retrospective study. The patients who treated for DDH, followed regularly for at least 4 years and at the last 5 years and above in time of the last controlled. Group 1 (≤18 months) comprised patients who underwent open reduction through the anterior approach, and Group 2 (>18 months) comprised patients who underwent anterior open reduction plus Salter innominate osteotomy.

Results: With respect to clinical and radiological outcomes, although Group 1 was more successful than Group 2, there was no significant difference between the groups (p=0.332 and p=0.425, respectively). In contrast, the necessity of a revision surgery and avascular necrosis of Group 2 from Group 1 was higher, and there was a significant difference between the groups (p=0.30 and p=0.046, respectively).

Conclusion: Successful in terms of clinical and radiological results to be higher than the rate in group 1 is remarkable. Moreover, avascular necrosis development and implementation of secondary surgery were less observed in young children who were treated with only open surgery, thereby suggesting that better results are achieved with simple procedures and at an early age in DDH treatment.

Keywords: Developmental dysplasia of the hip, open reduction, ınnominate osteotomy, avasculer necrosis

INTRODUCTION

Developmental dysplasia of the hip (DDH) is a general term for a spectrum that includes anatomical defects of the hip, varying from mild dysplastic changes to dislocations accompanying abnormal pathological findings, which can develop because of various prenatal, natal, or postnatal causes (1-4). DDH is one of the most important childhood orthopedic pathologies and a health problem that may lead to a disability if it remains untreated or is diagnosed late (5, 6). The main problem with respect to all stages of DDH treatment is the reduction of the hip and correction of instability in the joint. There are various treatment options for different age groups. Nowadays, treatment algorithms have been developed to select the most appropriate option (7-9).

The main stimulant for the development of a normal acetabulum is a stable, concentrically reduced femoral head. A period of 18 months is regarded as a critical time frame for DDH. Conservative treatments and closed/open reduction of the hip are sufficient for reshaping the acetabulum and femur in the pre-18-month period when bone and soft tissue pathologies are unclear, whereas femoral/acetabular osseous correction surgeries that establish the anatomical and physiological integrity of the hip must be performed at a later stage, particularly after the age of 18 months, when the pathologies are clear (10, 11). Good results have been reported in the literature with the inclusion of primary open reduction and femoral and/or pelvic osteotomies after 18 months (12-15).

In this study, we examined the effects of age and performed treatment based on clinical and radiological results in children with DDH who were treated before and after the age of 18 months.

METHODS

In total, 46 hips of 35 patients who were radiologically and clinically diagnosed with typical DDH, who were treated and followed up over a 14-year period between January 1997 and December 2010 in the clinics where the authors worked, who underwent unilateral or bilateral surgical intervention, who were regularly followed up for at least 4 years, and who were aged ≥5 years during the final examination were included in the study. Approval was obtained from the local ethics committee. Consent for using the medical records for scientific purposes was obtained from

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the parents of the patients at the final examination. The patients were retrospectively separated into two age groups to investigate the effects of age at which surgery was performed and the performed procedure on the clinical and radiological results.

Group 1 comprised patients aged ≤18 months who underwent open reduction with anterior intervention. The modified Smith–Petersen incision was used for the open reduction with an anterior approach (16). Patients postoperatively underwent pelvipedal casting with a flexion of 60°–70° and an abduction of 25°–30°.

Group 2 comprised patients aged >18 months who underwent Salter innominate osteotomy (SIO) with anterior open reduction. Salter's method was used for pelvic innominate osteotomy following open reduction (17). Postoperatively, the hip was placed in a pelvipedal cast at 40° flexion, 30° abduction, and 20° internal rotation; the knee was cast at 25°–30° flexion; and the ankle was in the neutral position. In unilateral cases, the healthy hip was cast in a neutral position as far as the knee. Postoperatively, it remained in cast twice for 6 weeks. The hip was examined at 2-week intervals. Then, a Dennis–Brown orthosis was worn full-time and part-time for 6 weeks each. Cast care and orthosis use were explained to the parents. Following orthosis use, both groups were clinically and radiologically followed up once every 3 months for the first year and once every 6 months for the second year.

At their final examination, the patients were evaluated as successful (good and very good results) or unsuccessful (average and bad results) based on the clinically modified McKay criteria (18). Radiological success results were evaluated according to the Ömeroğlu et al. classification (19). Acetabulum evaluation was measured according to criteria reported by Ogata et al. (20), and other radiographic measurements [acetabular index (AI), center–edge (CE) angle, head–neck angle, acetabular (Sharp angle etc.)] were obtained according to the original descriptions (21).

A diagnosis of avascular necrosis (AVN) was established according to the criteria reported by Salter et al. (22). AVN classification was performed according to the criteria reported by Kalamchi and McEwen (23).

Statistical Analysis

Statistical analysis was performed using SPSS 15.0 (Statistical Package for the Social Sciences Inc., Chicago, IL, USA). Descriptive statistics and frequency of the patients' sociodemographic characteristics were calculated. The Kolmogorov–Smirnov test was used to assess fit of the data to a normal distribution. Clinical and radiological results obtained during the primary and initial treatment method were assessed for determining differences with respect to revision and AVN. Differences between the age groups were analyzed using the chi-squared and Fisher's exact tests. The Mann–Whitney U test was used to compare the results of angular measurements between the groups. The results are presented in a table as number, percentage, mean and standard deviation, and p-values. A p-value of <0.05 was considered to be significant.

RESULTS

Group 1 comprised 22 hips of 17 patients (four boys and 13 girls). Five cases were bilateral and 12 were unilateral (five right and seven left hips). Group 2 comprised 24 hips of 18 patients (five boys and 13 girls). Six cases were bilateral and 12 were unilateral (four right and eight left hips). One patient in Group 1 had previously undergone closed reduction, and three hips in Group 2 had undergone open reduction at other centers before the age of 18 months. Open reductions in the bilateral cases of Group 1 were performed in the same session, but those in the bilateral cases of Group 2 were performed in subsequent sessions. Patients in neither group underwent preoperative traction.

Despite the fact that successful results in terms of clinical evaluation were more frequent in Group 1 compared with Group 2 (86.4% versus 75%), there was no statistically significant difference between the groups (p=0.332). In terms of radiological evaluation, successful results were again more frequent in Group 1 compared with Group 2 (77.3% versus 66.7%), but the difference was not statistically significant (p=0.425). On the other hand, four (18.1%) cases in Group 1 and eight (33.3%) cases in Group 2 required revision surgery, and the difference was statistically significant (p=0.030). AVN was observed in five (22.7%) cases in Group 1 and 10 (41.7%) cases in Group 2, indicating a statistically significant difference (p=0.046). Two cases in Group 2 developed superficial pin tract infections. They were treated with debridement and antibiotherapy.

Table 1. Distribution and comparison of demographic and angular parameters between the groups

	Group 1 (n=22)		Group 2 (n=24)		
Parameter	**Min-Max**	**Mean±SD**	**Min-Max**	**Mean±SD**	**p***
Age (months)	11–18	14.55±2.60	21.00–76.00	33.25±14.48	0.000
Follow-up duration (months)	50–168	84.00±29.46	52.00–168.00	96.83±38.54	0.454
Acetabular angle (degrees)	47–53	49.50±1.90	45–52	49.17±1.90	0.866
Center edge angle (degree)	11–25	17.78±3.99	13–28	18.62±4.03	0.565
Inclination angle (degrees)	112–153	135.5±9.72	106–150	127.21±13.27	0.081
Acetabular index (Preop)	31–43	37.55±3.99	26–43	34.92±4.47	0.088
Acetabular index (Postop)	15–27	21.23±3.70	12–28	20.50±5.24	0.551
Acetabular index correction	10–25	16.32±4.83	2–25	14.42±6.06	0.354

Min: minimum; Max: maximum; SD: standard deviation; *Mann–Whitney U test

Figure 1. a, b. Preoperative (a) and final examination of follow-up (b) radiography of a 17-month-old girl from Group 1

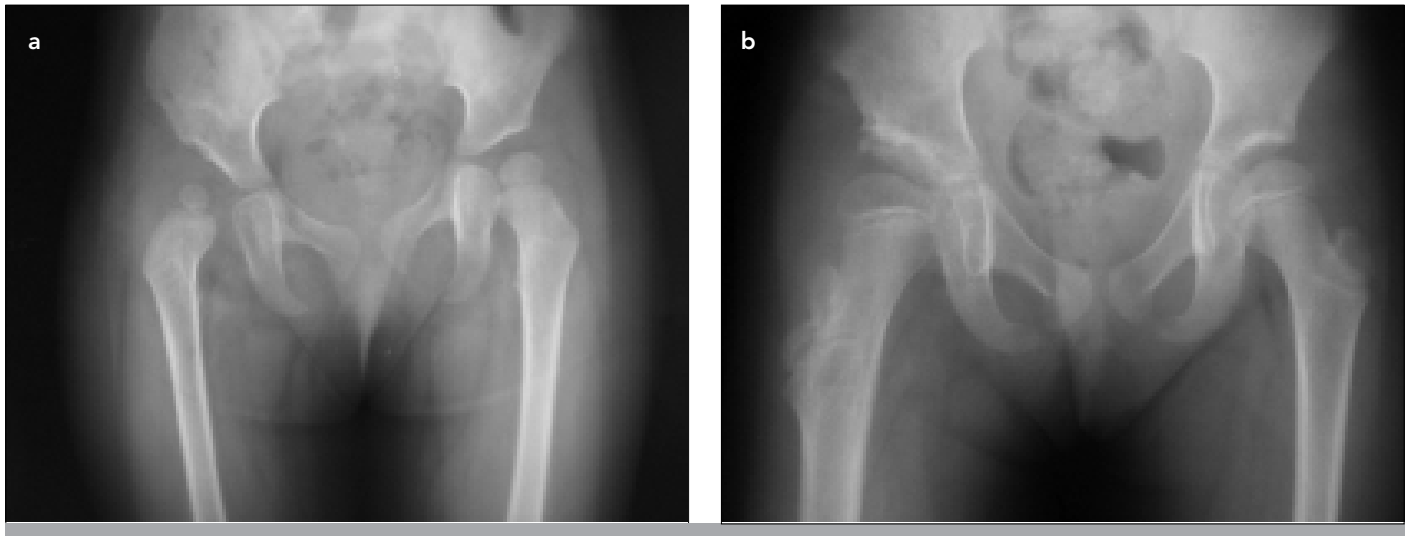

Figure 2. a, b. Preoperative (a) and final examination of follow-up (b) radiography of a 25-month-old girl from Group 2

Although there was a significant difference between the groups regarding age, there was no significant difference regarding the follow-up duration (p=0.000 and p=0.454, respectively). Clear improvements in both groups in terms of AI compared with preoperative measurements demonstrate that the patients benefitted from the surgical treatment (Table 1). However, there was no statistically significant difference between the groups pertaining to all angular measurements (Table 1).

Sample cases from the groups are presented as Figures 1 and 2.

DISCUSSION

DDH is more commonly observed in girls and in the left hip. Bilateral involvement is reported to occur in 20%–25% of the cases. In bilateral cases, particularly in those that require osseous intervention, surgical treatment is performed on the more heavily deformed hip first. Following the healing and rehabilitation of the initially operated hip, the other hip is treated (24-26). However, some authors argue that both hips should be surgically treated simultaneously in the same session, particularly during soft tissue interventions (27, 28). At present, early diagnosis and treatment constitute the most important factors for the successful treatment of DDH. Fewer surgical interventions are performed in patients diagnosed at an early age and stage, with a higher number of successful results (1-8).

In accordance with the literature, DDH was more frequent in girls and on the left hip in our study as well. Open reductions of bilateral cases in Group 1 were performed in the same session. In the unilateral cases in Group 2, acetabular osteotomies along with open reductions were performed in a single session. In the bilateral cases in Group 2, however, they were performed in subsequent sessions. On the other hand, despite the mean age of the cases in Group 1 being lesser than that of those in Group 2, the mean follow-up duration was longer in Group 1 than that in Group 2. At the start of this study, osteotomy was also needed in addition to open reduction because diagnoses and initial treatments of patients were performed at older ages for various

reasons. However, over time, because of earlier diagnoses, treatments with just open reduction or simpler methods were sufficient. This might have caused the difference in the mean follow-up duration between the groups.

There are various treatment options for DDH based on the different age groups. Closed or open reduction performed with conservative methods or under anesthesia can be sufficient in DDH patients who are diagnosed before toddlerhood, whereas bone surgery directed at the proximal femur and acetabulum may be necessary in and after toddlerhood (9-14). Although the performed treatments are standardized in some of the studies in the literature that compare various ages (8, 29, 30), others lack standardization (25, 31, 32). On the other hand, many authors emphasize the following: the first 18 months of age is a very critical time: the effective development of the acetabulum occurs within the first 18 months of life; the acetabulum will not sufficiently develop on its own after the age of 18 months; and acetabular dysplasia must be surgically corrected: only open reduction is not sufficient after the age of 18 months, and additional surgery will be required (12, 17, 33, 34). In various retrospective studies with a design based on age groups, clinical and radiological results are reported to be better in lower-age groups and for simpler surgical treatments compared with combined procedures (25-32). It must be noted, however, that a majority of these studies lack proper standardization and homogeneity because investigating the effects of multiple treatments in groups separated by age can lead to overestimating the success rate of the results.

Taking into account the reasons stated here, cases were separated into two groups: patients aged ≤18 months and those aged >18 months. The patients in Group 1 were younger, i.e., they were diagnosed with DDH earlier, and open reduction, which only included soft tissue intervention, yielded more successful results. The cases in Group 2, however, underwent SIO and open reduction. In addition, cases in both groups underwent other treatments depending on their age and stage, but these cases were not included in the study to ensure the homogeneity of the evaluated groups.

Anterior open reduction has been reported to be advantageous, providing optimal access to the joint, protecting the vascular structure of the femoral neck, and allowing simultaneous capsulorrhaphy. In the clinical evaluation of various studies, 77.1%–98% were reported to have obtained satisfactory results according to McKay's criteria (29, 34, 35). In terms of radiological results, open reduction through an anterior approach is reported to be successful in many studies. In their long-term study, Szepesi et al. (36) performed open reduction through an anterior approach in 49 hips of patients aged 6–24 months. They reported radiologically satisfactory results in 96% according to the Severin criteria.

In our study, clinical success was 86.4% and radiological success was 77.3% in Group 1, in which we performed anterior open reduction. Our radiological success rate, in particular, was slightly lower compared to that reported in the literature. We argue that this result is due to the evaluation criteria used in our study; the reasons for this are discussed in detail in the following paragraphs.

Successful clinical results are reported in the age range from 18 months to 6 years for open reduction accompanied with SIO (4-6, 12, 26, 37-40). Various studies have reported successful results for the treatment of DDH using a single-stage combined procedure (open reduction and osteotomy) in children aged >2 years. Radiological results are reported to be successful in 45%–83% cases and clinical results in 74%–92% cases (12, 39-43). Barret et al. (18) report that performing open reduction and innominate osteotomy at the same time does not influence the result and that 85% of the cases yielded perfect or good clinical results.

When we evaluated the cases aged >18 months in Group 2 wherein the patients underwent open reduction with SIO in our study, the clinical success was 75.0% and radiological success was 66.7%.

As stated above, the reason our radiological success rates are slightly lower than those reported in the literature is the evaluation criteria that we used in our study. Studies that question the reliability of the radiographic evaluation system defined by Severin (44) emphasize its limited objectivity and inclusion of subjective concepts and argue that a new evaluation system needs to be developed because of the low reliability of the current system (45). It is reported that the observed reliability of the radiographic evaluation system developed by Ömeroğlu et al. (19) is sufficient and that it evaluates not only the final state of the hip but also the success of primary therapy. It is reported that Severin's system (44) yields more optimistic results than this new system (19). On the other hand, studies in the literature have used the modified McKay criteria for evaluation. In our study, we have revised these criteria and used them to deem the results as successful or unsuccessful. Radiological evaluations in the literature are usually performed based on Severin's criteria. We, however, evaluated our radiological results with a more objective and comprehensive classification developed by Ömeroğlu et al. (19). Based on these criteria, only cases that were at least 5-year old during the final examination were included.

In the postoperative follow-up of DDH, certain undesirable complications such as redislocation, insufficient reduction, and most importantly, AVN were observed. For these reasons, revision surgery may be necessary (32, 43, 46, 47). AVN secondary to DDH is diagnosed using radiographic findings, and many classification systems have been developed for this, including Kalamchi–MacEwen and Bucholz–Ogden (48). Radiologically, AVN can be observed in the first postoperative year (22). However, in comprehensive studies regarding the number of cases and follow-up duration, the follow-up duration for AVN is at least 2 years (49, 50).

Various studies report that AVN occurs in 4.2%–54.5% of the cases and redislocation occurs in 2%–12.1%, and the necessity for revision surgery can be as high as 73% (13, 18, 32, 43, 47). Various causes have been proposed for AVN, which is the most important complication during DDH treatment. Karakurt et al. (25) encountered AVN in six hips, and they associated this with recurring intervention. Popischill et al. (51) evaluated 78 hips with DDH, identified AVN in 40%, and stated that those that underwent open reduction with osteotomy as well as those that underwent secondary surgical intervention were at high

risks of developing AVN. Morin et al. (52) performed SIO on 180 dislocated, subluxed hips or hips with acetabular dysplasia and followed them up for an average of 12 years. As a result, they reported that the patient being <4 years positively affects the prognosis, but the formation of AVN and prior unsuccessful surgeries negatively affect the results. They further noted that the height of the dislocation, sex, side, and preoperative AI value did not affect the prognosis. Holman et al. (53) reported that an increase in the age at surgical treatment negatively affects the results. They further noted that AVN and redislocation are indicators of bad clinical and radiological results. In a topical and comprehensive systematic review, treatment with only open reduction is reported to have clinically and radiologically more satisfactory results and lower AVN risk compared with treatment with osteotomy (pelvic/femoral) in addition to open reduction (3).

In our study, four (18.1%) cases in Group 1 and eight (33.3%) cases in Group 2 required revision surgery, and the difference between the groups was statistically significant (p=0.030). Avascular necrosis was observed in five (22.7%) cases in Group 1 and 10 (41.7%) cases in Group 2, which was a statistically significant difference (p=0.046). Our results were in accordance with the literature.

CONCLUSION

Despite the fact that there were no statistically significant differences between the groups, the high clinical and radiological success rates in cases with lower ages and less surgical treatments (Group 1) and the significant difference in favor of Group 1 regarding AVN development and secondarily performed surgeries demonstrate that better results can be achieved by the treatment of children with DDH at an early age and with uncomplicated, simpler interventions. In addition to supporting the current literature, we here report a new evaluation system that we have developed for our radiological findings. We maintain that because it includes more comprehensive parameters, the evaluation system reported by Ömeroğlu et al. (19) reflects the results more objectively compared with that reported by Severin (44) that is widely used in the literature.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Süleyman Demirel Universty Faculty of Medicine.

Informed Consent: Written and verbal informed consent was obtained from the parents of the patients who participated in this study.

Peer-review: Externally peer-reviewed.

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