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Is male gender a prognostic factor for developmental dysplasia of the hip? Mid-long-term results of posteromedial limited surgery

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ABSTRACT

Objective: The aim of this study was to determine if male sex is a poor prognostic factor for developmental dysplasia of the hip (DDH) and to determine the mid-long-term radiological and clinical results of male patients in comparison with female patients following an open reduction with posteromedial limited approach.

Methods: We examined 54 hips of 41 male patients (12.38 ± 4.82 months) and 96 hips of 82 female patients (11.11 ± 4.93 months) with DDH. All the patients underwent open reduction with posteromedial limited approach. The average follow-up time was 108 months for the male patients and 110 months for the female patients. The Tönnis grade, acetabular index, Kalamchi and MacEwen classification, and Severin classifications were determined for all patients. The Mc Kay classification system was used to evaluate the functional results.

Results: From the total, 25 (60%) male and 70 (85%) female patients had satisfactory radiographic outcomes (Severin Ia, Ib, or II) according to the Severin classification. There was a significant difference between the two groups in terms of the Severin classification ($P = 0.04$). Residual acetabular dysplasia (RAD) was observed in 12 (15%) female and 17 (41%) male patients ($P = 0.001$). Grade 2 or higher osteonecrosis was observed in 7 (9%) patients in female and 6 (15%) patients in male group. The clinical outcomes in terms of the Mc Kay classification showed satisfactory outcomes in 72 (87%) female and 34 (82%) male patients. Further, 8 (9.7%) female patients and 6 (14.6%) male patients underwent a second operation. However, there was no difference between the two groups in terms of postoperative osteonecrosis presence ($P = 0.982$), functional outcomes ($P = 0.571$), and secondary operation rates ($P = 0.298$). Male sex was associated with poor outcomes in terms of the Severin classification ($P = 0.04$) and RAD ($P = 0.001$).

Conclusion: Although our results indicated that male sex is a poor prognostic factor for radiological results and RAD, there was no difference between male and female patients in terms of osteonecrosis, redislocations, and functional outcomes. Secondary surgical interventions should not be delayed in the absence of the spontaneous development of acetabulum.

Level of evidence: Level III, prognostic study.

Introduction

Developmental dysplasia of the hip (DDH) is a dynamic disease that includes a broad spectrum of symptoms, ranging from mild acetabular insufficiency to a completely dislocated hip, and has an incidence of 1 in every 1000 live births.[1–4] If not treated properly, it may result in arthritis and is a common cause of hip arthroplasty.[5] There are many studies in the literature to identify the patients who can develop long-term arthritis.[6,7] Although the risk factors are clear; there is no consensus about the prognostic factors.

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Parameters, such as bilaterality, age at the time of surgery, preoperative acetabular index angle, and center edge angle, have been analyzed as prognostic factors.[6,8] However, the effect of the female sex, a known risk factor for DDH, is not clear for the prognosis of DDH.[9] Most authors have assessed male and female patients with dysplasia together, with the resulting cohort including only a small number of male patients. To the best of our knowledge, no study has compared the outcome of the posteromedial limited approach in a large series of male and female patients with dysplasia. We aimed to determine whether male sex is a prognostic factor for DDH by comparing the mid-long-term outcomes according to sex following a posteromedial limited surgery, a surgical method between the classical closed reduction and open reduction, with those following a classical method. We also discuss the mid-long-term radiological and clinical result of male patients with DDH in comparison with female patients with DDH following the posteromedial limited approach.

Material and methods

Our institutional review board approved the study, and written informed consent was obtained from every participant before initiating the study. We retrospectively analyzed the medical reports of all patients with DDH who were operated at our clinic using the posteromedial limited approach between 1993 and 2012. The exclusion criteria were as follows: neuromuscular diseases, syndromic presentations, secondary hip problems due to infections, and less than 5 years of clinical or radiological follow-up period. We examined 54 hips of 41 male patients and 96 hips of 82 female patients who had a similar operation side and age at the time of the surgery. In total, we reviewed the medical records and serial follow-up radiographs of 123 patients.

The average follow-up time was 108 months (range, 60–276 months) for the male patients and 110 months (range, 60–282 months) for the female patients. Further, 27 patients (13 male and 14 female) showed bilateral involvement of hips. At the time of surgery, the average age of the male patients was 11 months (range, 3–18 months), and the average age of the female patients was 12 months (range, 3–19 months). All patients were operated on by the same senior surgeon (AB) using a posteromedial limited approach that was identified by Biçimoğlu et al.[10] Both hips were operated during the same surgery in patients who had bilateral involvement. No preoperative traction was applied for any patient. Using the posterior margin of the adductor longus tendon as a reference, a 5-cm longitudinal incision was made. After reaching the adductor longus tendon, a tenotomy was performed. Using the minor trochanter as a guide, an iliopsoas tenotomy was performed. Then, 1 cc of contrast agent [Urografin ® 76%, 100 ml (sodium amidotrizoat and meglumin amidotrizoat)] was injected into the hip joint, and a hip radiographic image was obtained in human position. We performed an arthrotomy in patients who had grade 2 or 3 reductions based on the Tönnis intraoperative grading system and had a narrow safe zone. The inferomedial capsule was opened, and the ligamentum teres and transverse acetabular ligament were incised. Pulvinar was not excised for any of the patients. Arthrotomy was performed in 20 hips of 16 male patients and 36 hips of 28 female patients ($P > 0.05$). After confirming the reduction through an X-ray film, a hip spica cast was applied, and the surgery was concluded. All the patients under 6 months at initial admission received Pavlik harness treatment that was unsuccessful before surgical intervention.

After 3 months of wearing the hip spica cast, all the patients started using abduction braces with 90°–100° flexion and 45°–60° abduction for 3 months. Regular clinical and radiological follow-ups were scheduled postoperatively at 3, 6, and 12 months; once a year until 10 years of age; and once every 2 years until the completion of skeletal maturity.

All the radiographs were analyzed by two researchers (EC and AB) who determined the Tönnis grade, acetabular index, Kalamchi, MacEwen, and Severin classifications.[11,12] The Tönnis grade and acetabular index angles were determined based on the radiographs taken immediately before surgery. Severin classifications were determined based on the final control radiographs. For the Kalamchi and MacEwen classification, the presence of any osteoarthritis was decided upon after examining all the follow-up radiographs. The final clinical outcomes were categorized based on the Mc Kay classification. Inter- and intra-observer reliabilities of the Severin classification were analyzed, and interclass correlation coefficients were found to be 0.712 [95% confidence interval (CI), 0.506–0.812], and 0.802 (95% CI, 0695–0.896), respectively. Any presence of residual acetabular dysplasia (RAD), redislocations, and the need for secondary operations were recorded as postoperative complications. All the radiographs were evaluated, and the Mc Kay classification was determined in a blinded fashion. In bilateral cases, we accepted asymmetrical results if there was one grade or more of difference in the Severin or McKay classification between the two hips.

Statistical analysis was performed using the SPSS 21.0 software version. The variables were investigated using visual (histogram and probability plots) and analytical methods (Kolmogorov–Smirnov test) to determine whether they were normally distributed. For normally distributed variables; the Student's t-test was used to compare between the patients based on sex. Mann–Whitney U test was used to compare the variables that were not normally distributed. Bilateral cases were assessed by patient instead of hips with the aim of comparing the latest radiography and clinical results. In these cases, the worse side was chosen as the index hip for analyses. If the Severin or McKay classification was asymmetrical in unilateral cases, we focused on the left side due to a general left hip preponderance in these patients. A multiple logistic regression analysis was used to identify variables associated with the Severin classification. A power analysis was performed where a sample size of 120 patients would provide 80% power with a 5% significance level on any differences between the study groups. A P-value <0.05 was considered to be statistically significant.

Results

There was no difference between the two groups based on age at the time of operation, average follow-up time, and bilaterality ($P > 0.05$). There was a difference between the two groups in terms of preoperative acetabular index and Tönnis grade of the dislocation (Tables 1 and 2).

Based on the last follow-ups and Severin classification, 22 (54%) male patients and 70 (85%) female patients had satisfactory radiographic outcomes (Severin Ia, Ib, or II) (Fig. 1A, B). There was a significant difference between the male and female patients in terms of the Severin classification ($P = 0.04$). From the total, 12 (15%) female patients and 17 (41%) male patients were classified as Severin III. Further, 2 (5%) male patients were classified as Severin

Table 1
Patient characteristics of the study.

	Male (N = 41)	Female (N = 82)	P values
Preoperative AI[a] (°)	38.46 ± 5.38	41.32 ± 6.68	0.015
Bilaterality [number (%)]	13 (31.7)	14 (17)	0.236
Age at surgery[a] (months)	12.38 ± 4.82	11.11 ± 4.93	0.168
Follow-up[a] (years)	9.31 ± 4.74	9.30 ± 4.46	0.956

[a] The mean values and standard deviations are provided, and Student's t-test was used.

Table 2
Preoperative Tönnis grading of patients.

	Male (N = 41)	Female (N = 82)	P value
Tonnis Grade[a]			0.000
Grade 1	0	0	
Grade 2	25 (61)	24 (29)	
Grade 3	14 (34)	38 (46)	
Grade 4	2 (5)	20 (25)	

[a] Given numbers are number of patients, with the percentages in parentheses. Mann–Whitney U test was used.

Table 3
Comparison of radiological results of male and female patients.[a]

	Male (N = 41)	Female (N = 82)	P value
Severin Classification			0.04
Ia	15 (37)	38 (46)	
Ib	7 (17)	22 (27)	
II	3 (7)	12 (15)	
III	14 (34)	10 (12)	
IV	2 (5)	0	
V	0	0	
VI	0	0	

[a] Given numbers are number of patients, with the percentages in parentheses. Mann–Whitney U test was used.

Table 4
Comparison of osteonecrosis of male and female patients.[a]

	Male (N = 41)	Female (N = 82)	P value
Kalamchi Mc Ewan			0.982
0	34 (83)	68 (83)	
I	1 (2)	6 (7.5)	
II	5 (13)	6 (7.5)	
III	0	0	
IV	1 (2)	2 (2)	

[a] Given numbers are number of patients, with the percentages in parentheses. Mann–Whitney U test was used.

IV, but no female patients were in this class (Table 3). However, no difference was observed between the male and female patients in the presence of postoperative osteonecrosis ($P = 0.982$). Additionally, 7 (9%) female patients and 6 (15%) male patients had grade 2 osteonecrosis or higher (Table 4) (Fig. 2A–C). The evaluation of functional outcomes according to the Mc Kay classification at the final follow-up showed that satisfactory outcome (excellent or good) were obtained for 72 (87%) female patients and 34 (82%) male patients with no difference based on sex ($P = 0.571$) (Table 5).

From the total, 12 (15%) redislocations were recorded in female patients, but none were recorded in male patients ($P = 0.004$). All the redislocated hips were reduced as soon as possible, and this was achieved by opening the capsule in all these hips. RAD was observed in 12 (15%) female patients and 17 (41%) male patients ($P = 0.001$) (Fig. 3A, B). During the follow-ups, due to insufficient acetabular coverage, secondary operations were performed for 8 female patients (Salter osteotomy, Dega osteotomy, and radical reduction for 4, 2, and 2 girls, respectively) and 6 male patients (Salter Osteotomy, Dega Osteotomy, and radical reduction for 2, 1, and 3 boys, respectively). Based on the secondary operations, there was no difference between the male and female patients ($P = 0.298$). Further, 19 patients (9 male and 10 female) showed asymmetrical results and 27 patients (13 male and 14 female) patients showed bilateral involvement.

A multiple logistical regression analysis was used to assess the risk factors in the Severin classification. Higher age at the time of operation, higher Tönnis grade, and male sex were associated with poor outcomes. No relationship was found between the Severin classification, bilaterality, and follow-up time (Table 6).

Discussion

There is no consensus regarding whether sex affects DDH prognosis. Although it is known that female sex is a risk factor for DDH, its effects on prognosis are unclear. In the current literature, male and female patients were studied together, and male patients constituted only a small part of the cohorts.[13,14] To the best of our knowledge, this is the first study comparing male and female patients based on the mid-long-term results of the posteromedial limited approach. We agree with Wang et al[7] and Moussa and Al-Othman[15] that suggested bilateral cases should be assessed focusing on patients rather than hips. In patients who had bilateral involvement and different clinical and radiological results, the worst side was chosen as the index hip.

The Severin classification is most commonly used for the evaluation of radiological results after treatment for DDH. Cha et al used the Severin classification in their study examining the long-term results of closed reduction; however, the groups were formed as walking and non-walking preoperatively. There was no analysis based on sex.[16] Baki et al also used the Severin classification in their study to analyze the radiological results of patients who underwent the posteromedial limited approach and Pemberton osteotomy. Only 1 of the 22 patients was a male.[13] In their study of mid-term radiological results after the posteromedial limited approach, Biçimoğlu et al concluded that sex does not make a difference in terms of radiological results. The above mentioned study consisted of 127 female patients and 16 male patients. Because the number of

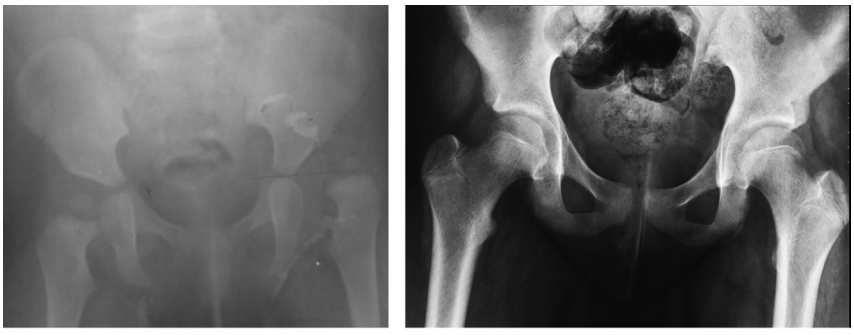

Fig. 1. **(A)** Preoperative and **(B)** 12-year postoperative follow-up radiograph of a male patient. Age at the time of operation, 10 months. There was Tönnis grade 3 dislocation on the left hip. AI angle was 46° on the left. According to final control, the Severin classification was Ia, and the McKay score was excellent.

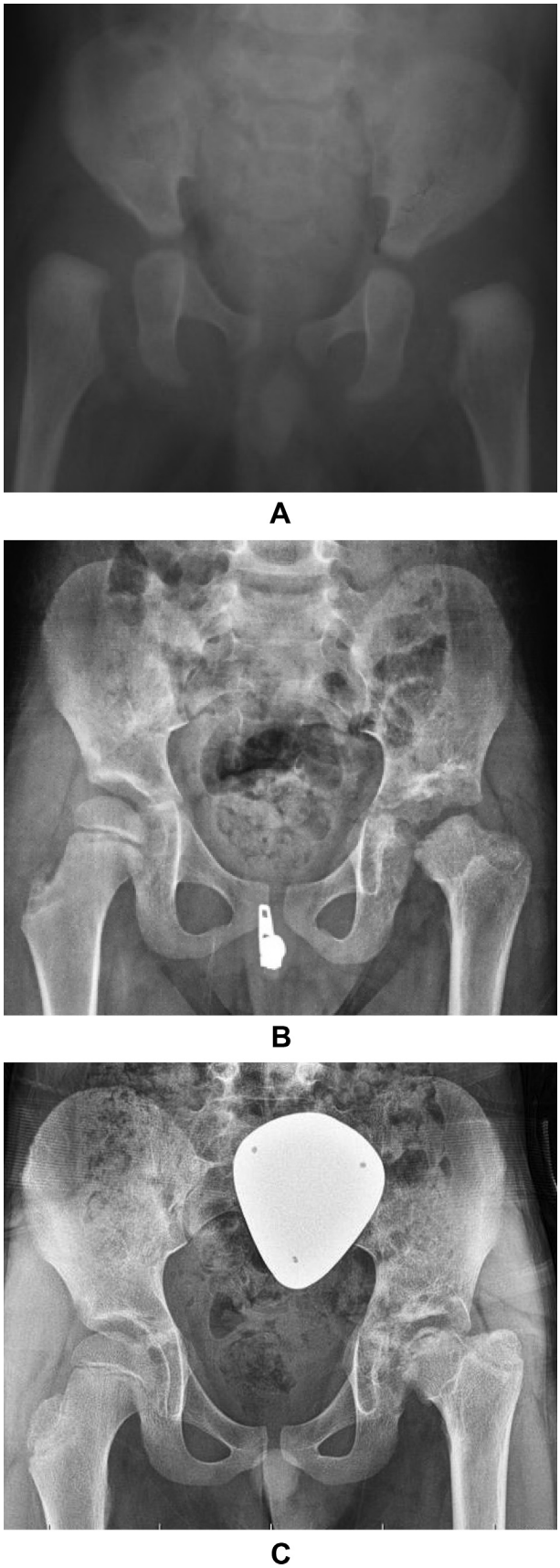

Fig. 2. **(A)** Preoperative X-ray. Male patient was operated on at 5 months of age. The patient has Tönnis grade 2 dislocation on both hips. Preoperative AI angle was 37° on the right hip and 41° on the left hip. **(B)** Control during postoperative year 5. Although the right hip was normal, Type 4 AVN was observed on the left hip **(C)** Postoperative year 11. Severin classification was 4, and McKay score was good.

Table 5
Comparison of functional results of male and female patients.[a]

	Male (N = 41)	Female (N = 82)	P value
McKay Classification			0.571
Excellent	32 (78)	68 (83)	
Good	6 (15)	10 (12)	
Fair	2 (5)	4 (5)	
Poor	1 (2)	0	

[a] Given numbers are number of patients, with the percentages in parentheses. Mann–Whitney U test was used.

female patients was 8 times higher than the male patients, it was difficult to draw conclusions about the radiological consequences of sex from a statistically perspective. Additionally, these authors analyzed the radiological results using a scoring system developed by them instead of the Severin classification.[10] Although the results regarding sex are given in these studies, the statistical reliability is limited. Our study consisted of 41 male patients and 82 female patients with similar operative side and ages. This resulted in a statistically stronger design in terms of determining the radiological and functional outcomes of sex.

The outcome is a consequence of the locomotory system development and surgery performed on the hip. The shape of the pelvis and hips differs in females and males and influences the biomechanical parameters, such as the resultant hip force.[17] It was found that the geometry of the male hips and pelvis is on an average more favorable because it yields lower resultant hip force. The Severin classification provides limited information on the geometry that determines hip stress distribution. It is possible that a poorer Severin index of the male group could be compensated by more favorable geometrical parameters that determine hip stress distribution and are not included in the Severin classification. Conversely, the outcome could be influenced by the success of the operation. Functional results appear the same at 10 years postoperatively. This is before the adolescent growth spurt. It appears that those male patients with higher Severin scores may start having symptoms sooner, particularly if they have a higher activity level than female patients.

In their study of 7 male patients and 65 female patients, Vandergugten et al mentioned that male sex is a risk factor only for secondary operations and had no effect on the radiological and functional outcomes.[18] In this abovementioned study also, the number of male patients was low. Conversely, in their study of midterm results, Biçimoğlu et al specified that the rate of secondary operations is three times higher for female patients than for male patients.[10] However, it will be more accurate to see the long-term results of this study because we think that there will be patients who will need secondary operations during the later follow-ups, and this will change the results. In our current study, although the secondary operation rate was higher for male patients, there was no statistical difference.

Osteonecrosis is the most severe complication and the most common cause of disability after treatment for DDH.[19] AVN rates after open reduction using the posteromedial limited approach are between 0% and 66% in the literature.[10] In their study of long-term results of open reduction using the posteromedial limited approach, Farsetti et al mentioned that they observed an AVN rate of 18% after 22 years of follow-up.[20] In our study, osteonecrosis rates were 17% for both male and female patients. Our rates were relatively lower compared to the literature. The reasons could be due to not using preoperative traction, having an intraoperative

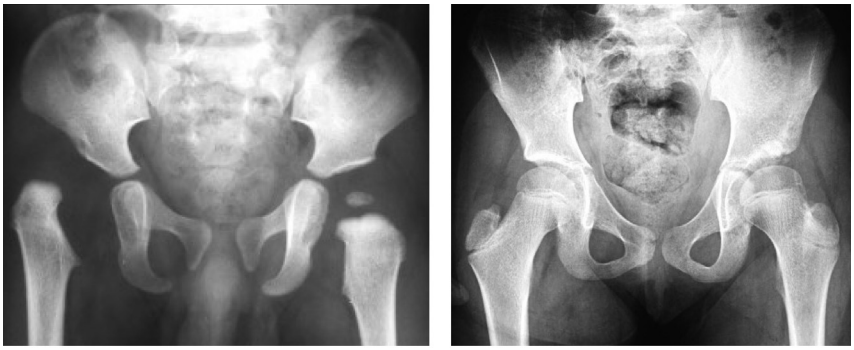

Fig. 3. **(A)** Preoperative X-ray. Male patient was operated at 8 months of age. There was Tönnis grade 3 dislocation on the right hip. AI degree of left hip was 48°. **(B)** Postoperative year 15. Type 2 AVN and RAD was present. Severin classification was 4, and McKay score was good.

Table 6
Association of Variables with Poorer results in Severin Classification by Multiple Logistic Regression Analysis.

Variable	Odds Ratio	Std. Error	P value
Age at operation	1.12	0.26	0.032
Sex	1.09	0.04	0.006
Bilaterality	1.74	0.78	0.204
Follow-up	1.19	1.34	0.416
Tönnis Grade	1.23	0.38	0.028

gentle reduction, obtaining a wide safe zone (>30), and eliminating all extraarticular and intraarticular obstacles.

In our study, although no male patients had redislocation, RAD was almost three times more common in male patients. Higher redislocations rates in female patients may be due to a greater ligamentous laxity due to hormonal causes.[19] The majority of male patients with RAD (8 patients) were suggested to undergo secondary operations as soon as acetabular insufficiency was noticed but they refused, and they developed RAD during their follow-ups. Biçimoğlu et al also reported no redislocations and higher RAD rates for male patients.[10] They did not find any statistical significance similar to our study. This may be because the male:female ratio of the sample was low.

This study has some limitations. Firstly, although a control group (female patients) of similar age and hip side was studied, there may be bias. When the incidence of DDH is considered, it seems impossible to create a randomized and similar control group design in terms of sex. In order to minimize bias, female patients who had similar age and hip side as male patients were sampled from the pediatric orthopedic database, and when there was more than one female patient meeting the same criteria, patients were recruited according to the order in which their cases were recorded in the database. Secondly, body mass index was not evaluated. Although height and weight percentile values are essential parameters in the studies involving children, they were not mentioned among the parameters related to the results of the surgical treatment of hip dislocation in children. This factor may be related to many unexplained outcomes. Finally, the individuals performing the surgery and evaluating the results were same, and this may affect the result obtained due to bias.

Conclusions

Although it was observed that male sex is a poor prognostic factor for radiological results and RAD, there was no difference between male and female patients in terms of osteonecrosis, redislocations, and functional outcomes. A close follow-up is recommended for patients with RAD, and secondary surgical interventions should not be delayed in the absence of spontaneous development of acetabulum. In future, similar studies with a more extended follow-up period and with more patients will lead to more accurate results.

Ethical review committee

Each author certifies that his institution approved or waived approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research and that informed consent for participation in the study was obtained.

Conflicts of interest

Each author certifies that he has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.

References

1. Ponseti IV. Morphology of the acetabulum in congenital dislocation of the hip. Gross, histological and roentgenographic studies. *J Bone Joint Surg (Am)*. 1978;60(5):586–599.
2. Shorter D, Hong T, Osborn DA. Cochrane review: screening programmes for developmental dysplasia of the hip in newborn infants. *Evid Based Child Health*. 2013;8(1):11–54.
3. Swaroop VT, Mubarak SJ. Difficult-to-treat Ortolani-positive hip: improved success with new treatment protocol. *J Pediatr Orthop*. 2009;29(3):224–230.
4. Weinstein SL, Mubarak SJ, Wenger DR. Developmental hip dysplasia and dislocation: part II. *Instr Course Lect*. 2004;53:531–542.
5. Massa BSF, Guarniero R, Godoy RM, Rodrigues Jr JC, Montenegro NB, Cordeiro FG. Use of inlet radiographs in the assessment of reduction after the surgical treatment of developmental dysplasia of the hip. *Bone Joint J*. 2017;99-B(5):697–701.
6. Ryan MG, Johnson LO, Quanbeck DS, Minkowitz B. One-stage treatment of congenital dislocation ofthe hip in children three to ten years old. Functional and radiographic results. *J Bone Joint Surg Am*. 1998;80(3):336–344.
7. Wang TM, Wu KW, Shih SF, Huang SC, Kuo KN. Outcomes of open reduction for developmental dysplasia of the hip: does bilateral dysplasia have a poorer outcome? *J Bone Joint Surg Am*. 2013;95(12):1081–1086.
8. Eamsobha P, Kamwong S, Sisuchinthara T, Jittivilai T, Keawpornsawan KJ. The factor causing poor results in late developmental dysplasia of the hip. *J. Med Assoc Thai*. 2015;98(8):32–37.
9. Grauer JN. *Orthopaedic Knowledge Uptade*. 12th ed. Connecticut: American Academy of Orthopaedic Surgeons; 2017.
10. Biçimoğlu A, Agus H, Omeroglu H, Tumer Y. Posteromedial limited surgery in developmental dysplasia of the hip. *Clin Orthop Relat Res*. 2008;466(4):847–855.

11. Barrett WP, Staheli LT, Chew DE. The effectiveness of the Salter innominate osteotomy in the treatment of congenital dislocation of the hip. *J Bone Joint Surg Am*. 1986;68(1):79–87.
12. Severin E. Contribution to the knowledge of congenital dislocation of the hip joint: late results of closed reduction and arthrographic studies of recent cases. *Acta Chir Scand*. 1941;84(63):1–142.
13. Baki ME, Baki C, Aydın H, Arı B, Özcan M. Single-stage medial open reduction and Pemberton acetabuloplasty in developmental dysplasia of the hip. *J Pediatr Orthop B*. 2016;25(6):504–508.
14. Cai Z, Li L, Zhang L, Ji S, Zhao O. Dynamic long leg casting fixation for treating 12- to 18-month-old infants with developmental dysplasia of the hip. *J Int Med Res*. 2017;45(1):272–281.
15. Moussa M, Al-Othman A. Bilateral developmental dysplasia of the hip; asymmetric outcome in the older child. *Clin Orthop Relat Res*. 2001;392(11):358–365.
16. Cha SM, Shin HD, Shin BK. Long-term results of closed reduction for developmental dislocation of the hip in children of walking age under eighteen months old. *Int Orthop*. 2018;42(1):175–182.
17. Kersnic B, Iglic A, Kralj-Iglic V, Srakar F, Antolic V. Increased incidence of arthrosis in women could be related to femoral and pelvic shape. *Arch Orthop Trauma Surg*. 1997;116(6–7):345–347.
18. Vandergugten S, Traore SY, Docquier PL. Risk factors for additional surgery after closed reduction of hip developmental dislocation. *Acta Orthop Belg*. 2016;82(4):787–796.
19. Herring JA. *Tachdjian's Pediatric Orthopaedics*. 5th ed. Philadelphia,PA: WB SaundersCompany; 2014:483–579.
20. Farsetti P, Caterini R, Potenza V, Ippolito E. Developmental dislocation of the hip successfully treated by preoperative traction and medial open reduction. *Clin Orthop Relat Res*. 2015;473(8):2658–2669.