Comparison of Open Reduction Alone and Open Reduction Plus Pemberton Osteotomy Techniques in the Treatment of Developmental Hip Dysplasia at Walking Age

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ABSTRACT

Objective: Open reduction (OR) alone and OR plus Pemberton periacetabular osteotomy (PPO) techniques are commonly used in the treatment of developmental dysplasia of the hip at walking age. However, discussions on the timing of acetabular osteotomy are still ongoing. The aim of the present study was to compare the results of patients who underwent Ferguson OR (FOR group) and OR plus PPO group.

Materials and Methods: Between 2008 and 2017, we performed surgery on the hips, which we thought were used for closed reduction but could not be reduced as closed, or that the reduction was not stable. Patient follow-up was ≥12 months. The study included 75 hips of 57 patients of which 20 (26.7%) patients with FOR and 55 (73.3%) patients with PPO. Preoperative and postoperative acetabular indices (AIs), additional surgical intervention rates, and avascular necrosis (AVN) rates were compared. The Kalamchi–McEwen classification system was used to evaluate AVN.

Results: The average age of the patients was 12.38 (9-14) months. The mean follow-up period was 38.95 (12-140) months. AVN developed in 21 (24%) hips (6 (8%) type 1, 13 (17.3%) type 2, and 2 (2.7%) type 3). AVN developed in 7 (35%) hips in the FOR group and 14 (25.5%) hips in the PPO group. No statistically significant difference was found between the two groups (p=0.416). Revision surgery was performed in 2 (3.7%) cases of the PPO group and 6 (31.5%) cases of the FOR group. Statistically, the PPO group had less revision surgery (p=0.004). The PPO group had an AI of 13.33° (5°-27°) that was significantly lower (p<0.001) than that of 27.98° (18.39°) of the FOR group.

Conclusion: Ferguson and Pemberton techniques are current and effective in the treatment of patients with developmental hip dysplasia at walking age. There was no significant difference between the two groups when examined from the point of view of AVN, but the results of PPO surgery were found to be better with respect to AI and revision surgery.

Keywords: Avascular necrosis, developmental dysplasia of the hip, open reduction, pemberton

Introduction

Developmental dysplasia of the hip (DDH) contains various abnormalities from simple hip imbalance with capsular laxity to completely removed femoral head, depending on the abnormal acetabular cavity [1]. Achieving stable and durable anatomic hip reduction has been aimed for many years by orthopedic surgeons. The authors defending closed reduction do so because of postoperative range of motion and decreased avascular necrosis (AVN) risk [2]. However, closed reduction cannot be performed, and surgical intervention is required especially for infants with advanced age [3].

The most common two open reduction (OR) approaches are medial or anterior [4-6]. The anterior approach allows for capsular plication and pelvic osteotomy and can be applied to patients of all ages [6]. In 1908 and 1973, Ludloff and Ferguson, respectively, reported on a surgical technique that targeted major obstacles to the concentric reduction of the femoral head to the acetabulum [4, 7, 8]. When this operation was performed relatively early in the course of DDH, acetabular developmental stimulation and prevention of secondary dysplasia may be more prominent [7]. Therefore, it is preferred as an early surgical intervention. The OR method commonly used in our clinic is the OR method defined by Ferguson and used the FOR technique in all ORs [8].

Pemberton periacetabular osteotomy (PPO) [9] with OR is also a preferred treatment modality in DDH for walking age patient. In FOR and PPO, the main purpose is to provide concentric hip reduction. While the acetabular roof is not touched by FOR, the acetabular roof is lowered with PPO. Two different pediatric surgeons in our clinic underwent surgical intervention on the hips that failed closed reduction. These patients were operated by one surgeon with FOR and the other surgeon with PPO. We were confused with these two options when surgical intervention was performed in patients with DDH at walking age, such as most pediatric orthopedists. When the studies in the literature were examined, there was no publication comparing two surgical options. Therefore, the present study contributes to the literature by comparing the results of FOR and PPO surgeries.

Materials and Methods

This was a retrospective study. It has been reported that the study can be done by the 8 numbered meeting and 10 numbered decision of the Clinical Research Ethics Committee of Atatürk University Medical Faculty on 12/27/2018. The present study was performed on radiographs of patients and hospital records. A retrospective search was performed between 2008 and 2015, and 120 patients who underwent FOR or PPO for DDH aged between 9 and 14 months were identified. These patients were of the same age group and had a history of closed reduction failure or redislocation. Patients were followed up for at least 12 months, and preoperative and postoperative radiographies were among the criteria first determined. Patients with cerebral palsy or neurological disease, a follow-up of <12 months, a comorbid disease, a history of successful closed reduction, and patients who had femoral shortening or derotational osteotomies were excluded from the study. As a result of our investigations, 57 (75 hips) patients were included in the study. FOR (FOR group) surgery was performed for 20 hips, and PPO (PPO group) surgery was performed for 55 hips.

All operations were performed by two different pediatric surgeons (Ezirmik N. and Aydın A.) in the same clinic. All patients were immobilized with pelvipedal cast for 2 months after the operation. The patients in the PPO group were kept in the abduction device for 24 h after casting for 2 months. For the immobilization of the patients in the FOR group, 4–6 months abduction device was used for immobilization.

Patients were evaluated preoperatively radiographically according to the Tonnis classification and acetabular indices (AIs). The results of the patients were evaluated with the last pelvis anteroposterior radiography. Patients' AI and AVN were evaluated according to these radiographs. Radiographic evaluation was performed by another pediatric surgeon (Yılar S.). According to the data obtained, the results of the FOR group and PPO group were compared. The Kalamchi and McEwen classification was used for the evaluation of AVN [10].

Statistical Analysis

Data were analyzed using The Statistical Package for the Social Sciences (SPSS) version 20 statis-

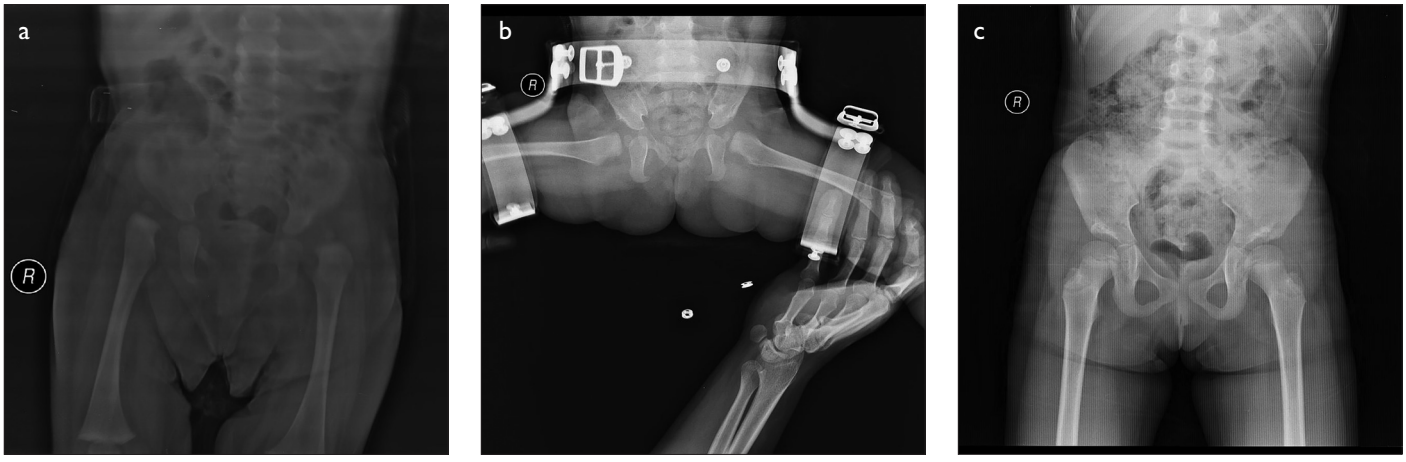

Figure 1. a-c. (a) A 9-month-old girl with right Tonnis type 3 and left Tonnis type 2 DDH. (b) The radiograph after the Ferguson surgery for the right hip and closed reduction for the left hip. (c) Postoperative month 56 of follow-up radiography.

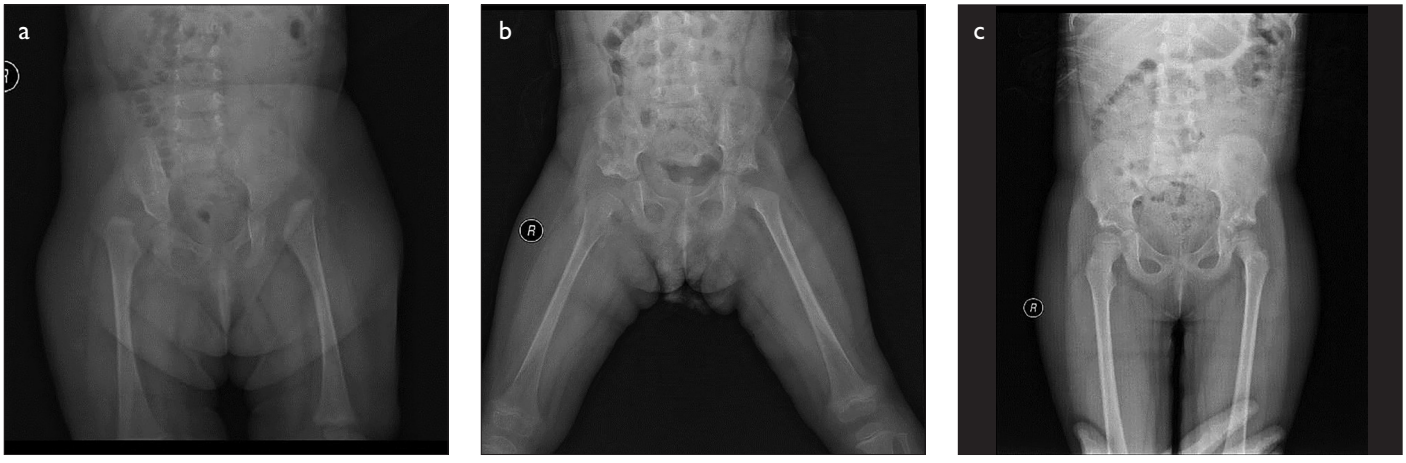

Figure 2. a-c. (a) A 12-month-old girl with right Tonnis type 3 and left Tonnis type 4 DDH. (b) Reluxation after closed reduction casting at month 13, bilateral Pemberton surgery was performed. (c) Postoperative month 36 of follow-up radiography.

tics analysis program (IBM Corp; Armonk, NY, USA). Data were presented as average, standard deviation, median, minimum, maximum, percentage, and numbers. Continuous normal distribution of variables sampling size was <50, Shapiro–Wilk W test was used, this size was >50, and Kolmogorov–Smirnov test was used. When the normal distribution condition was provided for comparisons between the two independent groups, independent samples t-test was used, and Mann–Whitney U test was used if it was not provided. In the 2×2 comparisons between categorical variables, Pearson chi-square test was used for expected value (>5), chi-square Yates test was used for expected value (3-5), and Fisher's exact test was used for expected value (<3). In comparison with categorical variables >2×2, Pearson's chi-square test was used in case of the expected value (>5), and Fisher–Freeman–Halton test was used in case of the expected value (<5) between categorical variables. A p value <0.05 was accepted as statistically significant.

Table 1. Comparison of the FOR group and the PPO group according to the Tonnis classification of patients [11]

Grade	FOR group	PPO group	Total
II	6 (8%)	13 (17.3%)	19 (25.3%)
III	12 (16%)	29 (38.7%)	41 (54.7%)
IV	2 (2.7%)	13 (17.3%)	15 (20%)
Total	20 (26.7%)	55 (73.3%)	75

Results

The average age of the patients was 12.38 (9-14) months (FOR group: 11.42 (9-14) months and PPO group: 13.32 (11-14) months). There was no statistically significant difference between the two groups. Of the 57 patients, 51 (89.4%) were female, and 6 (10.5%) were male. Of the 75 hips, 39 (52%) were affected on the left side, and 36 (48%) were affected on the right side. Bilateral DDH was present in 18 patients. OR (FOR group) was performed by AA in 20 (26.7%) hips (Figure 1), and OR plus Pemberton osteotomy (PPO group) was performed in 55 (73.3%) hips by NE (Figure 2).

According to the Tonnis classification (grades 1-4), 19 (25.3%) hips were evaluated as grade 2, 41 (54.7%) hips were evaluated as grade 3, and 15 (20%) hips were evaluated as grade 4 (Table 1).

The mean follow-up period was 38.95 (12-140) months (FOR group: 48.6 (12-110) months and PPO group: 35.9 (12-140) months).

The mean preoperative AI of the patients was 41.2° (33°-55°) (FOR group: 41.33° (33°-55°) and PPO group: 41.4° (35°-53°)). There was no statistically significant difference between the two groups (p>0.05). The mean postoperative AI of the patients was 16.94° (5°-39°) (FOR group: 27.98° (18°-39°) and PPO group: 13.33° (5°-27°)). When the two groups were compared, the AI of the PPO group was statistically significantly lower (p<0.05) (Table 2).

According to the Kalamchi–McEwen classification, there were no AVN findings in 54 (72%) of the total 75 hips. AVN was developed in 21 (24%) hips (6 (8%) type 1, 13 (17.3%) type 2, and 2 (2.7%) type 3). In the FOR group, 7 (35%) patients developed AVN (2 (10%) type 1 and 5 (25%) type 2). In the PPO group, AVN was developed in 14 (25.5%) patients (4 (7.2%) type 1, 8 (14.5%) type 2, and 2 (3.6%) type 3). No statistically significant difference was found between the two groups (Table 3).

Finally, when evaluating revision surgery, 6 (28.6%) revision surgeries were performed in the FOR group, and 2 (3.7%) revision surgeries were performed in the PPO group (these 2 revision surgeries are femoral corrective osteotomy). When we compared the two groups, the revision surgery rate was significantly higher in the FOR group (p=0.004) (Table 4).

Table 2. Comparison of the FOR group and the PPO group according to pre- and postoperative acetabular indices

Type of surgery	Total	FOR group	PPO group	p
Preoperative acetabular index	41.2° (33°-55°)	41.33° (33°-55°),	41.4° (35°-53°)	0.722
Postoperative acetabular index	16.94° (5°-39°)	27.98° (18°-39°)	13.33° (5°-27°)	<0.001

Table 3. Comparison of the FOR group and the PPO group according to the Kalamchi–McEwen criteria [12]

Type	Criteria	Total	FOR group	PPO group	p
Normal	Total	21 (28%)	7 (35%)	14 (25.5%)	0.416
1	Changes confined to the ossific nucleus	6 (8%)	2 (10%)	4 (7.2%)	
2	Type 1+lateral physeal damage (coxa valga)	13 (17.3%)	5 (25%)	8 (14.5%)	
3	Type 1+central physeal damage (coxa breva)	2 (2.7%)	0	2 (3.6%)	
4	Total damage to the head and physis	0	0	0	
Total		75 (100%)	20 (26.7%)	55 (73.3%)	

Table 4. Comparison of the rate of revision surgery after the FOR group and the PPO group

Tonnis type	Total	FOR group	PPO group	p
Total	8 (10.6%)	6 (28.6%)	2 (3.7%)	0.004
II	1 (1.3%)	1 (5%)	0 (0%)	
III	5 (6.6%)	4 (20%)	1 (1.8%)	0.134
IV	2 (2.6%)	1 (5%)	1 (1.8%)	

Discussion

The main goal in the treatment of DDH is to obtain a concentric reduction in the development of the acetabular roof. Many different treatment options have been developed for this purpose. The two most commonly used of these are FOR and PPO [8, 13]. These two treatment options can also be used in patients with DDH at walking age. The advantages of FOR are shorter operative time and less invasive surgical intervention. However, the most important disadvantage of this surgical intervention is that the acetabulum cannot be interfered. Therefore, the development of the acetabulum cannot be affected with FOR, and a long waiting time would be needed. Hence, a large number of patients require additional surgical intervention [14, 15].

In their study, Zionts et al. [16] found that acetabular development continues until age 2-3 years if there was subluxation, and that development continues until age 6 years if there was no subluxation. The mean age at the last follow-up of our patients was 51.33 months. During this period, 28% of the patients underwent additional surgical intervention to achieve acetabular roof development in the FOR group, whereas this rate was only 3.7% in the PPO group. Gotoh et al. [17] reported that 86% of patients with AI >26° are worse after age 5 years. In addition, Kitoh et al. [18] reported that the most reliable AI results in DDH patients with closed reduction are achieved at age approximately 5-6 years. As it is understood from these studies, even if FOR treatment is a good option to provide reduction, the femoral head cover is not able to

do well because it does not provide good development of the acetabulum roof (Figure 1). In our study, according to the last follow-up graphs of our patients, AI was 27.98° in the FOR group and 13.13° in the PPO group. Therefore, we are concerned about the increase in the rate of revision surgery in the FOR group when our follow-up period is prolonged.

One of the most important disadvantages of FOR is the high rate of additional surgical intervention. In their study, Kiely et al. [15] had to undergo additional surgical intervention in 11 of the 49 hips undergoing FOR. In their review, Kothari et al. [14] reported a 56% revision surgery rate in OR patients compared with 11% revision surgery rate in pelvic osteotomy patients. In our study, the rate of revision surgery in the FOR group (28.6%) was significantly higher than that in the PPO group (3.7%).

The greatest concern with acetabular osteotomy is the increased rate of AVN because it is a more aggressive intervention. In their review study in 2016, Kothari et al. [14] reported that no difference is found between patients who underwent OR and patients with OR plus pelvic osteotomy. Moreover, in the study reported by Issın et al. [3], OR and OR plus Dega osteotomies were compared between the two groups, and no significant difference was found between the two groups. Similarly, in our study, we found no significant difference between the FOR group (7 (35%)) and the PPO group (14 (25.5%)).

OR and OR plus acetabular osteotomy are frequently used in patients with DDH at the age of walking. Although there are studies comparing OR and OR plus pelvic osteotomy or Dega osteotomy in the literature [3, 14], we could not find a publication comparing OR and OR plus periacetabular osteotomy. For this reason, to the best of our knowledge, this is the first study in this field. The first limitation of our study was that the number of patients who underwent FOR in our study was low. The most important reason for this is that most surgeons in our clinic prefer PPO in this age group. The second limitation is that we included patients who were age ≥12 months in our study although our mean follow-up period was adequate. The most important reason for this is the absence of AVN and the fact that we do not have a graph to reduce radiation exposure to patients who do not have problems in their clinical examination.

As a result, since there is no significant difference between the two groups with respect to AVN, we think that PPO is a more preferable method than FOR to avoid additional surgical intervention from future complications.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Atatürk University, School of Medicine, meeting number: 8 and decision number: 10, date: 12/27/2018.

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

Peer-review: Externally peer-reviewed.

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