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A retrospective analysis of the effects of femoral shortening osteotomy on clinical and radiologic outcomes in open reduction and Pemberton pericapsular osteotomy for Tonnis type 4 dysplasia of the hip

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Ethics Committee Approval
The study was approved by the Ataturk University Faculty of Medicine Clinical Research Ethics Committee (13.02.2019, No: B.30.2.ATA.0.01.00/).
All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.

Conflict of Interest
No conflict of interest was declared by the authors.

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Abstract

Background/Aim: Open reduction (OR) and Pemberton's periacetabular osteotomy (PPO) are efficient and reliable methods for treating late-diagnosed developmental dysplasia of the hip. However, various studies have reported an avascular necrosis (AVN) rate of up to 80% with this technique, which is increased in Tönnis type 4 hips. In this study, we hypothesized that femoral shortening osteotomy (FSO) would reduce the rates of AVN by decreasing the post-reduction pressure on the femoral head.
Methods: In this retrospective cohort study, we reviewed patients who had undergone OR and PPO between 2006 and 2016. Only hips with Tönnis type 4 dislocation were included. The subjects were divided into two groups: Group 1, who had undergone OR+PPO, and Group 2, who had undergone OR+PPO+FSO. The Kalamchi-MacEwen system was used for AVN classification. The groups were compared regarding the pre- and postoperative acetabular indices and the rate of AVN and other complications.
Results: We included 76 hips of 50 patients who met the inclusion criteria in the study. Group 1 consisted of 46 hips of 32 patients, and Group 2 consisted of 30 hips of 18 patients. The mean age of the patients was 31.5 months, and Group 1 (30 months) had a significantly lower mean age than Group 2 (34 months) (P=0.019). There were no statistically significant differences regarding the pre- and postoperative acetabular indices. In Group 1, 27 (58%) out of 46 hips had AVN, whereas the rate of AVN was ten (30%) out of 30 hips in Group 2. Out of the 27 hips with AVN in Group 1, 12 were type 1, five were type 2, and ten were type 3. Out of the 10 hips with AVN in Group 2, seven were type 1, two were type 2, and one was type 4. There was a statistically significant difference between the groups regarding the rates of AVN, with Group 2 having better outcomes not only in comparison to the rate of all AVNs (P=0.031) but also in comparison to high-grade AVNs (P=0.042) (Grade 3 and Grade 4).
Conclusion: Performing FSO with OR and PPO provides a significant decrease in the rate of AVN without altering acetabular development after surgery.

Keywords: developmental dislocation of the hip, femoral shortening, avascular necrosis, Pemberton's acetabuloplasty

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Introduction

Developmental dysplasia of the hip (DDH) is one of the most common congenital deformities [1]. The primary goal of treatment is to achieve and maintain a stable, concentric reduction to attain a pain-free, functional hip joint. The contemporary use of ultrasound (USG) screening for DDH facilitates early diagnosis and treatment. However, despite national screening programs, some patients are still diagnosed after they begin walking. Achieving reduction of the hip joint in late-diagnosed patients requires challenging surgical intervention. The soft tissue around the hip joint is contracted, the acetabulum is shallow due to the lack of reduction, the joint capsule is elongated, and there is an increase in femoral anteversion [2]. These issues are significant challenges in surgical treatment and may result in certain complications after treatment, such as soft tissue contractures, pain, aberrant gait, and early-onset osteoarthritis [3–5].

Two alternative options exist for relieving pressure on the femoral head in late-diagnosed, high hip dislocations. The first is preoperative skeletal traction. However, various studies report no improvement in outcomes with traction methods [6,7]. The second option is femoral shortening surgery (FSO), proposed by Hey Groves and Ombredanne in 1920 [8,9]. Many articles reported that femoral shortening in DDH improves outcomes [7,10–12]. The decision to perform femoral shortening is made during surgery when the reduction of the hip joint is forceful or the hip joint is under excessive tension after reduction [13–15]. Therefore, there is no specific indication for femoral shortening, and the decision mostly depends on the surgeon's experience. Certain studies aim to reveal the indications for femoral shortening, most of which conclude that it is required in late-diagnosed high hip dislocations [14–17].

Although femoral shortening is reported to improve outcomes, there is a limited number of comparative studies [13,14], and the results of these studies are conflicting. In this study, we hypothesized that femoral shortening would reduce the rates of avascular necrosis in late-diagnosed DDH cases with high-grade dislocations. To test this hypothesis, we compared the outcomes of patients who had undergone open reduction (OR) and Pemberton's periacetabular osteotomy (PPO) with those of patients who had undergone OR+PPO+FSO.

Materials and methods

The clinical ethical board of our institution approved the study (Ataturk University Faculty of Medicine Clinical Research Ethics Committee, approval date: February 13, 2019, protocol number: B.30.2.ATA.0.01.00/). We retrospectively reviewed patient data who had undergone OR and PPO between 2006 and 2016. To be eligible for the study, patients had to have undergone PPO and OR, be between 24-48 months of age, have Tönnis grade 4 dislocation, and have a follow-up period of at least 24 months [18]. Exclusion criteria included patients with neuromuscular or systemic disorders and teratologic hip dislocations, those with prior operative or non-operative interventions due to DDH, and those with insufficient radiologic follow-up data.

A total of 103 hips from 68 patients who were operated on between 2006 and 2016 at our department were initially eligible for the study. Seven patients with neuromuscular pathologies or teratologic hip dislocations were excluded, as were 11 patients with a follow-up period of fewer than 24 months. Ultimately, 76 hips from 50 patients met the inclusion criteria and were included in the study.

All patients were operated on via a Smith Petersen approach by the same senior surgeon experienced in DDH surgery. Separate approaches were used for femoral osteotomy and adductor tenotomy [19]. Open reduction was carried out with extensive soft tissue release and iliopsoas tenotomy at the level of the trochanter minor. A T-shaped incision was made on the joint capsule to facilitate capsulorraphy. Hypertrophic pulvinar, transverse acetabular ligament, and ligamentum teres were excised. Muscles were reflected from the inner and outer aspects of the ilium, and Pemberton osteotomy was performed [19]. An autogenous triangular iliac bone graft was inserted into the osteotomy line. Afterward, the hip joint was gently reduced. In cases of forceful reduction with excessive tension in the hip joint, FSO was performed. When reduction was achieved with excessive internal rotation and abduction, derotation and varus osteotomy were done. Semitubular titanium plates were used for fixation. Patients were kept in spica casts for 6–8 weeks, and an abduction orthosis was suggested afterward. Radiological results were evaluated using a digital PACS system with X-ray views of the patients taken before and after surgery and at their last follow-up.

The patients were divided into two groups: PPO+OR (Group 1) and PPO+OR+FSO (Group 2). Preoperative and postoperative acetabular indices and rates of avascular necrosis were recorded. The Kalamchi-MacEwen system was used to grade the severity of AVN [20].

Statistical analysis

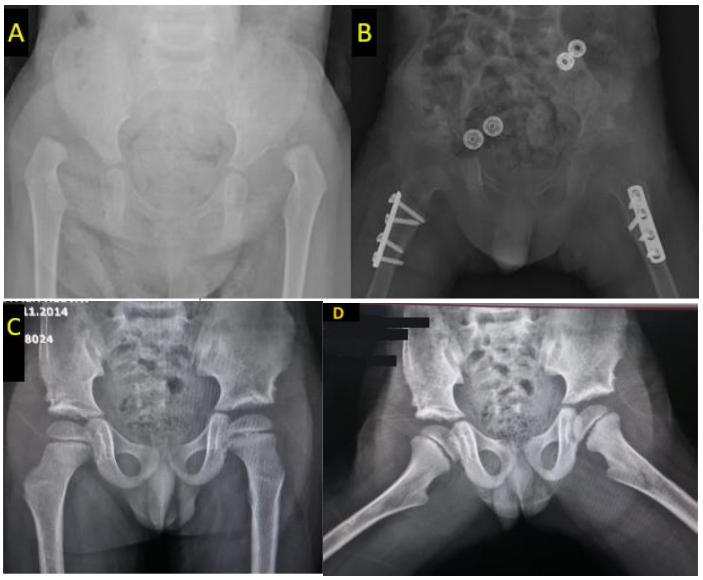
IBM SPSS 20 software was used for statistical analysis. Data were presented as mean, median, minimum, maximum, standard deviation, percentage, and ratio. The normal distribution of continuous variables was calculated using the Shapiro-Wilk test if the sample size was greater than 50 and the Kolmogorov-Smirnov test if the sample size was less than 50. An independent samples t-test was used to compare two independent groups with a normal distribution, and if not, the Mann-Whitney U test was used. If the value of 2 × 2 comparisons between groups was more than 5, the Pearson chi-square test was used, and if it was less than 5, Fisher's exact test was used. A *P*-value less than 0.05 was considered statistically significant.

Results

A total of 76 hips from 50 patients with Tönnis grade 4 dislocations were included in the study, and the mean follow-up period was 44.1 months (range: 24–130 months). The mean age at the time of surgery was 31.5 months (range: 24–48 months), with ten male and 40 female patients. Group 1 consisted of 32 patients (46 hips) who had undergone PPO+OR (Figure 1), while group 2 consisted of 18 patients (30 hips) who had undergone OR+PPO+FSO (Figure 2).

Figure 1: A: 2.5 years female with bilateral Tönnis grade 4 dislocation. B: postoperative X-ray AP view. C: AP view 68th month postoperative X-ray view with bilateral type 3 avascular necrosis.

Figure 2: A: 33 months male with bilateral DDH. Plain X-ray AP view. B: Plain X-ray AP view two months after the operation, showing good containment of the femoral head. C, D: AP view 41st month postoperatively with an excellent radiographic outcome.



The mean preoperative acetabular index (AI) was 37 in group 1 and 39 in group 2, and there was no statistically significant difference between the groups (P=0.25). However, the mean age of patients in group 1 (30 months) was significantly lower than that in group 2 (34 months) at the time of operation (P=0.019) (Table 1).

Table 1: Summary of the clinical features of study subjects

Characteristics	All Hips	No femoral shortening	Femoral shortening	*P*-value
Patients(hips)	76	46	30	
Male	15	10	5	
Female	61	36	25	
Age	31.5	30	34	0.019
Preop AI	37.5	36.7	38.6	0.25

AI: Acetabular Index

In group 1, which did not have FSO, 27 out of 46 patients (58%) developed AVN. Among those with AVN, 12 had type 1, five had type 2, and ten had type 3, according to the Kalamchi-MacEwen classification. In group 2, which had FSO, ten out of 30 patients (33%) developed AVN, with seven having type 1, two having type 2, and one having type 4, according to the Kalamchi-MacEwen classification. Statistical comparison of both groups regarding AVN revealed significantly better outcomes for group 2 (P=0.031).

After excluding patients with grade 1 and grade 2 AVNs, group 1 had ten cases (22%), while group 2 had only one case (3%) of grade 3 or grade 4 AVNs. The group comparison also showed significantly better outcomes for group 2 (P=0.044) (Table 2).

Table 2: Result of the acetabular index and avascular necrosis.

Characteristics	All Hips	No femoral shortening	Femoral shortening	*P*-value
Postop AI	14,5	14.2	14,5	0.12
AVN	37 (48.7%)	27 (59%)	10 (33%)	0.031
Type 1	19	12	7	
Type 2	7	5	2	
Type 3	10	10	-	0.042
Type 4	1	-	1	

AI: Acetabular Index, AVN: Avascular Necrosis

Discussion

Treating developmental dysplasia of the hip (DDH) diagnosed after the walking age is challenging. Open reduction is the gold standard option for this condition, and in many cases, additional procedures such as acetabular and femoral osteotomies are necessary [14–16].

In a study by Gholve et al. [16] involving 49 hips with DDH in walking-age children, with a follow-up period of 9.7 years, only 12 patients did not require additional procedures after open reduction. Moreover, no patient younger than 18 months underwent femoral shortening, while all patients older than 36 months required PPO and FO. The study also reported better outcomes for patients who had undergone femoral osteotomies than those who had not.

In a study by Cordier et al. [21], 118 hips of patients who had undergone OR when less than 4 years old were evaluated and followed up for 10–21 years. Of these, 86 hips required additional procedures along with OR. The mean age of patients who underwent only OR was 7 months. The study reported no cases of AVN among those who had femoral shortening osteotomies in this series.

Most surgeons prefer to decide about femoral shortening osteotomy intraoperatively in cases of forceful reduction and excessive tension after reduction [13–15]. However, there is still no consensus on performing femoral shortening osteotomies. Reviewing the literature on this issue, the mean age of patients who underwent FSO was 36 months, and most had high dislocations [14,15,21]. FSO was usually not required for patients younger than 18 months of age [16,21]. To eliminate bias and have a homogenous group of patients, we included only patients between 24-48 months of age with Tönnis grade 4 dislocations.

Although numerous studies have investigated the outcomes of femoral shortening osteotomy, there is a limited number of studies focused on the requirement of FSO. Comparative studies have been criticized for having inappropriate control groups. For instance, Akgül et al. [13] studied the reliability of FSO with Dega osteotomy in 26 patients with Tönnis grade 3 and grade 4 dysplasia; they performed femoral shortening osteotomy on 13 patients and reported no significant difference in outcomes between the groups. However, the mean age of the group who had undergone FSO was 49 months, while the non-FSO group had a mean age of 27 months, which could have resulted in bias in comparing the groups. Many studies have reported worse outcomes with increasing age at the

time of treatment for DDH [11,22]. Therefore, we believe this study also had a significant bias in comparing the groups.

In our study, all of the patients had Tönnis grade 4 hips, and the mean age of the patients was similar (group 1, 30 years old; group 2, 34 years old). We only included patients who had PPO by the same senior surgeon to have homogenous groups who had undergone the same procedures at the same age, with a close number of subjects. So we aimed to clearly define the effect of femoral shortening osteotomy in this cohort of patients in this unique study

There was no significant difference between the two groups in terms of acetabular indices at follow-up, indicating that the central pressure point of the joint after reduction did not affect the development of the acetabulum. This finding is consistent with previous studies [13]. Due to the absence of redislocations in either group, we could not compare the groups in this regard [7], which is a limitation of our study. However, the AVN rate was significantly lower in the FSO group despite the higher mean age at surgery. Our findings suggest that femoral shortening osteotomies may be a valuable addition to OR and PAO in patients with DDH who are over 24 months of age.

Limitations

Despite having the most homogenous group of patients, our study had certain limitations, such as its retrospective design and limited follow-up period. Prospective studies with a larger cohort of patients could provide further insights into this issue.

Conclusion

A femoral osteotomy is an effective option for treating patients with high-grade dislocations who are over 24 months old and who have undergone open reduction and pelvic osteotomies to provide acetabular coverage. This procedure does not impede acetabular development and significantly reduces the rate of avascular necrosis.

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