Original Article

Mid term results of Pemberton pericapsular osteotomy

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Abstract

Background: Treatment for developmental dysplasia of the hip (DDH) varies according to the age of the patient. For children under 3 months, the preferred treatment is Pavlik bandaging and/or dynamic hip orthosis;for children of 3–18 months (with/without arthrography), closed and open reductions (ORs) are most common; and for children 18 months and older, pelvic osteotomies are used. Radiological and functional outcomes of patients between 16 months and 7 years of age who underwent Pemberton pericapsular osteotomy (PPO) were evaluated.

Materials and Methods: Twelve patients with developmental dysplasia of the hip (DDH) received treatment on 14 hips between 2001 and 2006. All patients with DDH had PPO as pelvic osteotomy. PPO was done solely in 3 hips, PPO and open reduction (OR) in and OR + PPO + femoral shortening in 6. The average age was 39.85 months (range 16–83 months). All had 1-stage surgery. Acetabular index (AI) and the grade of displacement were determined according to Tönnis'. Center-edge (CE) angle was evaluated. Clinical evaluations were made as described by McKay, radiological assessments by Severin's criteria and femoral head avascular necrosis measurements by Kalamchi–MacEwen's criteria. Average followup periods were 83.35 months (range 48–115 months).

Results: Preoperative and postoperative average AI levels were 41.92° (range 30–50°) and 19,5° (range 5–34°), respectively ($P < 0.001$). According to Severin's classification, 11 (78.57%) patients were Ia, 1 (7.14%) was Ib, 1 (7.14%) was II and 1 (7.14%) was III. According to Kalamchi–McEven criteria, 12 (85.71%) patients were type I, 2 (14.28%) patients were type II. CE postoperatively was measured as 24.24° (range 12–41°). Clinically (McKay), the functional results in 13 (92.85%) patients were very good (I) and in 1 (7.14%) was good (II).

Conclusions: Functional and radiological mid term outcomes were found to be comparable in most of the patients with DDH undergoing PPO between the ages of 16 months and 7 years.

Key words: Developmental dysplasia of hip, Pemberton pericapsular osteotomy, supraacetabular osteotomy
MeSH terms: Osteotomy, bone dysplasias, hip dysplasia, congenital

Introduction

Treatment for developmental dysplasia of the hip (DDH) varies according to the age of the patient. For children under 3 months, the preferred treatment is Pavlik bandaging and/or dynamic hip orthosis; for children of 3–18 months (with/without arthrography), closed and open reductions (ORs) are most common; and for children 18 months and older, pelvic osteotomies are used.[1-9] Pemberton described an acetabuloplasty, now called the Pemberton pericapsular osteotomy (PPO), where an iliac osteotomy ended at the posterior limb of the triradiate cartilage and the anterolateral rim of the acetabulum was hinged downward and laterally.[3] PPO performed with OR may be adequate for DDH patients over 18 months, but femoral shortening (FS) osteotomy is often performed alongside pelvic osteotomy for patients aged 3 years plus.[10,11] At this age, soft tissue and muscle have developed to the point where femoral head reduction of the acetabulum is not possible. FS, which permits the muscles surrounding the hip to perform like a lengthened muscle and thereby reducing the force required to achieve concentric reduction, helps to ensure reduced pressure on the femoral head, which may otherwise result in avascular necrosis (AVN) of femoral head.[12] The use of FS has been shown to decrease complication such as redislocation and AVN.[13,14]

Owing to the risks involved in surgical treatments, such as AVN, joint stiffness, shortening of extremities and ongoing complications like subluxation and dysplasia due to insufficient covering of the femoral head, PPO, rather

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than OR, has become the most commonly used treatment as it provides better coverage for the acetabular roof of the femoral head in patients over 2 years of age. On the other hand, FS is also often necessary in older patients. There has, however, been a debate about at what age FS may be necessary. Sankar *et al*., uses the term "older" to refer to children over 3 years of age.[10] Klisic and Jancovic[15] reported good results in a patient series over 5 years of age, whereas Galpin *et al*.[12] uniformly performed FS over the age of 2 years. Wenger *et al*., even advocated FS in certain children younger than 2 years of age.[13]

In our study, we evaluated the mid term results of DDH patients who had received a PPO (alone or with OR or OR + FS together with according to patients' age, hip dysplasia and soft tissue). We aimed to investigate and benefit the possible difference in outcome younger age group (between 16 months and 7-year-old) of the patients which undergone PPO (alone PPO, with OR or with OR + FS + DR) through the evaluation of clinical and radiological results, using acetabular index (AI),[16] Center-edge (CE) angle (Wiberg), Severin classification,[17] Tönnis grading,[5] Kalamchi–MacEwen,[18] and McKay's[19] criteria. Our aim was to evaluate the effectiveness of PPO in the treatment of 16-month and 7-year-old children.

Materials and Methods

12 DDH patients (14 hips) who were operated between 2001 and 2006 were included in this retrospective study with the diagnosis of DDH was based on plain radiographs. Patients with teratological and neuromuscular dislocations and those who had undergone operations prior to this PPO procedure were excluded. There were 9 females and 3 males, 10 had unilateral involvement. There were 5 left hips and 9 right hips involved. The average age of our patients was 39.85 months (range 16–83 months) at the time of surgery [Table 1].

All the patients with DDH had PPO as pelvic osteotomy. Three patients (3 hips) received PPO (group 1) [Figure 1]. Four patients (5 hips) received PPO + OR (group 2) [Figure 2]. And also 6 hips of the 5 patients received OR + PPO + FS (group 3) [Figures 3 and 4]. The surgery was done in a single stage in all patients. AI and the grade of displacement were determined according to Tönnis' method. Clinical evaluations were made as described by McKay, radiological assessments were performed by Severin's criteria and femoral head AVN measurements were taken by Kalamchi–MacEwen's criteria. As the AI of all patients was high and hip joints were not centralized, we performed PPO and PPO + OR when necessary. For older patients (>3 years) who had not received prior treatment for hip dislocation,

Table 1: Clinical details of patients

Hip number	Gender	Side	Age at time of operation (months)	Followup duration (months)	Group	Surgery type	AI-preoperative	AI-postoperative	CE postoperative (Wiberg)	Severin Rad	Kalamchi–McEven	Tönnis-preoperative	Tönnis-postoperative	McKay
1	Female	Right	33	111	1	Pemberton	34	20	26	Ia	I	2	I	I
2	Female	Left	16	58	1	Pemberton	40	16	31	Ia	I	2	I	I
3	Male	Left	36	99	1	Pemberton	37	27	12	III	II	2	I	II
4	Female	Right	21	85	2	Pemberton + OR	41	21	21	Ia	I	2	I	I
5	Female	Right	18	60	2	Pemberton + OR	41	5	23	Ia	I	4	I	I
6	Female	Right	27	62	2	Pemberton + OR	46	18	27	Ia	I	4	I	I
7		Left	25	60	2	Pemberton + OR	45	15	25	Ia	I	4	I	I
8	Male	Right	26	115	2	Pemberton + OR	37	13	26	Ia	I	2	I	I
9	Female	Right	36	48	3	Pemberton + OR + FS + DR	46	34	17	Ib	I	4	I	I
10	Female	Left	72	78	3	Pemberton + OR + FS + DR	44	Closed	24	Ia	I	4	I	I
11	Male	Right	20	80	3	Pemberton + OR + FS + DR	50	26	24	Ia	I	4	I	I
12	Female	Right	65	88	3	Pemberton + OR + FS + DR	30	Closed	25	II	II	4	I	I
13	Female	Right	80	113	3	Pemberton + OR + FS + DR	48	Closed	41	Ia	I	4	I	I
14		Left	83	110	3	Pemberton + OR + FS + DR	48	Closed	20	Ia	I	4	I	I

OR=Open reduction, FS=Femoral shortening, DR=Derotation, CE=Center-edge angle, AI=Acetabular index

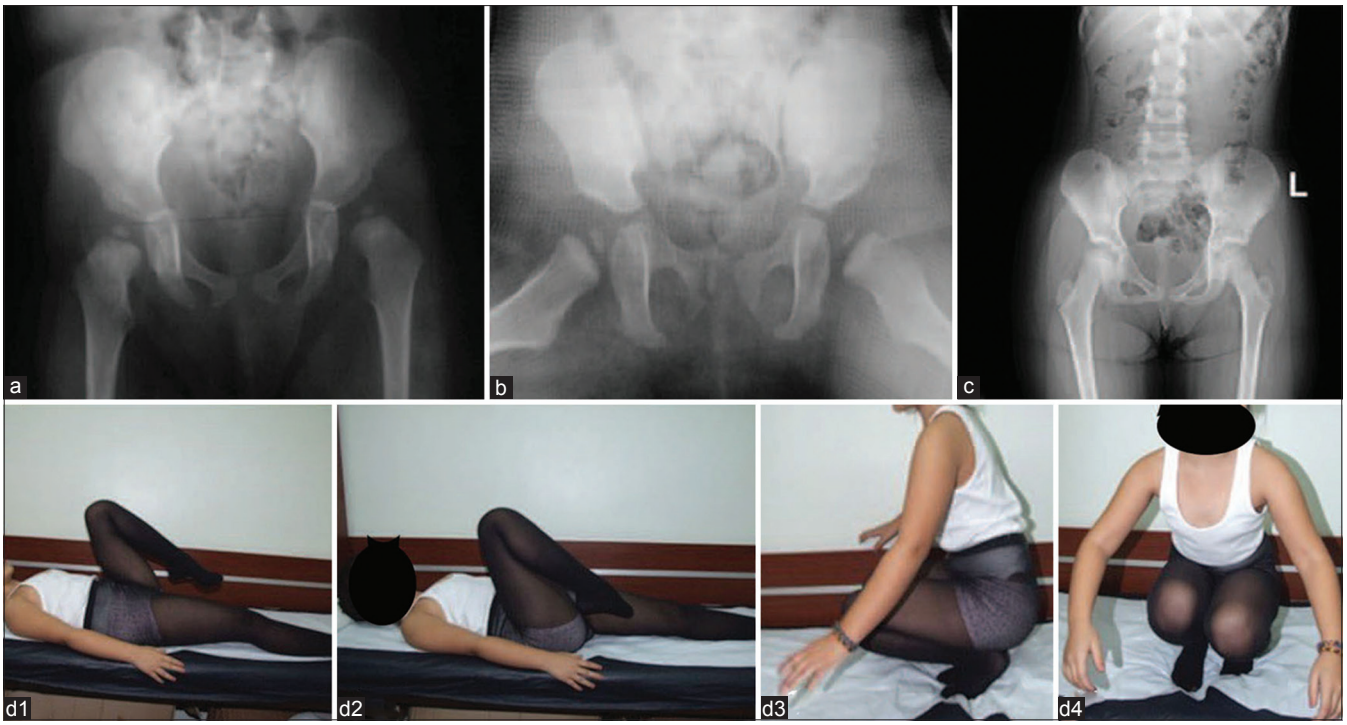

Figure 1: (a) X-ray pelvis with both hip joints anteroposterior view of Group 1, female, 16 months old (preoperative) showing dysplasia of the left hip. (b) X-ray frog leg lateral view showing early postoperative, left Pemberton pericapsular osteotomy (c) X-ray pelvis with both hips anteroposterior view at 58 months followup showing concentric hip left side (d1 - d4) Clinical photographs at 58 months followup showing range of motion

we performed FS in addition to PPO. However, for some patients in a lower age group FS was necessary; one patient (age 20 months) had an AI degree of 50 and received PPO + FS.

During the operation, a tricortical trapezoidal iliac graft was placed in the osteotomy space. "K" wire or fixation materials were not used in patients who received only PPO. For FS patients, a Harris–Müller plate (Hipokrat, İzmir, Turkey) (3 or 4 holes) was applied for stabilization. All patients had an adductor tenotomy immediately prior to the PPO and an iliopsoas tenotomy was performed during the course of the operation. With the exception of three patients, all patients received OR, during which a ligamentum teres and pulvinar excision was made and the transverse ligament released. All OR patients received hip capsule plications.

Increased femoral anteversion often occurs in DDH patients. To avoid this complication, all the FS patients in the study received derotation. An anterolateral oblique incision was made for PPO and OR and for FS patients a separate lateral incision was made to the proximal femur. A varus osteotomy was not applied. The same surgeon (M.B.B.) conducted all surgeries, pre and postoperative evaluations.

A hip spica cast was applied for 1.5 months and following the removal of the cast, a Dennis–Brown bar was prescribed for 1-month. At 2.5 months postoperative, we began mobilization with physiotherapy and partial weight bearing of the lower extremities. Followup was done for 1st, 6th, 12th and 24th months postoperatively, with an ongoing annual checkup of the hip.

The grade of displacement was calculated according to Tönnis[5] grading and AI[16] was determined preoperatively and postoperatively and CE postoperatively. Clinical evaluations were made according to the modified McKay's[19] criteria, which include assessments of pain, range of motion of the affected and the contralateral hips, instability, limp and Trendelenburg sign; radiological assessments were made according to Severin's[17] classification which is a system that helps surgeons to rate the long term outcomes of an operation against future possible osteoarthritis and femoral head AVN measurements were taken with criteria proposed by Kalamchi and MacEwen.[18]

All FS patients received OR with excision of the inner acetabulum pulvinar and ligamentum teres and release of the transverse ligament. The proximal femoral osteotomy was performed with the derotation and stabilization was achieved with a Harris–Müller plate. No traction was applied prior to the operation. Adductor tenotomy was applied to all patients. The same method was applied to both groups postoperative.

Descriptive statistics was given as mean (minimum-maximum) values for continuous data and as percentages (%) for the categorical data. Shapiro–Wilk test[20] was used to test

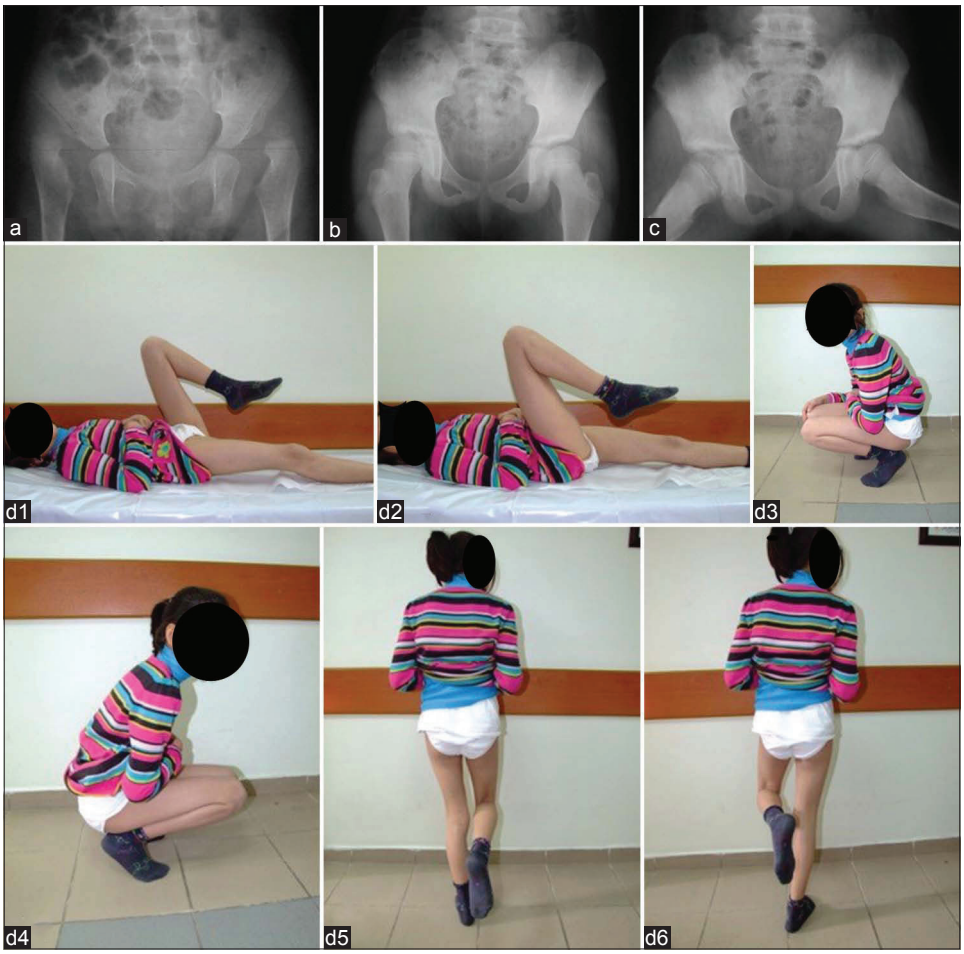

Figure 2: (a) X-ray pelvis with both hip joints anteroposterior view of group 2, female, 27 months old (preoperative) showing bilateral developmental dysplasia of the hip. (b) X-ray pelvis with both hip joints anteroposterior and (c) frog leg lateral view of same patient at 62 months followup showing concentric reduction (d1 - d6) Clinical photographs of patient at 62 months followup showing range of motion

normality of variables. Repeated measures were tested by *t*-test. $P < 0.05$ as considered to be significant.

Results

The average followup period was 83.35 months (range 48–115 months). Hips were evaluated pre and postoperatively according to Tönnis classification.[21] In all patients, five patients were evaluated preoperatively, as being at Tönnis II and nine patients at Tönnis IV, but they were all evaluated as Tönnis I postoperatively [Table 1]. This observation supports that the patients showed the same long term recovery rates in spite of the differences in the preoperative Tönnis classification among patients.

Furthermore, we examined the effect of PPO on the AI during the preoperative and last followup in all patients. The average AI was 41.92° (range 30°–50°) preoperatively and 19.5° (range 5°–34°) postoperatively (95% confidence interval: 16.26–28.13, $P < 0.001$). PPO treatment provided a significant correction in the AI of the patients.

Center-edge angle provides useful information after the age of 5 years; angle formed by a line drawn from the center of the femoral head to the outer edge of the acetabular roof and a vertical line drawn through the center of the femoral head. Angle >25° is considered normal; <20° indicates DDH.[21] In our series, average CE was measured as 24.24° (range 12°–41°) postoperatively. But 2 (14.28%) patients had severe dysplasia (<20°), which received surgery in the 36th month (1 male group 1, 1 female group 3), for this reason, acetabular roof coverage may be necessary as additional surgery. Other remaining 5 (35.71%) patients were mild dysplasia (<25°) and 7 (50%) were normal.

Acetabular roof operations with or without FS sometimes negatively affect the femoral head. In the long term, such operations may, therefore, result in AVN. For this reason, the Severin classification and the Kalamchi–MacEven classification can be used to evaluate the femoral head radiologically. According to Severin's classification, 11 (78.57%) patients were in the rank Ia, 1 (7.14%)

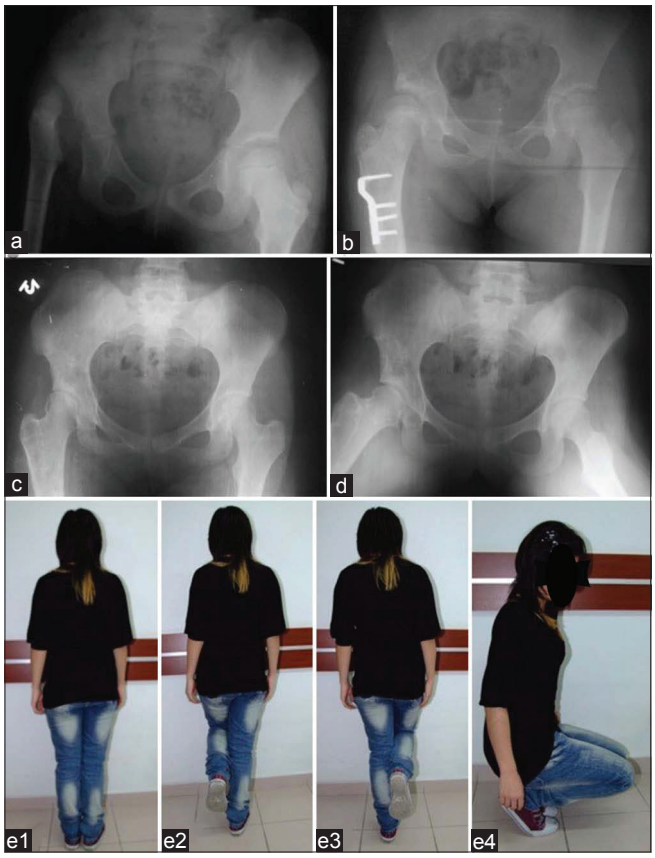

Figure 3: (a) X-ray pelvis with both hip joints anteroposterior view of Group 3 female 65 months old (preoperative) showing right developmental dysplasia of hip (b) X-ray pelvis with both hips anteroposterior view at 18 months followup showing concentric reduction with implant *in situ* (c) X-ray pelvis with both hips anteroposterior view and (d) frog leg lateral view at 88 months followup showing concentric reduction (e1 - e4) Clinical photographs at 88 months followup showing range of motion of hip

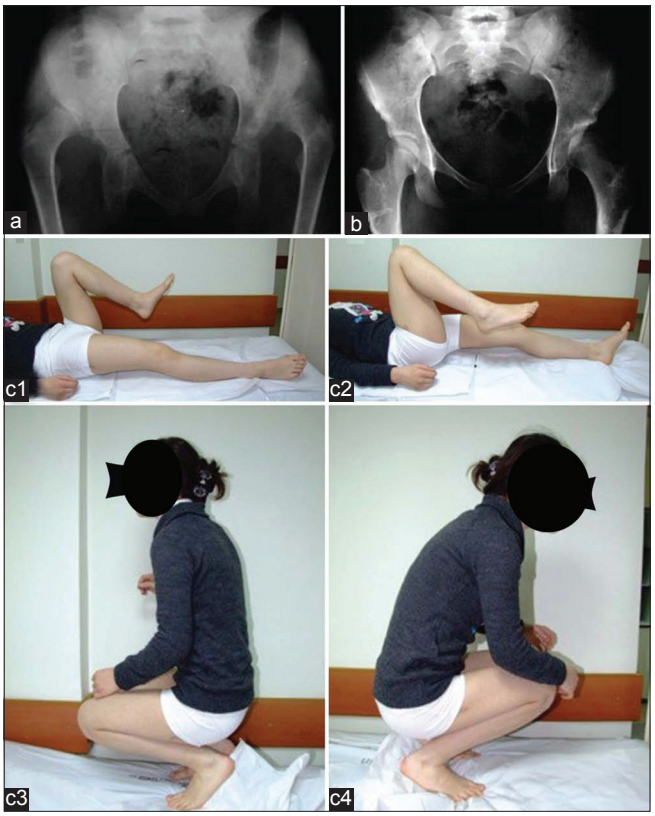

Figure 4: (a) X-ray pelvis with both hip joints anteroposterior view of Group 3 female, 80 months old (preoperative) showing bilateral developmental dysplasia of hip (b) X-ray pelvis both hip joints anteroposterior view of same patient at 113 months (R) and 110 months (L) hip followup showing concentric reduction (c1 - c4) clinical photographs of same patient at final followup showing range of motion

was in rank Ib, 1 (7.14%) was in rank II and 1 (7.14%) was in rank III. According to Kalamchi–McEven criteria, 12 (85.71%) patients were in the type I, 2 (14.28%) patients were in type II. Clinically (McKay), the functional results in 13 (92.85%) patients were very good (I) and in 1 (7.14%) patient was good (II). According to the modified McKay's clinical criteria, the functional results were 13 (92.85%) very good (I), 1 (7.14%) good (II) [Table 1].

Patients who received FS developed hip joint contractures postoperatively. Especially in advanced ages, more hip flexion contraction developed in comparison to patients not having FS. However, following cast, no hip flexion developed in the long run. No significant difference was found in three patients who had group 1. The contractures were dissolved during the rehabilitation period. No patients showed any neurological deficit or shortening in the extremities and no secondary operations were needed for hip joints.

Discussion

The aim of any DDH treatment is to provide sufficient coverage of the acetabular roof, which must be provided in order to prevent displaced hips from developing and to allow for a concentrated reduction of the hip joint. Both incomplete (Pemberton, Dega) and complete (Salter) iliac osteotomies can be used successfully in DDH patients.[3,4,6-9] However, incomplete osteotomies are advantageous since they do not require an internal fixation.

One of the most important factors in DDH surgery is matching the correct surgical method to the right age group. Since the AI of DDH patients is normally high, PPO is a preferred choice to reduce the AI angle and allow for better coverage of the acetabular roof. The effect of PPO on AI is expected to be different according to age group. Periacetabuler osteotomy/PPO aims to reduce AI and provide coverage for the femoral head while PPO + FS helps to reduce femoral head and protect against vascularization and prevent AVN in patients aged 3 years and older.

The recommended age period for the performance of a Pemberton osteotomy is 1.5–14 years.[3] However, there has been some debate about the fixing of recommended ages for procedures since, according to Sankar *et al*., patient age is also an unclear indication for surgery.[10]

For older patients (>3) in our study, we decided to perform FS in addition to PPO as most literature indicates that FS helps to reduce pressure on the femoral head, thus lowering the risk of AVN and future hip problems.[11] Six of the patients in our study groups required FS with group 2. Since it was clear from the results of the two groups that FS patients showed no difference in AI correction and overall recovery in the mid term followup to the younger age group who had not received FS, we suggest that the performance of group 2 in an older age group can bring comparable results to those of group 1 in a younger age group. The AI values for both groups showed significant changes preoperatively.

All patients showed good or very good results according to the McKay measurements taken for our clinical evaluations, indicating a probable good long term outcome to the PPO procedure. No significant difference was found while comparing individual patients.

Developmental dysplasia of the hip patients who receive acetabular osteotomies or PPO with FS may develop AVN of the femoral head. The patients in our study received the following scores according to the Kalamchi–MacEwen AVN measurement analysis: 12 (85.71%) patients were type I, 2 (14.28%) patients were type II. One major finding of our study was that none of our patients had experienced any problems with AVN irrespective of whether they had undergone group 1 or group 2. The results of our study showed that patients who received FS did not have any ensuing hip disorders. Neither patient showed any development of AVN.

It is known that PPO provides a notable correction in AI and allows for the rotation of the acetabulum.[22] For DDH patients with a clear defect in the anterior and superolateral walls of the acetabulum, PPO is the preferred choice. The rotation center is located near the hip joint, and PPO allows for good coverage.[3,23,24] Although Tachjian[23] demonstrated that there is a decrease in the volume of the acetabulum, Solomczykowski *et al*.[25] showed that PPO increases the volume. Our results showed that PPO provided good coverage of the femoral head.

In general, FS is used with children over 3 years of age.[11] However, one patient (20 months) in our study had necessitated FS owing to the difficult reduction and centralization.

The limitation of our study is the relatively small sample size. Therefore additional studies are needed with a larger patient group with a longer followup period.

The functional and radiological mid term results of DDH patients who received PPO could be classified as very good. This indicates that PPO or PPO + FS + DR is indeed a useful option for surgeons and patients. Since the future possibility of developing AVN is one of the main considerations postoperatively, the good results we received in both the Severin classifications and McKay's criteria suggest that the quality of life of the patients was not only improved postoperative, but would also continue to be so. In addition to this, the results we observed after performing group 3 in a patient under the age of 3 also suggest that this procedure may be carried out in younger patients when the AI measurement dictates so.

References

1. Akel I, Tumer Y. Residual acetabular dysplasia-natural history and indication for surgery. Turkiye Klinikleri J Orthop Traumatol Spec Top 2010;3:10-3.
2. Bursali A, Tonbul M. How are outcomes affected by combining the Pemberton and Salter osteotomies? Clin Orthop Relat Res 2008;466:837-46.
3. Pemberton PA. Pericapsular osteotomy of the ilium for treatment of congenital subluxation and dislocation of the hip. J Bone Joint Surg Am 1965;47:65-86.
4. Salter RB, Dubos JP. The first fifteen year's personal experience with innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. Clin Orthop Relat Res 1974;98:72-103.
5. Tönnis D. An evaluation of conservative and operative methods in the treatment of congenital hip dislocation. Clin Orthop Relat Res 1976;119:76-88.
6. Tukenmez M, Perc S, Tezeren G, Cingoz MA. The outcomes of salter innominate osteotomy in the treatment of developmental dysplasia of the hip. Turkiye Klinikleri J Med Sci 2006;26:390-5.
7. Utterback JD, MacEwen GD. Comparison of pelvic osteotomies for the surgical correction of the congenital hip. Clin Orthop Relat Res 1974;98:104-10.
8. Bhuyan BK. Outcome of one-stage treatment of developmental dysplasia of hip in older children. Indian J Orthop 2012;46:548-55.
9. El-Sayed M, Ahmed T, Fathy S, Zyton H. The effect of Dega acetabuloplasty and Salter innominate osteotomy on acetabular remodeling monitored by the acetabular index in walking DDH patients between 2 and 6 years of age: Short- to middle-term followup. J Child Orthop 2012;6:471-7.
10. Sankar WN, Tang EY, Moseley CF. Predictors of the need for femoral shortening osteotomy during open treatment of developmental dislocation of the hip. J Pediatr Orthop 2009;29:868-71.
11. Vitale MG, Skaggs DL. Developmental dysplasia of the hip from six months to four years of age. J Am Acad Orthop Surg 2001;9:401-11.
12. Galpin RD, Roach JW, Wenger DR, Herring JA, Birch JG. One-stage treatment of congenital dislocation of the hip in

older children, including femoral shortening. J Bone Joint Surg Am 1989;71:734-41.
13. Wenger DR, Lee CS, Kolman B. Derotational femoral shortening for developmental dislocation of the hip: Special indications and results in the child younger than 2 years. J Pediatr Orthop 1995;15:768-79.
14. Schoenecker PL, Strecker WB. Congenital dislocation of the hip in children. Comparison of the effects of femoral shortening and of skeletal traction in treatment. J Bone Joint Surg Am 1984;66:21-7.
15. Klisic P, Jankovic L. Combined procedure of open reduction and shortening of the femur in treatment of congenital dislocation of the hips in older children. Clin Orthop Relat Res 1976;119:60-9.
16. Berkeley ME, Dickson JH, Cain TE, Donovan MM. Surgical therapy for congenital dislocation of the hip in patients who are twelve to thirty-six months old. J Bone Joint Surg Am 1984;66:412-20.
17. Severin E. Congenital dislocation of the hip; development of the joint after closed reduction. J Bone Joint Surg Am 1950;32-A: 507-18.
18. Kalamchi A, MacEwen GD. Avascular necrosis following treatment of congenital dislocation of the hip. J Bone Joint Surg Am 1980;62:876-88.
19. Classic. Translation: Hilgenreiner on congenital hip dislocation. J Pediatr Orthop 1986;6:202-14.
20. Razali NM, Wah YB. Power comparisons of Shapiro-Wilk, Kolmogorov-Simirnov, Lilliefors and Anderson-Darling tests. J Stat Model Analytics 2011;2:21-33.
21. Bulut M, Gürger M, Belhan O, Batur OC, Celik S, Karakurt L. Management of developmental dysplasia of the hip in less than 24 months old children. Indian J Orthop 2013;47:578-84.
22. Omeroglu H, Biçimoglu A, Agus H, Tümer Y. Measurement of center-edge angle in developmental dysplasia of the hip: A comparison of two methods in patients under 20 years of age. Skeletal Radiol 2002;31:25-9.
23. Coleman SS. The incomplete pericapsular (Pemberton) and innominate (Salter) osteotomies; a complete analysis. Clin Orthop Relat Res 1974;98:116-23.
24. Herring JA, editor. Developmental dysæplasia of the hip. In: Tachdjian's Pediatric Orthopedics. 3rd ed., Vol. 1. Philadelphia: W.B. Saunders; 2002. p. 513-654.
25. Solomczykowski M, Mackenzie WG, Stern G, Keeler KA, Glutting J. Acetabular volume. J Pediatr Orthop 1998;18:657-61.

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