The results of Pemberton's pericapsular osteotomy in patients with developmental hip dysplasia

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Objective: The aim of this study was to investigate the radiological and clinical outcomes of Pemberton's pericapsular osteotomy in toddlers and preschool children with developmental hip dysplasia.

Methods: Ninety-one hips of 86 patients (81 girls, 5 boys) with developmental hip dysplasia who underwent Pemberton's pericapsular osteotomy were included in this study. The mean age of the patients was 34 (range: 18 to 96) months. The mean duration of follow-up was 60 (range: 24 to 158) months. All patients underwent open reduction and Pemberton's pericapsular osteotomy, including 12 hips in which proximal femur osteotomy had been performed earlier. Clinical results were evaluated according to McKay's clinical evaluation criteria, radiological results according to Sever's radiological evaluation criteria, and the presence of avascular necrosis according to Kalamchi-MacEwen's classification criteria.

Results: At the final examinations the mean acetabular index was 12.04° (range: 5° to 24°) and the mean Wiberg's center-edge angle was 35.5° (range: 20° to 52°). Clinically, excellent results were obtained in 81 (89.0%) hips, good results were obtained in 2 (2.2%) hips, and fair results in 8 (8.8%) hips. Radiologically, excellent results were obtained in 79 (86.8%) hips, good results in 7 (7.7%) and fair results in 5 (5.5%) hips. Clinically and radiologically no poor results were noted. Type 1 avascular necrosis was detected in 9 (9.9%) hips, Type 2 in 7 (7.7%) hips, and Type 3 in one (1.1%) hip. There were no cases with Type 4 avascular necrosis.

Conclusion: Pemberton's pericapsular osteotomy is a safe and effective procedure for the surgical treatment of developmental hip dysplasia in toddlers and preschool children.

Key words: Developmental hip dysplasia (DDH); Pemberton's pericapsular osteotomy (PPO).

Pericapsular osteotomy of the ilium was defined by Paul A. Pemberton and is used for restoring the pathological changes of the acetabulum in the treatment of developmental hip dysplasia (DDH). The aim of this surgery is to increase the depth and sphericity of the acetabulum to promote containment of the femoral head. The remodeling capability of acetabulum is utilized as the deformity is corrected at the closest site to the origin.[1] Another treatment goal is to achieve concentric reduction and to preserve it until the end of

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treatment.[2,3] A concentrically reduced and stable femoral head is the primary stimulus for the normal development of the acetabulum.[2,4] Selection of the appropriate acetabular osteotomy is based on patient's age, the pathological anatomy of the acetabulum and proximal femur, and the surgeon's experience.[5,6] Salter's innominate osteotomy and Pemberton's pericapsular osteotomy (PPO) are the most common pelvic osteotomies. In PPO, a better covering of the femoral head is obtained as the rotational center is much closer to hip joint.[5,7,8] Salter's technique achieves an average of 10° of improvement in the acetabular index (AI),[9] and is recommended in cases with an AI up to 30°.[10] However, it is possible to obtain higher degrees of improvement with PPO[7-9] and the necessity of performing an acetabuloplasty, such as PPO, in cases with an AI of above 40° is emphasized.[7,8]

In our study, we aimed to retrospectively evaluate the clinical and radiological outcomes of PPO in our toddler and preschool patients with DDH.

Patients and methods

Ninety-one hips of 86 patients who underwent PPO after diagnosis of DDH and attended the final follow-up were included in our study. AI was measured using a radiograph of the pelvis taken in the neutral position. Hips were grouped according to Tönnis' classification system. The patients were sub-grouped in three groups based on their ages at the time of surgery: 18-24 months (Group 1), 24-36 months (Group 2), and 36 months and over (Group 3). Clinical examinations were performed and radiographs of the pelvis in the neutral position were taken at the final follow-up. AI, Sharp's angle and Wiberg's center-edge (CE) angles were measured. McKay's clinical evaluation criteria were used in the clinical assessment and Sever's criteria in the radiological assessment. In cases with avascular necrosis (AVN), the Kalamchi-MacEwen's classification was used. Clinical and radiological outcomes were assessed individually, based on age groups and level of hip dislocations.

According to Tönnis' classification system, 22 hips (24.2%) were Type 2, 38 hips (41.8%) were Type 3, and 31 hips (34.1%) were Type 4. The mean age of the patients at the time of surgery was 34 (range: 18 to 96) months. Group 1 was composed of 50 hips (54.94%), Group 2 of 18 hips (19.78%), and Group 3 of 23 hips (25.27%). Mean follow-up duration was 60 (range: 24 to 158) months.

Patients were operated either under general anesthesia or general and caudal anesthesia combined.

Open or percutaneous adductor tenotomy was performed on hips with tight adductor muscles. The hip joint was reached with an iliofemoral incision. Iliopsoas tenotomy, pulvinar tissue removal, ligamentum teres excision, and transverse acetabulum ligament release were performed as routine in all patients. The limbus was not excised; however it was released with longitudinal incisions when it was in an inverted position or in a position prohibiting reduction. The iliac apophysis was excised till the posterior one-third with a scalpel and the soft tissues were removed from the ilium subperiosteally using a periosteal elevator. Osteotomy was initiated at the lateral cortex of the iliac wing with a narrow and curved osteotome. Starting at 1 cm proximal of the joint capsule, the osteotomy was advanced from spina iliaca anterior inferior toward the posterior and inferior, with an incline. After the direction of the osteotome was confirmed with fluoroscopy or radiographs, the osteotome was advanced 1.5 cm further and the osteotomy of the lateral cortex of the iliac wing was completed. A second osteotomy was also performed on the medial cortex of the iliac wing, parallel to the osteotomy line of the lateral cortex. After completion of both osteotomies, a triangular bone graft was harvested from the anterior of the iliac wing, including the spina iliaca anterior superior. The wedge bone graft was curved to properly fit the osteotomy site. The osteotomy line was opened with either laminar spreaders or elevators. The lower part of the ilium was tipped toward the lateral, front and the distal and the graft was placed in the osteotomy line. The hip joint, which was displaced at the time of osteotomy, was reduced during the procedure. Additionally, the capsulorrhaphy was carefully conducted for soft tissue stability. The iliac apophysis was sutured and the skin was closed. A pelvipedal cast was applied for all patients with operated side hip in 20°-30° of flexion and 20°-30° of abduction, knees in 10°-20° of flexion and ankles in the neutral position. The cast was removed after six weeks and an abduction brace was then used for four weeks.

SPSS v.18 software was used in statistical analysis. Pearson's chi-square test was used to assess the relation between the factors; and the Student's t-test to assess differences between preoperative and postoperative mean angles. P values of less than 0.05 were considered statistically significant.

Results

Preoperative AI was 40.53° (range: 26° to 55°). AI at the final follow-up was 12.04° (range: 5° to 24°), a

Fig. 1. **(a)** Preoperative pelvis radiograph; 26-month-old girl patient; left DDH. **(b)** Pelvis radiograph after open reduction and PPO. **(c)** Pelvis radiograph after 6-year follow-up. **(d)** Pelvis radiograph after 12-year follow-up.

mean improvement of 28.48° (range: 27.13° to 29.83°) (Figs. 1 and 2). The difference between preoperative and final follow-up values was significant (p<0.01). The mean CE angle was measured as 35.5° (range: 20° to 52°). Sharp's angle was 42.60° (range: 33° to 55°) (Figs. 1 and 2).

According to McKay's clinical evaluation criteria, 81 hips (89%) were excellent, 2 hips (2.2%) were good, and 8 hips (8.8%) were fair. No poor results were observed (Tables 1 and 2). The inverse relation between the patients' age groups and obtaining better results was found statistically significant (p<0.01). Likewise, as the dislocation level of the hip increased the results deteriorated significantly (p<0.01).

According to Sever's radiological evaluation criteria, 79 hips (86.8%) had excellent, 7 hips (7.7%) had good,

Table 1. The distribution of results, based on modified McKay's clinical evaluation criteria, according to age groups at time of surgery.

Age at time of surgery	Excellent	Good	Fair	Bad
18-24 month	50 (100%)	0 (0%)	0 (0%)	0 (0%)
24-36 month	11 (61.1%)	0 (0%)	7 (38.9%)	0 (0%)
36 month and over	20 (87.0%)	2 (8.7%)	1 (4.3%)	0 (0%)
Total	81 (89.0%)	2 (2.2%)	8 (8.8%)	0 (0%)

(χ^2: 31.636, p<0.001)

Table 2. The distribution of results, based on modified McKay's clinical evaluation criteria, according to hip groups by Tönnis' classification system.

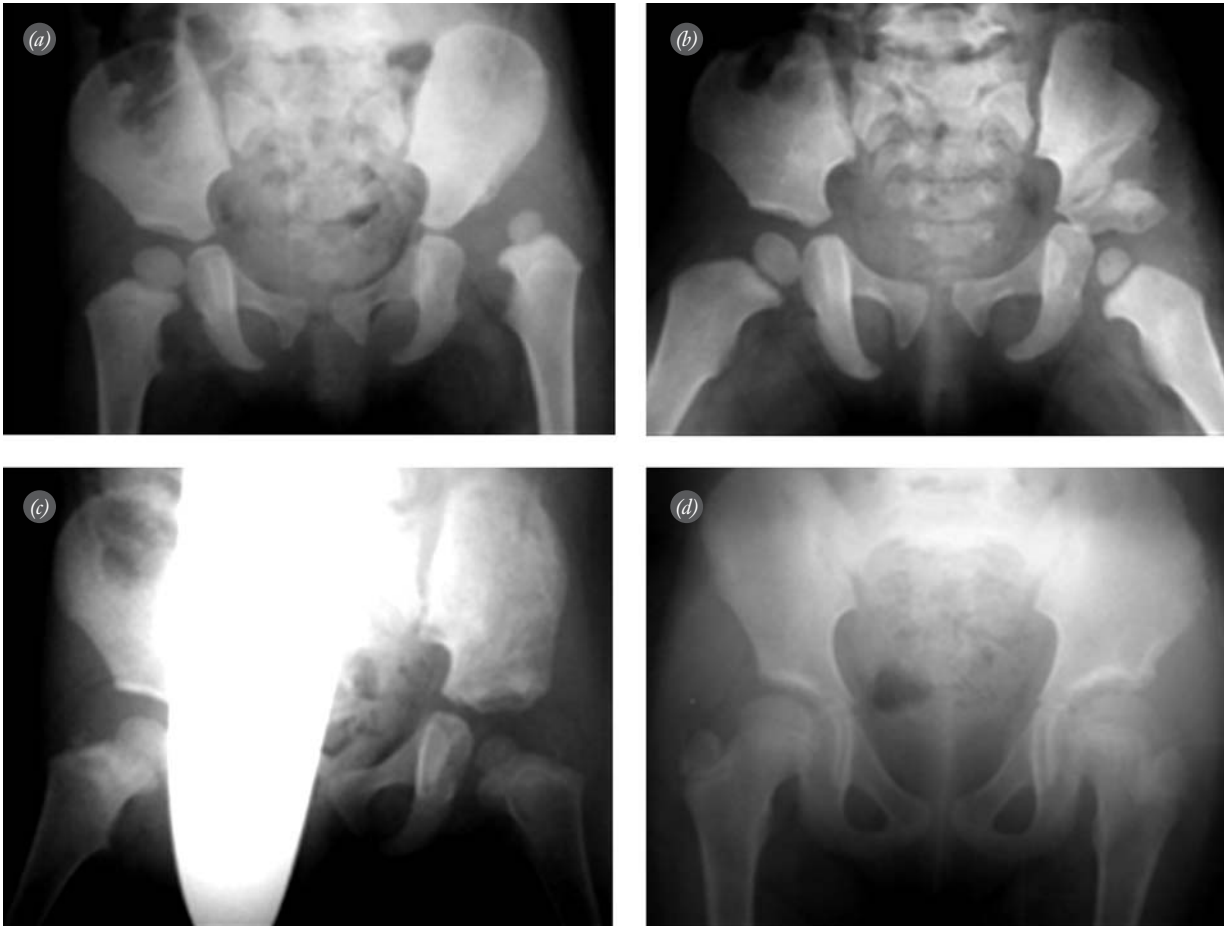| Hip groups	Excellent	Good	Fair	Bad
Tönnis Type 2	22 (100%)	0 (0%)	0 (0%)	0 (0%)
Tönnis Type 3	38 (100%)	0 (0%)	0 (0%)	0 (0%)
Tönnis Type 4	21 (67.7%)	2 (6.5%)	8 (25.8%)	0 (0%)
Total	81 (89.0%)	2 (2.2%)	8 (8.8%)	0 (0%)

(χ^2: 21.744, p<0.001)

Fig. 2. **(a)** Preoperative pelvis radiograph; 25-month-old girl patient; left DDH. **(b)** Pelvis radiograph after open reduction and PPO. **(c)** Pelvis radiograph after 4-month follow-up. **(d)** Pelvis radiograph after 4-year follow-up.

and 5 hips (5.5%) had fair results. None had poor results (Tables 3 and 4). As the patient's age group increased, excellent and good results decreased significantly (p<0.01). We observed a similar, significantly inverse relationship between the level of dislocation and better results (p<0.01).

According to Kalamchi-MacEwen's classification, AVN was detected in the proximal femur in 17 hips (18.6%). Of these, 9 hips (9.9%) were Type 1, 7 hips (7.7%) were Type 2, and one hip (1.1%) was Type 3. There were no Type 4 AVN. AVN did not develop in 81.3% of the cases (Tables 5 and 6). As age increased, the development of AVN also increased significantly (p<0.01). Additionally, as the level of dislocation increased, the development of AVN also increased significantly (p<0.01).

Table 3. The distribution of results, based on Sever's radiological evaluation criteria, according to age groups at time of surgery.

Age at time of surgery	Excellent	Good	Fair	Bad
18-24 month	50 (100%)	0 (0%)	0 (0%)	0 (0%)
24-36 month	11 (61.1%)	3 (16.7%)	4 (22.2%)	0 (0%)
36 month and over	18 (78.3%)	4 (17.4%)	1 (4.3%)	0 (0%)
Total	79 (86.8%)	7 (7.7%)	5 (5.5%)	0 (0%)

(χ^2: 23.078, p<0.001)

Table 4. The distribution of results, based on Sever's radiological evaluation criteria, according to hip groups by Tönnis' classification system.

Hip groups	Excellent	Good	Fair	Bad
Tönnis Type 2	22 (100%)	0 (0%)	0 (0%)	0 (0%)
Tönnis Type 3	38 (100%)	0 (0%)	0 (0%)	0 (0%)
Tönnis Type 4	19 (61.3%)	7 (22.6%)	5 (16.1%)	0 (0%)
Total	79 (86.8%)	7 (7.7%)	5 (5.5%)	0 (0%)

(χ^2: 26.754, p<0.001)

Table 5. Distribution of AVN according to age groups.

		AVN			
Age at time of surgery	None	Type 1	Type 2	Type 3	Type 4
18-24 months	47 (94.0%)	3 (6.0%)	0 (0%)	0 (0%)	0 (0%)
24-36 months	9 (50.0%)	2 (11.1%)	7 (38.9%)	0 (0%)	0 (0%)
36 months and over	18 (78.3%)	4 (17.4%)	0 (0%)	1 (4.3%)	0 (0%)
Total	74 (81.3%)	9 (9.9%)	7 (7.7%)	1 (1.1%)	0 (0%)

(χ^2: 36.633, p<0.001)

Table 6. Distribution of AVN according to hip groups by Tönnis' classification system.

		AVN			
Hip groups	None	Type 1	Type 2	Type 3	Type 4
Tönnis Type 2	22 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Tönnis Type 3	33 (86.8%)	5 (13.2%)	0 (0%)	0 (0%)	0 (0%)
Tönnis Type 4	19 (61.3%)	4 (12.9%)	7 (22.6%)	1 (3.2%)	0 (0%)
Total	74 (81.3%)	9 (9.9%)	7 (7.7%)	1 (1.1%)	0 (0%)

(χ^2: 20.970, p<0.01)

One hip underwent open reduction and capsular plication 6 months postoperatively, after resubluxation was observed. Type 3 AVN was detected in the final follow-up at the third year. Supracondylar femur fractures developed in due course in three patients. Two patients had superficial wound infections which resolved with antibiotherapy.

Discussion

The main objective in the treatment of DDH is to provide a stable reduction.[2,11,12] Concentric reduction performed in the pre-toddler period can be retained until the end of treatment.[13,14] Successful results may not always be obtained in a single session of closed or open reduction performed on toddlers or older patients with DDH.[15,16] A significant proportion of patients require a pelvic or femoral osteotomy due to the development of dysplasia or subluxation.[15-18] One of the most commonly performed pelvic osteotomies is PPO. The main advantage of PPO is the better covering of the femoral head, as the rotational center is very close to the hip joint.[5,7,8] It is possible to achieve a high degree of improvements with PPO.[7-9] Several studies have reported the superiority of PPO over Salter's innominate osteotomy, in cases of increased AIs.[1,10] It is also known that excellent results are also possible with PPO in long term.[5,7,19,20] Kessler et al. reported a mean postoperative AI of 18°, versus the preoperative mean of 33°.[21] Gordon et al. measured the CE angle as 28° in their final follow-up.[22] AI, CE and Sharp's angles from various studies are shown in Table 7.[7,23-27] In our study, we found a preoperative mean AI of 40.53°, a mean 5th year final follow-up AI of 12.04°, a mean CE angle of 35.5°, and a Sharp's angle of 42.6°.

Bilateral PPO can be performed in a single session as it does not affect pelvic stability. Significant differences between single and two consecutive session surgeries have been reported in duration of anesthesia,

Table 7. PPO results from several studies in the literature.

	AI improvement	CE angle	Sharp's angle	Clinical result	Radiological result	AVN
Shea et al.[23]	17°	38°		100%		0%
Faciszewski et al.[7]	22°	35°	40°	98%	98%	0%
Vedantam et al.[24]		30°	36°		80.7%	0%
Wada et al.[25]		24°	44°	82.3%	76.4%	
Szepesi et al.[26]	19°	17°		81%	79%	1%
Hamzaoğlu et al.[27]	21°	25°		78%		7%

antibiotic prophylaxis cost, length of hospital stay, and total hospital expenditure.[28] Another benefit of PPO is avoiding limb length discrepancy.[29] As the graft is firmly placed in the osteotomy line, fixation materials such as K-wires are not used making a second surgical intervention for implant removal unnecessary.[5] In light of this information, we performed a single session (and in presence of bilateral DDH, bilateral) PPO in all our cases when no mismatch between the femoral head and acetabulum was found.

Pemberton reported good results in 94.3% of his cases.[1] Wada et al. reported excellent and good results according to McKay's clinical evaluation criteria in 82.3% of 17 hips of patients over 7 year of age who underwent PPO.[25] Szepesi et al.[26] reported successful results in 81% of 80 cases and Faciszewski et al.[7] reported excellent and good results in 51 of 52 hips treated. In our study, we had excellent results in 81 hips (89.0%) and good results in 2 hips (2.2%).

Szepesi et al. reported successful radiological results in 80 hips (79%).[26] Wada et al. confirmed a success rate of 76.4% in 17 hips of cases over 7 years of age.[25] Vedantam et al. reported excellent and good radiological results in 14 of 16 hips (80.7%).[24] In our study, we had excellent results in 79 hips (86.8%) and good results in 7 hips (7.7%), based on Sever's radiological evaluation criteria.

Pemberton reported coxa plana in 15 of his 300 patients.[5] Gordon et al. stated that they did not see any AVN in their series.[22] Likewise, Hellinger and Schmidt did not report any AVN in their series and attributed this to their application of reduction and intertrochanteric osteotomy to all patients.[30] Faciszewski et al. did not report any case of AVN in their series of 52 hips.[7] Hamzaoğlu et al. reported AVN in one hip out of 14 which received PPO, reduction, derotation and varus osteotomy.[27] In our study, we had 9 Type 1 hips (9.9%), 7 Type 2 hips (7.7%) and one Type 3 hip (1.1%) with AVN, according to Kalamchi-MacEwen's AVN classification criteria. We did not monitor any Type 4 AVN. We also observed that 81.3% of cases did not develop AVN. The probability of complication increased in patients with Tönnis Type 4 hip dislocation, in patients over 3 years of age, and in cases in which a second surgery was necessary. The level of hip dislocation affects the clinical and radiological outcome more than the age of the patient. While the results were excellent in Tönnis Type 2 and 3 hips, they were dramatically different in Type 4 hips, increasing the probability of complication.

In conclusion, we believe that in the treatment of toddlers and preschool children with DDH, PPO is an effective and safe method that returns excellent clinical and radiological results in cases with no femoroacetabular incongruence. However, as the level of hip dislocation and patient age increase, the success rate begins to decline.

Conflicts of Interest: No conflicts declared.

References

1. 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.

2. Malvitz TA, Weinstein SL. Closed reduction for congenital dysplasia of the hip. Functional and radiographic results after an average of thirty years. J Bone Joint Surg Am 1994;76:1777-92.

3. Fleissner PR Jr, Ciccarelli CJ, Eilert RE, Chang FM, Glancy GL. The success of closed reduction in the treatment of complex developmental dislocation of the hip. J Pediatr Orthop 1994;14:631-5.

4. Harris NH, Lloyd-Roberts GC, Gallien R. Acetabular development in congenital dislocation of the hip. With special reference to the indications for acetabuloplasty and pelvic or femoral realignment osteotomy. J Bone Joint Surg Br 1975;57:46-52.

5. Pemberton PA. Pericapsular osteotomy of the ilium for the treatment of congenitally dislocated hips. Clin Orthop Relat Res 1974;(98):41-54.

6. Millis MB, Kaelin AJ, Schluntz K, Curtis B, Hey L, Hall JE. Spherical acetabular osteotomy for treatment of acetabular dysplasia in adolescents and young adults. J Pediatr Orthop B 1994;3:47-53.

7. Faciszewski T, Kiefer GN, Coleman SS. Pemberton osteotomy for residual acetabular dysplasia in children who have congenital dislocation of the hip. J Bone Joint Surg Am 1993;75:643-9.

8. Tachdjian MO. Pediatric orthopaedics. 2nd ed. Philadelphia: W.B. Saunders; 1990. p. 297-549.

9. Utterback JD, MacEwen GD. Comparison of pelvic osteotomies for the surgical correction of the congenital hip. Clin Orthop Relat Res 1974;(98):104-10.

10. Chapchal G. Indications for the various types of pelvic osteotomy. Clin Orthop Relat Res 1974;(98):111-5.

11. Williamson DM, Glover SD, Benson MK. Congenital dislocation of the hip presenting after the age of three years. A long-term review. J Bone Joint Surg Br 1989;71:745-51.

12. 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.

13. Tumer Y, Bicimoglu A, Agus H. Surgical treatment of hip dysplasia through the medial approach. Acta Orthop Traumatol Turc 2007;41 Suppl 1:31-6.

14. Aksoy MC. Closed reduction in the treatment of developmental dysplasia of the hip. Acta Orthop Traumatol Turc 2007;41 Suppl 1:25-30.

15. Kerry RM, Simonds GW. Long-term results of late non-operative reduction of developmental dysplasia of the hip. J Bone Joint Surg Br 1998;80:78-82.

16. Kershaw CJ, Ware HE, Pattinson R, Fixsen JA. Revision of failed open reduction of congenital dislocation of the hip. J Bone Joint Surg Br 1993;75:744-9.

17. Zionts LE, MacEwen GD. Treatment of congenital dislocation of the hip in children between the ages of one and three years. J Bone Joint Surg Am 1986;68:829-46.

18. Karakurt L, Yilmaz E, Incesu M, Belhan O, Serin E. Early results of treatment for developmental dysplasia of the hip in children between the ages of one and four years. Acta Orthop Traumatol Turc 2004;38:8-15.

19. Abel MF, Sutherland DH, Wenger DR, Mubarak SJ. Evaluation of CT scans 3-D reformatted images for quantitative assessment of the hip. J Pediatr Orthop 1994;14:48-53.

20. Weinstein SL. Congenital hip dislocation. Long-range problems, residual signs, and symptoms after successful treatment. Clin Orthop Relat Res 1992;(281):69-74.

21. Kessler JI, Stevens PM, Smith JT, Carroll KL. Use of allografts in Pemberton osteotomies. J Pediatr Orthop 2001;21:468-73.

22. Gordon JE, Capelli AM, Strecker WB, Delgado ED, Schoenecker PL. Pemberton pelvic osteotomy and varus rotational osteotomy in the treatment of acetabular dysplasia in patients who have static encephalopathy. J Bone Joint Surg Am 1996;78:1863-71.

23. Shea KG, Coleman SS, Carroll K, Stevens P, Van Boerum DH. Pemberton pericapsular osteotomy to treat a dysplastic hip in cerebral palsy. J Bone Joint Surg Am 1997;79:1342-51.

24. Vedantam R, Capelli AM, Schoenecker PL. Pemberton osteotomy for the treatment of developmental dysplasia of the hip in older children. J Pediatr Orthop 1998;18:254-8.

25. Wada A, Fujii T, Takamura K, Yanagida H, Taketa M, Nakamura T. Pemberton osteotomy for developmental dysplasia of the hip in older children. J Pediatr Orthop 2003;23:508-13.

26. Szepesi K, Rigó J, Bíró B, Fazekas K, Póti L. Pemberton's pericapsular osteotomy for the treatment of acetabular dysplasia. J Pediatr Orthop B 1996;5:252-8.

27. Hamzaoğlu A, Esenkaya İ, Durmaz H, Aşık M, Arıtamur A. Operative treatment of congenital hip dislocation in older ages with "open reduction, shortening, derotation, variasion and Pemberton acetabuloplasty." [Article in Turkish] Acta Orthop Traumatol Turc 1990; 24:9-12.

28. Zorer G, Bagatur AE. Single-stage bilateral Pemberton's pericapsular osteotomy in bilateral developmental dysplasia of the hip. [Article in Turkish] Acta Orthop Traumatol Turc 2002;36:288-94.

29. McKay DW. A comparison of the innominate and the pericapsular osteotomy in the treatment of congenital dislocation of the hip. Clin Orthop Relat Res 1974;(98):124-32.

30. Hellinger J, Schmidt H. The pericapsular osteotomy of the os ilium in the treatment of flat acetabula. Arch Orthop Trauma Surg 1982;101:53-7.