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Comparison of Salter innominate osteotomy and Pemberton pericapsular osteotomy combined with open reduction through medial adductor approach on acetabular development in the treatment of developmental hip dysplasia

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ABSTRACT

Objective: Combined with open reduction through medial adductor approach, Salter innominate osteotomy (SIO) and Pemberton pericapsular osteotomy (PPO) methods are common procedures for the repair of incomplete acetabulum structure in patients with developmental hip dysplasia (DHD). The aim of this study is to compare the outcomes of acetabulum development in patients treated using these two methods.

Patients and Methods: We retrospectively reviewed the medical records of 50 (65 hip joints) children who underwent SIO or PPO for DHD. Thirty-three patients underwent SIO and 32 patients underwent PPO as surgical treatment. The criteria of Tönnis, modified McKay, and Severin, and angles of acetabular index (AI) and acetabular center-edge (CE) angles of both groups were compared.

Results: There were significant differences between two groups in the time of operation, follow-up time after operation, preoperative and postoperative AI angles, and postoperative 1st year CE angles. AI was detected as lower in the PPO group at 1st month postoperatively. Whereas, mean AI was detected as higher in the preoperative PPO group. In addition, the acetabular CE angle was significantly lower in the PPO group at 1st year postoperatively. However, there was no significant difference between the groups in terms of the CE angle value measured at the final follow-up.

Conclusion: Salter innominate osteotomy and PPO methods used in the treatment of DHD have specific advantages and disadvantages. Preoperative and intraoperative evaluations of patients are very important in determining which procedure should be performed. When the choice is made properly, clinical and radiological results are both satisfactory.

Keywords: Developmental hip dysplasia, Pemberton pericapsular osteotomy, Salter innominate osteotomy

1. INTRODUCTION

The purpose of treatment for developmental hip dysplasia (DHD) is reduction and stabilization of the joint and establishment of the physiological development of the hip. Patients <24 months of age are routinely performed open reduction through medial approach, and surgical outcomes are satisfactory especially for patients <12 months [1]. This is a simple, less traumatic and safe procedure with minimal soft tissue dissection and blood loss, also it can be applied to both hips in the same session [2]. But, after 18 months of age, structural changes around the dislocated hip may prevent concentric reduction. In such hips, medial approach has two major disadvantages: i) capsulorrhaphy which is required to prevent recurrent luxation or subluxation cannot be performed, and ii) acetabular osteotomy is not an option [2].

Salter innominate osteotomy (SIO) and Pemberton pericapsular osteotomy (PPO) are common procedures that can be performed in addition to open reduction through medial adductor approach for the repair of dysplasic acetabulum in patients with DHD; especially >18 months of age [3,4]. SIO is a complete osteotomy that reorients the entire acetabulum to achieve the best possible femoral head-acetabulum accordance [3]. However, PPO is an incomplete osteotomy performed to change the shape of the acetabulum depending on the horizontal branch of the triradiate cartilage [5]. The objective of both methods are to improve the antero-lateral coverage of the femoral head [6,7].

Our hypothesis is; there are some differences between the two methods that should be considered by the surgeon, by evaluating each patient individually, to achieve similar clinical and radiological results. Based on this hypothesis; this study aims to compare the results of acetabulum development in patients who underwent SIO or PPO in addition to open reduction through medial adductor approach, for the treatment of DHD.

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2. PATIENTS and METHODS

Patients and ethical consideration

The data of patients who underwent DHD surgery in the Department of Orthopedics and Traumatology, Faculty of Medicine, Karadeniz Technical University, between 1980 and 2010 were collected retrospectively. Using the contact information in the files, the patients were invited to the clinic for a final follow-up, for which 52 patients applied. As a result, 65 hip joints of 52 patients were included in the study.

All procedures were based on the 1975 Declaration of Helsinki Human Declaration revised in 2000. The Experimental Committee was conducted in accordance with ethical standards and ethics committee approval was obtained by Karadeniz Technical University Faculty of Medicine Scientific Research Ethics Committee with the letter numbered 24237859-216 and dated 26/04/2016

Exclusion criteria

Patients who did not come to final controls, were not followed up regularly, had hip dislocation due to teratological, neurological and other pathological causes, required additional intervention for any reason, had missing data, were not included in the study.

The study was conducted with 65 hip joints of 50 patients, who met the inclusion criteria. Patients who did not meet the exclusion criteria and who volunteered to participate in the study and signed an informed consent form were included in the study. DHD was bilateral in 15 patients, on the left side in 39 patients and on the right side in 26 patients. In addition to open reduction through medial adductor approach; 33 patients had undergone SIO (Group 1), and 32 had undergone PPO (Group 2).

Surgical method and follow-up

Open reduction through medial approach was performed to the hip joint by a longitudinal incision between the adductor longus and gracilis muscles. The minor trochanter of femur was revealed through a blunt dissection, and iliopsoas tenotomy was performed. The hip joint capsule was opened longitudinally and inferomedially. Intensive care was given during the retraction to avoid damage to adjacent vessels in the operation area. The transverse acetabular ligament was divided into two and pulvinar was removed if hypertrophic. After the reduction of the femoral head to acetabulum, the stability of the hip was tested in various directions [2]. The hips requiring abduction and flexion for stability and/or having an acetabular angle above 35° on preoperative radiography, underwent osteotomy. Osteotomy was performed without capsulorhaphy as specified by the abovementioned criteria. A straight incision, starting just above the anterior-inferior iliac spina and ending in the major sciatic incisura, and a curved incision extending to the posterior wing of the triradiate cartilage were performed, for SIO and PPO; respectively [5]. After the osteotomy, the lower part of the osteotomy patient was moved downward, outward and forward. The triangular graft taken from the iliac crystal was placed on the osteotomy site. In all SIO cases, the graft was fixed with two K-wires, while most of the PPO cases did not require fixation. After osteotomy; hip stabilization was re-tested in the walking position. Hip spica plaster was applied to the hips in 20° of flexion, 30° of abduction and 10° of internal rotation for six weeks. After removal of the cast, the abduction splint was used continuously for three months.

Clinical and radiological evaluations

Pelvic anteroposterior X-ray graphies that were taken preoperatively, in the 1st year after the operation and in the last follow-ups were used. The position of the ossification center of femoral head was evaluated using Tönnis method on preoperative radiographies [8], acetabular center-edge and femoral neck angles were measured on all radiographies.

Acetebular index (AI) angle: Based on AP pelvis radiography, AI was determined as the angle between horizontal line (Hilgenreiner line) connecting two triradiate cartilages and the line connecting lowest side point of the ilium in the Y cartilage and the lateral edge of the sclerotic part of the acetabulum [9,10]. Pre-AI refers to preoperative acetebular index, and post1-AI refers to acetebular index measured one month after the operation.

Acetabular center-edge (CE) angle: CE was determined as the angle between vertical line (parallel to the midline of the trunk) passing through the center of the femoral head and, the line connecting the center of the femoral head and outermost point of the acetabulum [9,11]. The femoral head was fixated with the help of a template including central concentric circles [12]. CE-1 refers to CE angle in the postoperative 1st year and CE-last refers to the CE angle that was measured in last follow-up. McKay criteria, modified by Berkeley et al., were used for clinical evaluation [13] (Table I), and Severin criteria was used for radiological evaluation [14] (Table II).

Table I. *The modified McKay criteria [13]*

Class	Rating	Description
1	Excellent	Painless, stable hip; no limp; more than 15° internal rotation
2	Good	Painless, stable hip; slight limp or decreased motion; (–) Trendelenburg's sign
3	Fair	Minimum pain; moderate stiffness; (+) Trendelenburg's sign
4	Poor	Significant pain

Table II. *Severin's classification for radiological grading of hip dysplasia [14]*

Group	Criteria	Centre-edge angle (degrees)	Age Range
1	Normal hip	>15 >20	5 to 13 >14
2	Concentric reduction of the joint with deformity of the femoral neck, head or acetabulum	>15 >20	5 to 13 >14
3	Dysplasia but no subluxatio	<15 <20	5 to 13 >14
4	Articulation with false acetabulum		
5	Subluxation		
6	Redislocation		

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Statistical Analysis

Shapiro-Wilk test was used to evaluate whether or not the groups had homogeneous distribution (were distributed normally). Since, the groups were not homogeneously distributed, Mann-Whitney U-test was used for binary comparisons. A p value of <0.05 was considered statistically significant.

3. RESULTS

The comparison of some descriptive and clinical outcomes of Group 1 and Group 2 are shown in Table III. There was a significant difference in age of operation (month) (p=0.010), follow-up period after the operation (month) (p<0.0001), pre-AI (p=0.002), post1-AI (p=0.001), and CE-1 (p<0.0001) values, between two groups. The operation age was higher in Group 1 (31.4±22.2 and 19.8±2.53 months; p=0.010). Postoperative follow-up period (278.5±107 and 143.1±34.6 month, p<0.0001), Post1-AI (22.88±4.65 and 19.22±3.33, p=0.001,), postoperative CE-1 were significantly higher in Group 1 (33.76±2.57 and 31.03±2.96; respectively, p 0.0001). The mean pre-AI was higher in Group 2 (39.73±6.40 and 44.38±5.12; respectively, p=0.002). However, there was no significant difference between the groups in terms of the CE-last values.

Table III. *Comparison of some descriptive and clinical results of SIO and PPO.*

	Group	Number	Mean	SD	Min.	Max.	p
Operation age (month)	Salter	33	31.42	22.22	12	96	0.010
	Pemberton	32	19.84	2.529	16	24	
Postoperative follow-up period (month)	Salter	33	278.48	106.98	132	408	<0.0001
	Pemberton	32	143.13	34.59	96	240	
Preoperative Tönnis grade (%)	Salter	33	2.73	0.801	2	4	NS.
	Pemberton	32	2.47	0.671	2	4	
McKay clinical evaluation score	Salter	33	1.09	0.292	1	2	NS.
	Pemberton	32	1.06	0.246	1	2	
SS	Salter	33	1.15	0.364	1	2	NS.
	Pemberton	32	1.09	0.296	1	2	
Pre-AI	Salter	33	39.73	6.400	29	55	0.002
	Pemberton	32	44.38	5.123	34	52	
Post1-AI	Salter	33	22.879	4.649	15	39	0.001
	Pemberton	32	19.219	3.329	15	26	
CE-1	Salter	33	33.76	2.574	29	38	<0.0001
	Pemberton	32	31.03	2.957	25	38	
CE-last	Salter	33	34.30	5.120	20	45	NS.
	Pemberton	32	35.59	3.564	28	43	
Percentage (%)	Salter	33	32.4633	11.812	14.29	56.67	NS.
	Pemberton	32	49.1399	12.656	20.41	75.56	

NS: *Not significant,* ***SD:*** *Standard deviation,* ***SIO:*** *Salter innominate osteotomy,* ***PPO:*** *Pemberton pericapsular osteotomy,* ***CE:*** *Acetabular center-edge (CE) angle* ***SS:*** *Severin radiological evaluation score,* ***p:*** p *value*

The results of clinical and radiological evaluations (Table IV) indicated that; in Group 1; 16 (48.5%) patients were Tönnis Grade 2, 10 (30.3%) were Tönnis Grade 3, and 7 (21.2%) were Tönnis Grade 4. Modified McKay was excellent in 30 (90.9%) hip joints and it was good in 3 (9.1%). Additionally; 28 (84.8%) patients were Severin Class 1 and 5 (15.2%) were Severin Class 2. In Group 2; 20 (62.5%) patients were Tönnis Grade 2, 9 (28.1%) were Tönnis Grade 3, and 3 (9.4%) were Tönnis Grade 4. Modified McKay was excellent in 30 (93.8%) hip joints and it was good in 2 (6.3%). Additionally, 29 (90.6%) patients were Severin Class 1 and 3 (9.4%) were Severin Class 2. No significant differences were found in any of these parameters, between two groups (p=0.968 and p=0.708; respectively).

Table IV. *Comparison of some clinical results of patients undergoing SIO and PPO.*

Clinical Parameters	Salter [n (%)]	Pemberton [n (%)]	Total [n (%)]	p
Tönnis Grade 2	16 (48.5%)	20 (62.5%)	36 (55.4%)	
Tönnis Grade 3	10 (30.3%)	9 (28.1%)	19 (29.2%)	
Tönnis Grade 4	7 (21.2%)	3 (9,4%)	10 (15.4%)	
Modified McKay Excellent	30 (90.9%)	30 (93.8%)	60 (92.3%)	NS.
Modified McKay Good	3 (9.1%)	2 (6,3%)	5 (7.7%)	
Severin Class 1	28 (84.8%)	29 (90.6%)	57 (87.7%)	
Severin Class 2	5 (15.2%)	3 (9,4%)	8 (12.3%)	

NS.: *Not significant,* ***SIO:*** *Salter innominate osteotomy,* ***PPO:*** *Pemberton pericapsular osteotomy,* ***p***: p *value*

During the follow-up period, no residual dysplasia was observed. Avascular necrosis occurred in 5 patients in the SIO group and 4 patients in the PPO group.

4. DISCUSSION

Salter innominate osteotomy and PPO was mainly developed for children aged 18 months to 6 years and PPO was mainly developed for children aged 18 months to 6 years [3,4,15]. Accordingly, these procedures were performed to the similar age group, in our study. However, Huang and Wang reported good results in patients, who were younger than 18 months but at walking age, using open reduction and Salter osteotomy [16]. The primary objectives of SIO and PPO adequately cover the femoral head, especially in the anterolateral plane, and provide stable reduction. SIO was shown to be more suitable for patients older than 18 months, whose AI is between 30-40° [3], on the other hand; PPO was shown to be more suitable for patients with anterolateral insufficiencies, patients aged between 2-4 years with AI above 40° or patients aged between 4-6 years with AI above 35°[5]. In our study, SIO patients were older than PPO patients; but the AI criteria were similar with these studies (between 30-40 in SIO and >40 in PPO). We think that AI is the first parameter for the choice of surgical procedure. AI and CE angles were used to evaluate the adequacy of femoral head cover, in a previous study; by using these angles, PPO was shown to provide better femoral head covering and a better anatomical position of the pelvis than SIO [15]. Ezirmik et al.,

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compared the results of SIO and PPO surgeries, which they performed on each hip in the same session in children with bilateral DHD. They found that postoperative AI angle (15,16 and 12,11, respectively) was significantly lower and the mean angle of AI improvement was better in the PPO group (18.33 and 25.78, respectively, p<0.05) [6]. Studies have shown that the mean AI angle correction is between 10-23.5°with SIO and between 5-35° with PPO [17-19]. Ezirmik et al., found that the mean CE-last was significantly higher in the PPO group (37.15 and 43.11 in the SIO group and PPO group, respectively) [6]. In the present study, post1-AI was lower; but the mean pre-AI was higher in the PPO group, compared to SIO group. These findings are consistent with the literature. In this study, the CE-1 of the acetabulum was significantly lower in the PPO group. However, there was no significant difference between the groups in terms of the CE-last value. These results suggest that there is no difference between these two surgical methods in terms of this parameter.

Wang et al., compared long-term results of SIO and PPO (at least 10 years after surgery) in 42 patients with DHD, they evaluated pelvic height, increases in iliac crest and sacral inclination, besides Lumbar Cobb angle, Short Form-36 (SF-36) and Harris hip scores. They reported that while there was initially a higher increase in pelvic height in the children with Salter osteotomy (Salter 10.1%; Pemberton 4.3%, p<0.001), no significant difference was found between the two groups at the 10th year (Salter 4.4%; Pemberton 3.1%, p=0.249). Similarly, they found no significant difference between the two groups in terms of lumbar Cobb angle, SF-36 and Harris hip scores. Moreover, they reported no difference in functional outcomes or pelvic imbalance between Salter osteotomy and Pemberton acetabuloplasty in the treatment of children with DHD in the long-term [7].

In this study, 92.3% of our cases were evaluated as excellent and 7.7% as good according to the Modified McKay clinical criteria. The sequence and rates of SIO and PPO groups were also similar to those in the total group and there was no significant difference between the groups. Çıtlak et al., found these rates as 94.6% and 5.5%, respectively, consistent with our results [20].

According to Severin radiological classification, most of our cases (87.7%) were Severin 1, which was followed by Severin 2 (12.3%). The sequence was the same and the rates were similar in SIO and PPO groups. Çıtlak et al., found the rates of Severin 1 and 2 as, 74.6% and 11.8%; respectively [20]. These rates are lower than ours. In addition, they reported Severin 3 and 4 with a rate of 13.6%, but no Severin 3 and 4 were found in the present study.

Long-term follow-up of patients is required for accurate analysis of SIO and PPO surgical outcomes because many hips wear away over time. Severin 1+2 rate was 71% in the operated 93 hips that were followed up for approximately 10 years [21]. Other studies reported excellent and good results in 98% of hip joints that were followed for eight years after the surgery [22], 75% in those who were followed up for 10 years [1] and 79% in those that were followed up for 19.8 years [23].

Conclusion

SIO and PPO methods used in the treatment of DHD, have both advantages and disadvantages. Preoperative radiological and intraoperative evaluations are very important in determining which procedure should be performed. We believe that the present study will help surgeons determine the appropriate surgical procedure in patients with DHD.

Compliance with the Ethical Standards

Ethical approval: This study was approved by Karadeniz Technical University Faculty of Medicine Scientific Research Ethics Committee with the document numbered 24237859-216 and dated 26/04/2016

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Conflict of interest: The authors have no conflicts of interest to declare.

Authors' contibutions: BA: Conceptualization, data curation, formal analysis, investigation, methodology, validation, writing-original draft. HA: Funding acquisition, investigation, methodology, project administration, resources.

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