

Result of Shelf Acetabuloplasty in Adults: 20 Years of Follow-Up

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Received: 23 Aug. 2010; Received in revised form: 1 Sep. 2010; Accepted: 15 Sep. 2010

Abstract- The current study was conducted in order to examine the effectiveness of shelf procedure in symptomatic adult patients due to hip dysplasia. This study is retrospective and was performed on patients who had undergone surgery by one orthopaedic surgical team during the past 20 years. Twenty-three men and twenty-three women were enrolled in the study with a mean age of 29.3 years at the time of operation and they were followed up for a mean of 9.3 years. Shelf acetabuloplasty was performed unilateral in 30 patients and bilateral in 16 patients. Results demonstrated that mean Harris Hip Score and CE Angle significantly improved after the operation, while osteoarthritis got more severe post-operatively. The severity of osteoarthritis and the Harris Hip Score respectively significantly increased and decreased 14 years after the operation. Results also demonstrated that as the age of the patient was less, and the patient was more satisfied and the degree of osteoarthritis was less at the time of the operation, the mean change of the Harris Hip Score would be higher and the results of the operation would be more favorable. The preoperative osteoarthritis was significantly worse in to-be-operated hips than their control hips, this difference was not significant after the operation. And finally, although Harris Hip Score has been lower in to-be-operated hips before the operation, it was higher in these very same hips than the control hips after the operation. In short, according to this study although the shelf acetabuloplasty is a salvage procedure and cannot cover the femoral head concentrically like the modern redirection osteotomies, but it is an effective procedure for a young patient to postpone the progression of the hip osteoarthritis (OA) once it occurs in order to perform reconstructive surgeries later when justified.

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Acta Medica Iranica, 2011; 49(8): 536-542.

Keywords: Shelf acetabuloplasty; Hip dysplasia; Hip osteoarthritis; Salvage procedure

Introduction

Dysplasia of the hip happens in 0.25% to 0.65% of neonates and most of them are not readily detected (1). Dysplasia of the hip, if left untreated, is the most common cause of osteoarthritis of the hip (2), treatment of which may necessitate hip arthrodesis or total hip arthroplasty. In the first case, the patient can't move the affected hip normally and in the second case, apart from the huge expenses, consequences follow including limitation of motion, dislocation and lower quality of life especially in a young patient. The course of dysplasia of the hip may obviously unfavorable (3).

Several surgical and non-surgical techniques have been proposed in order to delay the consequences of dysplasia of the hip. Despite huge advances in orthopedic surgery, the surgical treatment for untreated acetabular dysplasia among adults is still controversial (4). Pelvic osteotomies that are commonly used for this

condition include: 1) Redirectional acetabuloplasty (Salter, Steel, Ganz), 2) Reshaping osteotomy (Pamberton, Dega), and 3) Salvage augmentation procedures. The third group consists of two main approaches: Chiari acetabuloplasty (5) and shelf acetabuloplasty. Certainly today, reorientation of the acetabulum is a much more common procedure and makes more anatomic sense with respect to gaining coverage three-dimensionally, as well as medializing the hip joint center, since the vast majority of adult dysplastic hips are lateralized. Considering the possibility of more advanced redirection osteotomies there is a dramatic decrease in the number of shelf operation today and narrows the indications for this procedure. Salvage augmentation procedures are based on the hypothesis that uneven distribution of the weight on the joint surface is the main cause of osteoarthritis (6), the weight can be better distributed through salvage augmentation procedure and the occurrence of

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osteoarthritis can be delayed. Stulberg *et al.*, found a strong association between osteoarthritis and dysplasia of the hip (7) supporting the hypothesis, but Lievence *et al.*, found similar associations just among young patients (8). Therefore, management of the dysplasia of the hip among young patients gains importance.

Chiari acetabuloplasty is used for adult patients in whom lateralization of the femoral head is associated with severe acetabular dysplasia (9), while shelf acetabuloplasty is done when acetabular dysplasia is not associated with lateralization of the femur and acetabulum is not congruent with the head of the femur (9). Shelf acetabuloplasty is the first surgical procedure proposed for dysplasia of the hip By Konig *et al.* in 1891 (10). In 1926, Gill modified the procedure (11), and Wiberg improved the technique and the results of the procedure (12). Since then, many studies have been conducted on the effectiveness of this procedure, but most of them have been done on children and young adults (13-15). Long-term effects of the procedure have been studied in skeletally mature adults and have had controversial results (16-18).

Considering the controversy of previous studies on the effectiveness of shelf acetabuloplasty among adults and the decreasing number of such procedure today and it is a unique chance again to qualify this procedure, the aim of the current study is to explore the clinical and radiological effectiveness of this procedure among skeletally mature patients.

Materials and Methods

This study is a retrospective case-series in which patients have been included through convenience sampling. All adult patients who were included in this study were operated during the past 20 years by one orthopedic team. The patients who entered the study with the diagnosis of Developmental Dysplasia of the Hip (DDH) were under 50 years of age at the time of surgery. There was no subluxation of the hip. The uncovered hips of non dysplastic diagnosis were excluded. Finally, 46 patients were included in the study. Thirty (n=30) patients have undergone unilateral surgery and the rest (n=16) have had bilateral surgery. The cases were the operated hips with diagnosis of DDH and the control groups were in the same category but were not operated despite its dysplastic nature due to the patient's preference or lesser severity in comparison to the operated groups. The patients for whom other operations other than shelf osteotomy had been done were excluded from the study. Hip dysplasia is a three-

dimensional deformity with deficient anterior and lateral coverage so a proper preoperation planning is inevitable. The main modality is the conventional X-Ray rays including AP, Lateral and false profile view (ventral center edge angle), CT scan for three dimensional orientation and finally MRI for evaluation of labrum. Exposure of the hip joint is through the standard Smith Peterson approach. The correct position of the graft is absolutely important. By partial detachment of abductor muscles off the iliac crest over the capsule the insertion slot is prepared exactly at the acetabular margin. We managed to install the iliac graft with a T-shape tubular plate unlike many other techniques. The plates were not removed (Figure1). Post operatively patients were not allowed to bear weight for a minimum of 8 weeks after which progressive partial weight bearing were allowed. Deep vein thrombosis (DVT) prophylaxes were considered for all the patients.

The severity of osteoarthritis was measured before and years after the surgery based on width of the joint space. We used the classification of De Mourgues and Patte to grade the osteoarthritis of the hip: Grade 1 is normal, Grade 2 is sclerosis without joint narrowing, Grade 3 is narrowing of joint <50%, Grade 4 is narrowing >50% and Grade 5 is complete loss of joint space (19). Harris Hip Score and CE Angle were measured before and years after the surgery in both hips, operated or intact. Finally, patients' satisfaction before and years after the surgery was measured by a three grade scale, from bad to good and very good.

Source of funding

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Statistical methods

Data were analyzed by SPSS version 16.0 (Chicago, IL). The comparison of the mean Harris Hip Score and CE Angle before and after the operation was made based on paired t-test. The comparison of patient satisfaction of operated hips before and after the operation was made based on Wilcoxon Signed Ranks Test.

Linear regression was used to regress preoperative and postoperative severity of osteoarthritis, preoperative and postoperative Harris Hip Score, and preoperative and postoperative CE Angle on age.

In order to compare the mean change of Harris Hip Score among patients with different levels of satisfaction or osteoarthritis, analysis of variance (ANOVA) was used.

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To compare the mean change of Harris Hip Score in patients followed for less than 14 years with those patients followed for 14 years or more, t-test was used. Similar comparison for osteoarthritis (less than 14 years and 14 years or more) was made using Mann-Whitney U test. Also, to compare satisfaction in patients followed for less than 6 years with those followed for 6 years or more, Mann-Whitney U test was used.

The comparison of preoperative and postoperative osteoarthritis and satisfaction between operated and control hips was made using Mann-Whitney U test. The comparison of Harris Hip Score before and after the operation between operated and control hips were made using t-test. Finally, in order to compare mean change in Harris Hip Score pre- to postoperatively between operated and control hips, t-test was used.

Results

Forty six patients were included in the study: 23 patients (50%) were male and 23 patients (50%) were female. The age of the patients at the time of the operation ranged from 17 to 47 years old, with a mean of 29.3 years and standard deviation of 6.5 years. Patients were followed up between 2 to 20 years after the operation, and the mean years of follow-up were 9.3 years. The operation was unilateral in 30 patients and bilateral in 16 patients, and thus, 62 hips were operated: 34 hips on the right side and 28 hips on the left side.

The mean Harris Hip Score before the operation was 59.8 which has reached 89.9 after a mean of 9.3 years of follow-up postoperatively in operated hips ($P < 0.001$ based on paired t-test). Patients' satisfaction of the dysplastic hips was significantly better postoperatively compared to the same preoperative dysplastic hips based on Wilcoxon Signed Ranks Test ($P = 0.001$). The mean CE Angle has increased from 11.8 preoperatively to 41.9 postoperatively, and the difference based on paired t-test was significant ($P < 0.001$). In the next step, CE Angle was categorized into abnormal (20 degrees or less), moderate (between 21 and 25 degrees), and normal (above 25 degrees). All of the operated hips had abnormal CE Angle before the operation and normal CE

Angle after the operation. The coefficients of linear regression of preoperative and postoperative severity of osteoarthritis, and preoperative and postoperative Harris Hip Score on age were 0.047, 0.042, -0.317, and -0.632 respectively, while P -values were < 0.001 , < 0.001 , 0.034, and < 0.001 respectively. The coefficients of linear regression of preoperative and postoperative CE Angle on age were not significant.

The mean change of Harris Hip Score pre- to post-operatively was 31.6 among patients who had sclerosis of the acetabular roof before the operation, 27.7 among patients with less than 50% narrowing of the joint space before the operation, and zero among patients with more than 50% narrowing of the joint space before the operation. The mean change of Harris Hip Score based on ANOVA was significantly better in patients who had less severe osteoarthritis preoperatively ($P < 0.001$) (Table 1). The mean change of Harris Hip Score pre- to post-operatively was significantly higher in the group who were followed for less than 14 year after the operation (31.3) than the group who were followed for 14 years or more after the operation (25.9) and the P -value based on t-test was 0.041. The severity of the post-operative osteoarthritis had the same pattern: the severity of post-operative osteoarthritis was significantly less in patients who had been followed for less than 14 years after the operation than those patients who were followed for 14 or more years after the operation ($P = 0.023$ based on Mann-Whitney U test). Patients' satisfaction was significantly higher among patients who were followed for less than 6 years after the operation than those patients who were followed for 6 years or more post-operatively ($P = 0.018$ based on Mann-Whitney U test).

The non-operated hips were either diagnosed to be dysplastic or normal based on their CE Angle in radiography; thus, hips that had abnormal or moderate CE Angle were diagnosed to be dysplastic. Based on this categorization, 8 hips were abnormal, 18 hips were moderate and 4 hips were diagnosed to be normal. Excluding the 4 normal hips from the study the rest (26 hips) were compared to the operated hips as the control groups.

Table 1. The mean change of Harris Hip Score and its relation to preoperative osteoarthritis

Change in Harris Hip Score	N	Mean change of Harris Hip Score	Standard Deviation	95% Confidence Interval		P-value
				Lower limit	Upper Limit	
Osteoarthritis						
Sclerosis	45	31.6	7.7	29.3	33.9	
Joint narrowing < 50%	16	27.7	7.7	23.6	31.8	<0.001
Joint narrowing >50%	1	Zero	-	-	-	
Total	62	30.1	8.7	27.9	32.3	

* P -value is calculated based on ANOVA

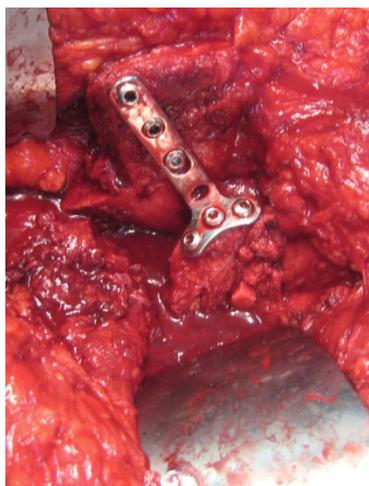


Figure 1. The actual picture of one of shelf acetabuloplasty procedures in which T plate is being installed.

The difference of preoperative osteoarthritis between operated and control dysplastic hips was significant: control hips had significantly less severe preoperative osteoarthritis than operated hips based on Mann-Whitney U test ($P < 0.001$). But the same comparison for post-operative osteoarthritis was not significant ($P = 0.432$).

Patients' satisfaction preoperatively was significantly better in control dysplastic hips than operated hips ($P < 0.001$), but the same comparison was reverse for patients' satisfaction post-operatively: patients were more satisfied with their operated hip than their control dysplastic hip ($P < 0.001$ based on Mann-Whitney U test) (Figure 2).

Harris Hip Score preoperatively was significantly higher in control dysplastic hips than operated hips ($P < 0.001$) (Table 2), but the same comparison was reverse for Harris Hip Score post-operatively as well: operated hips had higher Harris Hip Score than their control dysplastic hips ($P < 0.001$ based on t-test) (Table 3).

And finally, the mean change in Harris Hip Score pre- to postoperatively was positive in operated hips (30.1) but negative in control dysplastic hips (-6.5), and obviously the difference based on t-test was significant ($P < 0.001$) (Table 4).

Table 2. The difference in mean pre-operative Harris Hip Score between operated and control dysplastic hips.

	N	Mean	Standard Deviation	P-value*
Operated hips	62	59.8	7.8	<0.001
Control Dysplastic Hips	26	89.6	8.2	

*P-value was calculated based on t-test.

Table 3. The difference in mean post-operative Harris Hip Score between operated and control dysplastic hips.

	N	Mean	Standard Deviation	P-value*
Operated hips	62	89.9	7.3	0.005
Control Dysplastic Hips	26	83.8	10.7	

*P-value was calculated based on t-test.

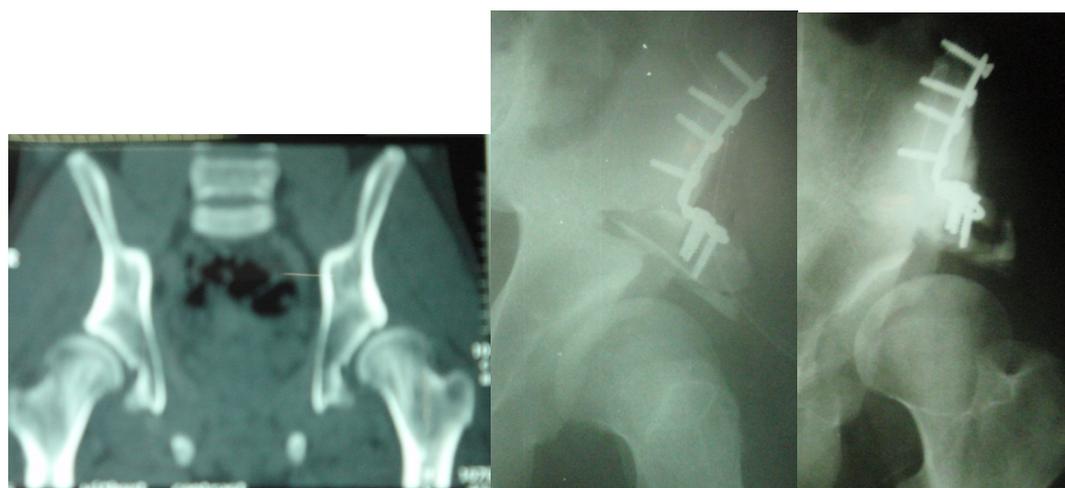


Figure 2. 18 year-old man before, exactly after, and 5 years after operation. At the last follow up, the operated hip is symptom-free and the nonoperated hip is symptomatic.

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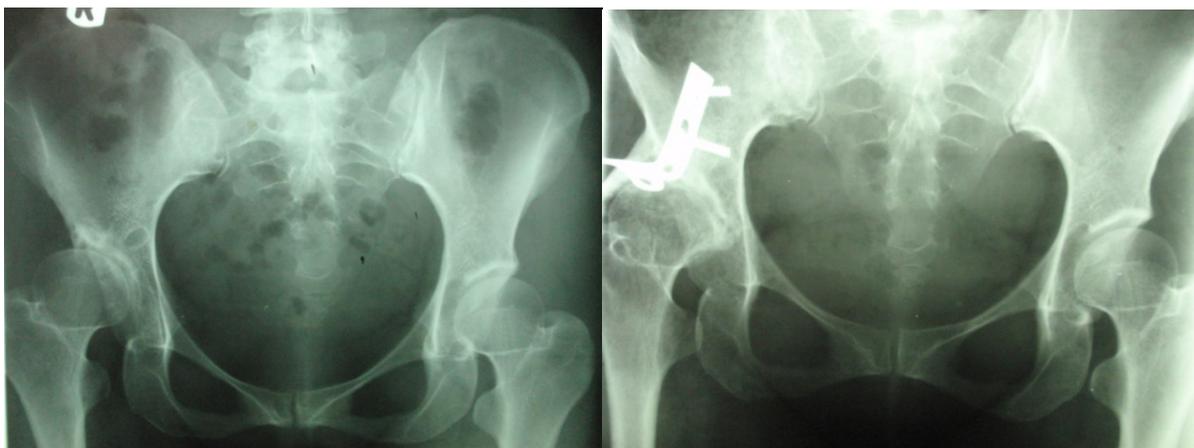


Figure 3. A 26 year-old woman with more than 50% of joint narrowing on the right hip. After 14 years of follow up, the patient is disabled on the operated hip with advanced osteoarthritis.

Table 4. The difference in mean change of Harris Hip Score pre- to post-operatively between operated and control dysplastic hips.

	N	Mean change	Standard Deviation	P-value*
Operated hips	62	30.1	8.7	<0.001
Control Dysplastic Hips	26	-6.5	7.0	

*P-value was calculated based on t-test.

The complications associated with the procedure in our hand were 8 cases of meralgia paraesthesia and one case of pulmonary embolism following DVT which was treated effectively. Two patients had wound infection which was treated by I.V antibiotic followed by oral antibiotic. Surprisingly, there was no complication related to the internal plate.

Discussion

Our results in the current study state that patients' subjective satisfaction with the dysplastic hip and the Harris Hip Score increases in the hip after the operation, which is congruent with results that Love *et al.*, and Bickel *et al.*, have reported (17, 20). Although White *et al.*, have followed their patients for the mean of 10 years, which is similar to our follow-up, they have not recommended shelf acetabuloplasty for dysplastic hips, perhaps because their interpretation of pain and limping has not been adequately quantified as it happens when we calculate the Harris Hip Score.

We have also found that pre- and post-operative osteoarthritis gets worse with increasing age and Harris Hip Score gets less with increasing age, while pre-

post-operative CE Angle is not related to age, which is congruent with results that Fawzy *et al.*, have published (21).

Based on our results, as the preoperative osteoarthritis gets worse, the mean change of Harris Hip Score gets less. Also the mean change of Harris Hip Score is higher among patients who are more satisfied with their dysplastic hips. This finding shows that the results of the shelf osteotomy is better in patients who have less severe osteoarthritis and more satisfaction with their hips, which is congruent with results that Rosset *et al.*, and Migaud *et al.*, have reported (18, 22) (Figure 3). The cutoff of 14 years of follow-up was found to be significant for mean change of Harris Hip Score and post-operative osteoarthritis, while the cutoff for patient subjective satisfaction was 6 years of follow-up.

The next results concern the comparison of operated hips with their control dysplastic hips. Before the operation, osteoarthritis is significantly more severe in to-be-operated hips than the control hips, but the difference is not significant after the operation, which demonstrated that shelf acetabuloplasty is successful in preventing osteoarthritis of the hip. Similar results show that patients' satisfaction and Harris Hip Score are both lower in to-be-operated hips than their controls, but the results are reverse after the operation, which again demonstrates the effectiveness of the shelf procedure. These results are all in line with studies that Girard, and Pompe have carried out (23, 24). Finally, our results show that the mean Harris Hip Score decreases in control dysplastic hips, while it increases in operated hips (Figure 2).

It is possible that the tearing of the labrum may unfavorably affect the result of the shelf operation (25,

26); however, more recent results by Girard *et al.*, have demonstrated that the tearing of labrum has no negative effect on the result of the operation (23). In either case, it is the main limitation of our study as we had no access to arthrography or MRI of operated or control hips of the patients which might have had influenced the result of shelf acetabuloplasty negatively. The average central edge angle was assessed to be 42 post operatively in our study, while most authors consider 41 degrees excessive coverage. However, we had no significant limitation due to this degree of coverage.

In short, according to this study although the shelf acetabuloplasty is a salvage procedure and cannot cover the femoral head concentrically like the modern redirection osteotomies, but it is an effective procedure for a young patient in postponing the progression of the hip osteoarthritis once the arthritis starts in order to perform reconstructive surgeries later when justified. However, respecting the three-dimensional nature of acetabular deficiency and all efforts must be done to correct the deformity as concentric as possible to expect a reasonable result from Shelf acetabuloplasty in a non-concentric arthritic hip dysplasia.

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