J Turgut Ozal Med Cent
ISSN 1300-1744 2017;(24:2):173-7
Submit a Manuscript: http://my.ejmanager.com/totm/ DOI: 10.5455/jtomc.2017.02.21

ORIGINAL ARTICLE

Assessment of hip development in the early period in patients who underwent dega osteotomy due to developmental dysplasia of the hip

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Abstract
Objective: To examine hip development in a patient who underwent Dega osteotomy due to developmental dysplasia of the hip (DDH) by means of radiography.
Materials and Methods: Dega osteotomy was performed on 43 hips (7 were bilateral) of 36 patients with DDH. In preoperative and final follow-up; the acetabular index (AI), acetabular depth ratio (ADR) and Wiberg's center-edge angle (CEA) were measured in anteroposterior pelvic radiographs. Hips were classified in accordance with Tönnis classification system. Radiological findings were evaluated in accordance with Severin classification system. Avascular necrosis (AVN) of the hips were evaluated according to Kalamchi-MacEwen classification system.
Results: The mean age was 87 months (48-130 months), mean follow-up period was 30.5 months (15-62 months). The mean preoperative and final follow-up values of AI were 43° (28°to 60°) and 19° (6° to 34°), respectively. The mean preoperative and final follow-up values of ADR were detected as 14 (8 to 24) and 26 (18 to 42), respectively.The mean CEA was found as 38° (18° to 61°) at the final follow-up. Of the hips, 37 were Tönnis type 4 and 6 were Type 3. Totally 10 hips had AVN; of those, 6 were Type 1, 2 were Type 2 and 2 were Type 3 hips. According to Severin classification, 11 hips were Type 1a, 3 were Type 1b, 22 were Type 2a, 5 were Type 2b and 2 were Type 3.
Conclusion: In patients who underwent Dega osteotomy, hip development can be detected radiographically with satisfactory levels.

Keywords:.Hip; Dysplasia; Osteotomy.

INTRODUCTION

The aim in the treatment of developmental dysplasia of the hip (DDH) is to obtain a healthy hip joint development by maintaining a concentric reduction of the femoral head into the acetabulum (1). The consistency between femoral head and acetabulum and the continuity of it are required for development of hip joint. Hip dysplasia is generally treated with closed reduction procedure in children under the age of walking. At walking and later ages, pelvic osteotomy might be required together with open reduction procedure for reshaping or redirecting the dysplastic acetabulum to maintain a concentric hip reduction (2-4).

Dega technique was defined as a periacetabular transiliac osteotomy in DDH to perform especially on children at walking and later ages (5).

Received: 01.02.2017
Accepted: 13.02.2017

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In the original Dega technique, incomplete osteotomy was done to the lateral aspect of ilium and osteotomy was completed by leaving an intact hinge posteriorly (intact posteromedial iliac cortex and sciatica notch). On the other hand, there are modifications involving anterior and posterior bicortical osteotomy and lateral middle part incomplete osteotomy (6).

Dega osteotomy can be performed when triradiate cartilage is opened or closed; however, there were studies asserting that osteotomy must be performed before the closure of triradiate cartilage to enable hinge-like function of the triradiate cartilage (7). In the present study, we aimed to investigate the radiographic results of hip development in patients who underwent Dega osteotomy.

MATERIALS and METHODS

In our study, 43 hips of 36 patients who were admitted to Harran University, Medical Faculty Hospital between the years of 2010 and 2016 and underwent Dega osteotomy due to DDH were retrospectively evaluated. Prior to the surgery, detailed information was given to the patients' relatives regarding the surgical procedure and its possible outcomes and their consents were taken. The study was conducted in the direction of

Helsinki principles. Anteroposterior and frog-leg radiographs were evaluated in the preoperative and at the final follow-ups of the patients (figure 1). Acetabular index (AI), acetabular depth ratio (ADR) (8) and Wiberg's center-edge angle (CEA) (9) were assessed by means of radiographic approach. ADR was calculated by acetabular depth/acetabular width x 100. Acetabular width is measured as the distance between the lateral margin of the sourcil and the most inferior aspect of the acetabular teardrop and acetabular depth is defined as the perpendicular distance between the halfway point of the acetabular width and the roof of the acetabulum (10) (Figure 2).

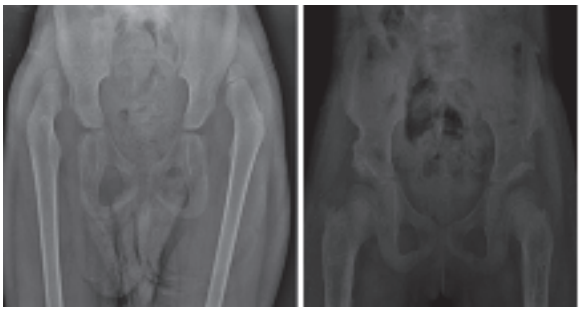

Figure 1 a-b. Development of hip joint, prior to Dega osteotomy and at the final follow-up, in 63 month-old female patient (a- preoperative image b- 24-month follow-up roentgenography)

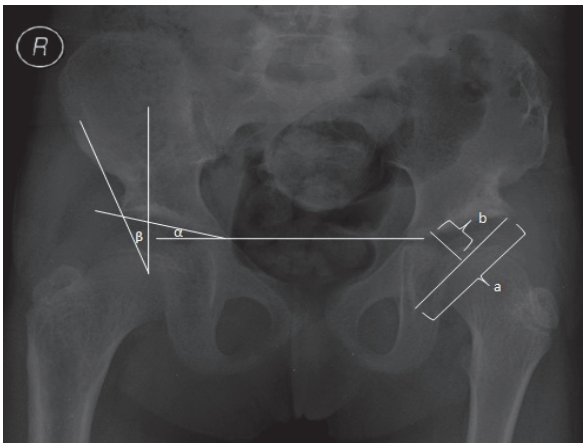

Figure 2. Radiological measurements in a patient with bilateral Dega osteotomy. (α: Acetabular index angle, **β:** Center-edge angle, acetabular depth ratio: b/a x100)

Dysplastic hips were graded according to the Tönnis Classification System (11). Avascular necrosis (AVN) was evaluated according to Kalamchi-MacEwen Classification System (12). According to these findings, Grade 1; variations in the center of femoral ossification (no or Grade-I osteonecrosis), Grade 2; lateral physeal injury, Grade 3; central physeal injury, Grade 4; total injury in femoral physis. Radiographic findings of the operated hips were classified according to Severin Classification System (13,14). According to Severin Classification, hips in Group 1 and Group 2 were evaluated as satisfactory and hips in Group 3 and Group 4 were evaluated as unsatisfactory (table 1).

Table 1. Severin Classification

Group	Radiography	Age	CEA
1. Normal			
1a		6-13	>19°
		≥ 14	>25°
1b		6-13	15°-19°
		≥ 14	20°-25°
2. Proximal femur, mild-medium deformation of acetabulum			
2a		6-13	>19°
		≥ 14	>25°
2b		6-13	15°-19°
		≥ 14	20°-25°
3 Dysplasia without subluxation, Shenton's line is intact			
		6-13	<15°
		≥14	<20°
4 Subluxation, Shenton's line is broken			
4a			≥0°
4b			<0°
5 Femoral head and false acetabulum form a joint			
6 Redislocation			

(CEA: Center-edge angle)

Surgical Technique

In all patients, adductor tenotomy was initially performed on dysplastic side. Tenotomy to iliopsoas and open reduction was done to all hips. Ilioinguinal (bikini) incision was performed for pelvic osteotomy. Dega osteotomy was performed by incomplete semicircular transiliac osteotomy, starting from just above the anterior inferior iliac spine and 1 cm superior to the acetabulum rim towards the sciatic notch in the posterior (6). Subtrochanteric femoral shortening and derotation was done through a separate lateral incision. The amount of shortening was determined preoperatively by measuring the distance from the inferior margin of the femoral head and the floor of the acetabulum.

Following the maintenance of derotation after femoral shortening, dynamic compression plate was used for femur detection. We applied a resected femoral segment for the pelvic osteotomy line as a graft. Pelvipedal plaster was applied for postoperative 6 weeks in all patients. And then, patients were closely followed-up during orthosis-therapy (Figure 3).

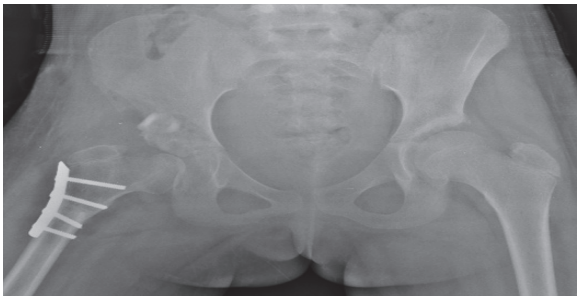

Figure 3. The view of the osteotomy line and autogen graft in a patient with Dega osteotomy. Early postoperative radiography

Statistical Analysis

The statistical relationship between preoperative and final follow-up radiographic findings of the patients was evaluated. According to this evaluation, data distribution was determined by Kolmogorov-Smirnov test. The data with normal distribution was evaluated by paired t-test. The data that were not normally distributed were evaluated by using Wilcoxon test. Pearson correlation test was performed for correlation analysis. Statistical tests were done by using IBM SPSS 22.0 version (IBM Corporation, Armonk, NY, USA) and $p< 0.05$ was accepted as statistically significant.

RESULTS

Dega osteotomy was performed on 43 hips (7 were bilateral) of 36 patients in total. Of the patients, 6 were male and 30 were female. The mean age was 87 months (range, 48-130 months), the mean follow-up period was 30.5 months (range, 15-62 months). While the mean preoperative AI angle was 43° (range, 28 °to 60°), it was 19° (range, 6° to 34°) at the final follow-up. The mean variation was 23° (range, 9° to 36°) in AI. While the mean preoperative ADR value was 14 (range, 8 to 24), it was 26 (range, 18 to 42) at the final follow-up.When preoperative and final follow-up AI and ADR parameters were compared to each other, a statistically significant difference was detected in both parameters ($p < 0.001$). The mean CEA was detected as 38° (range, 18° to 61°). When the correlation between radiographic parameters were investigated, a correlation was detected between the decreased AI values and increased CE angles ($p = 0.002$). There was a correlation between age and CE angle ($p = 0.036$) (table 2).

Table 2. Radiographic assessment of hips in patients who underwent Dega osteotomy

AI		ADI		CEA	Kalamchi-MacEwen Classification			Tönnis Classification		Severin Classification				
Preoperative	Final follow-up	Preoperative	Final follow-up	Final follow-up	Type 1	Type 2	Type 3	Type 3	Type 4	Type 1a	Type 1b	Type 2a	Type 2b	Type 3
43°(28°-60°)	19°(6°-34°)	14 (8-24)	26 (18-42)	38°(18°-61°)	6 hips	2 hips	2 hips	6 hips	37 hips	11	3	22	5	2

(AI: Acetabular index, ADR: Acetabular depth ratio, CEA: Center-edge angle)

Of the hips, 37 were Tönnis Type 4 and 6 were Type 3. According to Kalamchi-MacEwen classification, totally 10 hips had AVN; of those, 6 were Type 1, 2 were Type 2 and 2 were Type 3 hips. All hips with AVN were Tönnis Type 4.

According to Severin Classification, 11 hips were Type 1a, 3 were Type 1b, 22 were Type 2a, 5 were Type 2b and 2 were Type 3. Therefore, only the radiographic outcomes of 2 hips were unsatisfactory in terms of dysplasia. These 2 hips were Type 3 according to Kalamchi-MacEwen Classification. The mean follow-up period was 30.5 months and neither subluxation nor redislocation was detected in the hips.

DISCUSSION

Whatever the age group is, the aim of DDH is to obtain a healthy hip joint development by enabling a consistency between femoral head and acetabulum (15). Thus, Dega osteotomy has been defined for this purpose and it is one of the pelvic osteotomies that can be applied on DDH patients at the age of walking (2,16). Pelvic osteotomy, femoral shortening and open reduction are basic approaches that are applied to children at the age of walking for DDH treatment. Wenger recommended primary femoral shortening, anterior open reduction and capsulography (with or without pelvic osteotomy) in children older than 3 years (17). Dislocated hips with DDH must be reduced as early as possible. The anatomical structure, such as iliopsoas, adductor muscles, lateral capsule and the reflected head of rectus femoris, might cause deformations in femoral head and acetabulum. Muscle tension might result in deformities including coxa valga and antetorta in dislocated proximal femur (18).

In the original technique of Dega osteotomy, osteotomy was not performed on the posterior sciatic notch (5). However, the anterior and posterior parts of the iliac bone were osteotomized bicortically by means of the modified techniques in the later years (6,19). Thus, acetabulum was more covered to femoral head. We prefered modified Dega osteotomy in our cases as well. In our study, the mean final follow-up angle of AI was 19° and it was decreased by 23° in average in comparison to preoperative period. According to the relevant studies in the literature, Ming-Hua et al. and Kim et al. found a regression in AI angles from 38° to 20.8° and from 39° to 15°, respectively (20). When we compared to other certain studies, we detected similar and satisfactory outcomes in between AI angles (7,21).

Just as in Pemberton osteotomy, Dega osteotomy is an acetabular reconstruction procedure reshaping the acetabulum (5,22). Morphological variations might be seen in the acetabulum after both procedures. Thus, they might result in alterations in the acetabular volume. The effects of Dega and Pemberton osteotomies on the acetabular volume are contradictive (23), and it has been reported in MR and CT studies that Dega osteotomy cause an increase in acetabular volume (24,25). The radiographic alterations in ADR might give us an idea regarding the acetabular volume. In our study, the final follow-up radiographic outcomes of ADR were increased in comparison to preoperative period. This variation in ADR is also the indicator of increased level of coverage between acetabulum and femoral head.

We are using femoral graft in iliac osteotomy in all patients who underwent femoral shortening. Therefore, we do not result in an additional morbidity by obtaining iliac graft. In another case series, we compared iliac crest

graft morbidity with femoral graft morbidity in patients that we performed Pemberton osteotomy. We detected lower morbidity in patients in whom we performed femoral grafting (26).

Wiberg's CEA is a radiographic parameter that further comes to the forefront, especially for the presentation of relationship between acetabulum and femoral head.In our study, an increase in CEA was detected that was correlated with the decrease in AI. An increase was also detected in CEA by means of reduced acetabular dysplasia and normal development of well-covered femoral head. Ming-Hua et al. found CEA as 29° after the high osteotomy cut Dega procedure (20). In another study, it was detected as 31° in average (27). In the present study, the mean CEA was 38°. We might conclude that we obtained a satisfactory femoral head coverage between femoral head and acetabulum.

The remodalization capacity of acetabulum depends on the age. In the literature, there is not a particular consensus on the age limit. However, the remodalization capacity was stated to be decreased towards the age of 6 (20, 28). Ponseti revealed that the acetabulum has been developed and acetabular depth has been increased by means of interstitial growth in the acetabular cartilage, the appositional growth at the periphery of this cartilage and periosteal new-bone formation at the acetabular margin (29). Owning to this growth capacity, patient should be followed-up until the maturation of skeletal system. When the patients with unilateral dysplasia were followed-up closely, the possibility of contralateral dysplasia formation has been shown in these patients (30). The development of AI value was shown to be gradually decreased in a hip with reduction and without subluxation in contrast to the discontinuation of AI development within 2 to 3 years in a hip without reduction (31). Assessment of the acetabular development, AI is not adequate by itself. The CEA, especially as child grow older (after 5 years of age), is a radiographic criteria that has to be evaluated together with AI. According to Severin Classification, it has been shown that acetabular development will be stopped after 4 to 5 years in the presence of grade 3 and grade 4 hips; however, it might take several years in the presence of grade 1 and grade 2 hips (32). In our study, we detected type 3 hip only in 2 hips according to Severin Classification. Despite of satisfactory outcomes regarding the AI values in these hips with follow-up periods of 19 and 26 months, respectively, net data will be obtained by longer follow-up periods about hip development. In the remaining 43 hips that underwent Dega osteotomy, we acquired satisfactory outcomes according to the Severe Classification. In a similar study including 43 hips that underwent Dega osteotomy and followed-up for 2 years in average, unsatisfactory results were obtained in the radiographic parameters of only 5 patients (33). In another study consisting of 58 hips, the outcomes were not satisfactory in accordance with the Severin Classification in 16 hips (34). Therefore, when we examined the similar studies in the literature and considered that the outcomes were unsatisfactory only in 2 hips, it might be concluded that we obtained satisfactory results according to Severin Classification indicating the final radiographic condition of the treated hips.

AVN is one of the complications in the DDH treatment. Kalamchi-MacEwen is frequently used in the classification of AVN. The symptoms of AVN might arise even months or years after the treatment. The involvement of lateral growth plate of femoral head, especially in type 2 AVN, emerges at the age of 10 years in average (35). In a study performed by Kim et al., AVN was detected only in 2 hips and it was detected in 6 patients in another study (17,36). In our study, the symptoms of AVN were confirmed totally in 10 hips; however, of those, 6 were type 1. There are opinions indicating that type 1 AVN is not an AVN entirely and it is the indicator of developmental remodelization in treated hip (12). In this context, we might remark that the ratio of AVN in our patient group shows similarity to those in the literature.

In conclusion, we obtained satisfactory radiographic outcomes at hip joint following Dega osteotomy. As we revealed in our study, there was a dramatic and radiographic developmental process in the hip joint at the early period following a regular surgical treatment that was performed considerately to the soft tissue and enabled a consistency between femoral head and acetabular. In order to make a healthier assessment, long-term outcomes should also be addressed.

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