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Assessment of the endoprosthesis offset in a dysplastic coxarthrosis

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Incorrectly developed acetabulum and subluxated hip joint may cause many problems for proper implantation of endoprosthesis. The aim of this work is to assess the radiological results of offset restoration and selection of endoprosthesis implant in a dysplastic hip joint. The study group consisted of patients who had a surgery in the period between 2016 and 2018. All of them had a cementless total hip endoprosthesis. The group consisted of 91 patients (96 hip joints), with an average age of 42 years (31-47 years). 55 left and 41 right hip joints. 70 females and 21 males. The control group consisted of patients who were not diagnosed with hip joint dysplasia. The control group consisted of 70 patients (70 hip joints), with an average age of 35 years (19-55 years). 53 females and 17 males. The radiographic assessment included the measuring of medialization and distalization which describe the offset of hip joint. The joint decentration was classified according to Crowe. Based on radiographic measurements we have achieved statistically significant ($p<0.05$) changes in medialization and distalization parameters. We have not noticed a statistically significant difference for medialization parameter ($p=0.8259$) after a surgery when compared to the control group. For all patients we have achieved a restoration of correct offset in the horizontal plane. The main idea behind endoprosthesis in a dysplastic coxarthosis is the implantation of endoprosthesis cup in an anatomically correct location. Small screw-in cup and conical stem offer great possibility of restoring correct offset of a dysplastic hip joint.

Keywords : hip dysplasia; hip offset; hip endoprosthesis.

INTRODUCTION

Joint degenerative disease is one of civilisation diseases. It causes pain and early exclusion of those affected from the labour market. Hip joint is especially prone to degenerative changes to its unique function. Among the surgical treatment methods of advanced degenerative and deformative changes of hip joint, endoprosthesis is an efficient and common treatment method *(1-4)*. Residual hip joint dysplasia is one of the main causes of early developing hip joint degenerative diseases *(5-15)*. Among young patients (up to 40 years of age) in 80-90% of cases the hip joint degenerative disease develops as a result of residual hip joint dysplasia. A defect, which has not been diagnosed or fully treated during early childhood, causes difficulties in

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everyday life and negatively impact the quality of life. The main symptoms are pain, reduced mobility, and limping. Subluxation of hip joint causes failure of hip abductor muscles *(13,16,17)*.

Medialization and distalization of dysplastic hip joint are important parameters due to the reposition of hip joint's centre of rotation into the anatomical location. This position provides proper conditions for improving the joint's dynamic stabilization and lengthens the arm of gluteal muscles. This increases the moment of force stabilizing the hip joint and reduces the arm of person's own force acting on the joint *(10,13,18-21)*. It seems necessary to consider the extending the term "acetabular offset" to "medialization of acetabular offset" and "distalization of acetabular offset". Medialization is the movement of the acetabular component, and consequently the entire joint, towards the median line of the body in the horizontal plane. Distalization is a parameter describing the correction of a subluxated hip joint in the vertical plane towards the lower extremities.

In everyday practice there are numerous technical solutions brought by the constant development of hip joint endoprosthesis implants. On the pre-operation endoprosthesis planning stage in a dysplastic hip joint we should pay special attention on certain important aspects. Patient's young age might require a revision in the future. Dysplastic hip joint is characterized by developmental anomalies of the acetabulum (shallow, steep acetabulum with underdeveloped anterior wall) and anomalies at the proximal end of the femur (torsional abnormalities and valgus position of the femoral neck, narrow femoral canal) *(22,23)*. In addition, Mahieu presents a study based on a 3D reconstruction of the femoral head-acetabular relationship, which concludes that femoral head abnormalities increase significantly with decreasing acetabular bone coverage, decreasing hip offset, increasing anteversion, valgus and flattening of the femur head, is most pronounced at the peripheral part of the head, in specific the femoral head-neck region *(24)*.

When treating patients with dysplastic coxarthrosis, usually we use conical stem and small-sized endoprosthesis cup (Fig. 1).

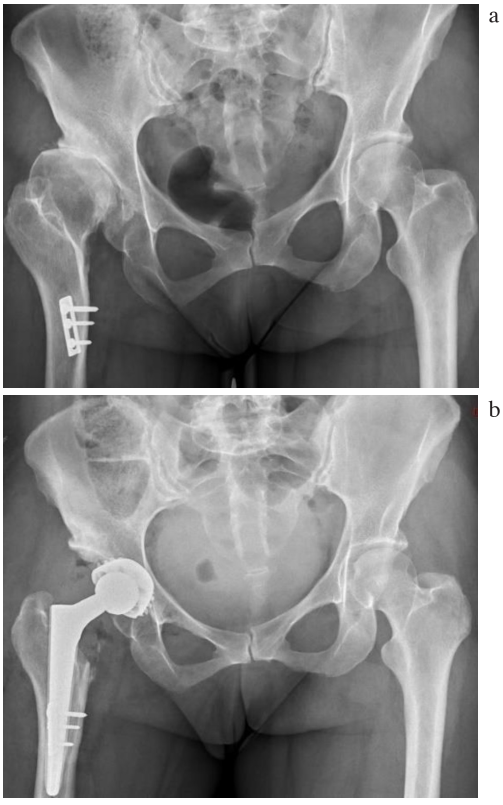

Fig. 1. — Radiological result of surgical treatment: a) dysplastic coxarthrosis of the right hip joint, Crowe type 3; b) total cementless endoprosthesis of the right hip joint: conical Wagner cone, screw-in cup 42mm, ceramic head 28mm.

The aim of this paper is the assessment of radiographic values of endoprosthesis offset in a dysplastic hip joint in comparison to a healthy hip joint. An additional aim of this paper was an attempt to assess the selection of a hip joint endoprosthesis implant in a dysplastic hip joint affected by a degenerative disease.

PATIENTS AND METHODS

The retrospective study group consisted of 91 patients with 96 hip joints treated with complete cementless hip endoprosthesis in the years 2016-2018, who fulfilled the criteria of inclusion and exclusion from the study.

Inclusion criteria:

– coxarthrosis resulting from hip joint dysplasia.

Exclusion criteria:

– idiopathic and post-traumatic coxarthrosis.

Average age was 42 years (31-47). There were 55 left and 41 right hip joints treated. Sex distribution in the study group: 70 females and 21 males. Average observation period: 25 months (12-36 months). The retrospective study control group consisted of people who were not diagnosed with degenerative disease and residual hip joint dysplasia, treated or other conditions in our hospital. 70 patients (70 hip joints) have been qualified for the control group. With an average age of 35 years (19-55). The group consisted of 53 females and 17 males.

We have performed retrospective assessment of anterior-posterior (A-P) projection on digital x-ray photos of patients with coxarthrosis resulting from residual hip joint dysplasia, who were surgically treated with complete hip joint endoprosthesis, as well as A-P digital x-ray photos of patients without diagnosed degenerative hip joint disease,

a
b

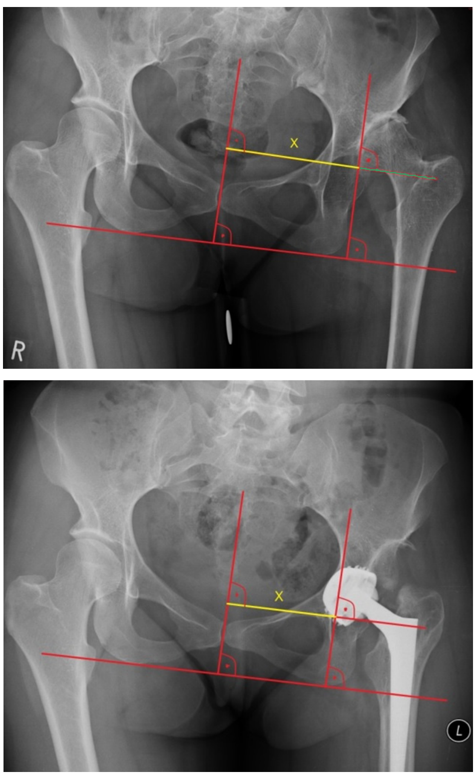

Fig. 2. — Measurement of medialisation of dysplastic coxarthrosis (x) - (segment connecting the median line of the body and them most medial edge of the femoral head/ endoprosthesis head); a) dysplastic coxarthrosis of the left hip joint; b) total cementless endoprosthesis of the left hip joint.

a
b

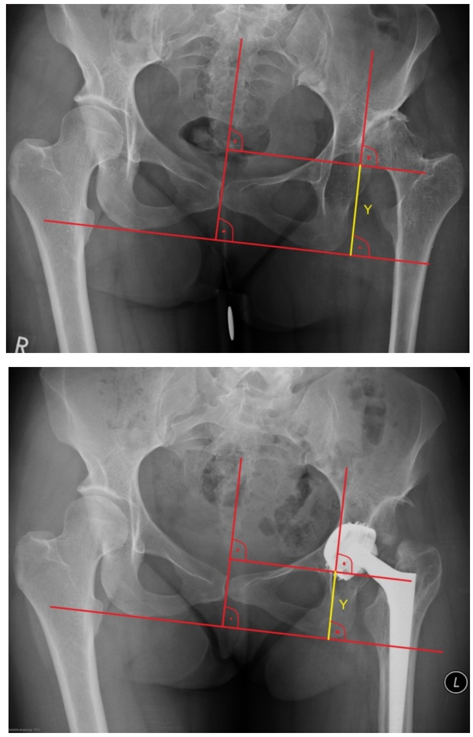

Fig. 3. — Measurement of distalization of dysplastic coxarthrosis (y) - (segment connecting the baseline connecting the tuber ischii and the lowest edge of the femoral head/ endoprosthesis head); a) dysplastic coxarthrosis of the left hip joint; b) total cementless endoprosthesis of the left hip joint.

who constituted the control group. The difference length of lower limb was also measured clinically.

The radiographical assessment included the following parameters: medialization, measured as the distance between the median line of the body and the most medial edge of the femoral head/ endoprosthesis head (Fig. 2), and distalization, measured as the distance between the base line connecting the sciatic tubers and the lowest edge of the femoral head/ endoprosthesis head (Fig. 3). By using straight perpendicular lines, we can indirectly determine the change of acetabular offset of the dysplastic hip joint in vertical and horizontal plane. Measurements were made by one surgeon researcher. For assessing the degree of hip joint dysplasia, we have used Crowe classification *(25)*.

Based on the Shapiro-Wilk tests we have not achieved a normal distribution for all variables, therefore we have used Wilcoxon signed-rank test.

Software: Stata 11.0. Measurements accuracy: angles 0.5°, distance 0.5 mm (all measurements were done in CareStream Solution software). Significance level $p<0.05$.

RESULTS

The mean follow-up was 30 months (25-46). According to the Crowe classification we have obtained the following results: type 1 – 27 hips (28%); type 2 – 26 hips (26%); type 3 – 23 hips (24%); type 4 – 20 hips (20%). Before the surgical treatment, we observed a shortening of the limb with dysplastic coxarthrosis mean of 25 milimeters (20-30).

For all parameters we have achieved statistically significant ($p<0.05$) difference in measurements of dysplastic coxarthrosis before and after the surgical procedure of total endoprosthesis (Table I). We have achieved a correction of subluxated hip joint in the horizontal plane by 18.63 mm and in vertical plane by 18.88 mm.

For all parameters we have achieved a statistically significant ($p<0.05$) difference of measurements of dysplastic coxarthrosis before the operation when compared to the control group (Table II).

We also found no statistically significant ($p = 0.8259$) difference in the medialization parameter after hip dysplastic surgery compared to the control group. This proves that the cup of the prosthesis was properly medialized and placed in the anatomical site. We also observed a statistically significant ($p <0.0001$) difference in the distalization parameter after hip dysplastic treatment compared to the

Table I. — Measurement results (mm) of medialization and distalization of the dysplastic coxarthrosis pre- and post- operation hip joint endoprosthesis

	Preoperation	Postoperation	Difference	p-value
Medialization	97.96	76.06	18.63	<0.00001
Distalization	76.06	57.18	18.88	<0.00001

Table II. – Measurement results (mm) of medialization and distalization preoperation dysplastic coxarthrosis vs. control group.

	Preoperation	Control	Difference	p-value
Medialization	97.96	79.63	18.06	<0.00001
Distalization	76.06	45.14	30.92	<0.00001

Table III. – Measurement results (mm.) of medialization and distalization postoperation hip joint endprosthesis surgery vs. control group

	Postoperation	Control	Difference	p-value
Medialization	76.06	79.63	-0.57	0.8259
Distalization	57.18	45.14	12.04	<0.00001

Table IV. – Measurement results (mm.) of medialization and distalization postoperation hip joint endoprosthesis surgery vs. opposite hip joint

	Postoperation	Opposite	Difference	p-value
Medialization	76.06	80.81	-1.75	0.4647
Distalization	57.18	52.91	4.27	>0.0552

Fig. 4. — Box-plot of medialization measurement results: before endoprosthesis surgery (med0), after endoprosthesis surgery (med1) and control group (med.).

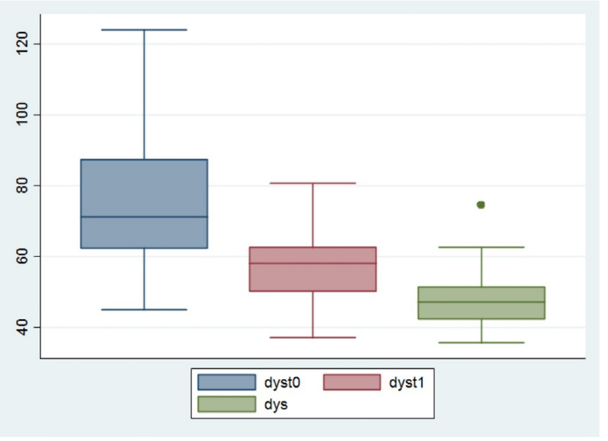

Fig. 5. — Box-plot of distalization measurement results: before endoprosthesis surgery (dyst0), after endoprosthesis surgery (dyst1) and control group (dys).

control group. We believe that this relationship was achieved due to the small size (28 mm) of the prosthesis head (Table III).

The measurement results of medialization and distalization before and after surgery, as well as in the control group, are presented in the below box-plot tables (Fig. 4 and Fig. 5).

We have also compared the hip joint endo-prosthesis offset with the opposite healthy hip joint. We have observed a lack of statistically significant difference in medialization ($p=0.4647$) and distalization ($p>0.055$) measurements of a healthy and surgically treated hip joint. This is a proof that we have achieved a correct offset of hip joint for surgically treated patients suffering from one-sided dysplastic coxarthrosis (Table IV). Clinically, after surgery, we observed a lower limb length alignment.

DISCUSSION

Precise restoration of hip joint biomechanics is one of the main goals of surgical treatment of a dysplastic hip joint suffering from a degenerative disease *(1,26)*. Authors of various publications suggest that restoring the correct offset of a hip joint has tremendous effect on the endoprosthesis longevity *(2,3,4,27)* and proper functioning of gluteal muscles *(28-30)*. Pre-operation planning and selection of a proper endoprosthesis is key for a successful surgery. Czwojdziński et al. and Sionek et al. report, that using conical stem in treating dysplstic coxarthrosis offer better possibility of correcting the torsion disorders of the proximal end of femur and reduces the risk of periprosthetic fracture *(31,32)*. Desteli et al. reported to a significantly higher rate of complications in the case of arthroplasty in severe cases of Crove III or IV hip dysplasia, and propose a simultaneous shortening of the subtrochanteric osteotomy of the femur *(26)*.

Sheerlink et al. define the acetabular offset as the shortest distance between the acetabular centre rotation (ACR) and the line perpendicular to the line drawn through the most medial part of the Kohler's teardrop *(33)*. Reducing the acetabular offset through excessive medialization of the acetabular component might result in limping and instability of the hip joint endoprosthesis. Increasing the acetabular offset can result in overloading the endoprosthesis insert *(34)*. Moving the hip's centre of rotation (COR) proximally or distally will mostly influence the length of the leg and tension of hip abductors. When the hip centre of rotation is moved proximally, the leg becomes shorter and the gluteal muscles lose their tension. And when the distalization is too great, the forces exerted on the endoprosthesis insert are increased *(35)*. Delp and Malloney described the influence of medialization and distalization of the centre of hip joint on the strength of hip abductor muscles *(36)*. The authors present a significant influence of lowering the centre of hip joint on the strength and abductors arm of a dysplastic hip joint. According to the authors, the simultaneous medialization and distalization of the centre of a dysplastic hip joint has a beneficial effect on the muscle force distribution. Dastane et al. (n=82; n=2 DDH arthritis) have measured the acetabular offset by measuring the shortest distance between the femoral head COR with the line perpendicular to the line passing through the centre of Kohler's tear drop. The average offset change was 1.5 mm. Moreover, the authors note the necessity of partially freeing the psoas muscle from the proximal part of the lesser trochanter in cases where we deal with a significant valgus of the femoral neck. This prevents the occurrence of overuse inflammation of the abovementioned muscle's tendon *(1)*. Shofer et al (n=104 DDH arthritis) also point out the necessity of implanting the acetabulum in its anatomical location. They have conducted the radiographic measurements according to Griffith's description *(37)*. Displacement of the acetabulum's position towards the COR (centre of rotation) of the hip joint by an average of 20.8 mm and towards the distal direction by an average of 11.4 mm (p<0.01) [38]. Yong Nie et al. (n=20 DDH arthritis) measured the location of the hip joint endoprosthesis acetabulum in the horizontal plane as the distance between the hip joint's centre of rotation and the Koehler's teardrop, the measurements described by Russotti and Harris *(39)*. The acetabulum's location in the vertical plane, measured as the distance between the centre of the femoral head and the line connecting the bottom edges of Koehler's teardrops. A "high" hip joint was defined as one located at least 35 mm from the line connecting the Koehler's teardrops *(40)*. Bjarnson et al. (no DDH arthritis) proposed a measurement of acetabular offset in the horizontal plane as:

1. Distance between the median line of the body and the most medial part of the hip joint acetabulum;
2. Distance between the median line of the body and the hip joint centre of rotation (COR).

Measurement of offset in vertical plane as:

1. Distance between the horizontal line connecting the sciatic tubers and the hip joint centre of rotation (COR).

The average offset change in horizontal plane was 2.0 mm, while in the vertical plane it was 1.3 mm (p=0.822) *(41)*. Our observation suggest that the repeatability in determining the center of femoral head or COR of a dysplastic hip joint is often difficult due to the deformation of proximal femur and lack of congruence of the hip joint. We believe that measuring and determining the COR works great during radiographic measurements in idiopathic original hip joint degenerative disease. We also note the deficiencies of our method of measuring the "offset distalization" related to using small acetabulum and endoprosthesis head (28 mm), which has a significant effect on the statistical end result. The abovementioned distalization and medialization parameters are adapted from measuring the hip joints affected by residual dysplasia, which qualifies them for surgical treatment conserving patients own hip joints. They are suggestions for further considerations regarding the proper determining the correct acetabular offset of an endoprosthesis in a dysplastic hip joint. Tanaka et al. assessed the medialization based in the DBSPFH (distance between symphysis pubis and femoral head) measurement, done using 3D CAT scan after a hip joint acetabular osteotomy procedure. The authors also noted the difficulties in repeatability of determining the centre of femoral head, which is quite significant when measurements are done in scale of millimetres *(42)*. Beverland et al. determine the implantation of endoprosthesis acetabulum during the surgery based on the location and orientation of TAL (transverse acetabular ligament) *(43)*.

Vanlommel et al. reported to a significantly higher percentage of complications related to nerve paralysis of the lower limb in the case of high hip dislocation arthroplasty compared to the general population of patients. The authors present the operational method of DAA arthroplasty assisted by neuromonitoring. The authors obtained an average limb elongation of 24mm, without any neurological disorders in the operated lower limb *(15)*.

The study conducted confirm that embedding the endoprosthesis cup in an anatomic location provides conditions for restoring the correct acetabular "offset" of a dysplastic hip joint, especially important when we deal with a disease of only one hip joint. At the same time the conditions for correct operation of gluteal muscles are restored. Using small-sized cup offers better possibility of stable embedding the implant in an anatomical location. At the same time using conical stem offers much greater possibility of correcting torsion disorders of the proximal end of femur and reduces the risk of intraoperative femur fractures.

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