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PŮVODNÍ PRÁCE

Middle Term Results of Simple Open Hip Reduction of Irreducible DDH – What Is the Cut-off Age to Safely Perform It with Lower Complications?

Střednědobé výsledky jednoduché otevřené repozice kyčelního kloubu u irreponibilní DDH – jaká je věková hranice pro bezpečné provedení s nízkým počtem komplikací?

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ABSTRACT

PURPOSE OF THE STUDY

When developmental dysplasia of the hip (DDH) is irreducible by conservative means, then surgical open hip reduction is the choice. When done before walking age simple open hip reduction (SOHR) is most often enough to stabilize the hip.

We tested the hypothesis that simple open hip reduction gives enough stability even in severe Tönnis 4 grades of dislocation. We tried to find what is the cut-off age to safely perform SOHR with lower complications.

MATERIAL AND METHODS

From 193 open hip reductions (OHR) of irreducible DDH in 123 children for the period 1995–2010 year with X-ray follow up of at least 8 years and full documentation we investigated 75 SOHR. Mean age at follow-up was 13 years and 5 months for the whole group and 8 years and 3 months for the SOHR patients. Age at operation – 7 months to 7.5 years for all patients with OHR, with average OR age for SOHR – 18 months.

The traditional surgical technique of open hip reduction was performed through lateral Murphy's approach but with sparing the attachment of the piriformis muscle with the underlying blood supply to the epiphysis during circumferential capsulotomy.

We used McKay clinical criteria, radiological classifications of Tönnis, Severin, Herring-Mose and Kalamchi & MacEwen.

RESULTS

When analyzing the results, there came up a strong statistical correlation between bilaterality and Tönnis grade 4.

The final CE angle of Wiberg was on average 28º. According to Severin classification: 74% were excellent and 10% good or 84 % successful results. But according to Herring-Mose sphericity scoring – 60% were good and 30% fair. Mose's fair is a potential cam-type femoro-acetabular impingement (FAI). Clinically according to McKay criteria – 10% excellent and 54% good, or 64% of the operated hips were clinically acceptable, which correlates more with the radiological results according to Mose than with Severin.

Avascular necrosis (AVN) of the femoral head (FH) according to Kalamchi was: Type I – 6%, Type II – 12 %, Type III – 0%, Type IV – 8 %. Types II and IV represent 20 % of the operated hips. The presence of ossific nucleus in the femoral epiphysis on initial X-ray didn't have a statistical impact on AVN frequency.

When analyzing the impact of severity of dislocation and trying to find the cut-off age for fewer complications, there came up a strong statistical significance between AVN IV type appearance in Tonnis grade 4 hips when age at operation was above 9 months.

CONCLUSIONS

The thorough capsuloplasty after FH reduction in the acetabular socket is enough for stability even in Tonnis 4. When OR age is below 9 months severe AVN is lower and Herring-Mose FH sphericity scoring is higher.

Key words: DDH, simple open hip reduction, avascular necrosis of femoral head.

INTRODUCTION

Developmental dysplasia of the hip joint (DDH) is a dynamic entity with a potential to normalize or worsen with the intensive neonatal growth, but which way is more possible is unpredictable. Best solution for the dysplastic and unstable neonatal hip joint is early ultrasound diagnosis and conservative treatment.

Up to 50% of the cases of degenerative coxarthrosis in the elderly are secondary to untreated or unsuccessfully treated hip subluxation or residual acetabular dysplasia (19).

When DDH is irreducible by conservative means, then open hip reduction is the only choice. When done

before walking age most often simple open hip reduction without osteotomies is enough to stabilize the hip.

The objective of this study was to analyze the advantages and shortcomings of an original operative technique for open reduction of irreducible DDH and its modifications aiming at lowering the complications. We tested the hypothesis that simple open hip reduction (SOHR) gives enough stability even in severe Tönnis 4 grades of dislocation. **Our aim** was to find, what is the cut-off age to safely perform SOHR with lower complications.

We analyzed 123 children with 193 open hip reductions of severe, irreducible hip dislocations, for the time period 1995–2010 year, aiming at including more patients in our research down and up in the years. Criteria for inclusion were X-ray follow up of at least 8 years and full documentation. Mean age at follow-up was 13 years and 5 months (8–24 years; SD 3.4) for the whole group and 8 years and 3 months (8–11 years; SD 2.4) for the SOHR patients. Age at operation – 7 months to 7.5 years for all patients with OHR, with average OR age for SOHR – 18 months (7–40 months; SD 7.3). Ratio girl to boys was 9:1.

MATERIAL AND METHODS

Open hip reduction was performed through Murphy's lateral approach (12) according to the technique of Holevich, Boychev, and Vladimirov (8). We modified (2, 3) the technique by sparing the attachment of piriformis muscle with the underlying blood supply to the femoral head growth zone during circumferential capsulotomy. After reducing the FH in the acetabular socket, thorough bi-level circumferential capsuloplasty was performed with inside out technique of the inner capsular layer (Fig. 1).

On testing for stability of the reduced FH in the acetabulum before capsuloplasty, if excessive internal rotation and abduction was needed, then femoral derotation, shortening and varus osteotomy (FDVO) was performed according to the principles of Jan Zahradníček (23–26) and Janaki Holevich with osteosynthesis called Holevich blade. In recent years, Holevich blade was replaced at our department with the Synthes "LCP Pediatric Hip System" – 27- and 35-mm plates (6, 15, 16). This system gives precision and stability that allows early start of range of motion (ROM).Usually postoperative cast immobilization is only 3 weeks. On second stage was performed pelvic osteotomy (PO) according to Salter, Pemberton and Dega if indicated.

Clinically we classified our operated patients according to McKay criteria (10).

Radiographic methods used include Tönnis classification (21) of the initial roentgenogram and Severin classification (18) of the latest follow-up X-ray. We felt that the latter classification gives too optimistic results, that's why we analyzed also the FH sphericity according to Herring's modification (7) of Knud Mose classification.

Avascular necrosis (AVN) was accessed according to the five criteria of Salter (17) from 1969 and classified according to duPont classification of Kalamchi and MacEwen from 1980 (9).

Femoral head avascular necrosis was analyzed according to: severity of dislocation, age at operation, operative technique, presence of FH ossific nucleus.

We distributed our patients into **three groups** according to the open hip reductions performed:

1. Simple open hip reduction.
2. Open hip reduction + FDVO ± PO initially or on a second stage.
3. Historical group of Colonna arthroplasty or OHR with reaming + FDVRO + PO.

In this research study we investigated the first group. We have tested the hypothesis: Does simple open hip reduction give enough stability even in severe Tönnis 4 grades of dislocation? (Fig. 2). We tried to find what is the cut-off age to safely perform SOHR with lower complications?

Statistical analysis was performed using SPSS for Windows. Descriptive statistics (mean ± standard deviation) were calculated for age and follow-up period. Interferential statistics for hypothesis testing included the Fisher exact probability test and Pearson's chi-square test. A value of $p < 0.05$ was considered to be statistically significant.

RESULTS

In the present investigation we introduce only the results of the first group of patients – SOHR group. The first group consisted of 75 SOHR

Severity of dislocation in this group according to Tönnis grades was: Grade 2–44% of the hips and Tonnis 3–40%, Tonnis 4–16%. The severe dislocations of Tönnis 3 & 4 were 56% of the hips.

Our failures include 2 reluxations (1% of all hips operated or 2.6% of SOHR).

The first patient with redislocation was diagnosed several years after the operation with a rare type of neuro-muscular disease. Age at OR was 18 months. The second patient was neurologically normal with OR age 20 months. Both hips were Tönnis 2 grade.

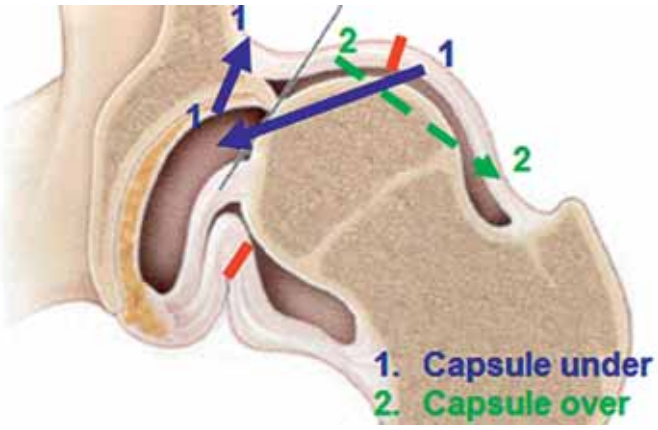

Fig. 1. Circumferential capsulotomy with inside-out bi-level capsuloplasty after FH reduction.

Fig. 2. Severe right hip dislocation. A – at age 8 months the right hip is Tönnis grade 4; B – simple open hip reduction was performed at age 9 months; C – eight years postoperatively without any AVN evidence on middle-term.

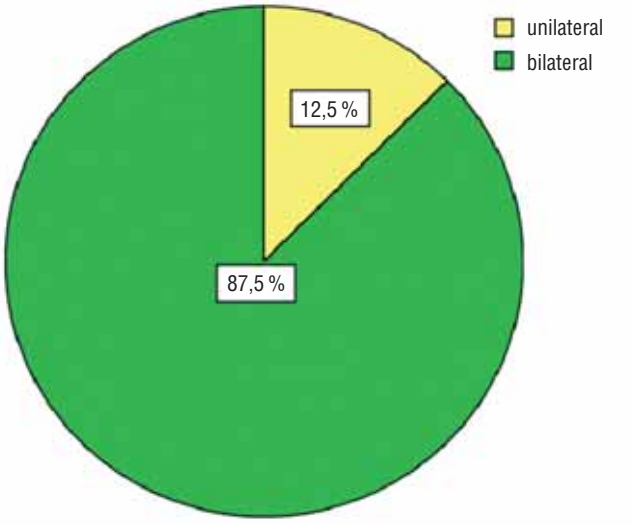

Fig. 3. Bilaterality in Tönnis grade 4 (χ^2 test, = 0.05).

Our results show that the final CE angle of Wiberg was on average 28º. According to Severin classification: 74% were excellent and 10% good or 84% successful results. But according to Herring-Mose sphericity scoring – 60% were good, 30% fair. Mose's fair is a potential cam-type femoro-acetabular impingement (FAI) and that's why Mose's 60% good results is the more realistic final successful result. Clinically according to McKay criteria – 10% excellent and 54% good or 64% of the operated hips were clinically acceptable, which correlates more with the radiological results according to Mose than with Severin.

Avascular necrosis of the femoral head according to Kalamchi was: Type I – 6%, Type II – 12%, Type III – 0%, Type IV – 8%. Types II and IV represent 20% of the operated hips.

The presence of ossific nucleus in the femoral epiphysis on initial X-ray didn't have a statistical impact on AVN frequency

In 46% of SOHR, an unsuccessful trial with Pavlik harness for a longer than the recommended 1 month trial (1) leaded to progression of DDH from Tönnis 2 to higher degrees.

When analyzing the results, there came up a strong statistical correlation between bilaterality and Tönnis grade 4 (Fig. 3). This can be explained by the hip joint patho-biomechanics and is possibly due to the overload when both joints are involved resulting in worsening of severity of dislocation.

Table 1. Statistical significance of severity of dislocations – Tonnis grade 4 compared to lower Tonnis grades and bilaterality compared to unilaterality in correlation with the appearance of AVN IV type and the other unfavorable radiological and clinical results. All statistical significances are calculated by Pearson's chi-square test

	McKay poor/fair	Severin poor/fair	Mose poor/fair	Kalamchi AVN IV type
Tonnis 4 grade vs Tonnis 2&3	**63%**	**25%**	**63,00%**	**83,00%**
p value	0.2	0.8	0.002	0.009
Bilaterality vs Unilaterality	**81%**	**100%**	**87%**	**83,00%**
p value	0.02	0.01	0.007	0.009

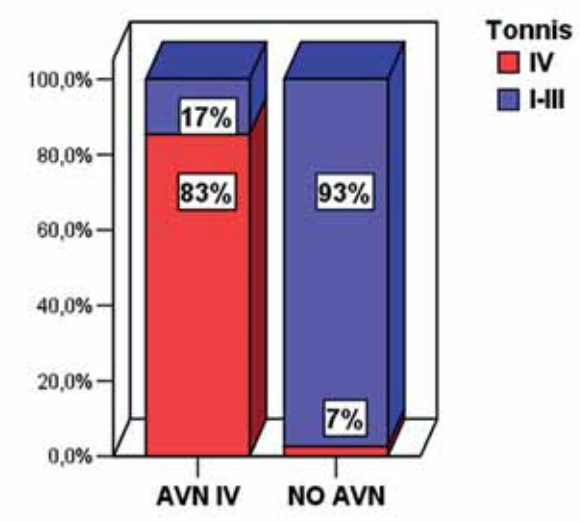

Fig. 4. Tönnis grade 4 influence on Kalamchi IV AVN compared to severity of dislocation in cases without complication of AVN. (Fisher Test, p = 0.0001).

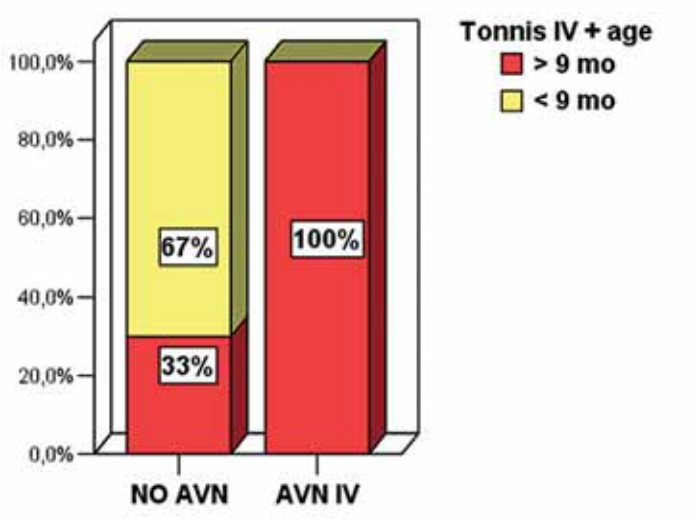

Fig. 5. Influence of age at operation over 9 months in Tonnis grade 4 hips in Kalamchi IV AVN complications. (Fisher Test, p = 0.03).

The significance of severity of dislocation and bilaterality on the appearance of high-grade IV type AVN and poor clinical and radiological results is presented in Table 1.

When analyzing the impact of severity of dislocation on the poor clinical and radiological outcome, Tonnis grade 4 in patients with AVN IV type shows strong statistical significance (p = 0.0001) in comparison with cases without complication of AVN, where lower grades of Tonnis severity predominate (Fig. 4).

Aiming to find the cut-off age for performing our operative technique with fewer complications and while investigating into a closer detail the interaction between Tonnis 4 and AVN IV, we found age at operation above 9 months in Tonnis grade 4 hips to be with a statistically significant impact (p = 0.03) on AVN IV complicated hips when compared to the hips without AVN (Fig. 5).

DISCUSSION

Our results are comparable to others.

Doudoulakis (4) investigated like us only hips, treated by SOHR although according to Somerville with excision of the iliac growth zone – the labrum. He studied 69 operated hips with an average age 7 months, which is much lower than our average age at operation. Follow-up is 13 years. His success rate is 83% when radiologically measured, comparable to our 84%. Rate of AVN is only 13% and presented mainly in hips, operated before age 6 months. We do not have hips operated by open hip reduction before that age.

Wenger (22) suggested performing an open reduction and femoral shortening osteotomy at a younger age in special circumstances to reduce the pressure on the femoral head in younger patients. Their series of 20 hips resulted in a 10% incidence of osteonecrosis (ON). We also conclude that open hip reduction above 9m age is with higher risk for AVN when no femoral osteotomy is done.

Morcuende (11) investigated 93 operated hips with DDH but not only with SOHR like our presented group of patients. Average age at operation was 14 months and average age at last follow-up was 11 years. Excellent and good results according to Severin were 71%, which is comparable to our over 80%. Avascular necrosis was present in 43% of the operated hips, which is much higher than our results, but our series still do not have so long follow-up and that may worsen our AVN incidence. Morcuende states that more severe hip dislocation and age over 2 years increase the risk of AVN.

Firth (5) retrospectively reviewed 101 (133 involved hips) with DDH treated with either open (56 hips) or closed (77 hips) reduction. With a new AVN classification they found that type of reduction (closed with traction versus open without femoral shortening) but not age influenced the risk of ON. They also found open reduction without femoral shortening was associated with an increased severity of ON. We also find that lack of FO is increasing the risk of AVN, but in severe group Tonnis 4 after certain age.

Pospischill (14) suggests open reduction with concomitant osteotomies without femoral shortening and secondary reconstructive procedures for acetabular dysplasia predict the development of ON. Patient age at the time of reduction, preliminary traction, history of failed Pavlik harness treatment, and hip immobilization after reduction do not seem to influence the incidence of ON. Their observations suggest shortening of the femur when performing open reduction with concomitant pelvic and/or femoral osteotomies in children after walking age might have reduced the rate of ON. To minimize the risk of the development of ON, they advocate early reduction of the dislocated hip during the first year of life to avoid the need for concomitant osteotomies. We have the same observation with difference that we found specific age limit of 9 months, above which sparing FO raises AVN incidence in severe grade DDH.

Szepesi (20) presents their results after bony maturation of an early anterior approach open reduction performed using a modified technique on 49 hips at 6–24 months of age. They start postoperative functional treatment using a Pavlik harness and an abduction splint, abandoning plaster cast. Their results were 'satisfactory' (Severin Grade I, II) in 96% of the cases. We also have very short postoperative cast immobilization basically due to stability of bi-level capsuloplasty. We start PT 3 weeks postoperatively when no FO was done during early OHR.

Novais (13) investigated the occurrence of osteonecrosis and age at open reduction using data on 364 hips treated by medial open reduction and 220 hips treated by anterior open reduction. They did not find an association between closed or open reduction performed at or before 12 months of age and an increased risk of osteonecrosis of the FH. Delayed treatment past 1 year of age as a strategy to reduce the development of osteonecrosis was not supported by their meta-analysis. Our analysis suggests the same. They did not discuss association between age at reduction and severity of DDH on AVN severity.

CONCLUSIONS

The thorough capsuloplasty after FH reduction in the acetabular socket is enough for stability even in Tonnis 4. When OR age is below 9 months severe FH AVN is lower and Herring-Mose FH sphericity scoring is higher. Above this age the anatomical structures are tighter, bone (femur and acetabulum) dysplasia is more severe and simple open hip reduction is risky. In the older age a concomitant or at least after a very short time period FDVO or PO is needed to protect against FH redislocation and AVN.

Femoral head AVN depends on severity of dislocation, age at operation, but not on ossific nucleus presence on the preoperative X-ray.

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