

Triple Pelvic Osteotomy in the Treatment of Hip Dysplasia

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SUMMARY

Introduction Insufficient femoral head coverage is found in a variety of diseases, with acetabular dysplasia as the most frequent disorder and triple pelvic osteotomy as the most recently introduced surgical treatment.

Objective This study analyses pre- and postoperative pathoanatomic characteristics of triple in comparison to Salter and Chiari osteotomies, with a logistic regression analysis of outcome predictor and effect explanator factors in relation to the chosen type of operation.

Methods The study involved 136 adolescents treated with Salter and Chiari osteotomies or a triple pelvic osteotomy at the Institute of Orthopaedic Surgery "Banjica" in Belgrade. The patients were between 10-20 years old at the time of operation. We collected and analyzed data from all the patients: illness history, operative parameters, preoperative and postoperative pathoanatomic data. The data was statistically processed using the statistical software SPSS, defining standard descriptive values, and by using the appropriate tests of analytic statistics: t-test for dependent and independent variables, χ^2 -test, Fisher's exact test, Wilcoxon's test, parameter correlation, one-way ANOVA, multi-factorial ANOVA and logistic regression, according to the type of the analyzed data and the conditions under which the statistical methods were applied.

Results The average CE angle after triple pelvic osteotomy was 43.5°, more improved than after the Salter osteotomy (33.0°) and Chiari osteotomy (31.4°) ($F=16.822$; $p<0.01$). Postoperative spherical congruence was also more frequent after the triple osteotomy than after the other two types of operations, and with a high significance. Preoperative painful discomfort was found to be a valid predictor of indications for the triple osteotomy over both Chiari and Salter osteotomies. The valid explanators of effect for the triple osteotomy are: postoperative joint congruence (compared to the Chiari osteotomy) and increase in joint coverage (compared to Salter osteotomy).

Conclusion Triple pelvic osteotomy is the method of choice in the management of acetabular dysplasia and other disturbances of hip joint containment in adolescent age.

Keywords: hip dysplasia; Wiberg CE angle; triple pelvic osteotomy; effect explanator; outcome predictor

INTRODUCTION

Regarding the hip, acetabular dysplasia is by far the most frequent, most researched and most successfully treated disorder. It presents as an isolated form or as a prerequisite for subluxation or complete hip dislocation. If untreated, it develops early into degenerative changes followed by pain, loss of movements and serious disability. Insufficient femoral head coverage may develop even in cases of a well developed acetabulum due to the changes on the femoral head (Legg-Calve-Perthes disease, postreductional avascular hip necrosis) [1, 2, 3].

The importance of early detection of the diseases lies in early staged treatment – preventive treatment, thus preventing the development of arthritis or causing its significant delay. There are different options of the nonoperative treatment starting from the earliest age, while surgical treatment is considered only in cases of nonoperative treatment failure or in patients with progressed disease. The triple pelvic osteotomy is the most effective surgical management of both dysplasia of the hip and secondary insufficient coverage of the femoral head. According to several authors, it is performed starting from the age of eight. The conditions for performing the procedure are the ability of concentric postoperative acetabulum and femoral head congruence, preserved hip range of motion and absence of significant degenerative changes. Fulfilment

of these conditions along with anatomic improvement leads to an asymptomatic hip [4].

The triple pelvic osteotomy involves cutting of the pelvis in three places: pubic, ischial and iliac bone. According to the classic operating techniques it is done by three open incisions, and then adequately fixated, with an early start of rehabilitation and walking. The triple pelvic osteotomy is nowadays considered as the most contemporary surgical treatment of disturbances regarding central positioning, coverage and hip containment in children older than eight years. Throughout the history other methods have been also used, most frequently the Salter pelvic osteotomy – isolated or combined with corrective femoral osteotomy, and the Chiari pelvic osteotomy [1, 2, 5-16].

The original triple pelvic osteotomy technique was published by Tonnis in 1979. Compared to the majority of other osteotomy techniques, the advantages of this triple osteotomy consist in the proximal osteotomy of the ischial bone, very close to the acetabulum. Since the osteotomies of the pubic and the iliac bone are also close to the acetabulum, the anterolateral rotation is possible and performed much easier than in other osteotomies [12, 14, 17-23].

The modification of the technique by Vladimirov (used in our country) consists of the anatomic access through two incisions, thus sparing and allowing an easier and faster rehabilitation [12, 14, 23-26].

OBJECTIVE

Our objectives were: 1) To define the conditions of the triple osteotomy method in relation to the methods of Chiari and Salter pelvic osteotomies, or more precisely to set indications for the method implementation in adolescents; 2) To determine relevant preoperative parameters significant for choosing the type of operative treatment; 3) To compare the results of triple osteotomy, and Chiari and Salter pelvic osteotomies. At the same time to define the advantages of the triple pelvic osteotomy in adolescents; 4) Triple pelvic osteotomy results analysis, defining surgical procedure details linked to postoperative complications previously noted in clinical practice, modification suggestions in the attempt to prevent complications; 5) To determine relevant postoperative parameters as predictors of the difference between the methods of triple osteotomy, and Salter and Chiari osteotomies, all in the attempt to predict and evaluate the results in a more precise manner.

METHODS

This study involved 136 adolescents treated with the Salter and Chiari osteotomies or the triple pelvic osteotomy at the Institute of orthopaedic surgery „Banjica” in Belgrade. The adolescents treated with the Chiari and triple pelvic osteotomies were between 10-20 years old at the time of operation. The stated age range counted for the triple and Chiari osteotomies, while the adolescents treated with the Salter osteotomy were younger than 15.5 years. All the adolescent patients operated on using these methods in the observed period of time (57 patients were operated on using the triple pelvic osteotomy, and 33 patients underwent surgery using the Chiari osteotomy) were involved in a parallel statistical analysis of parameters gained by the triple and Chiari osteotomies. However, the statistical analysis of the differences between the triple and Salter osteotomies involved all patients operated on using the Salter osteotomy and 29 youngest patients who were from the triple osteotomy group. Defining a subset of patients from the triple osteotomy group was necessary for comparing them with the Salter osteotomy group. We defined the subset using the age distribution analysis in the triple osteotomy group of patients, selecting the size of the subset so that the age distribution was very similar to the group of patients operated on using the Salter osteotomy, and thus assuring that the two groups were comparable.

We collected and analyzed data from all patients:

1. Illness history: gender, type of possible prior treatment, presence of painful discomforts.
2. Operative parameters: diagnosis, type of operation, location (left/right hip), and the patient's age at the time of operation.
3. Preoperative pathoanatomic data: the CE angle of Wiberg of the diseased hip, preoperative leg length inequality, stage of Legg-Calve-Perthes (LCP) disease (Hirohashi-Koehler classification), preoperative joint containment (acetabular head index, only in LCP patients), preoperative femoral head deformity (Robert Seringe classification, only in PAN patients).

4. Postoperative pathoanatomic data: the CE angle of the operated hip, residual leg length inequality, congruence (Stulberg classification), type of residual deformity of the joint (only in LCP patients), postoperative joint containment (measured analogously to the preoperative measurements), and residual femoral head deformity (also measured analogously to the preoperative measurements).

All the patients were divided according to their diagnosis: 62 patients (45.6%) suffered from the developmental dysplasia of the hip (DDH), 34 patients (25%) suffered from LCP disease, 37 patients (27.2%) had post-reduction avascular necrosis (PAN), 2 patients (1.5%) had non-LCP avascular necrosis, and 1 patient (0.7%) had septic shock sequel. When statistically processed, the patients with avascular necrosis were relocated to the group of patients with LCP, due to similar pathophysiological parameters. The patient with septic shock sequel was relocated to the group of patients with post-reduction avascular necrosis according to the sequel classification (Hunka 2b) where this damage was considered equal to that in PAN. According to the pathophysiological substrate, we formed three groups and all three types of pelvic osteotomies were presented in each group (Table 1).

The data was statistically processed using the statistical software SPSS, defining standard descriptive values, and by using the appropriate tests of analytical statistics: t-test for dependent and independent variables, χ^2 -test, Fisher's exact test, Wilcoxon's test, parameter correlation, one-way ANOVA, multi-factorial ANOVA and logistic regression, according to the type of analyzed data and the conditions of applying the statistical methods.

The results were assessed according to the probability of the null hypothesis of 0.05 for the level of statistical importance, and 0.01 for the high level of statistical importance.

RESULTS

Patients' gender structure

Gender structure in 136 patients involved 53 male (39%) and 83 female patients (61%). There was a high statistical difference regarding the gender in patients with various diagnosis ($\chi^2=59.227$; $p<0.01$). In patients with DDH there were significantly more female than male patients (53:9), in patients suffering from LCP there were more male patients (33:3) and more female patients were found in those suffering from PAN (27:11).

Prior treatment

From the total number of patients included in this study, 42 patients (30.9%) had no prior treatment and 69 patients (50.7%) were treated nonoperatively. Among 25 operatively treated patients (18.4%), the Salter osteotomy as a form of prior treatment was done in 14 patients. There was a high statistical difference in the type of preoperative treatment regarding the diagnosis ($\chi^2=32.782$; $p<0.01$): in the group of 62 patients with DDH 20 patients had no prior treatment,

Table 1. Number of patients classified according to diagnosis and type of surgical treatment

Type of osteotomy	DDH	LCP	PAN	Total
Triple	31	10	16	57
Salter	13	22	11	46
Chiari	18	4	11	33
Total	62	36	38	136

30 patients were treated nonoperatively and 12 patients were operatively treated; in the group of 36 patients with LCP 22 patients had no prior treatment, 10 patients were treated nonoperatively and four were treated operatively; in the group of 38 patients suffering from PAN all were treated prior to this study, of whom 29 patients were treated nonoperatively and nine patients operatively.

However, the type of preoperative treatment did not result in significant difference regarding the values of preoperatively measured CE angle of Wiberg of the diseased hip.

Most of the patients who underwent the triple pelvic osteotomy had no prior treatment (71.9%), in patients where we performed the Salter osteotomy 56.5% of patients also had no prior treatment, in the group of patients where we performed the Chiari osteotomy the number of prior nonoperatively, operatively treated and untreated patients was equal (33.3%).

A high statistical difference was detected in the type of prior treatment regarding the type of the present operative procedure ($\chi^2=35.176$; $p<0.01$).

Preoperative discomforts

In the preoperative period painful discomforts of the diseased hip were present in 92 patients (67.6%). No statistical difference was found in the presence of pain among the three diseases, nor according to the preoperative patho-anatomic substrate; the phase of the LCP and the type of preoperative deformity in PAN.

However, there was a high statistical difference regarding the relation between painful discomforts and preoperative treatment ($\chi^2=9.529$; $p<0.01$); pain was present in 50% of untreated patients, in most of nonoperatively treated patients (78.3%) and in 68% of operatively treated patients.

Type of surgical treatment

From the total of 136 patients, the triple pelvic osteotomy was performed in 57 (41.9%): isolated in 49 cases (36%), with shortening femoral osteotomy in two cases (1.5%) and in six patients (4.4%) with the descensus of the great trochanter; in 46 patients we performed the Salter osteotomy (33.8%): isolated in 15 patients (11%), with femoral osteotomy in 28 patients (20.6%) and with the descensus of the great trochanter in three cases (2.2%); 33 patients underwent the Chiari osteotomy: isolated in 24 patients (17.6%), with shortening femoral osteotomy in three patients (2.2%) and with the descensus of the great trochanter in six patients (4.4%). All percentages referred to the total number of patients.

The left hip was operated on in 70 patients, and the right hip in 66 patients.

The total follow-up period was in the range from 8 months to 13 2/12 years, with the average of 37.9 months.

Regarding the gender structure, we detected a high statistical difference in various types of surgical procedures ($\chi^2=15.631$; $p=0.000$): in the group of triple osteotomies there were 22.8% male and 77.2% female patients, in the group of Salter osteotomies there were 60.9% male and 39.1% female patients, while in the group of Chiari osteotomies there were 36.3% male and 63.7% female patients.

A high statistical difference also existed in the performed type of operation regarding the preoperative diagnosis ($\chi^2=17.397$; $p=0.002$) (Table 1).

Anatomic parameters

CE angle of Wiberg

The values of the CE angle of Wiberg measured in all patients are displayed in Table 2.

Preoperatively measured CE angle of Wiberg of the operated hip was averagely 16.49° (SD=8.57), results were in the range of 0-37°, seven patients with a negative value of the Wiberg CE angle were not taken into account. Postoperatively measured CE angle was averagely 36.99°, with the range from 11-80° (SD=12.34), and with an increase of 20.5° (SD=13.07). Having this value in mind, there was a high statistical difference considering the preoperative results ($t=-21.112$; $p<0.01$), as well as a high statistical correlation between the preoperative and postoperative results ($t=0.438$; $p<0.01$). We determined a high statistical difference between the values of preoperatively measured CE angle of the diseased hip according to the preoperative diagnosis ($F=11.926$; $p<0.01$), where the difference came from the group of patients diagnosed with LCP (average 21.7°) as compared to the group of patients suffering from DDH (average 13.6°) and the patients diagnosed with PAN (average 15.9°).

The preoperative values of the CE angle of the diseased hip statistically highly correlated with the preoperative joint containment ($r=0.698$; $p<0.01$).

Further analysis revealed that the postoperative CE angle increase depended on the type of performed surgical treatment with high statistical significance ($F=16.622$; $p<0.01$). The increase in the average CE angle after the triple osteotomy was 25.4°, after the Salter osteotomy 14.5° and 28.4° after the performed Chiari osteotomy. The differences between the groups showed that the high statistical difference was formed due to the value measured in the Salter osteotomy compared to the other two surgical procedures.

According to the type of performed treatment, high statistical differences were established between the average

Table 2. CE angle of Wiberg

Variable		Preoperative	Postoperative
CE angle (degrees)	Min-Max	0-37	11-80
	SD	16.49±8.57	36.99±12.34



Figure 1. Right hip dysplasia treated by Salter osteotomy (a – preoperative; b – operative; c – final)

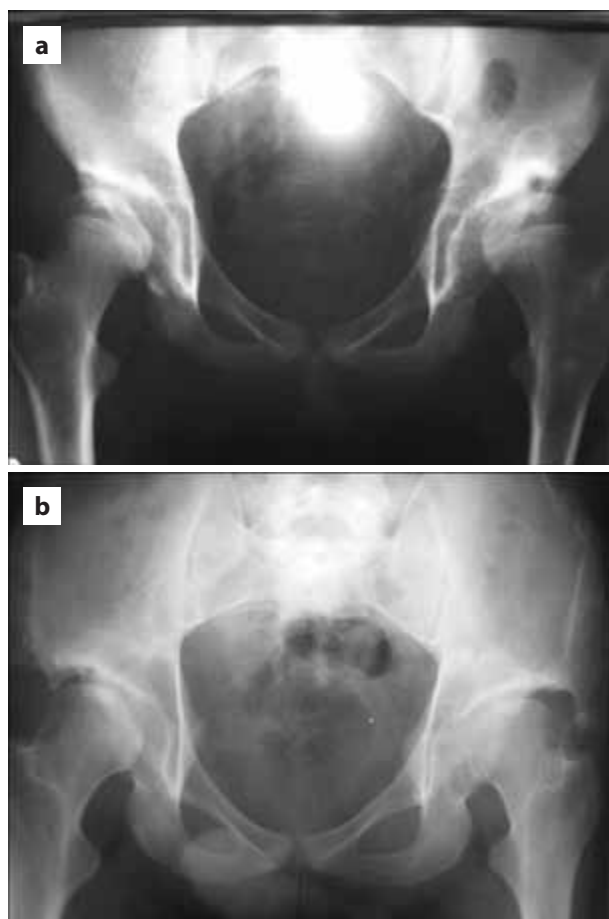


Figure 2. Bilateral hip dysplasia treated by Chiari osteotomy (a – preoperative; b – final)

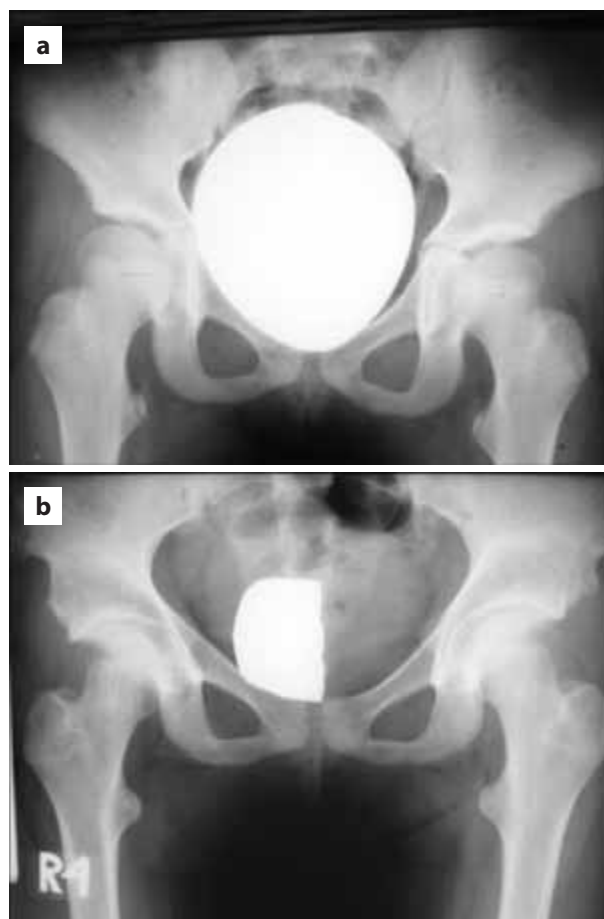


Figure 3. Bilateral hip dysplasia treated by triple pelvic osteotomy (a – preoperative; b – final)

values of the postoperative CE angle ($F=16.822$; $p<0.01$) due to the group of patients who underwent the triple osteotomy (average 43.5°) compared to the other surgical groups (average 33° after Salter and 31.4° after Chiari osteotomy) (Figures 1-5).

Also, the postoperative CE angle highly statistically correlated with the postoperative joint containment measured in the patients diagnosed with LCP ($r=0.704$; $p<0.01$), and with the increase of the CE angle after the surgery ($r=0.523$; $p<0.01$).

Postoperative hip congruence

From the total of 136 patients, postoperative X-rays revealed spherical congruence in 61 patients (44.9%), aspherical congruence in 62 patients (45.6%) and incongruence in

the remaining 13 patients (9.5%). There was a highly significant difference ($\chi^2=18.717$; $p=0.001$) in the congruence distribution regarding the type of operation: spherical congruence was detected in 59.6% of patients treated by the triple osteotomy, aspherical congruence was detected in 50% of patients treated by the Salter osteotomy and in 54.5% of patients treated by the Chiari osteotomy.

Logistic regression analysis

The above results speak in favour of the significance of mutual differences and correlations among certain parameters. Aiming at a quantitative analysis of their impact on the total significance of the difference among the three groups of the operated patients (by Salter, Chiari and triple osteotomy), it is accustomed in studies of this type to



Figure 4. Legg-Calve-Perthes disease of the right hip treated by triple pelvic osteotomy (a, b – preoperative; c – final)



Figure 5. Bilateral postreduction avascular necrosis, left hip treated by triple pelvic osteotomy and greater trochanter descent (a – preoperative; b – final)



Figure 6. Complication of triple pelvic osteotomy – pseudoarthrosis of both ischial and pubic bones

use the statistical method of logistic regression [17]. As the dependent dichotomous variable we introduced the decision variable to apply the triple and the Salter osteotomy. Thus we detected the predictors of belonging to one of the treatment modalities (predictors of indications) among the preoperative variables. In the same manner we detected the discriminators among the postoperative variables, namely the explainers of the impact of the type of performed operating procedure on the differences in treatment outcome.

Analyzing the results we concluded that the most significant preoperative predictor for choosing the triple osteotomy over the Chiari osteotomy was the presence of preoperative painful discomforts (Table 3).

The most significant explainers of the difference between the results of the triple osteotomy in regard to the Chiari osteotomy was the postoperative hip congruence (Table 4).

The presence of preoperative painful discomforts singled out as a strong predictor of indications for performing the triple osteotomy in regard to the Salter osteotomy. Less significant predictors were the data concerning the prior treatment of the patient (Table 5).

Postoperative increase of the CE angle could be established as the valid explainer for the triple osteotomy effect in regard to the Salter osteotomy (Table 6).

Surgical complications

The following complications were detected in the group of patients operated on using the triple osteotomy method: 1) One case of deep wound infection completely solved by early wound debridement and parenterally applied antibiotics; 2) One case of discrete peroneal palsy healed with corticosteroids, B vitamins and physical therapy without any consequences; 3) In seven cases we detected the formation of pseudoarthroses, in two patients pseudoarthrosis of the pubis, and in five patients pseudoarthrosis of both pubis and the ischium. All pseudoarthroses were asymptomatic. No pseudoarthrosis of the iliac bone was detected (Figure 6).

DISCUSSION

Acetabular dysplasia and hip incongruence are present in a large number of patients treated for DDH and LCP; therefore the treatment of these disorders presents a complex problem and calls for optimal guideline management

Table 3. Predictors of indications – triple osteotomy in reference to Chiari osteotomy

Variable	B	SD	p	RR	95% CI	
					Lower	Higher
Preoperative painful discomforts	2.51	0.95	0.008	12.35	1.91	79.91
Preoperative CE angle	0.15	0.05	0.008	1.16	1.04	1.29
Constant	-7.01	1.71	0.000			

B – logistic regression coefficient; SD – standard deviation; p – null hypothesis; RR – relative risk; CI – confidence interval

Table 4. Explanators of the effect – triple osteotomy in reference to Chiari osteotomy

Variable	B	SD	p	RR	95% CI	
					Lower	Higher
Increase of CE angle	-0.19	0.06	0.008	12.35	1.91	79.91
Postoperative CE angle	0.11	0.04	0.008	1.16	1.04	1.29
Postoperative joint congruence	-1.59	0.73	0.000			
Constant	-4.34	1.84				

Table 5. Predictors of indications – triple osteotomy in reference to Salter osteotomy

Variable	B	SD	p	RR	95% CI	
					Lower	Higher
Preoperative painful discomforts	3.1592	0.9150	0.0006	23.5516	3.9187	141.5464
Prior treatment	1.3905	0.5115	0.0066	4.0170	1.4741	10.9467
Constant	-2.2867	0.8677	6.9457			

Table 6. Explanators of effect – triple osteotomy in reference to Salter osteotomy

Variable	B	SD	p	RR	95% CI	
					Lower	Higher
Increase of CE angle	0.12	0.04	0.0016	1.1330	1.0483	1.2245
Constant	-4.7702	1.9937	0.0167			

adapted to different age and individual patient characteristics. Adolescent age features a lower biological remodelling potential (compared to younger children), a very negative hip burden and its biomechanical characteristic relation (emphasized physical activity and substantial body weight), as well as the impossibility of applying technologically improved aloarthroplastic methods (reserved for much older patients) [27].

Insufficient coverage in the anterior and superolateral part of the hip, often with present enlargement of the valgus and anteversion of the proximal femur is the pathophysiological substrate that guides the natural course of hip dysplasia in adolescents to early osteoarthritis and disability. The increase of the resultant mechanical forces in the joint along with decreased supporting surface of the acetabulum leads to hip joint contact pressure increase, further leading to painful discomforts, restricted movement, progressive damage of joint cartilage and osteoarthritis. In Perthes disease weakened mechanical features of the femoral head caused by the action of mechanical forces resultantly lead to subchondral collapse followed by femoral head deformity with extrusion and joint incongruence. Post-reduction femoral head osteochondritis also leads to joint surface deformation and disturbance of joint surface congruence. These negative biomechanical conditions also cause damage to acetabular joint surface leading to osteoarthritis.

The change of the geometric relation between the acetabulum and the femoral head by surgical procedures results in the increase of the acetabular supporting surface, change of the angle and intensity of the resultant mechanical forces in the hip, which further leads to alle-

viating symptoms and delaying of the development of definite osteoarthritic changes [28]. Functional improvement, measurable anatomic effect and joint deformity restitution are possible if the surgical procedure is adequately applied, and in the range of the biological remodelling potential in the adolescent age.

Modern surgical methods used for that purpose in the adolescent age are pelvic osteotomies: Chiari, Salter and the triple osteotomy. These surgical procedures have different preoperative indications, different performing techniques and different effects on the operated joint. The triple osteotomy, the most recent of all mentioned techniques, has been developed aiming at the elimination of the flaws of the other two osteotomies in the treatment of the damaged hip congruence. Comparison between these three methods is best made taking into account indications for all three methods, acetabulum dysplasia and hip incongruence in the adolescent age. In the literature there is data on the triple osteotomy compared to the Chiari osteotomy in older patient groups and in the field of already existing degenerative changes in the hip. Numerous statements also give comparison between the Chiari and Salter osteotomy for hip dysplasia treatment in the paediatric population. There is few data concerning the comparison between the Salter and triple osteotomy, and as far as we know, simultaneous comparison of all three methods done by one surgical team on a homogenous clinical sample has not been published until now.

The gender distribution of patients into three groups reflects the frequency of hip dysplasia, post-reduction osteochondritis and Perthes disease in males and females, the fact well known in the literature. The triple osteotomy is

followed by spherical congruence domination, while the other two osteotomies are usually followed by aspheric congruence. This can be explained by a higher therapeutic effect of the triple osteotomy and different characteristics of the above mentioned diseases. The Perthes disease more often features aspheric congruence than DDH, and due to a faster development of symptoms the Salter osteotomy is more often performed, mainly being used in the earlier adolescent period. In a similar way, the velocity of post-reduction avascular necrosis development, female gender domination, severity of pathological findings and affected both joint surfaces are the indications for the Chiari osteotomy, which is characterized by a lower capability for biological joint regeneration than reconstructive pelvic osteotomies.

The patients in our study were treated differently prior to operation. Half of them were previously surgically treated, about a third of the patients (30.9%) had no prior treatment, and the remaining ones were treated by various non-operative procedures. Similar findings have been observed in the literature, despite the level of the development of the method of DDH prevention in the involved communities, which is important regarding the age and the number of candidates for surgery. The type of preoperative treatment had no significant impact concerning the preoperatively determined radiological or functional parameters.

During the preoperative period painful hip discomforts were present in two thirds of the patients, which was without any significant difference regarding the diagnosis or the preoperative pathoanatomic substrate. The reason for such an independent pain feature in the analyzed clinical material partly lies in the extent of the age interval (10-20 years), and partly in the fact that in the situation of disturbed hip congruence pain arises from the summation of several pathoanatomic factors, and not necessarily as part of coxarthrosis limiting the possibility of performing the triple osteotomy. In the literature there is a data on smaller series of patients undergoing the triple osteotomy where preoperative pain was present in 100% of patients [29]. Progressive presence of pain in the hip and the thigh characterizes the observed disease progression. This explains the more often pain feature in preoperatively treated patients compared to the preoperatively untreated patients in our sample ($\chi^2=9.529$; $p<0.01$).

The CE angle of Wiberg is the most frequently used radiological parameter that gives us a good insight into the hip anatomic relations when dealing with disturbed joint congruence. The average preoperative and postoperative values are displayed in Table 2. The significantly smaller average value of the preoperative CE angle detected in the patients with DDH and PAN compared to the patients with LCP in our study is the reflection of the pathophysiological characteristics of the diseases themselves, and has no impact on the importance of this fact in further analysis. The postoperative increase of 20.5° represents a high statistical significance, and a highly significant correlation of the preoperative and postoperative results which speak in favour of the efficiency of surgical treatment and the possibility of predicting the postoperative result. At the same time, the CE angle postoperative increase is found to be

dependent on the type of performed operation. Similar findings have been described by other authors as well. Coverage improvement after the performed triple osteotomy in our study (25.4°) is among better ones compared to the results of other authors (16-36°) [6, 7, 11, 18, 20, 29, 30]. The detected CE angle increase of 14.5° in our study after the performed Salter osteotomy also fits into up till now published results of other authors (13.2-17.3°) [31, 32]. The evidence of increased CE angle correction (17-45.8°) after the performed Chiari osteotomy (28.4° in our case) has been published in the literature. The possibility of increased coverage after the performed Chiari osteotomy is very strong, but in this study it was performed on patients with a very small preoperative CE angle that followed the general disturbance of joint congruence, which is one of the criteria for performing the Chiari osteotomy. In other words, the adequate standard for a successful Chiari osteotomy compared to the triple osteotomy is the difference between the preoperative and postoperative CE angle values and not the size of the preoperatively measured CE angle. The logistic-regression analysis also confirmed this conclusion. However, postoperative X-rays after the Chiari osteotomy and the lateral edge of the covering surface are not always consistent and present a bit of a problem. Thus, the results gained after performing the Chiari osteotomy that significantly deviate from the average ones should be acknowledged with some reservations [28, 31, 33, 34, 35]. It is obvious that the triple osteotomy gives the opportunity of coverage improvement that is comparable with the one that is gained by performing the Chiari osteotomy, and significantly better than the improvement gained from the Salter osteotomy [34].

In the patients with LCP, the postoperative CE angle highly statistically correlated with postoperative joint containment and the postoperative CE angle increase. This confirms the sensitivity and uniqueness of these two types of hip coverage measuring, but also confirms the impact of CE angle correction by surgery at the final anatomic finding.

Of the total 136 patients, after the operation 61 patients featured spherical congruence, 62 patients featured aspherical congruence and 13 patients expressed joint incongruence. There was a highly significant difference in the type of performed operation regarding congruence: in the triple osteotomy group of patients, spherical congruence was the predominant finding, while in the other two groups of patients aspherical congruence was the most frequent finding. In the patients who underwent the Chiari osteotomy, such postoperative finding was partly the result of the specific age group that featured a biological remodeling potential, and partly the result of the fact that patients older than 14 years, who did not meet the triple osteotomy indications, were operated on using the Chiari osteotomy and without developing total incongruence. In accordance with the quotations from various studies, the effect of the Chiari osteotomy on the congruence enhancement of an already damaged joint is minor.

We established that over 60% of the patents suffering from Perthes disease were treated in the advanced stadium of the disease, when the radiographically verified fragmentation of the femoral head had already developed. Other

authors also state a similar percentage of patients in the advanced stadium of the disease, which confirms the global problem of early diagnosis and the need for a prompt treatment of Perthes disease [36].

The assessment of hip joint containment using the acetabulum-head index of Heyman-Herndon (HHI) is considered as very important, since it has been proved that this parameter is much more reliable than the CE angle of Wiberg, or in other words less dependable on the experience of the person conducting the measurements [3]. In patients with LCP, preoperative joint containment was 78.8% and postoperative 87.1%, with a high statistical difference and a high correlation of the results. Applying different surgical procedures brought no significant difference in the hip joint containment. On the other hand, there are studies indicating a bigger joint containment enhancement after the performed Chiari osteotomy (58% preoperatively, 97% at the end of follow-up) [28], and after the Salter osteotomy (60% preoperatively, 75% at the end of follow-up) [32]. In the subset of patients with LCP, a preoperative residual deformity featured in 28 patients, without any significant impact depending on the type of performed treatment.

In the patients suffering from PAN we detected a highly significant difference in postoperative deformity, regarding the type of performed treatment: no deformities featured in 75% of the patients after the triple osteotomy, and caput valgus deformity featured in 45% of the patients after the Salter osteotomy. In the Chiari group all the patients had some form of deformity and 45% had type 3 deformity. There was also a significant difference in the type of performed procedure and the type of preoperative deformity regarding the joint congruence. However, it is noticeable that the reconstructive osteotomies reorientating the acetabulum offer better biomechanical conditions for recovery of the damaged proximal femur than the Chiari osteotomy.

We were also enabled to quantify and more reliably evaluate each surgical procedure, so that further development and application could be followed and aimed in a scientifically justified and applicable manner, regardless of the number of studied patients, thus decreasing the need for perceiving the effect of surgery exclusively on a large, very hard to achieve, series.

The strongest predictor for choosing the triple osteotomy over the Chiari osteotomy is the presence of preoperative painful discomforts. The preoperative CE angle is considered as less powerful predictor. Thus, from all the observed parameters, the decision for choosing the triple osteotomy instead of the Chiari osteotomy is most consistent with the presence of painful discomforts and the anatomic relationship of hip coverage.

The most significant explainers of difference in the results regarding the Chiari osteotomy is postoperative hip congruence. This parameter has a negative sign, which points out the direction of proportionality: the absence of spherical congruence domination strongly distinguishes the results of these two groups, in favour of triple osteotomy. Less valid explainers are radiographic findings, such as postoperative increase of the CE angle.

Preoperative feature of painful discomforts is singled out as a strong predictor of indications for choosing the triple osteotomy rather than the Salter osteotomy. The data of prior treatment is a less strong predictor. Both parameters have a positive sign, meaning that pain feature and prior operative treatment with a statistically high significance determine the choice of the triple osteotomy.

In the groups of patients operated on using the triple and the Salter osteotomy (having in mind the sample formed of patients operated on using the triple osteotomy due to age comparability) parameters were assessed using the method of logistic regression and we defined postoperative increase of the CE angle as an explainer of effect.

Complications of the triple osteotomy [13-16]:

- One case of deep wound infection (1.3%), completely regenerated with early wound debridement and parenterally applied antibiotics. Such infection frequency is within the range of usual postoperative infection frequency in orthopaedic surgery.
- One case (1.3%) of discrete peroneal palsy, healed with corticosteroids, B vitamins and physical therapy without any consequences. Most likely the consequence of traumatic oedema of the ischial nerve due to harsher surgical work on somewhat lower osteotomy of the ischial bone and subsequent formation of haematoma. The finding is in accordance with the observations of other authors: according to Tonnis, this complication is expected in 1% of cases after performing the triple osteotomy, although various studies have reported this complication even in 4.6% of patients [18, 20]. Findings after the Chiari osteotomy are also comparable (1.1%).
- In seven cases we detected pseudoarthrosis, in two patients (2.6%) pseudoarthrosis of the pubis, and in five patients (6.6%) pseudoarthrosis of both pubis and the ischium. All pseudoarthroses were asymptomatic. No pseudoarthrosis of the iliac bone was detected. Other authors reported similar and even worse results, and also cases of painful pseudoarthrosis of the pubis that had to be operatively managed. There are authors who claim that pseudoarthroses are in positive correlation with age [6, 7, 11, 18, 20, 21, 30, 37]. All unhealed osteotomies are verified among the first operated patients in case of resection osteotomies. This leads to the conclusion that it is a matter of defect pseudoarthrosis as the result of too large resections during osteotomies and muscle interposition preventing bone contact and the usual good healing in such young patients.

CONCLUSION

In conclusion we may say that the triple pelvic osteotomy in adolescent age allows a total acetabular mobility and easy reorientation of the acetabulum, no increased pressure onto the femoral head, no significant difference in the postoperative leg length, good healing of the osteotomized bones (especially if the bone resection is not performed), and a prompt and total functional recovery.

Indications for the triple osteotomy include patients with hip dysplasia, with a preserved ability of establish-

ing congruence by anterolateral coverage (in the position of abduction and flexion of the upper leg) and patients older than 8-10 years with a preserved functional range of motion. In children up to 8-10 years the Salter osteotomy singles out as an adequate surgical procedure. In cases of distinctly different joint surfaces and developed degenerative changes, i.e. in cases of impossibility to establish hip congruence the Chiari osteotomy can provide pain reduction and improvement of joint function.

The modification of the original Tonnis technique by Vladimirov has been successfully adopted in our country, simplifying the surgical procedure, reducing the operative damage and accelerating the recovery.

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Трострука остеотомија карлице у лечењу дисплазије кука

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КРАТАК САДРЖАЈ

Увод Недовољна покривеност главе бутне кости је типична за многа ортопедска стања, а ацетабуларна дисплазија је најчешћи поремећај код којег се среће. Трострука остеотомија карлице је најновија хируршка метода лечења овога стања.

Циљ рада У раду су анализирани преоперационе и постоперационе патоанатомске одлике троструке остеотомије карлице у поређењу са остеотомијама по Салтеру (*Salter*) и Кјарију (*Chiari*).

Методе рада Истраживање је обухватило 136 адолесцената који су лечени Салтеровом, Кјаријевом или троструком остеотомијом карлице у Институту за ортопедско-хируршке болести „Бањица“ у Београду. У време операције болесници су били узраста од 10 до 20 година. Значајнима су се сматрали следећи подаци: анамнеза, преоперациони налаз, детаљи хируршког лечења, резултат након операције. У статистичкој обради материјала коришћени су програм *SPSS*, методе дескриптивне статистике и адекватни аналитички тестови: Студентов *t*-тест за зависне и независне узорке, χ^2 -тест, Фишеров (*Fisher*) тест, Вилкоксон (*Wilcoxon*) тест, тест корелације, једносмерна *ANOVA*, мултифакторска *ANOVA* и логистичка регресија.

Резултати Просечни Вибергов (*Wiberg*) угао (*CE*) после троструке остеотомије карлице био је 43,5°, већи него после Салтерових (33,0°) и Кјаријевих остеотомија (31,4°) ($F=16,822; p<0,01$). Потврђено је статистички значајном вероватноћом да је сферична конгруенција чешћи резултат после троструке остеотомије карлице него после друге две наведене врсте операција. Утврђено је да је заступљеност бола пре операције значајан индикаторни фактор који даје предност троструком остеотомији карлице у односу на Салтерову и Кјаријеву остеотомију. Битни показатељи ефекта троструке остеотомије карлице су: постоперациона зглобна подударност (у поређењу са Кјаријевом остеотомијом) и повећање зглобне наткровљености (у поређењу са Салтеровом остеотомијом).

Закључак Трострука остеотомија карлице је метода избора лечења ацетабуларне дисплазије и других поремећаја садржаности зглоба кука у адолесцентном добу.

Кључне речи: дисплазија кука; Вибергов (*Wiberg*) *CE* угао; трострука остеотомија карлице; показатељ ефекта; претпостављени исход