Triple pelvic osteotomy in the treatment of Legg-Calve-Perthes disease

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Abstract This article presents the results of Legg-Calve-Perthes (LCP) disease treatment using triple pelvic osteotomy. Thirty patients were analysed. The conditions for inclusion in the study were complete medical documentation and follow-up until the disease was resolved. Postoperatively, no patients were immobilised. Rehabilitation was initiated early in all patients, and full weight bearing was allowed after ten weeks. With this method, an increase of the CE angle of $17.43 \pm 4.020^\circ$ was achieved. Containment was increased from an initial 6.67% to 53.33% of patients at the final check-up. Similar improvement was achieved by using Herring classification of the damage; preoperatively most hips belonged to group C, and postoperatively to group A.

Postoperatively, functional results were also considerably improved. The authors recommend triple pelvic osteotomy as the method of choice in the treatment of severe cases of LCP disease.

Introduction

As much as one hundred years after the initial report and detailed description of Legg-Calve-Perthes (LCP) disease, there is still discussion regarding its treatment [7, 14, 17, 18, 24]. The best illustration of this is presented in the study of Hefti and Clarke from 2007 [11], which involved 151 members of the European Paediatric Orthopaedic Society (EPOS) who were offered four cases of LCP and asked to give their therapeutic propositions. The replies were diverse, from non-treatment to various modes of surgical treatment.

It is very difficult to standardise treatment for various reasons. Patients aged less than four years have a very good prognosis even without treatment, while those aged above ten years have a poor prognosis. In addition, treatment results depend on the degree of involvement of the disease; hip involvement up to 50% (Catterall types I and II) have better prognosis, while higher grade hip involvement (Catterall types III and IV) have considerably poorer prognosis [2, 11, 21, 24]. Naturally, treatment results are also influenced by the type of treatment; containment is best achieved by pelvic osteotomy (Salter or triple), which mostly results in spherical congruence of the hip, without leg shortening and gait disorders [2, 20, 24].

We are aware of all the methods that have been used; however, with the development of knowledge and experience, old methodologies (prolonged bed rest, different braces, revascularisation operations, varisation femoral osteotomies, Chiari pelvic osteotomy) have been discarded

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and the new ones (Salter pelvic osteotomy—alone or with femoral shortening, triple pelvic osteotomy) have been introduced. We decided that young patients without femoral head subluxation and/or risk signs should not be treated at all or treated with mild physical therapy and non-weight bearing in the phase of synovial effusion and pain, while others (older than four years of age, with femoral head subluxation and/or risk signs) should be treated surgically, primarily by pelvic osteotomy, isolated or combined with femoral shortening, as previously reported [24].

In 1996, we began to use the triple pelvic osteotomy described by Tonnis [1, 20] with some modification by Vladimirov [25]. The Vladimirov modification incorporates a more comfortable approach; at operation the patient is in supine position. Only two incisions are used; the iliac bone is approached through the Smith-Peterson's incision, while the pubic and ischial bones are approached through the common medial incision. By avoiding the posterior approach to the sciatic bone, during surgery the risk of ischial nerve damage is lowered.

The aim of this study was to present clinical and radiographic results of triple pelvic osteotomy in LCP disease and possible advantages of the method in relation to the previously used techniques.

Materials and methods

From 1996 to 2003, at the Institute for Orthopaedic Surgery “Banjica”, Belgrade, Serbia, 30 patients (30 hips) with LCP disease were treated by triple pelvic osteotomy according to Tonnis (modification of the technique by Vladimirov) [16, 23, 25]. All patients had complete clinical and radiographic data and with a minimum follow-up of three years. There were 28 male (93.3%) and two (6.7%) female patients. Mean age at surgical treatment was 10.0 ± 1.9 years.

Previously, 22 (73.3%) patients had been treated using various non-operative methods (prolonged bed rest, different braces). In two (6.7%) patients, the disease was bilateral, but only one hip was surgically treated.

At the time of surgery two (6.7%) hips were contained, 18 (60%) subluxated and ten (33.3%) subluxated with femoral head collapse. According to the stage of the disease (Waldenstrom classification) [2, 21], the hips were classified as follows: ten (33.3%) in the necrosis stage, 18 (60%) in the fragmentation stage, and two (6.7%) in the reossification stage. According to Catterall grading [2], the degree of epiphyseal involvement was: in group I ten (33.3%) hips, in group II four (13.3%), in group III six (20%), and in group IV ten (33.3%) hips.

The distribution of hips according to Herring classification [12, 13] was: six (20%) in group A, six (20%) in group B, eight (26.7%) in group B/C and ten (33.3%) in group C.

Twenty-six patients (86.7%) had at least one risk sign. The most frequent clinical risk signs included the presence of reduced range of motion (18 patients, 60%) and adductor contracture (12 patients, 40%). Radiographic risk signs included femoral head subluxation (18 patients, 60%), then horizontally positioned epiphyseal line (15 patients, 50%), Gage sign (11 patients, 36.7%), calcification laterally from epiphysis and diffuse metaphyseal changes (each 10 patients, 33.3%).

Radiographic assessment in preoperative, immediate postoperative and final evaluation periods, and classifications according to CE angle [1], phase of the disease by Hirohashi-Menelaus [11, 12], containment by Klisić-Menelaus [24], Catterall group grading and presence of risk signs [2, 24], as well as on the basis of Herring's classification [12, 13] were performed. Functional findings were evaluated according to the Harris hip score [10]. The results were additionally assessed according to Catterall [2], Goff-Mose [24], Harrison-Karpinski [7, 24] and Sponseller-Stulberg [21], as well as by measuring the time necessary to achieve a 45-degree active flexion of the operated hip [2, 21, 24].

In the statistical analysis and the study of statistical significance, methods of descriptive statistics, as well as *t*-test, χ^2 and Willcoxon test were used.

Postoperatively, none of the operated patients was immobilised; rehabilitation was initiated on the first postoperative day in all, and full weight bearing was allowed after ten weeks.

Results

Postoperatively, most hips were contained (Table 1; Figs. 1, 2, 3 and 4).

The distribution of patients according to epiphyseal damage was defined by Herring classification; the condition improved postoperatively and even more so at the final evaluation. Preoperatively only 12 of 30 hips were classified into groups A and B, postoperatively 15 hips belonged to those groups, and at the final evaluation 21 hips. At the beginning of the surgical treatment 18 hips belonged to groups B/C and C, while at the final evaluation only nine hips were classified into those groups (Table 2).

Using the Willcoxon test, we detected a significant difference between the preoperative and final findings ($W=98$, $W=22$, $p<0.05$). At the beginning of treatment group C prevailed and at the end it was group A.

Preoperative CE angle was 20.40 ± 3.18 degrees, the initial postoperative CE angle was 39.40 ± 7.85 degrees, while the final CE angle was 37.83 ± 5.37 degrees. Accordingly, the operation resulted in the increase of the CE angle of 7.43 ± 4.02 degrees, with a highly significant difference between the preoperative and the final postoperative findings ($W=667$, $p<0.01$).

Table 1 Distribution of patients according to hip containment

Group	Preoperatively	Postoperatively	Follow-up
Contained hip	2 (6.67%)	26 (86.67%)	16 (53.33%)
Subluxated hip	18 (60.00%)	0 (0%)	11 (36.67%)
Subluxated and collapsed femoral head	10 (33.33%)	4 (13.33%)	3 (10.00%)

Preoperatively, the mean Harris hip score (HHS) was 76.73 ± 8.38 , postoperatively it was 94.50 ± 4.33 , and at the final evaluation it was 94.63 ± 2.16 . There was a high statistical significance between the value of the preoperative

and the final average HHS ($t = -15.762$, $p < 0.001$). However, there was no statistically significant difference between the average postoperative and final values ($t = -0.328$, $p > 0.05$).

Preoperatively, seven (23.3%) patients had normal gait, two (6.7%) waddled (due to weakness of pelvitrochanteric muscles and positive Trendelenburg sign) and 21 (70%) patients limped. Postoperatively, 18 (60%) patients had normal gait, while 12 (40%) patients limped. In the final assessment, only three (10%) patients limped, while 27 (90%) walked normally. The difference between the initial and final findings was statistically highly significant, as confirmed by Willcoxon test ($W^+ = 273$, $W^- = 3$, $N = 23$, $p < 0.001$).

Average values of the range of motion preoperatively, postoperatively, and at the end of follow-up period are presented in Table 3.

Regarding the preoperative findings, a highly significant difference was seen in the final motion of extension ($t = -2.765$, $p < 0.01$), abduction ($t = -4.349$, $p < 0.01$), adduction ($t = -3.149$, $p < 0.01$) and internal rotation ($t = -8.27$, $p < 0.01$). Flexion showed a statistically significant increase in range ($t = -3.10$, $p < 0.05$), while external rotation had no statistically significant difference ($t = -1.7$, $p > 0.05$). The analysis was made using *t*-test to analyse the difference between the samples.

Preoperative leg length discrepancy was 1 cm in seven patients, with a mean of 0.25 cm for the whole group. Postoperative shortening average was 0.23 cm, and at the end of follow-up it was 0.1 cm.

According to Catterall classification [2], good outcome was achieved in eight (26.7%), satisfactory in 16 (53.3%) and poor in six (20%) patients. According to Goff-Mose classification [24], there were no cases of spherical femoral head at the end of the follow-up period, round head was present in eight (26.7%), ovoid in 14 (46.6%), contained and improved in two (6.7%) and poor in six (20%) patients. By grouping the results according to Harrison-Karpinski [7, 24], two (6.7%) patients had excellent results, 20 (66.7%) good and eight (26.6%) were considered fair. According to Sponseller-Stulberg [21], spherical congruence was detected in eight (26.7%) hips, aspherical congruence in 21 (70%) hips, while incongruence was seen in one (3.3%) patient only.

We analysed the influence of preoperatively determined containment according to Klisić-Menelaus [24] onto the final assessment by Sponseller-Stulberg [21]. It was assessed that there was no statistically significant difference

Fig. 1 **a** Legg-Calve-Perthes (LCP) disease of the right hip in a nine-year-old boy, preoperative anteroposterior (AP) view. **b** LCP disease of the right hip in a nine-year-old boy, preoperative lateral view. **c** The same patient, now a 12-year-old boy, three-years postoperative from triple pelvic osteotomy, AP view

Fig. 2 **a** Legg-Calve-Perthes (LCP) disease of the left hip in a ten-year-old boy, preoperative anteroposterior (AP) view. **b** LCP disease of the left hip in a ten-year-old boy, preoperative lateral view. The same patient, now a 14-year-old boy, four-years postoperative from triple pelvic osteotomy with AP (**c**) and lateral views (**d**)

in the final congruence in relation to the preoperative containment ($\chi^2=8.698$, $p>0.05$). We also analysed the influence of the preoperatively determined degree of epiphyseal involvement according to Catterall [2] on the finally assessed congruence according to Sponseller-Stulberg [21]. We found that there was no statistically significant difference in the final congruence in relation to the preoperative degree of epiphyseal involvement ($\chi^2=10.250$, $p>0.05$).

Active flexion of 45 degrees of the operated hip was achieved after an average of 9.03 ± 1.68 days. In this group of patients, there were no complications.

Discussion

There are many reports on triple pelvic osteotomies [1, 3–6, 8, 9, 15, 19, 20, 22], mainly regarding their application in hip dysplasia.

In LCP disease, triple pelvic osteotomy has been cautiously introduced more recently, and mostly in older children where hip containment was not easy to achieve using Salter pelvic osteotomy. Its use was mostly initiated by those who had already stopped prolonged conservative treatment. It was also used because at the end of disease course all that remained was a large insufficiently covered femoral head which later required surgical coverage; and it was also by those who rejected varisation osteotomies

because of the functional problems manifested by postoperative shortened leg and waddling gait [1, 3–5, 7, 11, 13, 14, 16, 17].

We also approached the problem cautiously. First, we added shortening of the femur to Salter pelvic osteotomy in older children with more severe subluxations, which enabled us to achieve the required containment more easily and to obtain good anatomical and functional treatment results [24]. Initially, following femoral osteotomy, we used immobilisation in children, which in the later course of treatment necessitated prolonged rehabilitation. With time, we stopped using immobilisation during the postoperative period, which enabled early rehabilitation. However, weight bearing was only allowed after the femoral osteotomy healed, which usually took a longer time than the bone consolidation of the pelvic side.

We were motivated to introduce triple pelvic osteotomy in the treatment of LCP disease by the possibility of shortening the period of treatment, and, with similar anatomical results to accelerate functional recovery, bearing in mind the psychosocial aspects of the long absence of the child from his natural environment. In 1996, we started to use triple pelvic osteotomy and, by 2003, we had operated on 30 children.

We respected the principles of many authors [1, 12], namely, that the indication for surgery was the presence of hip non-containment (93.3% patients), i.e. the presence of at least one risk sign (86.7% patients). In addition, in 80% of patients epiphyseal damage was classified in groups B

Fig. 3 **a** Legg-Calve-Perthes (LCP) disease of the left hip in a ten-year-old boy, preoperative anteroposterior (AP) view. **b** LCP disease of the left hip in a ten-year-old boy, preoperative lateral view. **c** The same patient, now a 13-year-old boy, three-years postoperative from triple pelvic osteotomy, AP view

and C according to Herring; and according to Catterall, in 66.7% of patients the degree of damage was 50% and higher (groups grade II, III, IV).

The final CE angle, as the best indicator of the hip containment, showed an increase of 17.43 degrees, which was higher than in the previously reported group [24], when it was 14.98 degrees. This indicates the extensive possibilities of pelvic triple osteotomy to improve containment of the preoperatively non-contained hip. Similarly, even better results (increase of 22 degrees) were reported by Kumar et al. in their series of patients [17].

Postoperatively a high percentage of contained hips (86.7%) was achieved; unfortunately, at the final evaluation

Fig. 4 **a** Legg-Calve-Perthes (LCP) disease of the left hip in a nine-year-old boy, preoperative anteroposterior (AP) view. **b** LCP disease of the left hip in a nine-year-old boy, preoperative lateral view. **c** The same patient, a ten-year-old boy, one-year postoperative from triple pelvic osteotomy, AP view. **d** The same patient, now a 14-year-old boy, five years postoperative from triple pelvic osteotomy, AP view

Table 2 Distribution of patients concerning epiphyseal damage according to Herring

Group	Preoperatively	Postoperatively	Final
A	6 (20.00%)	8 (26.67%)	11 (36.67%)
B	6 (20.00%)	7 (23.33%)	10 (33.33%)
B/C	8 (26.67%)	7 (23.33%)	1 (3.33%)
C	10 (33.33%)	8 (26.67%)	8 (26.67%)

the percentage of the contained hips decreased (53.3%) due to the development of the deformity of type coxa magna. Nevertheless, the difference showed a statistically highly significant difference between the preoperative condition and the outcome.

Based on the Herring classification [12, 13], there was postoperative improvement, particularly at the end of the follow-up period. Group C prevailed at the beginning, and group A at the end of treatment, with a statistically significant difference.

The functional recovery period was short due to early immediate postoperative rehabilitation, maintaining the range of movement and promoting an early weight bearing. There was a statistically significant difference of the HHS between preoperative and final values. The quality of gait was very good in 90% of patients, which is another significant difference. One factor that most likely contributed to the gait was the small leg-length discrepancy, as the postoperative shortening of the affected limb was insignificant with an average of 0.1 cm.

Using additional methods to assess the results, we found that they were good in most patients (according to Catterall [2] and Goff-Mose [24] classifications only 20% of patients had poor results, according to Harrisson-Karpinski [7, 24] there were no poor results, and according to Sponseller-Stulberg [21] there was only one hip marked as incongruent). The different incidence in poor treatment outcome obtained when using different classification systems resulted from a different number of categories within each system, as well as in the strictness difference of the designated classification requirements.

The results were mainly good due to easily achieved containment; similar results were reported by Grzegorzewski

et al. [7] (63% satisfactory results according to Mose classification and 74% satisfactory results according to Stulberg et al. classification).

No influence of preoperatively determined containment (according to Klisić-Menelaus [24]) was found on the finally assessed congruence according to Sponseller-Stulberg [21]; on this basis, it could be considered that the surgery contributed to good results. In addition, there was no statistically significant difference in the final congruence in relation to the preoperative degree of the affected epiphysis according to Catterall [2].

Although there were complications in the total series of triple pelvic osteotomies (seven cases of ischial and pubic bone pseudoarthrosis, one case of peroneal paralysis, one case of infection) [24, 25], in this series of patients, we had no complications. Other authors reported much larger incidence of complications [9, 14, 22].

By using triple pelvic osteotomy in the treatment of Legg-Calve-Perthes disease, we achieved very good anatomical and functional results. The anatomical results were similar to those achieved by other surgical treatment methods (varisation osteotomy of the femur, Salter pelvic osteotomy combined with femoral shortening) [25], which was also reported by Sponseller et al. [24], while functional results were even better.

By using triple pelvic osteotomy, we achieved a statistically significantly better coverage of the femoral head. The initial CE angle was 20.4 ± 3.18 degrees and final 37.83 ± 5.37 degrees ($t = -23.0$, $p < 0.01$). In the previous study, when using Salter osteotomy with femoral shortening, the average increase of CE angle after surgery was 14.98 degrees; there was no statistically significant difference between this and the improved CE angle achieved by triple osteotomy (the probability that these samples belong to the same group with a normal distribution of 0.0824).

The functional recovery period was highly statistically shorter when compared to Salter osteotomy with femoral shortening; the patients who underwent triple osteotomy achieved active flexion of 45 degrees in supine position after 9.03 days on average, and after 45 days when Salter osteotomy with femoral shortening was used.

The suggested triple pelvic osteotomy can also be regarded as preventive; if it is performed before the phases

Table 3 Average values of motion range

Motion	Preoperatively	Postoperatively	Follow-up period
Flexion	109.00±10.54	110.33±16.81	117.33±13.88
Extension	-3.50±11.23	0.50±9.32	6.00±12.21
Abduction	25.83±10.09	27.17±7.39	35.83±8.42
Adduction	20.00±6.70	18.83±6.39	26.50±10.27
External rotation	23.67±10.74	22.50±6.53	27.33±11.94
Internal rotation	11.33±8.70	14.00±8.65	23.83±9.53

of hip subluxation and femoral head collapse, it can secure a better remodelling of the femoral head, which is the major condition for the prevention of early secondary coxarthrosis in patients with LCP disease.

Some authors [7, 11–14, 18] have reported that if such treatment is initiated in the phase of fragmentation, there is a possibility to correct or eliminate some risk signs (primarily femoral head subluxation and limited hip abduction), which then additionally improve later results.

The principle of the use of the triple pelvic osteotomy concerning the sphericity of the femoral head as a condition *sine qua non* seems to be broken, especially in LCP disease. Even saddle-like deformities of the femoral head can be corrected [20, 24, 25].

The main advantages of triple pelvic osteotomy are in the achievement of excellent containment, quick bone healing, reliable bone fixation which postoperatively allows patients to avoid immobilisation and to undergo early rehabilitation with early full limb weight bearing.

Triple osteotomy allows the possibility of earlier foot support (on average 2.5 months) as compared to Salter osteotomy with femoral shortening (on average 3.1 months) [24]. It also avoids of increased pressure on the femoral head and of the difference in the length of extremities; a shorter duration of hospital stay (total duration of hospital treatment was shorter in triple pelvic osteotomy with an average of 3.2 months in relation to the Salter osteotomy of 4.1 months) [24, 25].

The authors recommend triple pelvic osteotomy as the method of choice in the treatment of severe LCP disease in all patients in whom treatment cannot be achieved using Salter osteotomy due to the patient's age, regardless of the disease stage, initial containment and the degree of damage.

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