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Research Article

Treatment of Legg-Calve-Perthes Disease Using Early Transphyseal Neck-Head Tunneling Combined with Late Hip Arthrodiastasis with the Ilizarov Apparatus. Comparative Study with Varus Intertrochanteric Osteotomy

Nuno Craveiro Lopes*

Orthopedic Department, Hospital Cruz Vermelha Portuguesa, Lisbon, Portugal

***Corresponding Author:** Dr. Nuno Craveiro Lopes, Orthopedic Department, Hospital Cruz Vermelha Portuguesa, Lisbon, Portugal.*

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Abstract

Introduction: Late-onset Perthes disease usually carries a poor prognosis. In these cases, there may be increasing pain, a decreased of range of motion and hinge abduction which is a contraindication for surgical containment, as femoral varus osteotomy and pelvic osteotomy. In these cases, hip arthrodiastasis may be a valuable tool to solve such condition.

Methods: The authors compare the results of a group of 15 patients treated by arthrodiastasis with an Ilizarov frame (ADT) with a group of 13 patients treated by intertrochanteric osteotomy (OTM). The ADT group included twelve boys and three girls, was treated between 2000 and 2008, with a mean follow up of 8 years. The OTM group consisted of 11 boys and two girls, treated between 1979 and 1989, with a mean follow up of 6 years.

To proceed to ADT, we used a frame with two Ilizarov arches fixed in the supra-acetabular zones and in the proximal femur with 6 mm conical pins with hidroxyapatite in three-dimensional position, maintaining an articular distraction of 8-10mm for an average of three to five months. The osteotomy technique in the OTM group included a triple effect wedge with excision of a anterior-medial bone fragment, stabilized with an Synthes pediatric plate.

We collected data about the severity of injury, operative time, need for blood transfusion, time to onset of deambulation and complications. We assessed the radiological final result based on measurement of epiphyseal and cervical index, epiphyseal, acetabular and Wiberg angle and articular deformity by the Stulberg classification. For assessing the functional clinical outcome, we analyzed the leg length discrepancy and determined the "Harris Hip Score". The statistical analysis of the significance of differences was performed using the student test and Fisher exact test.

Results: The comparative study with data based evidence, showed that the ADT group:

- Presented results slightly better but not statistically significant, with regard to neck length.
- Presented significantly better sphericity of the head, joint congruence and less joint deformity, less residual sequelae, particularly with regard to the existence of varus deformity and leg length discrepancy.
- Had significantly better functional outcome as measured by the Harris Hip Score.
- Unlike the OTM group, had no complications or sequelae that could lead to new interventions.
- The surgical procedure was significantly faster, had no blood loss, patients began to walk with support significantly earlier and did not require a second surgery for hardware removal.

Keywords: *Perthes; Osteotomy; Varization; Arthrodiastasis; Distraction; Legg-Calve-Perthes; osteonecrosis; avascular necrosis*

Introduction

There are consistent reports in the literature that the onset of Legg-Calve-Perthes disease (LCPD) in children over 6 years of age, usually has a worse outcome than in younger children. In this age group it is not uncommon the development of a hip subluxation, uncontained in the acetabulum, commonly known as a "hinge hip" [1,2,3,4,5,6,7,8]. This condition represents a challenge to treat using the standard surgical approaches [1,7,9,10,11,12]. In these cases, hip arthrodiastasis (ADT) may be a valuable tool to treat such condition [13,14,15].

The rationale of ADT in LCPD is based on its ability to reduce the subluxation of the femoral head and to decompress the hip joint, therefore protecting the head during the fragmentation stage. Moreover, the diastasis of the joint space, will allow the epiphysis to regain its spherical shape during the fragmentation stage due to the combined elastic memory of the articular cartilage and vacuum effect [13,16].

One of the obstacles is that distraction devices are only well tolerated by patients for a limited time, not being infrequent the presence of recurrent pin site infection, loosening of the pins and pain, requiring removal, often before the femoral head has regained enough consistency so as not to collapse again [13,14,16].

To avoid these facts, our treatment protocol for LCPD on children older than 5 years old, includes a transphyseal neck-head tunneling of the femoral neck and head (TNHT), done at the earliest possible time on the necrotic stage. This procedure has shown both experimentally and clinically to accelerate the development of the natural history of the disease [17,18]. After TNHT, we use a hip flexion-abduction orthosis or non weight bearing to protect the joint. If during the reconstruction stage a hinge hip develops, then we proceed with ADT.

Our experience with TNHT on LCPD from 1971 to 2008, includes 143 cases. Of these cases, only 17% (31 cases) required contention surgery for hinge hip. At the beginning of our series, 13 patients underwent a triple effect femoral osteotomy (OTM) [2,19]. Later on, we performed pelvic osteotomies in 3 cases and on the latest period, ranging from 2000 to 2008, we have performed ADT on 15 cases [4,17,19].

In this paper, the authors compare the results of the group of 15 patients treated with ADT with a group of 13 patients previously treated by OTM, fixed with plate and screws according to the technique described previously by the author [2,19] (Fig.13).

Materials and Methods

From 2000 to 2008, a total of 15 patients, 12 males and 3 females, were treated with TNHT followed by ADT. The control group treated by TNHT followed by a period of bed rest with traction to reduce the subluxation and triplanar OTM fixed with a Synthes pediatric blade-plate, supplemented in most cases with a pelvi-podalic plaster for 2-4 weeks, was treated between 1979 and 1989 and consisted on 13 patients, 11 males and 2 females.

Surgical technique

The surgical technique for TNHT has been described in previous papers [2,17,18,19]. It is indicated at the stage of necrosis or early fragmentation of LCPD. We use a 4.5mm cannulated drill or trephine, a tunnel is drilled aimed to the center of the necrotic bone (usually at the transition of the middle and lateral 1/3 portion of the epiphysis); the entry point is located at the lateral proximal metaphysis of the femur, passing through the middle of the growth cartilage and stopping at the subchondral epiphysis. The patient is placed on a radio-lucent table with the lower limbs draped free, using a c-arm, always kept perpendicular to the operating table. The affected limb is positioned in internal rotation in order to place the neck of the femur parallel to the ground; a Kirchner wire is used as an aiming device placing it on the anterior aspect of the hip to determine the proper level of the drilling procedure, as well as the proper entry point of the guide wire at the lateral side of proximal metaphysis of the femur. A stab wound is created for the introduction of the guide wire (Fig.1); fluoroscopic control is recommended after about 2 cm of insertion of the guide wire, using the C-arm on the anterior-posterior plane with the limb in neutral position, and on the lateral view by flexing the hip and knee at a 90º angle. On the a-p plane the guide wire should aim to the transition of the middle and lateral 1/3 of the epiphysis, and on the lateral view to the transition of the middle and anterior 1/3 of the epiphysis (Fig.2).

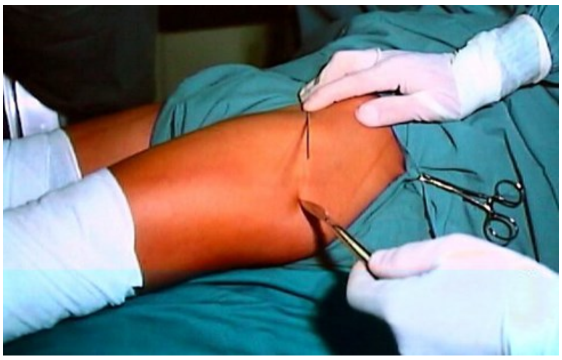

Fig.1 *– Determining the proper level and entry point of the guide wire.*

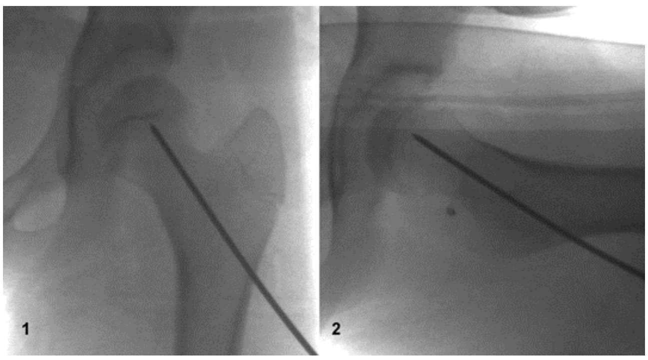

Fig.2 *– Introduction of the wire guide (1) a-p and (2) profile*

After confirming proper positioning, the guide wire is further inserted and stopped right before the level of the growth plate. Then the 4.5 mm cannulated drill is introduced with a hand drill or with a low-speed drill all the way to the subchondral bone of the epiphysis (Fig.3 and 4). If desired, a bone cylinder of the epiphysis can be obtained for research purposes, by replacing the cannulated drill with a trephine of the same diameter, right before starting drilling through the growth plate.

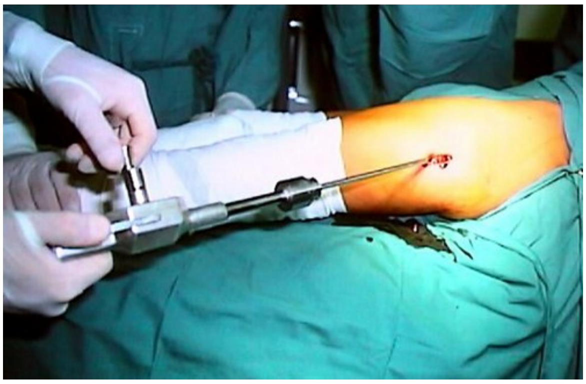

Fig.3 *– Introduction of the cannulated drill or trephine.*

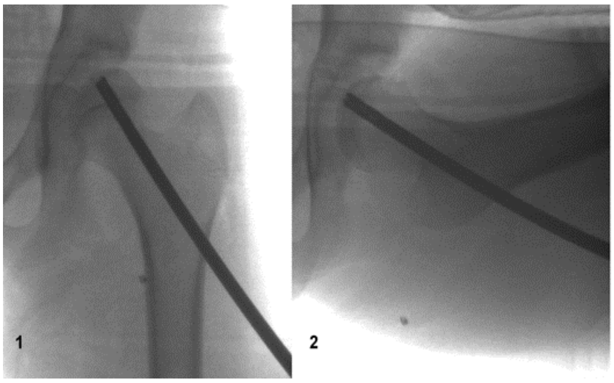

Fig.4 *– (1) a-p and (2) profile control of the position of the tip of the trephine on the subchondral bone.*

The patient is allowed to walk the day after surgery using an abduction orthosis or doing non weight bearing with crutches (Fig.8).

If during the course of the disease a "hinge hip" develops, with the classical signs of a stiff hip joint, subluxation of the head and lateral collapse of the epiphysis, an arthrodiastasis is indicated.

To obtain a stable ADT, we use a non hinged device assembly with components of the Ilizarov apparatus, fixed in the supra-acetabular region and proximal femur, with conical 6mm threaded pins covered with hidroxyapatite, introduced on 3 different planes of space. This assembly is simple, robust and well tolerated by the patient. The device is pre-assembled with two 100° arches joined by 3 threaded rods. We add an extra extension rod to place a third pin in the shaft of the femur in order to better control the femoral lever arm (Fig.5).

For the application of the device, the patient is positioned supine in an orthopedic traction table with the affected limb in 15º abduction and with medial rotation and 20º of flexion, to center the necrotic zone inside the acetabulum, while the opposite limb is in maximal abduction. Traction is applied in order to achieve a joint diastasis of about 8 to 10mm. The pre-assembled unit is then fixed to the hip, with three 6 mm conical threaded pins with HA in the supra-acetabular region, 2 in the trochanteric area, the proximal one transversing the trochanteric growth plate to slow down its growth and one in the shaft of the femur. Before locking the femoral pins to the device, medial translation is done pushing on them, thus reducing the lateral subluxation of the femoral head (Fig.6).

Next, traction on the limb is released, the knee is mobilized in flexion and extension several times, and distraction is applied on the frame to maintain the desired 8-10mm joint diastasis. The patient is allowed to walk the day after the surgery, with partial weight bearing using crutches.

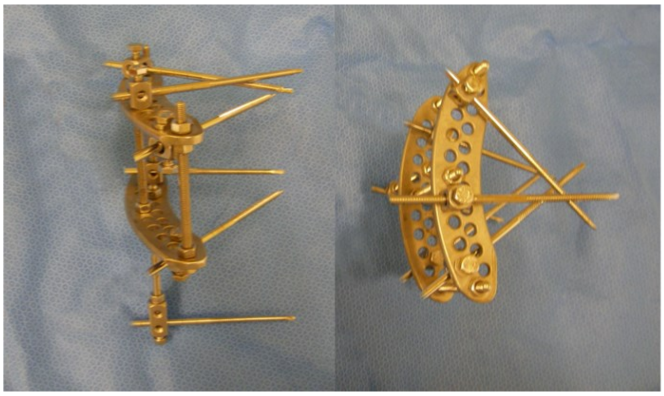

Fig.5 *– Pre-assembled Ilizarov frame with pins on 3 planes of space and extension rod to the shaft of the femur.*

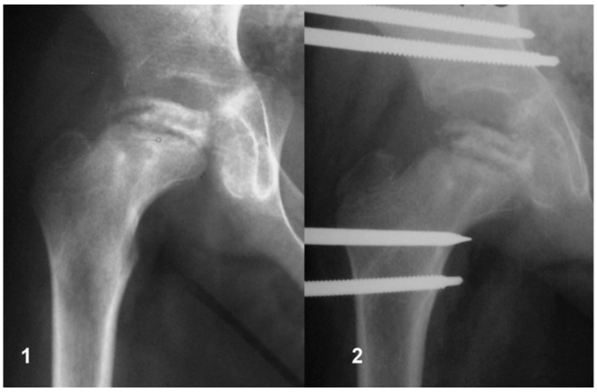

Fig.6 *– (1) LCPD with hinge hip. (2) Longitudinal pressure over the pins and translation of the femur to reduce subluxation.*

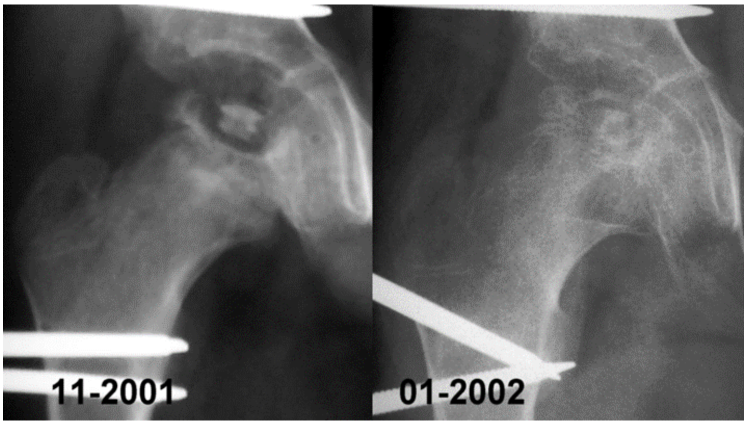

Fig.7 – *(1) Arthrodiastasis on fragmentation stage. (2) Artrodiastasis on inicial reconstruction stage with sub-chondral ossification.*

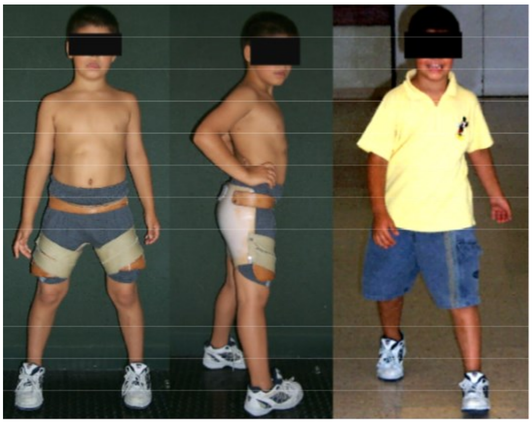

Fig.8– Abduction-flexion orthosis used after TTCC and ADT

Post operative control of the distraction, maintenance of the device and patient follow up is done every month. Our routine wound control protocol of the skin entry points, includes a daily shower with tap water, followed by application of a povidone-iodine foam solution, then drying with a clean towel and final disinfection with a dermal solution of the same product without applying any dressings to cover the wounds (Fig.9). When radiological signs of reconstruction with evidence of subchondral ossification are detected, usually after 3-4 months of treatment, if necessary using a CAT scan, the device is then removed at our outpatient clinic, under a mild sedation as an outpatient procedure (Fig. 7). After frame removal, the patient starts active and passive mobilization of the affected limb on daily basis with the exercise protocol recommended by Standard and Paley [16], associated with activities that warrant multidirectional mobilization of the hip without weight bearing, such as hydrotherapy, swimming, hippotherapy, bicycleting, etc. During his daily activities, the patient is non weight bearing with crutches for a period of 8 weeks full time.

Fig.9 – Ilizarov frame for arthrodiastasis. Patient doing his daily shower without dressings.

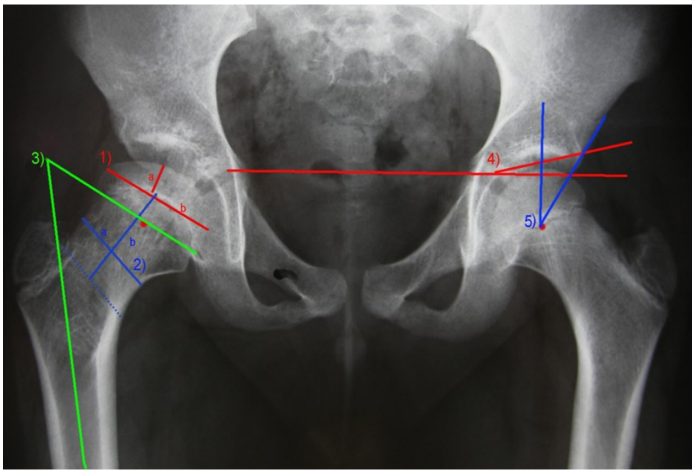

Fig.10 – Radiological evaluation. 1 - Epiphyseal index (a/b x 100). 2 – Cervical index (a/b x 100). 3 - Epiphyseal angle. 4 – Acetabular angle. 5 – Wiberg angle (Center-Edge).

Clinical and radiological evaluation

Radiographic follow-up of these patients was based on an A-P film, following the different criteria described in previous papers [20,21,22,23], including:

1 - Severity of injury using the Herring classification [7].

2 - Epiphyseal index (height/diameter of the epiphysis x 100). Normal values, between 55 and 75%. Lower values indicate gradual flattening of the epiphysis (Fig.10.1).

3 - Cervical index (diameter/length of the neck x 100). Normal values, between 65 and 90%. Higher values indicate progressive shortening of the neck. Values exceeding 110%, especially when associated to low values of epiphyseal angle, correspond to a positive Trendelenburg sign (Fig.10.2).

4 - Epiphyseal angle (angle between the plane of the growth cartilage and the axis of the femoral shaft). Normal values, between 55º and 70º. Lower values indicate varus deformity. Values lower than 35º, especially when associated with high values of cervical index, correspond with a positive Trendelenburg sign (Fig.10.3).

5 - Acetabular angle (angle between Hilgenreiner line and the line of acetabular inclination). Normal values, between 5º and 15º. Higher values indicate progressive acetabular dysplasia (Fig.10.4).

6 - Wiberg Angle "Center-Edge" (angle between the perpendicular to the line of Hilgenreiner and the acetabular rim, passing through the center of rotation of the femoral head). Normal values, between 20º and 40º. Lower values indicate poor head coverage by the acetabulum due to coxa magna/subluxation of the femoral head. An angle less than 10º, indicates progressive lateral subluxation of the femoral head (Fig.10.5).

7 - Calibrated limb length discrepancy.

8 - Congruence and joint deformity by Stulberg classification [24].

Operative time, the need for blood transfusion, time until the beginning of walking and complications of the procedures were recorded.

To measure clinical and functional outcomes, we used the Harris Hip Score [25], including assessment of pain, function, daily activities, range of motion of the hip and leg length discrepancy.

For the statistical analysis, we used the Student t-test for quantitative independent variables, accounting for data with equal and different variances. For qualitative variables, we used the Fisher exact test. We considered a statistically significant difference when $P<0.05$, and a very statistically significant difference when $P<0.005$.

Results

Characterization of the groups

The mean age of the ADT group was 7.3 years (5 to 10) and for the OTM group was 7.2 years (4 to 10). Follow-up for the 2 groups were 8.1 years (4 to 16) and 6.4 years (2 to 17), respectively, this data was not statistically significant (p=0.09). Likewise, the difference between the severity of injury in both groups, in all cases Herring group B and C, was not statistically significant (P=0.33).

The operative time was statistically much lower in the ADT group ($P<0.0005$), with an average of 28 minutes (20 to 40) compared with an average of 60 minutes (45 to 70) on the OTM group, as well as the blood loss, with a mean of 64.4cc on the ADT group (30 to 100) and 650cc on the OTM group (300 to 900).

Time until walking with crutches, was also statistically very different, being lower in the ADT group, with a mean of 3 days (2 to 4) than in the OTM, on average 42 days (35 to 56).

Patients were subject to arthrodiastasis on average 6 months after TNHT (4 to 9) and used the fixator for an average of 14 weeks (10 to 18).

Radiological evaluation

Epiphyseal Index of the ADT group had mean value of 31.8% (23 to 38.13) and the OTM group, 28% (17 to 36.7), values that were significantly different (P=0.03).

The cervical index mean values for the 2 groups were 107% (67 to 191) and 96.8% (68 to 123) respectively, this difference was statistically not significant (P=0.26).

The epiphyseal angle, however, showed values with very significant statistical difference (P=0.005). The ADT group had a mean of 69º (50 to 87) and the OTM group, 49.6° (31 to 72).

The mean acetabular angle showed no statistically significant differences in the 2 groups (P=0.08), with 12.8º (7 to 15) and 16.3º (8 to 28) respectively.

The angle of Wiberg (center-edge), also, did not show statistically different values (P=0.44), with 19° (13 to 28) and 19.4° (5 to 40) respectively.

Measurement of leg length discrepancy showed a difference on the 2 groups, statistically very significant (P=0.001), with the ADT group with residual leg length discrepancy of mean -1.3 mm (+8 to -9) and the OTM group with -21mm (-10 to -38). 6 of those patients presented more than 20 mm of leg length discrepancy.

The evaluation of congruence and joint deformity by Stulberg classification showed Stulberg type II and III results in both groups. The percentage of cases of Stulberg type III in the ADT group was 28.5%, while in the OTM group was 45.5%. This difference was statistically significant (P=0.037).

In all the patients that underwent arthrodiastasis, the frame was removed in an outpatient basis with a mild sedation. The only problems encountered were superficial infections of the pins in 5 cases, treated with proper wound care and oral antibiotics at the outpatient clinic.

All the patients in the group that underwent osteotomy required a second major procedure for hardware removal, under general anesthesia at the operating room, with a mean stay in ward of 3 days. In this group, there were complications in 4 patients: 3 patients had an exaggerated varus osteotomy resulting in a limping gait, with Trendelenburg gait due to severe leg length discrepancy, coxa vara and breva, and one case of deep infection that required hospitalization for intra-venous antibiotics and hardware removal at 8 weeks of the initial procedure, with healing of the infection.

Final functional evaluation

The evaluation of the final functional outcome by the Harris Hip Score, showed for the ADT group an average score of 98% (96 to 100) and for the OTM group, 94% (88 to 100), values with statistically significant differences (P=0,02).

Discussions

It has been shown experimentally [18] and clinically by other authors [26], and confirmed by the author [4,17] that the drilling of a tunnel representing less than 10% of the total area of the growth plate, as we do in TNHT, does not impair nor slow the growing of the growth plate. The drilling procedure we perform, represents less than 5% of the area of the growth cartilage of the femoral head in a 5 or more years old child, allowing a wide safety margin. We noted that the drilling procedure induces an acceleration of the natural history of the disease, shortening the time until the stage of reconstruction in 1/3 or half the time usually seen, while improving the conditions for reconstruction, due to increased arterial blood supply and venous drainage of the epiphysis [17,18].

It is our belief that TNHT associated to arthrodiastasis, allows a shorter and more effective external fixator usage, which in our patients was on average 3-4 months, unlike the average of 4-6 months established by other authors [8,13,14,15,27].

Several authors have described the effectiveness of arthrodiastasis using monolateral fixators. However, the weak bio-mechanical characteristics of those fixators impose the release of periarticular soft tissues or Botox injections, gradual distraction and non-weight bearing with crutches during the whole length of the procedure, to prevent instability of the frame, adduction deviation, infection, loosening, breakage or failure of pins and parts of the fixator, as stated by all authors [13,14,15,16,27,28,29,30,31]. The high incidence of these problems led to the addition of circular components to the most commonly known monolateral fixators in a attempt to overcome instability.

Kocaoglu[32], presents the only published work that we had access to, on the use of the Ilizarov apparatus in Perthes disease. This author used a long and complex Ilizarov frame very early on the fragmentation stage, with placement of pins in the iliac crest, with a low rate of success.

The assembly of the Ilizarov frame described by the author results in a more robust and stable construction with the use of arches and fixation with 6 mm threaded conical pins covered with HA in a three-dimensional construction. In our hands, this device was more robust and versatile and simple to use than the monolateral devices, allowing an acute dis-traction during the surgical procedure. Supplementary tenotomies or Botox are not needed to increase the stability as in the monolateral frames. In our series, there were any cases of loosening, broken pins or varus deviation during all the treatment periods.

Several authors [8,27], stressed the need to initiate treatment at the stage of necrosis or early fragmentation, before the onset of collapse of the femoral epiphysis, in order to maintain the sphericity of the femoral head. However, introduction of the frame in a early stage of the disease with long fixation, will determine the appearance of intolerance to the device, before signs of sound reconstruction are noted. Removal of the fixator before sufficient reconstruction has a high risk of relapse of epiphyseal collapse [14,27,30,31,32].

We only recommend the use of arthrodiastasis if patients develop collapse of the epiphysis during the fragmentation stage and clinical and radiographic signs of a "hinge hip”. In this stage of the disease the contents of the epiphysis are in a plastic stage and the combined effect of the elastic memory of the articular cartilage, intra-articular vacuum and the ef-fect of distraction, allows the return of its sphericity (Fig.11).

In our patients, ADT was started in advanced fragmentation stage, on average 9-10 months after onset of the disease and 5-6 months after the TNHT procedure. In all cases it was possible to re-gain the sphericity of the epiphysis and reaching the stage of reconstruction with subchondral ossification, permitting the removal of the frame on average after 3-4 months, without recurrence of the collapse (Fig.12).

All the references we revised [13,14,15,16,27,28,30,31,32,33,], mentioned the use of articulated frames. However, in most studies, it appears that such a practice is usually difficult and painful for the patient, eventually leading to an atti-tude of hip flexion with a restricted range of motion during frame wear. Moreover, an articulated frame is more difficult and time consuming to apply, so that the hinge is perfectly aligned with the center of rotation of the femoral head, leav-ing little or no room for error.

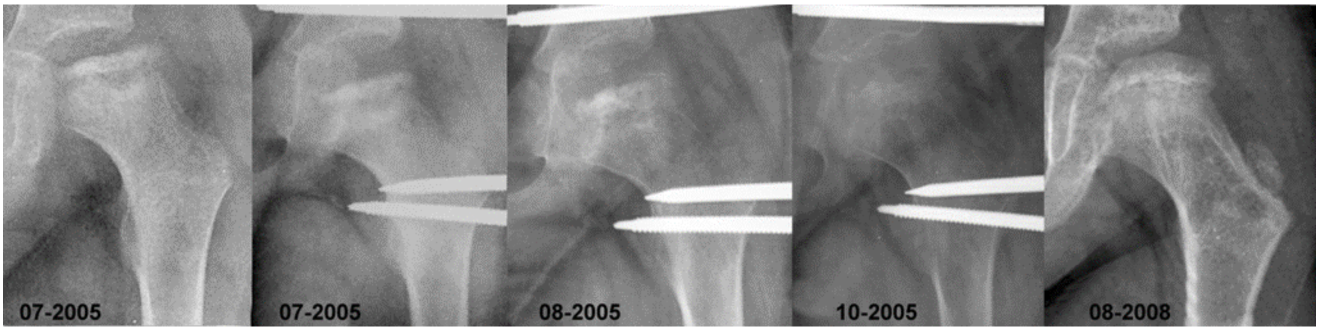

Fig.11 *– L.F. Male, 6 yo. Herring C, with “hinge hip”. Evolution along 3 months of arthrodiastasis, one can note the increasing sphericity of the epiphysis by the combined effect of the elastic memory of the articular cartilage and intra-articular vacuum over the epiphyseal content during the plastic stage of fragmentation. Three years after TTCC and ADT, patient has a result of Stulberg II with Harris score of 100%.*

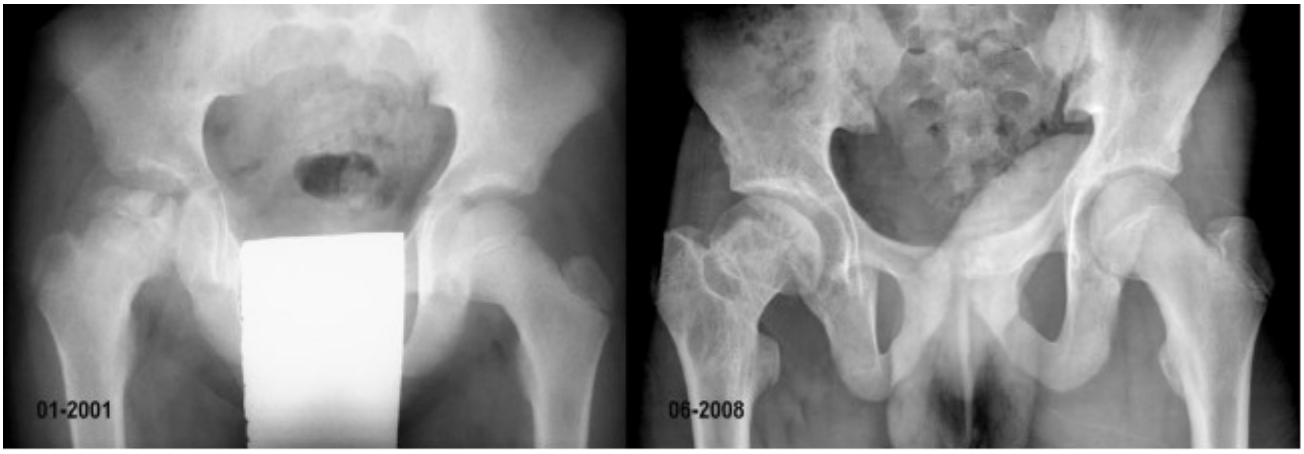

Fig.12 *–(1) F.C. male, 8 yo, 8years. Herring B with “hinge hip”. (2) 7 years after TTCC and AD. Functional result - Harris hip score of 97%, radiological result - Stulberg II.*

At the beginning of our series, we used an articulated frame and soon we realized that it was of great discomfort for the patient, without a real benefit for the improvement of range of motion. To improve the tolerability, we locked the frame with threaded rods placed on either side of the hinge, so as to correct the flexion attitude of the hip and allow walking without discomfort. Our experience with fixed osteotaxis of the hip in adults for treatment of fractures of the acetabulum, have shown that these patients quickly regain mobility of the hip after external fixator removal. So, we began to use a fixed frame also in children, replacing the hinged frame. This have shown to be much simpler, lighter and best tolerated by the patient. The operation to apply the fixed frame was easier and faster, not exceeding 30 minutes. The follow up is much simpler, needing a monthly visit to the clinic and home exercises. We found that patients so treated recovered the range of motion of their hips after 2 months of frame removal (Fig.13).

Fig.13 *–F.S. male, 8 yo. Herring C, with “hinge hip”. Clinical and functional result afer 7 years of TTCC and ADT. Harris hip score of 100%.*

Results after intertrochanteric osteotomy in the literature over the past 15 years, in series between 18 and 98 cases, with patients between 6-9 years old and Herring type B and C types, (33 to 70% Herring C), have shown results ranging from 37 to 67% of cases with a Stulberg type III or worst outcomes [12,34,35,36]. Our series of patients undergoing femoral osteotomy had a final result of 45.5% of Stulberg type III, outcomes, similar to other author's series. Our series of patients undergoing arthrodiastasis, presented a lower percentage of Stulberg type III hips (25.5%), with a difference statistically significant.

It should be noted that, from the radiological point of view, hips undergoing OTM showed significant residual sequels, as regards to the existence of varus deformity (49.6^0 to 69^0) and leg length discrepancy (-38mm to -10 mm) with differences that were statistically significant when compared to the ADT group. There were no significant differences found in, neck shortening and acetabular deformity and coverage (Fig.14).

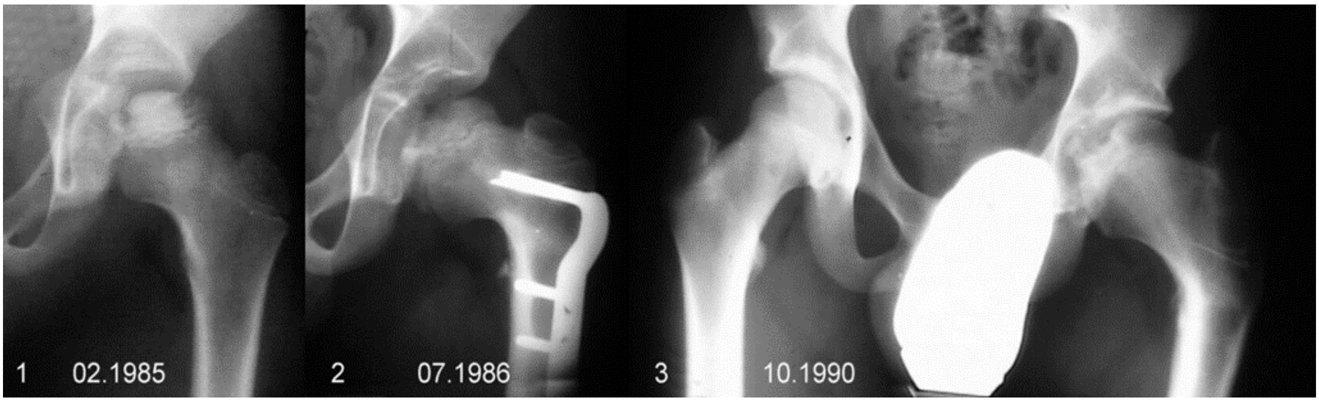

Fig.14 *– (1) - B.F. male, 8 yo. Herring B with "hinge hip". (2) – 1 year after OTM. (3) – At 14 years old. Dissecant osteochondritis, residual varus, leg lengh discrepancy with Tendelemburg sign. Functional result – Harris hip score of 88%.*

From the clinical and functional point of view, the final results of femoral osteotomy mentioned by other authors, showed rates of limping between 16 and 79%, Trendelenburg sign between 9 and 44% and leg length discrepancy of more than 20mm between 9 and 40% of cases [12,34,35].

Our series of patients undergoing femoral osteotomy showed a rate of 27% of limping, 9% of Trendelenburg and more than 20mm leg length discrepancy in 46% of the cases, values that fit the statistics of the other mentioned authors. Patients treated with ADT did not show any case of limping, Trendelenburg gait or leg length discrepancy exceeding 20mm.

According to the Harris Hip score, the functional outcome at mid-term follow up of our series was good in both groups, but was better on average 4 percentage points in the ADT group, a difference that was statistically significant.

Furthermore, it was found that the surgery was simpler, twice as fast and without blood loss. The patients began walking with crutches much earlier in the ADT group, data which is also statistically very significantly different.

Complications of femoral osteotomy is reported in a high number in the literature. When one includes the cases with limping, Trendelenburg gait and residual leg length discrepancy greater than 20mm, it ranged from 26 to 79%. Moreover, it included cases of iatrogenic femoral fracture, hardware fracture or failure, late consolidation and deep infection [12,34,35].

Our series of patients treated by femoral osteotomy had a complication rate of 36%, including 3 cases of limping, one with Trendelenburg gait and one case of deep infection. The series where ADT was used showed only 2 cases of tract pins infection, problem solved in an outpatient basis.

Moreover, it is noted that all patients in the series that underwent femoral osteotomy had a second major procedure for hardware removal.

Conclusion

This comparative study between 2 similar groups of patients with the same type of injury treated by transphyseal neck-head tunneling (TNHT) followed by intertrochanteric osteotomy (OTM) or arthrodiastasis (ADT), with a mean of 6 and 8 years of follow-up, showed with evidence-based data, that the ADT group:

- Presented results slightly better than the group subject to OTM regarding congruence and joint deformity and neck length.

- Had significantly better sphericity of the head and lower residual sequels, regarding the existence of varus deformity and leg length discrepancy.

- Had significantly better functional outcome, assessed by the Harris Hip score.

- Unlike the OTM group, ADT showed no complications or sequels that required further intervention in the short or medium-term.

- The operation was significantly faster, had no blood loss, patients started walking significantly earlier and did not require a second surgery for hardware removal.

Conflict of Interest

The authors declare no conflict of interest.

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