Outcome of arthrodiastasis in treatment of Perthes' disease

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Background
Hip distraction in Legg–Calvé–Perthes disease unloads the joint, which negates the harmful effect of the stresses on the articular surface, which may promote the sound healing of the areas of necrosis.
Patients and methods
Nonarticulated arthrodiastasis without soft tissue release using an Ilizarov external fixator was applied to 45 patients (50 hips) with Legg–Calvé–Perthes disease (>8 years at onset and lateral pillar type C or B).
Results
Follow-up period ranged from 1 to 8 years, with an average of 3 years. Forty-five (90%) hips had improvement of the range of motion postoperatively. Preoperatively, all patients had constant pain, whereas at last follow-up 40 (80%) patients had no pain and had an improvement. Stulberg classification was applied to 20 cases who reached skeletal maturity at the last follow-up: eight cases were type II, five cases were type III, five cases were type IV, and two cases were type V.
Conclusion
Nonarticulated hip distraction without soft tissue release seems to be a valid treatment option in cases with Legg–Calvé–Perthes disease where poor results are expected from conventional treatment.

Keywords:
arthrodiastasis, Legg–Calvé–Perthes disease, no soft tissue release

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Introduction

Treatment of Legg–Calvé–Perthes disease is a controversial issue [1]. The results for the treatment of patients with age of onset more than 8 years of age tend to be less favorable than the younger age. Greater involvement of the lateral pillar of the femoral head carries the risk of poor prognosis. Besides, marked restriction of hip motion precludes the application of osteotomies for management. Arthrodiastasis is a relatively new method of treatment. It does not change the anatomy of the joint. It provides unloading of the joint, which negates the harmful effect of the stresses on the articular surfaces, which may promote the sound healing of the areas of necrosis [1].

Arthrodiastasis usually describes articulated distraction and often open surgery of the hip as a treatment of a variety of conditions such as avascular necrosis, osteoarthritis, and chondrolysis [1]. The indications of arthrodiastasis had been extended to include cases with Legg–Calvé–Perthes disease where poor results were expected from other treatment modalities [2].

However, soft tissue release was performed in most cases, in addition to articulated distraction. We have been applying this method since 2000, but we observed that some patients who had severe pain refused to mobilize the operated hip. In fact, this was static hip distraction. Moreover, we could not clarify from the literature highlighting the indications, results, and complications of arthrodiastasis in Legg–Calvé–Perthes disease. Besides, we report our midterm results after application of nonarticulated arthrodiastasis without soft tissue release.

Patients and methods

From 2007 to 2015, 45 cases (50 hips) with Legg–Calvé–Perthes disease were treated with nonarticulated joint distraction in our institution. The inclusion criteria were as follows:

(1) Age above 4.8 years.
(2) Herring lateral pillar classification type B or C.
(3) Severe restriction of movement.
(4) Severe pain.
(5) One or more Catterall head at risk signs [3].

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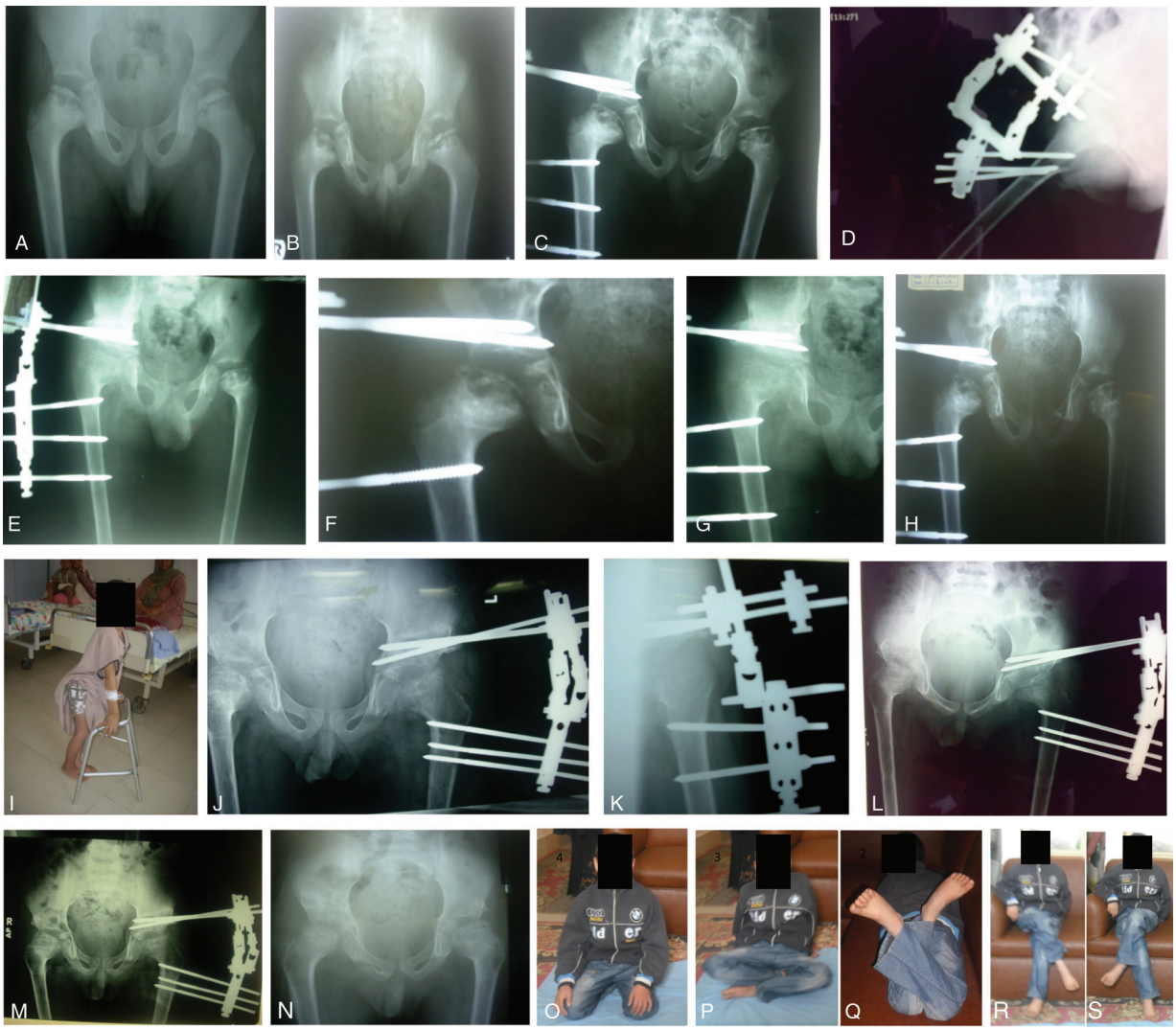
The age of patients ranged from 4.8 to 12.1 years (one case was 12 years). There were 42 boys and three girls. Forty cases were unilateral and five cases were bilateral. Four patients had previous operations (Fig. 1a–s).

The operative treatment included the application of an Ilizarov external fixator to the pelvis and the femur. Two or three Schanz screws of 5 or 6 mm in size were applied to the supra-acetabular area and fixed to 90° arch. One and half rings were applied to the femur using 1.8 mm tensioned wires in addition to the Schanz screws. The frame was connected while the femur is abducted ~15°. After 3 days, gradual distraction started at a rate of 1 mm/day until overcorrection of Shenton line by 5–10 mm. The patients were encouraged to walk with partial weight bearing using two elbow crutches immediately after the operation. We did not perform any soft tissue release for all patients. External fixation time ranged from 2.5 to 5 months. All the hips were graded as C Herring classification, except five cases that were graded as B.

There were 13 group III hips and 16 group IV hips according to the Catterall classification [4]. We have been able to apply Salter and Thompson classification to 24 cases, and 19 of them were in B group [5,6].

After fixator removal, the patients had daily physiotherapy with passive continuous and active-assisted movement, hydrotherapy with nonweight-bearing mobilization for 2 months, and progressive weight bearing and physiotherapy for 2 more months.

Figure 1



(a, b) Male patient, 1.5 years old; bilateral Perthes [preoperative, anteroposterior (AP) and lateral views (loss of abduction)]. (c) AP postoperative radiograph. (d) Laterai postoperative radiograph. (e, f) Two months of follow-up, postoperative radiographs of the same patient. (g, h) Five months of follow-up, postoperative radiograph of the same patient. (i) Nine months of follow-up, postoperative. (j, k) One year of follow-up, after healing right side and postoperative AP and lateral views radiograph left side of the same patient. (l, m) Last follow-up radiographs after 5 month postoperative. (n) 1 year follow-up postoperative AP radiograph. (o–s) Last follow-up photos with excellent result

The patients were assessed clinically and radiographically before the operation, after the operation, every 1 week until the end of distraction, and then every 3 weeks until removal of the fixator, every 1 month for 6 months, and finally every 6 months. Clinically, the presence and degree of pain, range of motion, functional activity level, and satisfaction of the patient were recorded. Stulberg classification was applied to the patients who reached skeletal maturity at last follow-up.

Pain was graded as no pain; mild pain; intermittent pain, which developed after exercises; moderate pain, which developed after regular activities; and severe pain, which is constant pain descerving the regular use of pain killers. The joint space was measured before and after the operation. The sphericity of the femoral head was evaluated at follow-up by Mose concentric rings [7].

Results

The follow-up period ranged from 2.5 to 11 years, with an average of 7.5 years. Forty-two cases (47 hips) (94%) had improvement of the range of motion postoperatively. Preoperatively, all patients had constant pain, whereas at last follow-up 38 cases (42 hips) (86%) had no pain and 7 cases (eight hips) had an improvement.

Preoperatively, the average hip flexion was 40° (range: 0–65°), whereas at last follow-up it improved to 80° (range: 120°). All patients were satisfied with the results, except one. The average joint space before surgery was 2.4 mm (range: 1–4 mm) and at the last follow-up it was 4.2 mm (range: 2–7 mm). At the last follow-up, 15 cases had spherical femoral head (deviation: <2 mm), nine cases had deviation between 2 and 4 mm, and five cases with more than 4 mm deviation. Stulberg classification was applied to 21 cases who reached skeletal maturity at last follow-up, of which nine cases were type II, seven cases were type III, four cases were type IV, and one case was type V. For the four cases of adolescent Legg–Calvés–Perthes disease (age >12 years), there was one case of type III, two cases of type IV, and one case of type V.

Complications

Pin-track infection developed in 30 cases. Treatment with parenteral antibiotics and more frequent dressing was enough in all cases except one, which required premature removal of the fixator after 2.5 months because of severe infection of the acetabular pins. There was marked knee stiffness in two cases on fixator removal, which resolved completely with physiotherapy. Chondrodiastasis occurred instead of arthordiastasis in one patient aged 14 years, with resultant lengthening of the femoral neck. Hip subluxation developed in one case 1 year after fixator removal, but the femoral head was contained at last follow-up with almost full range of movement and no pain (Fig. 2).

Discussion

The aim of treatment of Legg–Calvé–Perthes disease is to prevent or minimize the development of deformities of the hip [7]. Patients who are more than 8 years of age with type C lateral Pillar classification are expected to have poor outcome [8]. With increasing age, the time available for the remodeling phase is limited, which may lead to rapid joint deterioration [9]. A retrospective review was performed for 44 children (48 hips) with Catterall grade II, III, or IV Legg–Calvé–Perthes disease with onset over 8 years or older followed to maturity. Patients were divided into four groups (a no-treatment group and three interventional groups). Patients were in the sclerosis or early fragmentation phase at the time of the operation. Overall, for all treatment modalities, only 19% had a satisfactory Stulberg grade II outcome. Therefore, regardless of the treatment, the outcome is poorer with increasing age [10].

Combined innominate and femoral osteotomies are generally performed to better contain and to provide more coverage of the femoral head by the acetabulum. Radiographic outcomes of 20 patients with a disease onset of over 8 years who had undergone combined femoral and Salter innominate osteotomies were recorded. The classification of the hips was 11 lateral pillar group B, nine groups B/C, and two group C. The patients were evaluated with a mean follow-up of 5 years and 5 months using the Stulberg radiographic classification. Among these 20 hips, six were classified as Stulberg II (33%) and nine were IV. The main complication among this group was joint stiffiness in one case that was treated by adductor tenotomy and joint release [11,12].

The first description of arthrodiastasis was given by Aldegheri [13]. The aim of joint distraction is to neutralize muscle and weight-bearing forces, to prevent stress fractures of subchondral bone, and to promote creeping substitution [1,3]. Experimental studies revealed the importance of continuous passive motion or intermittent active motion in the repair of articular cartilage defects. Hence, articulated distraction could improve healing of articular cartilage in the rabbit

animal model [14]. Soft tissue release in some or all the cases was performed during fixator application [2,3,14–16]. We have been practicing articulated distraction in our center since 1992; however, the development of pain during passive or active hip motion leads to the refusal of most patients to mobilize the hip. Besides, we believe that the theoretical advantage of soft tissue release and joint motion during distraction has not been proven clinically. This theory was based on experimental studies regarding cartilage defects and not Legg–Calvé–Perthes disease. Hence, since 1995 we treated patients with nonarticuulated distraction and without soft tissue release.

Maxwell *et al.* [17] studied the impact of arthrodiastasis on the preservation of the femoral head in boys over the age of 8 years and girls over 7 years at the time of onset of symptoms of Legg–Calvé–Perthes disease. The patients were in the early fragmentation stage with minimal femoral head collapse (type A or B Herring Lateral Pillar classification at the time of the operation). After an average follow-up of 38.4 months, all the hips maintained their epiphyseal height except two (of the 15 operated cases). However, the follow-up was short and the sample included cases with minimal involvement, which may have the same results with other modalities of treatment.

Kucukkaya *et al.* [4] reported one child with avascular necrosis of the femoral head (Lee–Calvé–Perthes disease in eight of them) treated with articulated distraction. The patients with Legg–Calvé–Perthes

Figure 2

(a, b) Male patient, 9 years old; Perthes left side]preoperative, anteroposterior (AP) and lateral views]. (c, d) Postoperative radiograph. (e, f) Postoperatvie photos with Orthofix fixator. (g, h) 9 months postoperative AP and lateral views

disease were three and four Catterall classification [7] and B and C Lateral Pillar classification, and all of them had greater than 1 Catterall head at risk factor. Final follow-up results according to Stulberg were as follows: spherical congruency in four cases, aspherical congruency in three cases, and one case of aspherical incongruency. They recommended this type of treatment for children older than 6 years who have Catterall risk factors, and poor results are expected from other treatment modalities.

Other investigators [2] considered this type of treatment for children older than 8 years with severe form and the disease, with persistent severe pain, and with limited range of hip motion, which qualified them for salvage procedures. They reported good short-term clinical and radiologic results.

In our series, we had nine cases with spherical congruency (Fig. 1a–s), seven cases with a spherical congruency, and two cases with aspherical incongruency (of the 21 cases who reached skeletal maturity at last follow-up). Kucukkaya *et al.* [3] in 2000 had comparable results with the use of articulated distraction. The joint distraction without mobilization may carry the risk of hip joint stiffness. However, there was marked improvement of the range of motion from an average of 40° (range: 0–65°) to 80° (range: 0–120°) at last follow-up. Other investigators reported improvement of flexion by a mean of 20° after soft tissue release and articulated distraction [2].

The rate of pin-track infection was high (76%), with more prevalence in the acetabular side. This may carry the risk of potential infection if hip arthroplasty would be required in the future [18]. Another unusual complication occurred in a 14-year-old boy with completely stiff hip preoperatively and mushroom-shaped head. Physeal distraction instead of joint distraction occurred in this case. To the best of our knowledge, there were no reports of physeal distraction of the upper femoral epiphysis before. We could not identify the reason behind this unusual phenomenon. Perhaps, the tension was conveyed to the femoral epiphsis instead of the hip joint because of marked intra-articular adhesions.

The technique of physeal distraction included the application of the half pins or k-wires to the epiphysis and to the diaphysis perpendicular to the axis of bone and gradual distraction by an external fixator. We did not apply any sort of fixation to the epiphsis of the femoral head. It seems that the tension was accumulating over time until sudden epiphyseal fracture or chondrodiastasis occurred. Slow, controlled, and symmetrical distraction of the epiphyseal plate without fracture or rupture signifies chondrodiastasis. In our case, there was no complaint of intense pain during distraction. Plain radiography revealed 1.6 cm physeal distraction and lengthening of the femoral neck. At last follow-up after 8 years, there was no pain, no leg length inequality, but stiff hip was observed [18–21].

Table 1 Data of five different studies of arthodiastasis in Legg–Calvé–Perthes disease

	Maxwell *et al.* [16]	Aly and Amin [22]	Kucukkaya *et al*. [3]	Segev *et al.* [23]	This study
No cases	15	23	8	10	29
Age (years)	7.1–12.5	5–8	6–10	9.4–15.1	8–14
Lateral pillar Classification	A and B	B and C	B and C	B and C	B and E
Stage at operation	Fragmentation	Sclerosis or fragmentation	Fragmentation	Not clear	Fragmentation (classification for 21 cases only)
Stulberg classification	–	–	II, 4 cases	III, 3 cases	II, 9 cases
			III, 3 cases	IV, 7 cases	III, 7 case
			V, 1 case		IV, 4 cases
					V, 1 case
Complications	Pin-track infection in most of the casesFracture pin in 2 casesStiffiness of the hip in 2 cases	Pin-track infection in 1 caseHip joint infection after orthography in 1 case	Pin-track infection in most of the casesRestriction of the hip joint movement in 1 case	Not reported	Pin-track infection in 22 casesKnee stiffiness in 22 casesChondrodiastasis instead ofHip subluxation in 1 case nonarticulated
Type of distraction	Articulated	Articulated+soft tissue release	Articulated	Articulated +soft tissue release	

The limitations of this study were that there was no control group, as it was difficult to leave these patients with severe forms of the disease without treatment. Only (Table 1) 21 (72%) cases reached skeletal maturity at last follow-up. Besides, very few centers recommended arthrodiastasis [22,24]. The form of adductor tenotomy or illeopsoas release may be addedto the arthrodiastasis can be articulated or non articulated. Articulated hip distraction with soft tissue release has few theoretical advantages over nonarticulated distraction, which has not been proven clinically.

Arthrodiastasis has been used in the early stages of Legg–Calvé–Perthes disease (sclerotic or fragmentation phase) regardless of the age of the patient. It has been applied as a definitive treatment or as a first step before surgical containment [23,25]. It can also be applied as a salvage procedure in patients older than 8 years with severe types of Legg–Calvé–Perthes disease and with marked restriction of hip movement [26,27].

Conclusion

Nonarticulated joint distraction without soft tissue release seems to yield similar results to articulated hip distraction in older patients with severe forms of Legg–Calvé–Perthes disease.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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