Modified Dunn Osteotomy for Moderate and Severe Slipped Capital Femoral Epiphysis: A prospective study of twenty hips

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ABSTRACT

Background:
Slipped capital femoral epiphysis (SCFE) is one of the most common hip disorders affecting adolescents. For many years SCFE was traditionally treated by in situ fixation, without any reduction of the slip. More recently, it is observed that residual upper femoral epiphysis slips may lead to cam deformity which in turn may lead to acetabular cartilage injury in the long term. This concept encouraged the surgeons to try to correct the femoral head deformity and to try to restore the distorted anatomy. Modified Dunn techniques are one method to try to achieve this goal.

Patients and Methods:
A prospective study of twenty patients (20 hips) that underwent modified Dunn procedure for SCFE between March 2016 to September 2019, the mean age was 13.9 years, mean follow up period was 15.1 months.
Inclusion criteria were patients suffering from moderate or severe slips of the femoral epiphysis.
Exclusion criteria were cases with mild slips and patients with any previous surgical procedures at the affected hip.
Outcome assessment included measuring: lateral slippage angle pre and post-operative, alpha angle postoperative, and modified Harris Hip score preoperative and at the final follow-up.

Results:
The lateral slippage angle improved from 58.4° preoperatively to 3.55 ($p< 0.001$), the postoperative mean alpha angle was 48.5°. The preoperative mean modified HHS value was 67.6 and it improved postoperatively to 98.6($p<0.001$). Three patients had postoperative complications with a percentage of 15%.

Conclusion:
Modified Dunn procedure is a valid and reliable option in the treatment of moderate and severe degrees of SCFE, which if executed probably we can correct the deformed alpha angle and lateral slippage angle leading to nearly normal femoral head configuration protecting the hip joint from impingement and its long term complications as early osteoarthritis.

Keywords:
slipped; capital; Modified Dunn; alpha angle; SCFE.

INTRODUCTION

SCFE is considered one of the most common hip disorders affecting children between the ages of 8 and 15 years with an incidence ranging from 1 to 24.6 per 100,000 children. Its pathology includes gradually acquired malalignment of the proximal femoral metaphysis and capital epiphysis. This is caused by the weakening of the proximal femoral physis which may force the capital epiphysis to slip posteriorly with the femoral neck under the effect of the child's body weight. (Fig. 1, 2).[1]

Fig.1: SCFE left side anteroposterior view

Fig.2: 3D reconstruction for CT scan of SCFE right hip.

SCFE can be classified according to stability as stable, in which the patient can walk with or without support or unstable where the patient is unable to bear weight on the affected hip, this classification can help us to predict the expected prognosis and to decide the method of treatment. [2]

Treatment of unstable SCFE is still controversial, Dunn's technique for open reduction has not gained much popularity. [3]

Surgical management of SCFE had improved after surgeons began using in-situ pinning, which led to a considerable improvement of the outcomes. But there was still a major problem that in-situ pinning did not address which is a proximal femoral deformity. Now it is well known that residual deformity of the proximal femur does can lead to femoroacetabular impingement (FAI) causing a decreased hip range of motion, gait disturbance, and finally osteoarthritis. How and when to manage such deformity is a true challenge. [4]

Modified Dunn procedure is indicated for the management of moderate and severe SCFE. Mild cases are defined as those with a slippage angle less than 30°, moderate cases are between 30° and 50° while severe cases are greater than 50°.[5]

Mild cases can be safely managed by in-situ pinning, on the other hand, severe cases necessitate the anatomical restoration of the configuration of the proximal femur. Arora et al. and Novais et al. managed cases suffering from severe SCFE by realignment procedure. However, some recent articles recommend capital realignment for mild slips as well.[6]

Deformity at the physeal level can be corrected by the Modified Dunn technique, however, this technique is more complex than its alternatives and can be more difficult, it also has steep learning. [7][8]

In this study, we aim to describe our experience in the management of SCFE using the modified Dunn technique in 26 patients during three years to show that the modified Dunn technique is an effective option in the treatment of SCFE, and it is associated with significant improvement in postoperative hip function and restoration of the proximal femur morphology which can effectively save the hip from a probable incidence of future osteoarthritis.

PATIENTS AND METHODS

This study is a prospective case series study established between March 2016 to September 2019 in which twenty patients, 16 males, and 4 females underwent modified Dunn procedure for SCFE, the mean age was 13.9 years (range from 11-16 years), 12 hips were left side and 8 were right. According to the Loder classification of the 20 patients, 13 of them were stable while 7 hips were unstable. The mean follow-up period was 15.1 months (ranged from 9 to 23 months). The mean duration of preoperative symptoms was 16.3 days (ranged from five to 24 days). (Table 1)

Table 1: patients' demographic data

no	sex	age at time of operation in years	duration of symptoms in days	duration of follow up/months	side R/L
1	M	14	21	20	L
2	M	15	15	18	L
3	M	17	6	9	R
4	M	16	5	10	R
5	M	14	21	20	L
6	F	11	15	18	L
7	M	13	28	16	R
8	M	14	14	22	L
9	F	13	21	19	L
10	M	14	15	12	R
11	F	12	20	18	R
12	M	13	24	23	L
13	M	17	15	18	L
14	M	14	18	23	R
15	M	13	15	16	L
16	M	15	7	18	R
17	F	11.5	28	17	R
18	M	12.5	14	14	L
19	M	14	15	20	L
20	M	15	9	12	L

Inclusion criteria were patients suffering from moderate or severe slips of the femoral epiphysis with a slippage angle of more than 40°.

Exclusion criteria were cases with mild slips, moderate cases with a slippage angle of less than 40°, and patients with any previous surgical procedures at the affected hip.

All patients had full preoperative evaluation including history tacking, full examination and

radiological investigations. (Fig. 1,2) Laboratory investigations included routine preoperative tests to assess the patient's tolerability to the procedure.

Informed consent was taken from the patients' parents after discussing the steps of the procedure, the possible complications, the anticipated outcomes, and the rehabilitation plan.

Outcome assessment included measuring: lateral slippage angle pre and post-operative, alpha angle postoperative, and modified Harris Hip score preoperative and at the final follow-up.

Surgical technique

With the patient laying on the operation table at the lateral position, a lateral incision centered over the greater trochanter is performed. The fascia lata is split then the interval between the gluteus medius and Maximus is dissected to expose the piriformis tendon. The hip capsule is exposed by dissected the interval between the piriformis and gluteus minimus.

Using an oscillating saw the greater trochanter is osteomatised leaving about 2 mm to 3 mm of the gluteus medius tendon intact, this leaves the piriformis tendon insertion attached to the stable portion of the trochanter. Turning the displaced trochanteric fragment anteriorly allows the exposure of the capsule.

A capsulotomy is done in line with the femoral neck extending anteriorly towards the anteroinferior aspect of the acetabulum and posteriorly towards the piriformis tendon in line with the acetabular rim. Then the femoral head is dislocated by flexion and external rotation of the hip after transecting the ligamentum teres. (Fig. 3)

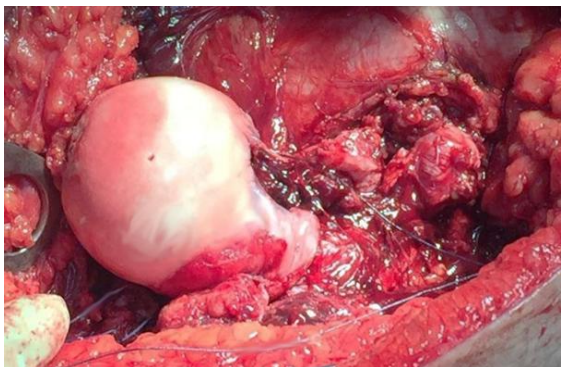

Fig. 3: Dislocation of the head femur.

The epiphyseal blood supply is checked by drilling a 2-mm hole in the anterior aspect of the femoral head. A thorough examination of the acetabular cavity is then carried for any chondro-labral lesions. The femoral head is relocated in the acetabulum and the retinacular soft tissue flap containing the nutrient vessels to the femoral head is developed by delicate dissection after the proximal portion of the stable trochanter is carefully removed.

The femoral neck is exposed completely by periosteal dissection. The femoral head is separated from the physis by using a curved osteotome as a lever and the posterior callus is removed from the metaphysis. Avoid excess shortening of the neck to prevent hip instability. Now we can reduce the femoral head to the femoral neck in an anatomical alignment and fix them with either two 4mm or 6.5-mm cannulated screws according to the patient's age and the size of the neck and head femur. (Fig. 4) Then reattach the periosteum loosely and close the capsule of the hip joint.

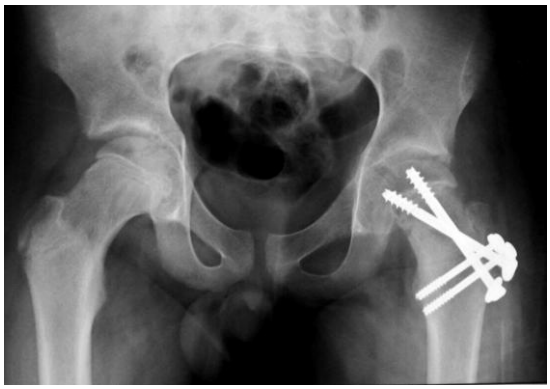

Fig. 4: Postoperative X rays showing screws fixation by 6.5 mm screws and trochanteric fragment fixation by 4 mm screws

After the reduction of the trochanteric fragment back to its bed, it is fixed by a compression technique anatomically. Finally, we close the wound in layers. weight-bearing is delayed for approximately 6 weeks after which the patient can begin protected weight-bearing with crutches for another 6 weeks.

RESULTS

Intraoperative there was bleeding at the site of reduced slipped epiphyses after reduction in 19 cases representing 95% denoting viability of the femoral heads.

The mean alpha angle postoperatively was 48.5° (ranged from 42° to 58°). There was a significant improvement of the lateral slippage angle from 58.4° preoperatively to 3.55° postoperatively with a p-value< 0.001 denoting marked improvement in the postoperative morphology of the proximal femur.

Hip function and pain were assessed pre and postoperatively using the modified Harris hip score (HHS). HHS improved from a mean value of 67.6 preoperatively to a postoperative mean

value of 98.6 at the final follow-up. Paired sample T-test showed significant results with p-value <0.001 which is considered an excellent result concerning postoperative hip pain and function improvement. (Tables 2, 3)

Table 2: patients' radio-clinical data

	Lateral slippage angle preoperative	Lateral slippage angle postoperative	Alpha angle postoperative	HHS preoperative	HHS postoperative
1	54	4	43	64	90
2	66	3	51	54	97
3	76	2	50	62	100
4	48	4	56	56	99
5	46	5	44	58	98
6	61	3	49	66	100
7	58	4	52	52	99
8	50	2	46	54	99
9	63	6	47	58	98
10	55	3	44	63	99
11	49	5	48	60	100
12	66	3	57	58	99
13	64	5	58	62	100
14	52	2	47	53	99
15	66	4	52	62	100
16	70	5	51	50	99
17	54	3	42	59	98
18	51	4	44	54	99
19	65	2	46	64	100
20	54	2	43	62	99

Table 3: patients' radio-clinical data

	physeal closure	Loder classification	bleeding femoral head post-reduction	complications
1	open	unstable	no	AVN
2	open	unstable	yes	nil
3	partially closed	stable	yes	nil
4	partially closed	stable	yes	screw penetration
5	Open	unstable	yes	nil
6	open	stable	yes	nil
7	open	stable	yes	nil
8	open	stable	yes	nil
9	Partially closed	stable	yes	nil
10	open	unstable	yes	nil
11	open	stable	yes	nil
12	open	stable	yes	Superficial infection
13	partially closed	stable	yes	nil
14	open	unstable	yes	nil
15	open	stable	yes	nil
16	open	unstable	yes	nil
17	open	stable	yes	nil
18	open	unstable	yes	nil
19	open	stable	yes	nil
20	open	stable	yes	nil

Statistical analysis

Using SPSS software on a personal computer, the data were coded, entered, and processed. A p-value < 0.05 was set as the cut-off value for significance. We used Student's paired sample t-test to assess the statistical significance of the difference during follow up of one population means involving dependent samples.

We had 3 cases of postoperative complications representing 15%. One case suffered from postoperative AVN of the head femur femoral head representing 5% of the total cases, the patient started to complain of hip pain after about three months postoperatively, MRI was done and confirmed the diagnosis of AVN, core decompression was done with postoperative pain improvement till the last follow-up. One case suffered from early superficial wound inflammation which responded well to antibiotics and the wound healed uneventfully and no more procedures were needed. Another case was found to have screw penetration which was detected in the postoperative X-ray, the patient was re-operated and the screw was changed by a proper one, no further complication s were detected till the last follow up.

DISCUSSION

Early Osteoarthritis resulting from FAI can be a complication of moderate and severe SCFE. There are several methods to try to decrease the risk or even to delay the hip osteoarthritis in patients with SCFE, but it is evident that correction of the deformity is the best way to achieve these goals. On the other hand, traditionally speaking, using osteotomies to realign the femoral head has been associated with a high risk of AVN. [9, 10]

Surgical dislocation allows adequate exposure of the proximal femur and subperiosteal dissection of the whole femoral neck, this facilitates precise capital realignment. Additionally, this makes restoration of the proximal femoral anatomy with correction of the slippage angle and head-neck offset possible. [11, 12]

Our postoperative HHS is close to that of the study conducted by Masse et al. who reported a mean HHS of 98.2 out of 100 points, despite that 6 patients in their study had only occasional mild pain. [13]

No doubt that AVN of the femoral head is the most devastating complication of SCFE treatment, which will lead to poor long-term hip function and early degenerative arthritis. [14] More studies are needed to investigate if the incidence of AVN is related to specific patient characteristics including the growth plate status and the severity of the femoral neck deformity or if it is directly related to the selected procedure and the surgeon's experience. In an attempt to decrease the risk of AVN, Souder et al. [15] recommended in-situ pinning but they reported that need additional management for residual FAI deformity may be needed.

The method of fixation used in the modified Dunn procedure is not yet well established. Huber et al. [16] in one study had a 13% of implant failure requiring revision of rate, on the other hand, Ziebarth et al. reported a 7.5% rate. [17]

To decrease the risk of AVN during capital reorientation, femoral neck cuneiform wedge resection is done to relieve the tension in the posterosuperior retinaculum which contains the end branches of the medial femoral circumflex artery. This wedge resection is tailored in size and location according to the degree of tension detected intraoperatively. [18,19]

There is not enough evidence till now directly linking the rate of AVN to the type of surgical procedure used. Slongo et al. managed 9 by sub-capital realignment procedures and they encountered one case of AVN. [20] Novais et al. reported the same rate of AVN in both groups of patients managed by pinning in situ and those managed by modified Dunn procedure. Ziebarth et al. and Masse et al. in their cases managed by modified Dunn procedure studies did not have any cases complicated by AVN. [21] Novais et al. and Souder et al. concluded that there was no sure relationship between the rate of AVN and method of management. [22]

Despite the steep learning curve of this technique, we think that surgical correction of the femoral head deformity with modified Dunn procedure is worth to be put into consideration while deciding the plan of management of moderate and severe patients of SCFE due to the relatively high incidence of unsatisfactory clinical results after in situ pinning in those patients.

In this study, the modified Dunn procedure is used to correct the proximal femoral deformity with a relatively low complication rate of 15%. It worth saying that with the relative short-term follow-up (15.1 months), we cannot determine if restoration of the femoral anatomy will ensure long-term joint protection.

Our findings imply that in the short-term patients will experience less hip pain, better hip motion, and more walking ability, which is evident by the marked postoperative improvement in modified HHS.

The postoperative radiological assessment showed marked improvement in lateral slippage and alpha angles, this implies that the modified Dunn procedure allowed for restoration of the morphology of the proximal femur. Saying that there is no assurance that in the long run these patients will not suffer from secondary osteoarthritis. There is a need for long-term studies to determine whether radiographic restoration of morphologic features of the proximal femur will protect against osteoarthritis.

CONCLUSION

Modified Dunn procedure is a valid option for treating moderate to severe SCFE, by which we can achieve capital realignment in cases suffering from moderate and severe SCFE with a relatively low complication rate of 15%. Nevertheless, long term studies are still needed.

Level of evidence: IV therapeutic study.

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