

Original Article

Simultaneous versus two stages surgical treatment of developmental dislocation of the hip with excessive femoral anteversion in children under the age of three years

Ahmed Kanaan Mansoor^{1*}, Baqer Kraidi¹, Luay M. Al-Naser²

Abstract

Background: Delayed diagnosis and improperly treated cases of developmental dysplasia of the hip (DDH) in the presence of excessive anteversion of femoral head may lead to undesirable consequences, including more extensive interventions with severe complications and functional disability. This study aimed to compare the clinical, radiological, and complication outcomes of simultaneously versus two-stage surgical procedures (open reduction and proximal femoral derotation osteotomy) in the treatment of DDH with excessive femoral anteversion among a sample of Iraqi children aged less than three years old.

Methods: A total of 26 DDH cases were treated in two groups (GI, GII) at Al-Wasity Teaching Hospital (Baghdad, Iraq) from January 2014 to March 2015. GI (15 hips) in 13 patients subjected to simultaneous open reduction (with/without salter osteotomy) and proximal femoral derotation osteotomy. GII (18 hips) in 13 patients operated in two stages procedure; open reduction (with/without salter osteotomy) followed by proximal femoral derotation osteotomy six weeks later.

Results: At the time of operation, the average age was 21.79 ± 3.51 months (range: 18-30). The mean follow-up period was 10.36 ± 1.45 months (range, 8 -12). Statistically, the postoperative clinical, radiological, and complication findings were not significantly different between the two groups. However, in post-operative clinical assessment (McKay's criteria), the satisfying results (excellent and good) were 93% in GI and 88% in GII, respectively. Moreover, in radiological assessment (Severins classification), the satisfying results (excellent and good) were 94% in GI and 83% in GII, respectively. Two cases of re-dislocation and avascular necrosis (AVN) were reported in GII.

Conclusion: When the clinical and radiological findings of one and two-stage open reduction and proximal femoral derotation osteotomy procedures are similar, the one-stage is more likely to overcome the two-stage in terms of minimizing the cost, length of stay and the risk of AVN of the femoral head.

Keywords: DDH, femoral anteversion, open reduction, proximal derotation femoral osteotomy, two-stage, Iraq

Background

Delayed diagnosis and improperly treated cases of developmental dysplasia of the hip (DDH) in the presence of excessive anteversion of femoral head may lead to undesirable consequences including the need for more extensive interventions with severe complications and functional disability which may negatively affect the quality of life of the patient [1,2]. The ultimate goal of treatment in DDH is to create an optimal condition for the normal growth of the acetabulum and the inside femoral head by achieving and maintaining concentric reduction [1,2,3]. However, this procedure is

significantly related to the age of the patient at which the detection was made and the appropriate intervention [4]. Conservative measures such as Pavlik's harness (abduction reduction) have been performed successfully among children younger than six months [4,5,6]. A review of the literature indicates that the treatment of late-diagnosed DDH at the walking age or later is more likely to be expensive and risky [7]. Surgeons recommend closed reduction often to avoid the postoperative risk of reduced range of motion and AVN [8].

However, the high incidence of re-dislocation and the necessity for secondary surgery after closed reduction increases the likelihood of adopting open at the expense of close reduction [8]. Open reduction can be operated with/without extra surgical procedures, such as femoral and pelvic

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osteotomy. However, there is an increasing trend to adopt one stage procedure consisting of open reduction in association with/without Salter's innominate osteotomy of the iliac bone in order to redirect the acetabulum" [9]. Moreover, there is no agreement among orthopedic surgeons to use derotation osteotomy to correct the excessive femoral anteversion [10].

In this study, two groups of Iraqi children aged less than three years old and presented with DDH with excessive femoral anteversion. In the first group (GI), we simultaneously operated open reduction (with\without Salter innominate osteotomy) and derotation femoral osteotomy, while in the second group (GII), we operated first open reduction (with\without Salter innominate osteotomy) and then followed by derotation femoral osteotomy after six weeks. The purpose of the study was to compare the results of clinical and radiological evaluations, in addition to complication outcomes between the two groups.

Methods

A retrospective comparative study was conducted between January 2014 and March 2015 at Al-Wasity Teaching Hospital, Baghdad, Iraq. A sample of randomly selected children (under the age of 3 years) presented with DDH with excessive femoral anteversion has undergone surgical treatment with combined open reduction and derotation femoral osteotomy. The inclusion and exclusion criteria are listed in table 1. Due to exclusion criteria, twenty-six patients (33 hips) have been included and subsequently divided into two groups. In the first group (GI), a total of 15 hips in 13 patients were planned to simultaneously operate open reduction (with\without Salter innominate osteotomy) and derotation femoral osteotomy. In the second group (GII), a total of 18 hips in 13 patients were planned to operate open reduction (with\without Salter innominate osteotomy) and followed by derotation femoral osteotomy after an interval of 6 weeks.

Table 1 Inclusion and exclusion criteria

No.	The Main Criteria	Inclusion	exclusion
1.	Age between 18 and 36 months	+	+
2.	Can walk at the time of surgery	+	+
3.	Willing to participate with parents signed consent form	+	+
4.	Previous surgery on the involved hip	+	+
5.	Teratologic dislocations with difficult walking ability	+	-
6.	Neuromuscular hip dysplasia with difficult walking ability	+	-
7.	Connective tissue disease with difficult walking ability	+	-
8.	Children aged less than 18 months	-	-
9.	Children aged more than 36 months	-	-

(+) Inclusion criteria, (-) Exclusion criteria

Preoperative evaluation

Medical history

At the time of admission, all eligible patients have undergone a full medical history, including data about the socio-demographic, genetic, and family social and economic history. Information about the contact family address and mobile numbers for follow up has been reported.

Clinical examination

Several known orthopedic tests such as Ortolani test, Barlow's test (maneuver), Galeazzi test (Allis sign or the Skyline test) were recruited to perform a thoughtful and thorough clinical examination to test for any shortening or asymmetrical lower extremity, asymmetric thigh folds, widened perineum (bilateral dislocations) and the asymmetrical skin creases and also to find out any associated anomalies like torticollis, metatarsus adductus, calcaneovarus and meningocele.

Radiographical assessment

All patients sent for new X-Ray of the pelvis (both hips); AP view (with or without Von Rosen view). Tonnis classification has been recruited to grade the preoperative subluxation or dislocation radiographic changes in a grade ranged from I to IV [11].

Grade I: hip dysplasia with only mild subluxation.

Grade II: the ossification center of the femoral head was migrated laterally but still inferior to the superolateral corner of the true acetabulum.

Grade III: the ossification center at a level of superolateral corner of the true acetabulum.

Grade IV: the ossification center at a level superior to the superolateral corner of the true acetabulum.

According to Tonnis classification, the center of the ossific nucleus of the femoral head is related to the Perkins line and a horizontal line at the level of the lateral margin of the acetabulum [11].

Surgical technique

All operations were done under general anesthesia. As usual, every child was sent for pre-operative anesthetic assessment and preparation, with the preparation of one pint of blood. In the beginning, all patients in this study (GI and GII) are subjected to adductor tenotomy (a tiny opening in the groin and surgically releasing the adductor tendon). Then all patients have undergone to open reduction through a curved anterolateral incision (iliofemoral approach). The redundant joint capsule was isolated from the surrounding gluteus muscles and the joint exposed with an incision parallel to the acetabular rim. The iliopsoas was released, and the intra-articular soft-tissue blockage was removed. The transverse ligament was transected to create space for the reduction (Fig. 1).



Figure 1. Open reduction

However, in eight patients, Salter osteotomies were added to achieve stability. Femoral osteotomy (subtrochanteric

derotation osteotomy) was performed through a separate lateral femoral incision and fixed with a small compression plate in all 33 hips (Fig. 2).

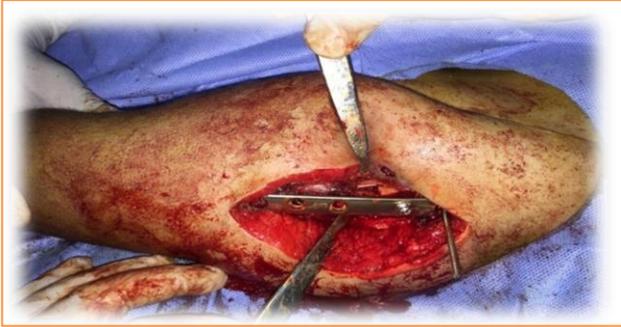


Figure 2. Femoral derotation osteotomy.

In GI (15 hips), femoral osteotomy performed simultaneously at the time of open reduction as one-stage surgery, while in GII (18 hips), the femoral derotation performed six weeks later. After the operation, open reduction checked by fluoroscopy. The capsular repair was performed in all operated hips, as described by Wenger et al. [12]. A spica cast was applied with the hip flexed 30°, abducted 30°, and in the neutral rotation in GI; however, the internal rotation was necessary to reach a reduction in GII. The cast was changed six weeks after the operation and an abduction brace or cast used for an extra six weeks. In GII (18 hips), after six weeks of open reduction, femoral derotation osteotomy is done, and spica cast applied for an extra six weeks.

Post-operative evaluation

Clinical evaluation

Post-operative clinical evaluation was performed depending on McKay's criteria [13] and as modified by Barrett et al. [14] in a grade ranging from I to IV.

Grade I (Excellent): stable painless hip, no limp, negative Trendelenburg sign, full range of movement.

Grade II (Good): stable painless hip, slight limp, negative Trendelenburg sign, slight loss of hip movement.

Grade III (Fair): stable, painless hip, limp, positive Trendelenburg sign, moderate stiffness.

Grade IV (Poor): unstable and or painful hip, severe motion limitation.

Modified McKay's classification is especially useful to assess the clinical results as follows:

Grade I (Excellent) and Grade II (good) were considered as satisfactory results.

Grade III (fair) and Grade IV (poor) were considered as unsatisfactory results [14].

Radiological evaluation

Post-operative radiological evaluation was performed according to Severin's classification (criteria), "is commonly used to assess the radiographic results of operations carried out for the treatment of DDH" in a grade ranging from I to IV [15].

Grade I (Excellent): Normal hip with normal central-edge (CE) angle <19.

Grade II (Good): Normal CE angle <19, mild to moderate deformity of the femoral head.

Grade III (Fair): CE angle is less than normal (>18), residual acetabular dysplasia, but no subluxation.

Grade IV (Poor): CE angle >10 with some degree of subluxation.

In the current study, we depend on Severin's measurement that considers the CE angle (after reduction) of more than 19 degrees is normal in children aged less than three years old [15].

Post-operative complications

The most frequent postoperative complication is avascular necrosis (AVN). The criteria of Kalamchi and MacEwen graded the presence of post-operative AVN of the femoral head in a grade ranged from I to IV [16].

Grade I: changes affecting femoral epiphysis only;

Grade II: lateral physical damage;

Grade III: central physical damage;

Grade IV: total damage to the femoral head and physis.

Statistical analysis

The Statistical Package for Social Sciences (SPSS Inc., Chicago IL, USA), version 16.0 was used for data entry and analysis. Data were presented in mean and standard deviation (SD ±). Statistical analysis was performed using the unpaired t-test. An alpha level of $p < 0.05$ is considered to be statistically significant.

Results

Descriptive analyses

The vast majority of our sample were girls (18, 69%) with 18 hips compared to 8, 31% boys with 11 hips. Out of 33 operated hips, 21 were left hips, and 12 were right hips. Seven children had a bilateral dislocation and twenty-six unilateral dislocations. The mean age of the patients was 21.79 ± 3.51 (range: 18-30) months. More than half of children (51.5%) were between 18 to 21 months old at the time of the surgery. The mean follow-up period was 10.36 ± 1.45 (range: 8-12) months. Results of preoperative radiographic assessment (Tonnis grade method) showed that six hips were type IV, 21 were type III, and 6 were type II, respectively (Table 2, Table 3). However, there was no significant difference between the GI and GII in terms of post-operative clinical, radiological evaluations, and post-operative complications. Table 2 presents the main findings of the GI. The postoperative clinical McKay's criteria showed that six hips were excellent, eight hips were good, and one hip was fair. Findings of the post-operative radiographic assessment (Severin's grade method) were excellent in ten hips, good in four hips, and satisfactory in one hip. However, one hip developed superficial Spica ulcer, and two hips developed a superficial infection of thigh wound. A blood transfusion was necessary for five patients. Table 3 presents the main findings of GII. The postoperative clinical McKay's criteria showed that five hips were excellent, eleven hips were good, one hip was fair, and the last one was poor. Findings of the post-operative radiographic assessment (Severin's grade method) were excellent in nine hips, good in two hips, satisfactory in two hips, and poor in one hip. However, one hip developed superficial Spica ulcer, one hip developed re-dislocation in Spica, and one case complicated with avascular necrosis. A blood transfusion was necessary for two patients.

Table 2 Data of patients treated by one-stage procedure

Case	Age At surgery (Months)	Sex	Affected Limb	Tonnis Classification	Derotation Osteotomy	Acetabular Osteotomy	Follow-Up Duration (M)	Clinical Outcome Per McKay Criteria	Radiographic Outcome Per Severin Criteria	Complication	Blood Transfusion
1	18	F	L	III	One Stage	Open Reduction	12	G	I		0
2	30	F	R	IV	One Stage	Open Reduction	8	G	I		0
3	24	M	L	II	One Stage	Open Reduction +Salter	12	E	I		1
4	24	F	R	III	One Stage	Open Reduction	12	F	III		0
5	18	M	L	III	One Stage	Open Reduction	12	E	I		1
6	22.5	F	L	III	One Stage	Open Reduction	12	E	I		0
7	23	F	L	III	One Stage	Open Reduction +Salter	9	G	II	Superficial Wound Infection	1
8	17	M	R	II	One Stage	Open Reduction	9	G	II		0
9	18	F	L	II	One Stage	Open Reduction	10	E	I		0
10	245	M	R	IV	One Stage	Open Reduction	12	G	I		0
11	19	F	L	III	One Stage	Open Reduction	10	G	II		0
12	19,5	F	L	II	One Stage	Open Reduction	12	E	I	Superficial Spica Ulcer	0
13	19	M	L	III	One Stage	Open Reduction +Salter	10	G	II		1
14	29	F	L	III	One Stage	Open Reduction	10	G	I	Superficial Wound Infection	0
15	18	F	R	III	One Stage	Open Reduction +Salter	10	E	I		1



Figure 3:
A case of 2 years old patient with left DDH, treated by the one-stage procedure. Preoperative radiograph of the pelvis (anteroposterior) showing dysplasia of left hips, grade 4 According to the Tonnis Classification.

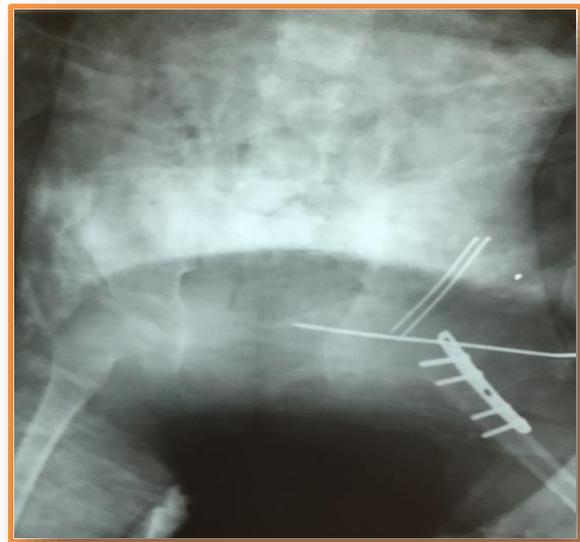


Figure 4:
A case of 2 years old patient with left DDH, treated by the one-stage procedure. Postoperative radiograph of the pelvis (anteroposterior). (Open reduction, K. Wire fixation, salter osteotomy and derotation femoral osteotomy).

Table 3 Data of patients treated by two-stage procedure

Case	Age At Surgery	Sex	Affected Limb	Tonnis Classification	Derotation Osteotomy	Acetabular Osteotomy	Follow-Up Duration (M)	Clinical Outcome Per Mckay Criteria	Radiographic Outcome Per Severin Criteria	Complications	Blood Transfusion
1	19,5	M	R	III	Two-Stage	Open Reduction	10	E	I	Spica Ulcer	0
2	22,5	F	L	IV	Two-Stage	Open Reduction	8	G	II		0
3	19,5	M	L	III	Two-Stage	Open Reduction	8	G	II		0
4	18	F	L	III	Two-Stage	Open Reduction + Salter	9	E	I		0
5	27	F	R	III	Two-Stage	Open Reduction	10	G	III		0
6	19,5	M	L	III	Two-Stage	Open Reduction	12	G	I		0
7	25	F	L	III	Two-Stage	Open Reduction	12	G	II		0
8	26	F	R	IV	Two-Stage	Open Reduction + Salter	12	E	I		1
9	19,5	M	L	III	Two-Stage	Open Reduction	10	G	II		0
10	22	F	R	II	Two-Stage	Open Reduction	8	G	I		0
11	27	F	R	IV	Two-Stage	Open Reduction + Salter	12	G	I		
12	19	M	L	III	Two-Stage	Open Reduction	12	G	II		0
13	26	F	L	IV	Two-Stage	Open Reduction	9	P	IV	Subluxated	0
14	22	F	L	II	Two-Stage	Open Reduction	9	E	I		0
15	23	F	L	III	Two-Stage	Open Reduction + Salter	11	G	I		1
16	18	F	L	III	Two-Stage	Open Reduction	11	G	I		0
17	20	M	R	III	Two-Stage	Open Reduction	10	E	II		0
18	21	F	R	III	Two-Stage	Open Reduction	9	F	III	AVN (I)	0

**Figure 5:**

A case of 2- years old patient referred to our hospital with left side DDH, by the two-stage procedure. Preoperative radiograph of the pelvis (Anteroposterior) showing dysplasia of the left hip grade 3 according To the Tonnis classification.

**Figure 6:**

A case of 2-years old patient referred to our hospital with left side DDH, treated by two-stage preoperative. Preoperative radiograph of the pelvis (anteroposterior). The left hip reduced and fixed with K. Wire fixation.

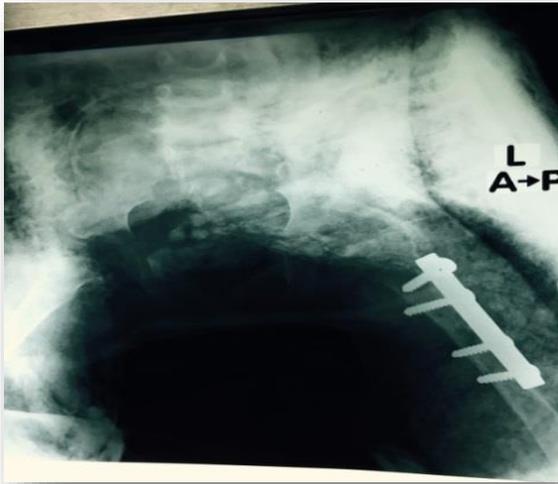


Figure 7:

A case of 2- Years old patient referred to our hospital with left side DDH, treated by the two-stage procedure. Pelvis (anteroposterior) radiograph done after six weeks. Derotation osteotomy is done for the left femur.



Figure 8:

A case of 2- years old patient referred to our hospital with left side DDH, treated by the two-stage procedure. Pelvis (anteroposterior) radiograph done After 12 months (After removal of the plate).

Discussion

The main objective in the treatment of DDH is restoring the normal function and position of the hip joint in order to bear body weight. Currently, there is an increasing trend [1,4] to consider the open reduction combined with Salter's osteotomy as a classical technique to redirect the acetabulum in DDH [17].

In the present study, two groups of young children having DDH were undergoing open reduction and proximal femoral derotation osteotomy. In the first group, the procedure was done simultaneously in one stage. However, in the second group, the proximal femoral derotation osteotomy was operated six weeks later after the open reduction. When the sociodemographic variables are not taken into consideration, there was no clinical (p -value = 0.729), radiological (p -value = 0.676) and complication (p -value = 0.296) statistically significant differences between the two groups. However, both of the clinical (excellent 40.0% and good 53.0%) and radiological (excellent 76.0% and good 27.0%) outcomes of the one-stage procedure (GI) were highly satisfied compare to the results of the two-stage procedure (GII). Similar findings were reported by Turkish, Nepalese and Pakistani, Egyptian, and Indian studies [18-22]. Karakurt et al. (2004) reported excellent to good results in about 86% clinically and 85% radiologically among patients aged one to four years old [18]. Banskota et al. (2005) reported 88.88% excellent results following simultaneous open reduction and Salter innominate among younger age DDH patients [19]. Pakistani study conducted by Bhatti et al. (2014) among DDH patients aged 18-36 months found that clinically about 40 (80%) hips behaved excellent and good on McKay's criteria, and radiographically about 38(76%) hips behaved excellent and good on Severin's criteria [20]. Abdullah (2012) and his team found that the post-operative radiological outcome was excellent and good in about 85% of DDH patients treated (after walking age) by the combination of open reduction and femoral osteotomy in one stage [21].

Bhuyan (2012) reported that 89.9% of the operated hips were clinically satisfied (excellent and good) results, and 83.0% were radiologically satisfied (excellent and good) results, respectively [22].

At the same time, our findings in GII (two-stage) showed that the post-operative clinical (excellent 28% and good 61%) and radiological (excellent 50% and good 33%) outcomes were less satisfied compare to the one-stage procedure. The results of our study come in line with earlier findings reported by Rimmel et al. (2009) in his research among 43 DDH patients in Orthopedic Hospital Rummelsberg, Germany [23]. Rimmel and his colleagues (2009) found that open reduction procedure followed by subtrochanteric derotation osteotomy after an average of 6.7 weeks was satisfy (excellent and good) in about 66% of operated DDH patients. Moreover, Rimmel et al. (2009) concluded that a two-stage procedure is more likely to minimize operative trauma, and he consequently recommended it as a successful principle in the operative treatment of DDH [24].

In fact, joining of pelvic or femoral osteotomies with open reduction yielded good results in the treatment of DDH [18-22]. In the Egyptian study, the authors indicated femoral derotation osteotomy for most of the operated DDH cases because of excessive anteversion [21]. Furthermore, the likelihood of the second procedure will be high when open reduction performed without simultaneous femoral osteotomy [1, 24]. Our findings were comparable to earlier results reported by the previous studies. Many researchers have indicated that the hip reconstruction procedure to treat cases of late-diagnosed DDH is more likely to be safe and effective in one stage [22,25-27].

It was clear that the younger the patients were at the time of operation, the better the results would be. Reviewing the results of several kinds of literature, including our results too, revealed an encouraging outcome when patients diagnosed and operated before or close to the walking age, [25] because "the excellent result may not be possible in most of the cases after certain age"

[28]. Avascular necrosis (AVN) is among the inevitably occurring postoperative complication in the treatment of DDH Patients. However, the reported incidence of AVN following open reduction with femoral or pelvic osteotomy was in a range of 7% to 22% [22,29-31]. Bhuyan (2012) reported that young children with DDH were safely treated by one stage of femoral and pelvic osteotomy with less likely to get AVN [22]. Our findings were close to this international range; however, one stage procedure reported no AVN compared to one case (6.0%) developed AVN after the two-stage procedure. This study has few limitations, such as the short period of postoperative follow-up, and a small number of participants.

Conclusion

Although statistically was not significant, the satisfy (excellent and good) radiological and clinical results in the one-stage procedure (open reduction and proximal femoral derotation osteotomy) were definitely better than results in the two-stage procedure (proximal femoral derotation osteotomy performed six weeks after open reduction). Moreover, the one-stage procedure is a medical, psychological, and economically safe and highly effective method in the treatment of DDH with excessive femoral anteversion. Because it is one surgery instead of two, it decreases the length of stay, lowering the incurred cost of treatment; and a low rate of serious postoperative complications.

Abbreviations

DDH: Developmental Dysplasia of The Hip; AVN: Avascular Necrosis
GI: Group One; GII: Group Two

Declarations

Acknowledgment

We render our special thanks to all patients and their parents for their patience and help during the study. Special thanks to all directors of Al-Wasity Teaching Hospital, including the doctors and paramedical staff, for their unlimited support and full cooperation during the data collection.

Funding

The author (s) received no financial support for the research, authorship, and/or publication of this article.

Availability of data and materials

Data will be available by emailing ahmed.k.mansoor@gmail.com.

Authors' contributions

AM is the principal investigator of the study who designed the study and coordinated all aspects of the research, including all steps of the manuscript preparation. He is responsible for the study concept, design, writing, reviewing, editing, and approving the manuscript in its final form. BK and LA contributed to the study design, analysis and interpretation of data, drafting the work, writing the manuscript and reviewed and approved the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

We conducted the research following the Declaration of Helsinki, and the Ethics Committee of the Iraqi Board for Medical Specialization and Al-Wasity Teaching Hospital, Baghdad, Iraq, approved the protocol (Ref: 9257 at 06-November -2018). Moreover, written informed consent was obtained from parents of each included patients who were willing to participate after explanation of the study objectives and the guarantee of secrecy.

Consent for publication

Not applicable

Competing interest

The authors declare that they have no competing interests.

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Article Info

Received: 08 November 2018

Accepted: 13 November 2018

Published: 23 November 2018

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