Salvage of dislocated hip and knee during limb lengthening for congenital femoral deficiency

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Background
The articular and soft tissue deficiencies associated with congenital femoral deficiency are reported to predispose to joint dislocation during limb lengthening, which would negate the value of limb lengthening.
Patients and methods
The cases of 17 children who suffered hip and/or knee dislocation as a result of femoral lengthening for congenital femoral deficiency of Paley's classification type 1 and 2a were included. Their ages ranged from 4.5 to 13 years (average: 6.8 years). The average lengthening achieved at the time of diagnosis of the dislocation was 5.7±1.048 cm (range: 4.5–8 cm). Hip dislocation only was present in seven (41%) cases, knee dislocation only in six (35%) cases, and combined dislocation in four (24%) cases.
Results
A center-edge angle of Wiberg less than 22° had a highly significant effect on hip dislocation (P=0.001), and all knee dislocations were associated with a hypoplastic lateral femoral condyle. Both joint dislocations were common when the child had a center-edge angle of 15–20° together with a hypoplastic lateral femoral condyle.
Discussion
and conclusion Hip dislocations were managed with soft tissue release and pericapsular acetabuloplasty with satisfactory Mckay's hip scores in all cases. Knee dislocations were reduced and stabilized by means of extra-articular ligament reconstruction with satisfactory Judet's knee criteria in 82% of cases.

Keywords:
acetabuloplasty, congenital femoral deficiency, hip dislocation, knee dislocation, limb lengthening

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Introduction

Congenital femoral deficiency (CFD) is a rare condition with variable degrees of severity of dysplasia of the femur [1–3].

For CFD, but with intact and mobile hip and knee joints, limb lengthening is an appropriate option [4–9]. However, the development of treatment-related complications would nullify the benefits of limb lengthening [10–14].

The articular and soft tissue deficiencies associated with CFD were reported to predispose to joint subluxation and dislocation during limb lengthening [5,15–19] (Fig. 1).

This study sought the causative factors for hip and knee joint subluxation and dislocation during femoral lengthening for CFD and presents our experience in their management. Moreover, the results of analysis of the variables that could affect the final clinical outcome are presented.

Patients and methods

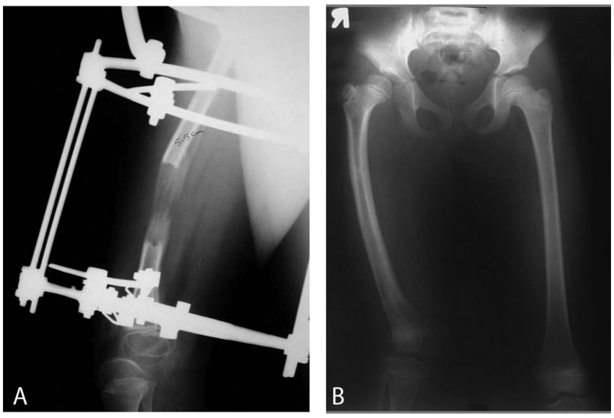
Limb lengthening for CFD, in this study, was performed for children who had unilateral CFD types 1 and 2a after Paley's classification for CFD [19]. This study approved by the Ethical committee of Department of Orthopaedic Surgery and Traumatology, Faculty of Medicine, University of Tanta, Tanta, Egypt. This classification is based on the factors that influence lengthening-reconstruction for the congenitally short femur: type 1: 'intact femur' with mobile hip and knee, and its subtypes are (a) normal ossification of the proximal femur and (b) delayed ossification of the proximal femur; type 2: 'mobile pseudarthrosis' with mobile knee, and its subtypes – (a) femoral head mobile in the acetabulum and (b) femoral head absent or stiff in the acetabulum;

type 3: 'diaphyseal deficiency' of the femur with subtypes – (a) knee motion of 45° or more, (b) knee motion less than 45°, and (c) complete absence of the femur; and type 4: 'distal deficiency' of the femur [19].

The material of this study included the cases of 17 children (11 boys and six girls). Their ages ranged from 4.5 to 13 years (average: 6.8 years).

To be included in the study, the patient should have limb length discrepancy due to unilateral CFD types 1 or 2a after Paley's classification [19]. All patients had joint subluxation and/or dislocations secondary to femoral lengthening.

Figure 1



(a and b) Radiographs of femoral lengthening using Ilizarov external fixator without protection of the knee. Hip and knee dislocation resulted after 5 cm of distraction.

Ten patients were referred to our hospital after having undergone limb lengthening elsewhere. They were referred due to the development of hip and/or knee subluxation or dislocation presented clinically as flexion-adduction deformity of the hip and valgus deformity and extension contracture of the knee. The remaining seven patients were initially seen and had their limbs lengthened in our department. Tables 1 and 2 present the demographic, clinical, and radiographic data of the study patients. All patients underwent femoral lengthening using an Ilizarov external fixator without joint protection, and no preoperative soft tissue releases or joint-stabilizing procedures were performed in any case.

The time between lengthening and reconstruction varied according to the presentation. If the patient presented with the dislocation after completion of lengthening and removal of the device, the reconstructive procedure was performed right away. However, if the dislocation was discovered during lengthening, the lengthening was stopped temporarily and soft tissue release was performed and joint protection was performed by extending the fixator across the joint. If the joint continued to dislocate after the protective measures, lengthening was stopped and the device was kept in

Table 1 Demographic radiological, and clinical data of the patients

Case nos	Sex	Age (years)	Side	CFD type	Length (cm)	Lengthening (%)	Used	Dislocated or subluxated joints	NSA (deg.)	ALDFA (deg.)	CEA initial/ final (deg.)	Knee flexion/ extension initial/final (deg.)	Hip abduction/ internal rotation initial/final (deg.)
1	M	5	Lt	1	7	21	Ilizarov	knee	119	70	25/28	0–10/0–70	35–20/45–25
2	F	8.5	Lt	2a	4.5	24	Ilizarov	Hip+knee	116	72	15/30	0–55/0–85	25–15/35–20
3	M	4.5	Rt	1	5.5	25	Ilizarov	knee	118	70	23/24	0–50/0–90	30–20/45–25
4	M	6	Rt	1	6	18	Ilizarov	knee	117	74	24/28	0–55/0–95	35–20/45–25
5	M	4.5	Rt	1	4.8	15	Ilizarov	knee	119	70	22/24	0–50/0–30	30–20/45–25
6	F	7	Lt	2a	6	20	Ilizarov	Hip+knee	115	76	15/34	0–50/0–90	25–15/35–20
7	M	6	Lt	2a	4.5	21	Ilizarov	Hip	110	79	−10/30	0–130/0–140	10–0/30–20
8	F	9	Rt	1	4.8	16	Ilizarov	Hip	115	80	−8/30	0–95/0–110	15–5/35–20
9	M	4	Lt	2a	4.5	22	Ilizarov	Hip	118	79	−10/30	0–90/0–120	10–0/30–20
10	M	6	Lt	2a	4.5	23	Ilizarov	Hip	119	79	15/34	0–85/0–105	25–10/45–25
11	M	13	Rt	1	6.2	25	Ilizarov	Hip	118	80	15/34	0–90/0–110	25–15/45–25
12	M	10	Rt	1	7	20	Ilizarov	Hip+knee	118	72	20/34	0–55/0–95	25–15/35–20
13	M	5.5	Rt	1	6	25	Ilizarov	knee	119	70	23/26	0–50/0–85	35–20/45–25
14	F	5	Rt	1	6.5	24	Ilizarov	knee	117	70	25/26	0–10/0–75	30–20/45–25
15	M	4.5	Lt	2a	6	25	Ilizarov	Hip+knee	116	74	−8/32	0–60/0–95	25–15/35–20
16	F	9	Rt	1	8	24	Ilizarov	hip	119	80	21/36	0–90/0–115	25–15/45–25
17	F	7.5	Rt	1	5.2	20	Ilizarov	hip	115	81	−10/28	0–120/0–130	15–5/35–20
Mean		6.8			5.7	21.6			116.94	75.05	11.6/ 29.9	0–67/0–96	25–14/40–23

ALDFA, Anatomic lateral distal femoral angle; CEA, center-edge angle; CFD, congenital femoral deficiency; F, female; Lt, left; M, male; NSA, neck-shaft angle; Rt, right.

place until complete consolidation of the lengthening and regeneration, and the reconstruction was performed later after fixator removal.

Preoperative clinical evaluation

The hip was examined for the range of movement, fixed deformities, periarticular soft tissue contracture, and Trendelenburg test after residual shortening compensation. McKay's clinical criteria for the hip were applied to all cases preoperatively and post-operatively: the excellent results indicate a stable painless hip, no limp, negative Trendelenburg sign, and full range of motion; good results indicate a stable painless hip, slight limp, and a slight decrease in range of motion; fair results indicate a stable painless hip, limp, positive Trendelenburg sign, and limited range of motion or a combination of these; and poor results indicate unstable or painful hip or both and positive Trendelenburg sign [20].

Table 2 Signs of hip and knee instabilities

Joints	Signs	*N* (%)
Hip joint	Clinical	
	Trendelenberg's test positive	11 (65)
	Radiological signs	13 (76)
	Femoral neck retroversion	
	NSA$<$120°	17 (100)
	CEA$>$20°	7 (41)
	CEA$<$20°	10 (59)
Knee joint	Clinical	
	Positive Lachman test	
	Radiological	
	Grade I	8 (47)
	Grade II	5 (29)
	Grade III	4 (24)
	Positive drawer test at 90° knee flexion	17 (100)
	Mediolateral knee instability	12 (71)
	Positive pivot shift	14 (82)
	Hypoplastic lateral femoral condyle	10 (59)
	Hypoplastic tibial spine	15 (88)

CEA, center-edge angle; NSA, neck-shaft angle.

The knee was examined for stability, integrity of the cruciate ligaments, deformity, soft tissue contracture, and range of movement. Judet's clinical criteria for the knee were applied to all cases preoperatively and postoperatively: excellent results indicate knee flexion greater than 100°; good results indicate flexion between 81° and 100°; fair results indicate flexion between 50° and 80°; and poor results indicate flexion less than 50° [21].

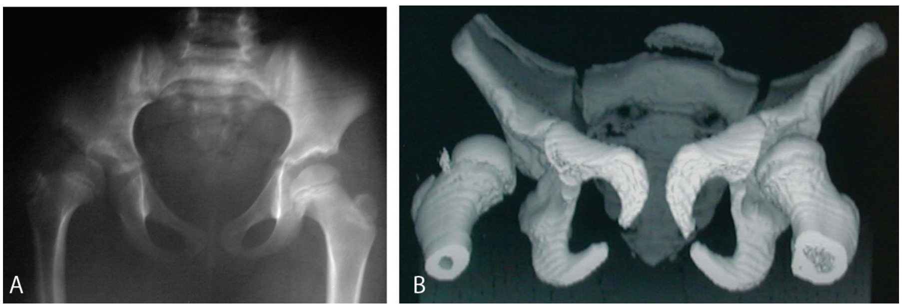
Preoperative imaging studies

The hip was examined using plain radiography and computed tomography scan with three-dimensional reconstruction. The images were studied for acetabular morphology, center-edge angle (CEA), neck-shaft angle, retroversion of the femoral neck, and morphology of the proximal femur (Fig. 2). The knee was examined on both sides by means of plain radiographic studies in the anteroposterior, lateral, and tunnel views. Moreover, MRI examination of the affected knee was performed. The images were studied for the presence of subluxation or dislocation, patellar size compared with the other side, development of the tibial spine, the development of the cruciate ligaments, and the shape of the femoral condyle (Fig. 3).

The procedure

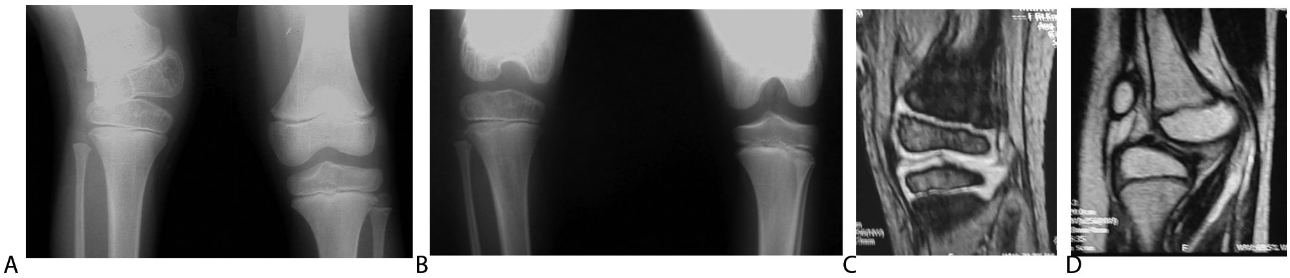
In cases of simultaneous hip and knee dislocation both joints were stabilized in one session starting with the hip joint. Periarticular soft tissue releases of the hip were performed. This included release of the adductor tendon and tendon of the straight head of the rectus femoris. The hip joint was then reduced and stabilized by means of pericapsular acetabuloplasty (San Diego technique) under fluoroscopic control [22] (Fig. 4). Capsulorraphy was performed at the time of pelvic osteotomy in cases of complete hip dislocation, but not in cases of subluxation.

Figure 2



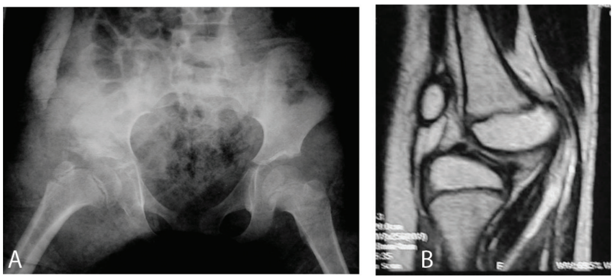
(a and b) Plain radiography and three-dimensional computed tomography scan of the pelvis and hips in a case of right congenital short femur and right hip dislocation. The images show the dysplasia of the acetabulum, hypoplasia of the proximal femur, and retroversion of the femoral neck compared with the healthy left side.

Figure 3



(a and b) Plain radiography of right congenital short femur, anteroposterior and tunnel views, show the subluxed knee, hypoplastic tibial spines, and shallow intercondylar femoral notch. (c and d) MRI images of the same knee, the coronal cut, shows the wedge-shaped distal femoral epiphysis due to hypoplasia of the lateral femoral condyle. The sagittal cut shows the absent cruciate ligaments and anterior subluxation of the tibia.

Figure 4



(a) Immediate postoperative radiography shows the pericapsular osteotomy and hip spica. (b) Follow-up radiography shows the coverage of the femoral head and maintained hip reduction.

No proximal femoral osteotomy was performed in this series.

The knee was reduced and stabilized by means of extra-articular ligament reconstruction. The distal half of the iliotibial tract (ITT) was approached through a lateral skin incision starting laterally proximal to the knee joint and curving antero-inferiorly on the knee. The common peroneal nerve was identified and protected and Z-lengthening of the biceps femoris tendon was performed. The ITT was dissected along its anterior and posterior margins where it blends with the intermuscular septa, and then the ITT was transected as proximal as possible and reflected downward and left attached distally to its tibial insertion. This strip was used for extra-articular stabilization of the knee where it was divided longitudinally into two bands. The posterior band was used for lateral collateral ligament augmentation, where it was passed under the periosteum at the femoral attachment of the lateral collateral ligament, and then curved downward to be sutured to itself at its tibial insertion. The anterior band was passed medially on top of the patella and then through a drill hole in the distal femoral metaphysis, proximal to the physeal plate, in a lateral direction to be sutured to itself at the tibial attachment of the ITT. The anterior band was fixed with the knee in the reduced position and 30° of flexion (Fig. 5). A unilateral hip spica was then applied.

Postoperative management

The spica cast was removed after 8–12 weeks depending on the progress of healing of the pelvic osteotomy. Physiotherapy was started to regain joints' range of motion. The patients were followed up clinically and radiologically every month for 3 months and then every 6 months.

Evaluation of results

At final follow-up the excellent and good clinical scores were considered satisfactory outcome, whereas fair and poor scores were considered unsatisfactory outcome.

Statistical analysis was performed using SPSS (version 11.0.1 for Windows; SPSS Inc., Chicago, Illinois, USA). The Fisher exact test and one-way analysis of variance, a nonparametric equivalent, and the Kruskal–Wallis test were used for variables that were small and/or not normally distributed. Moreover, one sample t-test was used to compare the means. A P value less than or equal to 0.05 was considered to be statistically significant.

Results

All patients (17 cases) were evaluated at the time of last follow-up. Follow-up ranged from 24 to 78 months (average: 37 months) after the reconstructive procedure for hip and knee dislocation. There were 11 (65%) cases of type 1 after Paley's classification and six (35%) cases of type 2a. None of the patients had undergone preoperative preparatory surgery before limb lengthening.

In all cases, certain defects were detected with varying severity. The femur was short and hypoplastic with proximal femoral varus angulation. In the hip, coxa brevia, coxa vara, femoral head retroversion, global acetabular dysplasia, and retroverted acetabulum were constant findings. In the knee, hypoplastic lateral femoral condyle, anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) deficiency, and tight posterolateral structures were common findings.

The average lengthening achieved at the time of diagnosis of the dislocations was 5.7±1.048 cm (range: 4.5–8 cm).

Hip dislocation only was present in seven (41%) cases; all of them had near-normal lateral femoral condyle. Knee dislocation only was present in six (35%) cases who had an average CEA of 23.667° (range: 22–25°). Combined dislocation was present in four (24%) cases. It was noted that with CEA more than 20° the femoral lengthening leads to greater dislocation of the hypoplastic knee joint. With a CEA of 15–20° both joints had a tendency to dislocate simultaneously in the presence of hypoplastic knee, and with a CEA of less than 15° the hip joint had more tendency to dislocate alone (Table 3).

Table 3 Relationship of hip and/or knee dislocation to the prelengthening radiological findings

Radiological findings	Normal lateral femoral condyle		Hypoplastic lateral femoral condyle	
	N	Dislocation	*N*	Dislocation
CEA 20°	1	Hip	6	knee
CEA 15–20°	2	Hip	3	Hip and knee
CEA 15°	4	Hip	1	Hip and knee

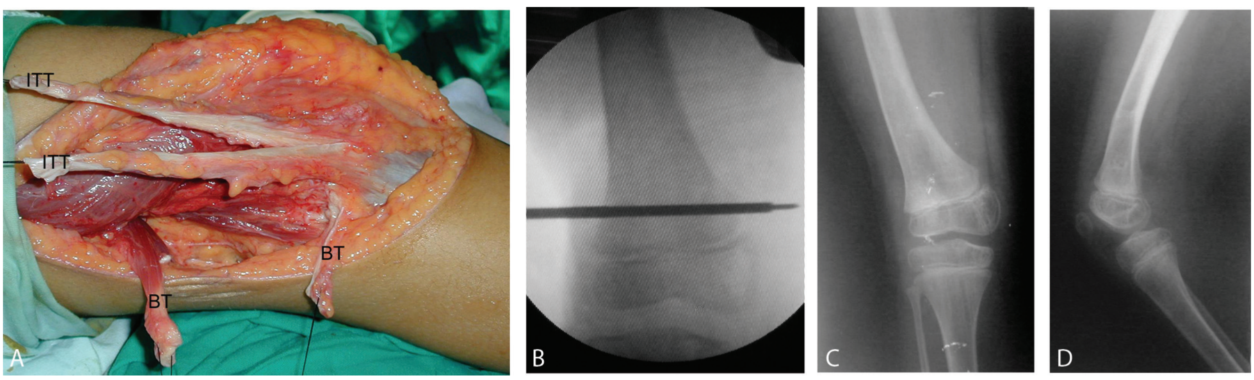
CEA, center-edge angle.

Dislocation, mostly of the hip, was noted in six (35%) cases that had lengthening less than 5 cm and in 11 (65%) cases that had more than 5 cm lengthening. Simultaneous dislocation of both joints occurred mostly after lengthening more than 5 cm (Table 4).

The nondislocated hip group during lengthening (six cases) had an average of 23.667°±1.211° CEA (range: 22°–25°), whereas the other group with dislocation (11 cases) had an average CEA of 5°±13.76° (range: −10° to +21°). The difference between the two groups was highly significant (P=0.001).

The preoperative CEA was −10° to +25° (average: 11.6°). The CEA at follow-up was +24° to +36° (average: 29.9°); the difference was highly significant (P=0.004). At latest follow-up, all hips remained stable (CEA≥24°) and Trendelenberg's test was negative in all cases. Hip abduction/internal rotation motions significantly improved (P=0.001) at the final follow-up as the initial means were 25/14 and the final means were 40/23, respectively. Although, all cases, postoperatively, ranged between excellent and good

Figure 5



(a) Intraoperative photograph shows the harvested iliotibial tract (ITT) divided into anterior and posterior bands, and the Z-lengthening of the biceps femoris tendon (BT). (b) Intraoperative image intensifier view shows the distal femoral metaphysis drilling, above the physeal plate, for the passage of the anterior band of the ITT in a medial to lateral direction. (c and d) Follow-up radiography show maintained reduction of the knee.

Table 4 Femoral lengthening amount and related hip and knee dislocation

Femoral lengthening	Hip dislocation (*n*)	Knee dislocation (*n*)	Both joints dislocation (*n*)	Total	Kruskal–Wallis test
Less than 5 cm	4	1	1	6	P=0.400*
More than 5 cm	3	5	3	11	
Total	7	6	4	17	

*Insignificant value.

McKay's clinical criteria, the improvement was statistically nonsignificant due to the small number of the study cases (Table 5). Excellent results were significantly common among Paley's type 1 cases and those with initial CEA more than 20° (Table 6).

The anterior drawer test remained positive. Anteromedial rotatory instability improved postoperatively. The Pivot shift test remained negative. One knee redislocated with further unprotected lengthening in another center; it was considered poor according to Judet's clinical criteria. The preoperative mean of knee flexion was 67° (range: 10°–130°), and the final mean of knee flexion was 96° (range: 30°–140°); the difference was highly significant (*P*=0.001). However, although 14 cases had finally excellent and good Judet's clinical criteria, the improvement was statistically nonsignificant due to the small study size (Table 7). Moreover, excellent results were nonsignificantly common in the following conditions: male sex; age below 8 years; Paley's type 1 pathology; cases with less than 5 cm initial lengthening; and absence of lateral femoral condyle hypoplasia (Table 8).

Table 5 McKay's clinical criteria for the hip preoperatively and at the final follow-up

McKay criteria [20]	Preoperative (*n*)	At final follow-up (*n*)	Kruskal–Wallis test
Excellent	0	9	*P*=0.714*
Good	6	8	
Fair	7	0	
Poor	4	0	
Total	17	17	

*Insignificant value.

Table 6 Factors affecting McKay's hip clinical criteria at the final follow-up

Factors	Excellent hip McKay's criteria (*n*)	Good hip McKay's criteria (*n*)	Total	Fisher exact test (*P* value)
Sex				
Male	7	4	11	0.335**
Female	2	4	6	
Age				
Below 8 years	7	5	12	0.620**
Above 8 years	2	3	5	
Paley's type				
Type 1	8	3	11	0.050***
Type 2a	1	5	6	
Femoral lengthening				
Less than 5 cm	2	4	6	0.335**
More than 5 cm	7	4	11	
Initial CEA				
More than 20°	7	0	7	0.002***
Less than 20°	2	8	10	

CEA, center-edge angle. **Nonsignificant value. ****Significant value.

Discussion

CFD is associated with several articular and soft tissue deficiencies, which together were reported to predispose to major joint instability and dislocation during limb lengthening [1–11]. Clinicians must recognize the factors that might predispose to joint subluxation or dislocation during limb lengthening for CFD. Such complications could be avoided by preparatory procedures to neutralize the dislocating forces and by applying secondary procedures in case joint dislocation developed [10,19,23].

The dislocation occurs due to conflict of force vectors at the hip and knee during lengthening. The dislocating forces are exerted by the tight periarticular tissues, mainly the ITT, which works against the anatomical bony deficiencies and with its biarticular attachment can cause hip and knee dislocation [24].

The ITT is tense when the limb is loaded, both in the neutral position and when the tibia is internally or externally rotated. Furthermore, different parts of the ITT are under tension at different positions of knee joint flexion, thus producing the pivot shift phenomenon in ACL-deficient knees [24,25]. Being tethered by the transfixing lateral pins, the ITT becomes tighter during femoral lengthening and works as a dislocating force to both the hip and knee.

The hip dislocated in the superolateral direction, which is attributed to the global deficiency of the acetabulum and the tight ITT working against the deficient bony support. The knee dislocated in the anterolateral, which is attributed to bony deficiency and the

Table 7 Judeta's clinical criteria for the knee preoperatively and at the final follow-up

Judet criteria [21]	Preoperative (*n*)	At final follow-up (*n*)	Kruskal–Wallis test
Excellent	2	7	*P*=0.495*
Good	5	7	
Fair	8	2	
Poor	2	1	
Total	17	17	

*Nonsignificant value.

Table 8 Factors affecting Judet's knee clinical criteria at the final follow-up

Factor	Excellent knee Judet's criteria (*n*)	Good knee Judet's criteria (*n*)	Fair knee Judet's criteria (*n*)	Poor knee Judet's criteria (*n*)	Total	Kruskal–Wallis test (*P*-value)
Sex						
Male	4	5	1	1	11	0.144*
Female	3	2	1	0	6	
Age						
Below 8 years	4	5	2	1	12	0.171*
Above 8 years	3	2	0	0	5	
Paley's type						
Type 1	4	4	2	1	11	0.114*
Type 2a	3	3	0	0	6	
Femoral lengthening						
Less than 5 cm	4	1	0	1	6	0.362*
More than 5 cm	3	6	2	0	11	
Hypoplastic lateral femoral condyle						
Absent	7	0	0	0	7	0.952*
Present	0	7	2	1	10	

*Nonsignificant value.

attachment of the ITT anterolaterally to the Gerdy's tubercle.

Dislocation of the hip and knee can occur simultaneously in the same patient. The highest incidence of subluxation and dislocation of either the knee or the hip was reported with the use of monolateral external fixators and circular frames without joint protection [5,23].

Bowen *et al.* [5] documented that a CEA less than or equal to 20° was the threshold for hip dislocation during femoral lengthening. In this study, the CEA greater than or equal to 22° had a highly significant effect on guarding against hip dislocation during femoral lengthening. A retroverted and globally deficient acetabulum adds to hip instability and should be considered in planning the pelvic osteotomy to stabilize the hip joint.

Grill and Dungl [23] reported the results of lengthening for CFD types III to IX (according to Pappas classification of CFD). They recognized knee subluxation or dislocation in eight of the 14 patients who had knee dysplasia. They treated this complication in various ways: with soft tissue release including the ITT (three cases), with extended use of the Ilizarov frame in three cases, and with simple traction in two cases. They also noted hip dislocation in two cases. In one case they adjusted the frame to relocate the femoral head. In the second case the dislocation resulted because of dysplastic acetabulum and retroverted femoral neck. They performed derotation osteotomy and posterior arthrotomy and Chiari pelvic osteotomy, but 1 year later redislocation of the hip recurred.

Dhawale *et al.* [26] reported three cases with hip dislocation during CFD lengthening. They achieved an average lengthening of 9 cm. They managed them all with soft tissue release, open reduction, femoral shortening, and an acetabular procedure (shelf acetabuloplasty in two cases and Dega osteotomy in one case).

In this study, the San Diego acetabuloplasty was performed for all dislocated hips with a satisfactory clinical outcome. There was no need for femoral shortening as there was no proximal migration of the dislocated head in our series in addition to the accompanied coxa vara element and the modest lengthening, which averaged only 5.7 cm. We believe that the San Diego pericapsular acetabuloplasty is more versatile in cases of CFD, compared with other pelvic osteotomies, as it allows adjustment of the amount of coverage in all directions unlike other osteotomies. Despite being dysplastic hip, in CFD types 1 and 2a, the hip usually has a good function in terms of stability, range of motion, and pain. When that hip dislocates, a timely surgical interference for soft tissue release and pelvic osteotomy to relocate and stabilize the hip joint is expected to yield a satisfactory outcome.

Simultaneous dislocation of both the hip and knee joints during femoral lengthening was observed, in this study, when the CEA was 15°–20° associated with a hypoplastic lateral femoral condyle. Similarly, Hazra *et al.* [14] had reported both joints' dislocation when the CEA was 15° and the knee had hypoplastic lateral tibial spine.

Before embarking on femoral lengthening, the surgeon must be aware of the stability of the knee and the subtle signs of an absent ACL. Subluxation or dislocation of the knee after femoral lengthening has often been attributed to the procedure itself, but a pre-existing ligamentous deficiency is suspected to be the main contributing factor [17,18]. According to this study, the presence of a hypoplastic lateral femoral condyle is considered a strong predictor of knee dislocation during femoral lengthening, especially if the amount of lengthening exceeded 5 cm. Moreover, it played a nonsignificant role in the functional outcome after extra-articular knee reconstruction. A distal femoral varus osteotomy, to correct the valgus deformity, would help to stabilize the knee when combined with soft tissue reconstruction.

Gillespie and Torode [7] reported the results of femoral lengthening using the Wagner technique in eight cases. In five of their patients posterior dislocation of the knee had occurred, in two cases the treatment included surgical release of the knee, and the others were managed with traction and casts.

On the basis of his description of the pivot shift phenomenon and its prevention, McIntosh described his lateral substitution reconstruction of the ACL utilizing a strip of the fascia lata and reported a subjectively satisfactory results in 75% of his patients at long-term follow-up (average: 11.3 years) [27]. However, these results were reported in adult patients who had normal bony architecture of their knees contrary to patients with CFD who have bony deficiencies, which destabilize the knee.

Recently, the extra-articular reconstruction of the ACL has almost been replaced by arthroscopic techniques [28]. However, such intra-articular procedures may not be suitable for younger children, especially patients with CFD who have distal femoral valgus deformity, due to hypoplastic lateral femoral condyle, which could be aggravated by intra-articular ACL reconstruction.

Despite its shortcoming in maintaining a stable knee, extra-articular knee reconstruction for children with CFD, who undergo femoral lengthening, would serve two purposes: it removes a dislocating force (ITT) and utilizes it as a knee-stabilizer until skeletal maturity when formal intra-articular procedures can be safely performed.

Conclusion

In limb lengthening for CFD the prelengthening preparatory procedures are necessary to prevent hip and knee dislocation; however, the effect of extra-articular knee stabilization is not long lasting in most cases and intra-articular physeal-sparing procedures should be adopted instead. However, the pericapsular acetabular osteotomy is a reliable stabilizing procedure and upper femoral corrective osteotomy would be of additive value. Better understanding of the deficiencies in CFD would help in the development of a pathology-targeted and reproducible treatment plan.

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Conflicts of interest
There are no conflicts of interest.

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