Symposium - Cerebral Palsy

Distal Femoral Extension Osteotomy with 90° Pediatric Condylar Locking Compression Plate and Patellar Tendon Advancement for the Correction of Crouch Gait in Cerebral Palsy

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Abstract

Background: Various treatment modalities are available for the correction of crouch gait, ranging from hamstring lengthening to a combination of soft-tissue and bony procedures. We report the results of distal femoral extension osteotomy (DFEO) fixed with 90° pediatric condylar locking compression plate (LCP) and patellar tendon advancement (PTA) for crouch gait in children with cerebral palsy. **Materials and Methods:** A total of 26 patients (52 knees) with a mean age of 14.36 years (range 11.6–20 years) who presented with crouch gait were treated with DFEO and PTA. Patients were analyzed prospectively using clinical (knee flexion deformity, knee range of motion, extensor lag), functional (modified Ashworth, Tardieu scores, muscle strength, gross motor functional classification system [GMFCS], functional mobility scale [FMS], gross motor functional measure [GMFM]) and radiological (Koshino Index) outcome measures and followed up at a mean of 22 months (range 12–53 months). **Results:** There was an improvement in all outcome measures postoperatively, with improved function and independence. The mean knee flexion deformity improved significantly from 20.7° ± 6.59 to 0.67° ± 2.62, mean muscle strength of quadriceps improved from 3.01 ± 0.5 to 3.5 ± 0.54 and mean extensor lag improved from 20° ± 7.14 to 4.13° ± 4.16. The mean Koshino Index improved from 1.4 ± 0.16 to 1.0 ± 0.08. The mean GMFM-D improved from 15.58 ± 6.2 to 26.31 ± 5.8 and mean FMS for 5 m improved from 2.9 ± 1.09 to 3.6 ± 0.84, indicating significant improvement in household ambulation. There were four complications; transient peroneal nerve palsy in 3 patients, which recovered completely and 1 superficial wound dehiscence. There was no loss of fixation, tendon pull-out or deep infection. **Conclusion:** The combined procedure of DFEO and PTA can correct knee flexion deformity, restore knee extensor strength, and improve function in patients with crouch gait. The pediatric condylar LCP provides stable fixation to allow early mobilization and faster rehabilitation.

Keywords: *Cerebral palsy, crouch gait, distal femur osteotomy, locking compression plate, patellar tendon*

Introduction

Crouch gait is one of the most common gait deviations observed in cerebral palsy, seen in 88% of children with quadriplegia and 74% of children with diplegia.[1] A child is generally classified as walking with a crouch gait if knee flexion is >20° at initial contact and >30° throughout the stance phase.[2] Crouch consists of a constellation of factors, in the form of excess muscle spasticity or contracture, muscle weakness, impaired balance, and abnormal body mass to muscle strength ratio; leading to a significant lever arm dysfunction.[2,3] This results in secondary changes such as patella alta, fixed knee contractures, altered patellofemoral forces, and anterior knee joint pain.[2,3]

Various treatment strategies have been in practice for crouch correction; ranging from physiotherapy, bracing, casting,[4] and soft-tissue procedures[5,6] to bony surgeries[7,8] or a combination of both.[9] Soft-tissue surgeries (hamstring lengthening, semitendinosus transfer, rectus femoris transfer) as part of single-event multilevel surgery (SEMLS) were popular for the correction of crouch gait over the years.[5,6] It was thought that crouch gait resulting from the tightness of hamstring muscles can be corrected by lengthening of the muscle-tendon unit. However, gait analysis studies have shown that the hamstrings can

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be of normal length, shorter, or even lengthened in cases of crouch.[10] Thus, over-lengthening of a normal muscle or an already elongated muscle will lead to an excessive anterior pelvic tilt, excessive lumbar lordosis, weakness of quadriceps, and hip extensors and a worsening of the deformity.[10]

The use of either distal femoral extension osteotomy (DFEO) or patellar tendon advancement (PTA) individually has been reported for the treatment of fixed flexion deformity (FFD) of the knee in neuromuscular disorders such as poliomyelitis and cerebral palsy with successful results.[11-13] The combined use of DFEO with PTA for crouch correction in cerebral palsy was first reported by Stout *el al*.,[14] in 2008 with encouraging results. Subsequently, a few studies have confirmed the effectiveness of this combined procedure in improving crouch gait by increasing knee extension in stance, improving quadriceps strength and extensor lag, and improving postoperative kinematic measurements of gait.[15-18]

Various implants have been in use for fixation of the DFEO including K-wires,[16] compression plates[15] and angled blade plates.[9,14] Locking compression plates (LCP) were introduced initially in traumatology for stable fracture fixation and later modified for use in children. As a derivative of the pediatric proximal femur LCP, an anatomically contoured implant with a 90° angle between the proximal part of the plate and the distal screws was designed for the use in distal femur in children and introduced in 2007.[17] This plate allows the osteotomy to be performed as distally in the metaphysis as possible, without any damage to the physeal plate, while providing stable fixation**.** It also allows early mobilization and quick rehabilitation, which is critical in patients with cerebral palsy. This implant has been recently become available in India, and as far as we know, no literature is available from our country regarding its use in distal femur osteotomy fixation in children with cerebral palsy. The aim of this study is to report our results of DFEO and PTA with 90° pediatric condylar LCP fixation for crouch gait in children with cerebral palsy.

Materials and Methods

This was a prospective study of consecutive patients with cerebral palsy, who underwent DFEO and PTA for treatment of crouch gait at our institute between December 2012 and April 2016. All the data were collected prospectively using a standardized proforma. The study was approved by the Ethics Committee and Institutional Review Board of the hospital. A written informed consent from parents and patients, and assent from children above 7 years of age were obtained before surgery. We included all patients of diplegic and quadriplegic cerebral palsy with crouch gait [Figure 1], knee flexion deformity of <30° and gross motor functional classification system (GMFCS) levels II, III, and IV, with a minimum followup of 12 months postoperatively. Patients with knee flexion deformity of >30°, children with dystonic cerebral palsy or GMFCS level V were excluded from the study.

Figure 1: Clinical photograph of an 11.6-year-old boy with spastic diplegia (gross motor functional classification system Level III) with crouch gait

Operative procedure

All patients underwent DFEO with PTA or tibial tuberosity advancement (TTA) procedure. The fixed flexion deformity of the knee was assessed clinically and with lateral knee radiographs taken with the knee in maximal extension. Surgery was performed in the supine position, under epidural anesthesia using a sterile tourniquet. Intravenous antibiotics were administered at the start of surgery. The surgery was performed using the standard lateral approach to the distal femur [Figure 2a], elevating the vastus lateralis muscle from the lateral aspect of the bone. The periosteum was incised and elevated in a limited fashion, and the appropriately sized plate (3.5 mm or 5 mm pediatric condylar LCP) was positioned, with its end just above the distal femoral physis. A V-shaped osteotomy, with the distal limb being perpendicular to the tibial shaft and the proximal limb perpendicular to the femoral shaft, was made. The osteotomy was performed, cutting out a full wedge of bone at the desired angle. The distal fragment was extended to close the wedge and posteriorly translated, to align the mechanical axis in the sagittal plane and prevent a secondary deformity. Torsional malalignment was corrected by de-rotating the distal fragment at this step. The osteotomy was temporarily stabilized with a 2 mm K-wire taking care not to cause any valgus or varus malalignment. The plate was placed and fixed distally with 3 locking screws. The proximal fragment was reduced to the plate using a reduction clamp and fixed with 3 locking screws, after ensuring that the proximal fragment was not dragged towards the plate by using a medialization device or a temporary spacer between the proximal fragment and the plate [Figure 2b]. The periosteum was closed over the plate. The wound was closed without drains and dressed.

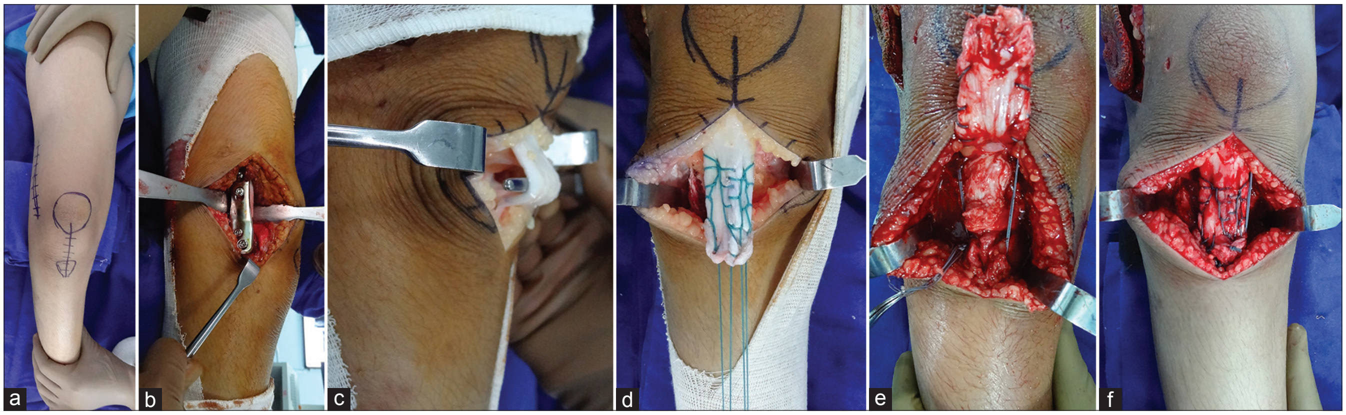


Figure 2: Clinical photos demonstrating the intraoperative steps of distal femoral extension osteotomy/patellar tendon advancement. (a) Anteroposterior view showing skin incisions marked. (b) Distal femoral extension osteotomy performed and fixed with 90° pediatric condylar locking compression plate. Note correction of the knee flexion deformity. (c) Laxity of the patellar tendon following correction of knee flexion deformity. (d) Patellar detached and secured with 4-tailed Krackow stitch using No.2 Ethibond suture. (e) Reinforcing No.2 Fiberwire passed through drill holes in the patella and tibia. (f) Patellar tendon advanced and final repair with overlapping periosteal flaps

PTA was performed as per the technique described by Novacheck *et al.*[19] A 5 cm anterior incision was made from the lower pole of the patella to the tibial tubercle. The patellar tendon was then exposed [Figure 2c] and elevated off the tibial tuberosity by sharp dissection, while in older children, a bone block was removed with the patellar tendon intact. In immature patients, a T-shaped periosteal flap was raised in the proximal tibia. A double Krackow stitch was taken through the patellar tendon with no. 2 Ethibond [Figure 2d] and passed through a drill hole in the proximal tibia at the level of tendon advancement. A No. 2 fiberwire (Arthrex) was passed through a patellar drill hole, through a subcutaneous tract and through the same tibial tunnel [Figure 2e]. It was secured in 60° of knee flexion. In mature patients for TTA, a slot was created 1.5 cm–2.5 cm below the tibial tuberosity. The bone block with the patellar tendon was inserted into the same slot and secured with a 4 mm cancellous screw. The T-shaped periosteal flap was closed over the advanced tendon [Figure 2f]. The surgical wound was closed without drain, a compression dressing was applied, and the limb was immobilized in a long knee brace. The goal of the procedure was to achieve full knee extension and restore an appropriate relationship between quadriceps mechanism and tension, to maintain knee extension during the stance phase of gait.

Rehabilitation protocol

A strict rehabilitation protocol was followed for all patients. Patients were immobilized in a long knee brace, and passive knee flexion was started from the 3rd postoperative day. Passive knee flexion of 0°–30° was allowed for initial 2 weeks, gradually increasing to 60° flexion by the 4th week and to 90° by the 6th postoperative week. Active knee extension and quadriceps strengthening exercises were initiated after 6 weeks. Partial weight bearing ambulation with a walker was started at 4 weeks using Ankle Foot Orthosis (AFO) with the resumption of full weight bearing by the end of 2 months. Night-time splinting was encouraged for upto 6 months.

Outcome measures

Patients were analyzed using clinical, functional, and radiological parameters [Table 1]. Clinical outcomes measured were knee flexion deformity, knee range of motion, and extensor lag. These were measured using a handheld goniometer with the patient in supine position, or in prone position, if there was a concomitant hip flexion deformity. Clinical measurements were made preoperatively and postoperatively at 1 month, 3 months, and then every 6 monthly until final followup.

Functional parameters assessed were the modified Ashworth and Tardieu scales for muscle spasticity, muscle strength assessment (hamstrings, quadriceps, and gastro-soleus) by manual muscle testing using the Medical Research Council grading, the Gross Motor Functional Classification System (GMFCS) and Functional Mobility Scale (FMS) to classify the extent of mobility and the Gross Motor Functional Measure (GMFM)– Dimension D. Functional parameters were measured preoperatively, 6 months postoperatively and at final followup. The GMFCS is a tool to stratify patients with cerebral palsy according to their functional level, is relatively stable, and is not responsive to intervention. The FMS is a validated scale to classify the extent of mobility across different environments such as home, school, and community. It is highly sensitive to detect changes after operative intervention. The GMFM is a standardized observational instrument designed and validated to measure the change in gross motor function over time in children with cerebral palsy.

Radiologically, osteotomy union and the Koshino Index were studied. The radiological union was defined as the presence of bridging callus and/or restoration of continuity in at least three of the four cortices in two orthogonal radiographs. The Koshino index[20] [Figure 3] is a tool used to measure the patellar height. It was measured on a plain X-ray lateral view with the knee in maximum extension, as the ratio of the distance from the center of the patella to the epiphyseal midpoint of the proximal tibia (PT) to that between the distances of the distal femur and proximal tibia (FT). The normal value ranges from 0.9 to 1.2 and is dependent on the degree of knee flexion. Radiological parameters were measured preoperatively, immediately postoperatively, every month for the first 3 months postoperatively, and at final followup.

Statistical analysis

For analysis of outcomes, paired *t*-test using SPSS software version 20 (IBM, USA, 2016) was used to assess changes between preoperative and postoperative measures. Statistical significance was set at 95% confidence interval ($P = 0.05$).

Results

Twenty- six patients (52 knee joints) who met the inclusion and exclusion criteria, with a minimum followup of 1 year were reviewed.

Demographics

Among the 26 children, 24 children had spastic diplegia and 2 had quadriplegic cerebral palsy. There were 14 male patients and 12 female patients with a mean age of 14.36 years (range 11.6–20 years). The mean followup period was 22 months (range 12–53 months). According to the GMFCS level, 1 patient was GMFCS II, 12 patients were GMFCS III, and 13 patients were GMFCS IV.

Table 1: Outcome measures

Clinical	Functional	Radiological
Knee FFD	Modified Ashworth	Koshino Index
Knee range of motion	Tardieu scales	Union rate
Extensor lag	Muscle strength	
	GMFCS	
	FMS	
	GMFM-D	

GMFCS=Gross Motor Functional Classification System, FMS=Functional Mobility Scale, GMFM-D=Gross Motor Functional Measure-Dimension D, FFD=Fixed flexion deformity

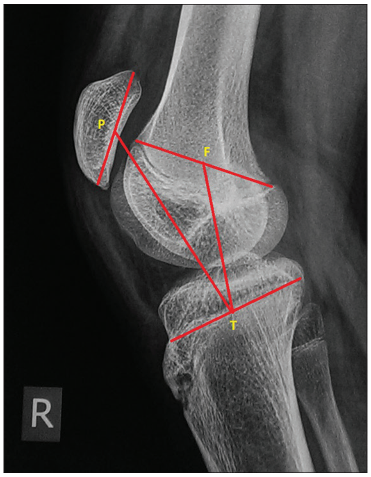


Figure 3: Preoperative lateral radiograph of knee in maximal extension showing calculation of Koshino Index. Here, the Koshino Index (PT/FT) = 1.44 indicating patella alta

Surgical analysis

All patients underwent bilateral DFEO and patellar tendon procedure. PTA was performed in 22 patients (44 knees) while TTA was done in 4 patients (8 knees) who were skeletally mature [Figure 4]. The mean duration of the surgery was 2 h (range 1.5–3 h), and the mean blood loss was 100 ml (range 50–150 ml). In 16 patients, the 5.0 mm pediatric condylar LCP was used while in 10 patients the 3.5 mm plate was used for osteotomy fixation. The mean wedge removed was 18.17° (range 10°–30°). The patellar tendon was advanced by a mean distance of 2.2 cm (range 1.5 cm–3 cm).

Concomitant surgeries and complications

Five patients underwent bilateral iliopsoas lengthening for associated hip flexion deformity. No other soft-tissue or bony procedures were performed concomitantly. Two patients had a superficial wound gape over the tibial tubercle which healed with regular dressing. Postoperative neuropraxia of the peroneal nerve occurred in three limbs: unilateral in one patient, and bilateral in another patient. The unilateral peroneal palsy recovered completely within 6 weeks, while the bilateral case took 5–6 months to recover with no permanent sequelae. Till then, the patient was made to ambulate with static AFOs.

Clinical and functional parameters

The mean knee FFD [Graph 1] improved significantly from 20.76 ± 6.57 to 0.67 ± 2.62 ($P = 0.0001$).The mean muscle strength of hamstrings remained the same preoperatively and postoperatively 3.48 ± 0.5 (range 3–4) while the mean

Figure 4: Postoperative anteroposterior and lateral radiographs of the left knee showing complete correction of knee flexion deformity, fixation with 90° pediatric condylar locking compression plate and correction of patella alta following tibial tuberosity advancement in a skeletally mature patient

muscle strength of quadriceps improved from 3.01 ± 0.5 to 3.5 ± 0.54 (*P* = 0.001). The mean extension lag improved from 20 ± 7.14° (range 0°–30°) to 4.13 ± 4.16° (*P* = 0.0001). The mean Tardieu scale (R1 and R2) for hamstrings showed a statistically significant change (*P* = 0.001).

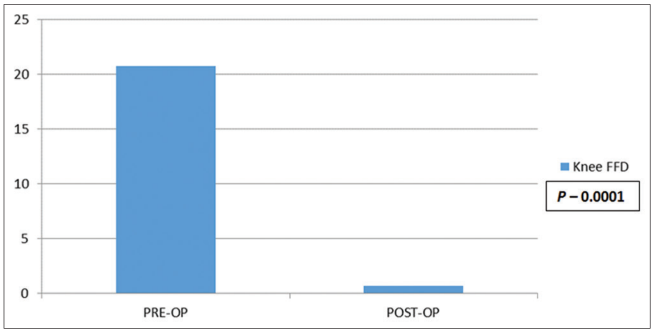
The mean GMFM-D [Graph 2] improved from 15.58 ± 6.2 to 26.31 ± 5.8 (*P* = 0.00012), while the mean FMS for 5 m improved from 2.9 ± 1.09 to 3.65 ± 0.84 (*P* = 0.001). Both these changes were statistically significant. The mean FMS for 50 m improved from 2.2 ± 1.3 to 2.8 ± 1.0 (*P* = 0.0631) and for 500 m from 1.7 ± 1.0 to 2.0 ± 1.14 (*P* = 0.324), but these were not statistically significant [Graph 3 and Table 2].

Radiological analysis

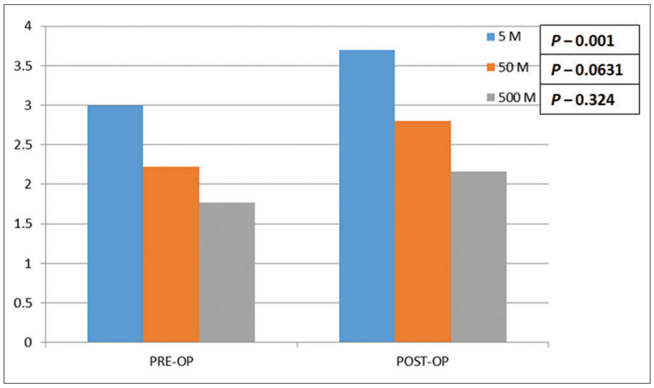
Union was seen in all patients at an average time of 9.4 weeks (range 8–12 weeks). No non-unions or malunions were seen, and there was no loss of correction or implant failure until final followup. The mean Koshino Index [Graph 4] improved from 1.4 ± 0.16 (range 1.04–1.76) preoperatively to 1.0 ± 0.08 (range 0.88–1.17) postoperatively, (*P* = 0.0001) and was maintained at last followup [Figure 5].

Discussion

The management of crouch gait in cerebral palsy has changed over the years, not only in the type of treatment but also the implants used in these surgeries. Rodda *et al*.,[6] described a comprehensive treatment program of SEMLS with the rehabilitation of individuals with severe crouch gait. Results indicated an improved gait at 5 years with increased function and independence in the community, but long term results showed a gradual decline in function. A study by Westberry *et al*.[4] described a serial casting protocol for patients with resistant or persistent fixed knee-flexion deformities after adequate hamstring lengthening, with good short term results.



Graph 1: Mean knee fixed flexion deformity

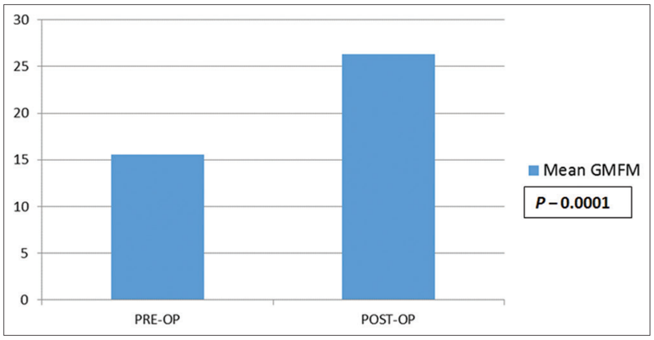


Graph 3: Mean functional mobility score

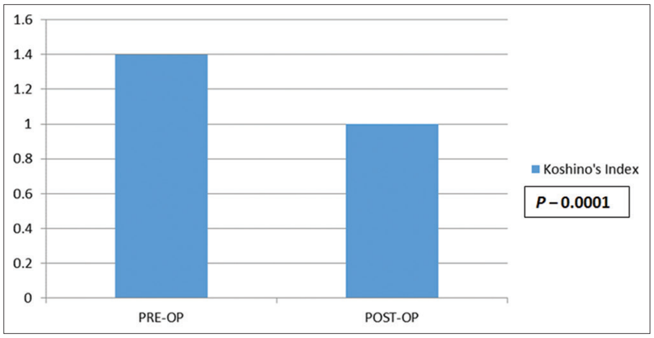
Table 2: Results

Parameters	Preoperative	Follow up	*P*
Knee FFD (mean)	20.7±6.59	0.67±2.62	0.0001
Muscle strength			
Hamstrings	3.48±0.5	3.48±0.5	NS
Quadriceps	3.01±0.5	3.5±0.54	0.001
Gastro-soleus	3.11±0.56	3.31±0.62	0.084
Extensor lag	20±7.14	4.13±4.16	0.0001
GMFCS	3.46±0.84	3.15±0.93	0.054
GMFM	15.58±6.2	26.31±5.8	0.0001
FMS (m)			
5	2.9±1.09	3.6±0.84	0.001
50	2.2±1.3	2.8±1.0	0.0631
500	1.7±1.0	2.0±1.14	0.324
Tardieu scale for hamstrings			
R1	85.38±9.59	54±11.17	0.0001
R2	69.61±13.42	36.11±10.35	0.0001
Koshino Index	1.4±0.16	1.0±0.08	0.0001

GMFCS=Gross Motor Functional Classification System, FMS=Functional Mobility Scale, GMFM=Gross Motor Functional Measure, FFD=Fixed flexion deformity, NS=Not significant



Graph 2: Mean gross motor functional measure



Graph 4: Koshino Index

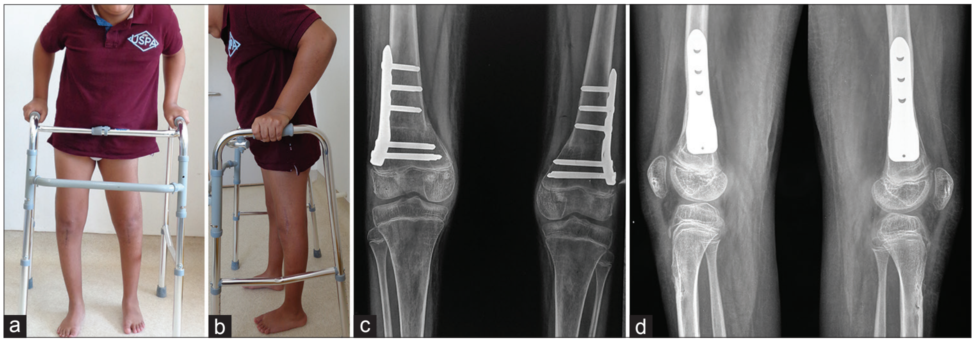


Figure 5: Clinical and radiological result in a 13-year-old boy (gross motor functional classification system Level IV) who underwent distal femoral extension osteotomy + patellar tendon advancement by the described technique. (a) Postoperative clinical photograph showing normal alignment in the anteroposterior view. (b) Postoperative clinical photograph showing complete correction of knee flexion deformity in the lateral view. (c) Anteroposterior radiograph of both knees showing fixation of the distal femoral extension osteotomy with 90° pediatric condylar locking compression plate. (d) Lateral radiograph of both knees showing complete correction of knee flexion deformity and patella alta

The advent of observational and instrumented gait analysis brought about various changes in the concepts of management of crouch gait. It has been shown that not all individuals who walk in crouch gait do so because of contracted or spastic hamstrings. Studies have shown that more than a third of children who walked in crouch gait did not show an identifiable pathology in the length or velocity of the hamstrings. In addition, it was noted that when hamstring lengthening was performed in a normal muscle, it led to weakness, progression of anterior pelvic tilt and worsening of the crouch over a period of time.[10]

The modern treatment of crouch gait has evolved from the first-generation soft-tissue procedures (hamstring lengthening) to a combination of bony and soft-tissue correction, incorporating the principles of lever arm realignment.[8,9,14-18] Correction of both the knee-flexion contracture and the elongation of the patellar tendon are necessary to restore upright posture. DFEO alone typically improves knee-flexion contracture, but most individuals continue to walk in crouch subsequent to the procedure[8,14] and hence, DFEO should rarely be done in isolation, but always in conjunction with patellar advancement/shortening. A combination of DFEO + PTA enables correction of static knee flexion contracture, maintenance of the length and power of the hamstring muscles, and improved power of the quadriceps mechanism; which in turn leads to an overall improvement in the plantarflexion– knee extension coupling.[14]

Various implants have been used for fixation of the distal femoral osteotomy. K-wires and pins used for osteotomy fixation require prolonged immobilization with plasters, as they do not provide rigid stability at the osteotomy site. Pin tract infections, pin loosening, disuse osteopenia, redisplacement due to inherent muscle spasticity, and difficult perineal hygiene care are other problems that may be encountered. In a study by Das *et al*.,[16] patients undergoing supracondylar extension osteotomy and fixed with crossed K-wires were immobilized in above knee plaster casts for 6 weeks. Knee ROM exercises commenced 8 weeks after surgery and weight-bearing was delayed to 12 weeks. Furthermore, none of the patients had a full correction of the knee flexion deformity postoperatively, and this in part may be related to inadequate stability provided by pin fixation. In another study conducted by Joseph *et al*.,[15] crouch correction was done in 2 stages; in the first stage, femoral shortening of 2.5 cm–3.5 cm was performed and fixed with a dynamic compression plate. The limb was immobilized in plaster for 6 weeks. At the end of 6 weeks, fractional lengthening of Hamstring muscles with semi tendinosis transfer was performed and immobilized for a further 6 weeks. Passive physiotherapy was started only after 12 weeks. Compression plates are load-bearing devices and have increased chances of plate failure, screw loosening, and stress shielding leading to failures. They are also not anatomically contoured to the distal femur and require prebending which further reduces the strength of the plate. The osteotomy has to be done at a higher level as fewer screws can be placed in the distal fragment to maintain a stable fixation and protect the physis.

The 90° pediatric condylar LCP has several advantages, as can be seen from our study. Using locking screw principle, better fixation stability is achieved in osteoporotic bones, and the angle-stable construct ensures early mobilization and weight bearing. This is particularly important to prevent knee stiffness and disuse osteoporosis, which is more so in children with cerebral palsy, who have poor bone quality and muscle imbalance. The pediatric condylar LCP is anatomically contoured to fit the distal femur in children. Hence, the osteotomy can be performed lower down in the metaphysis yet without disturbing the growth plate.[17] This has an added advantage of improved bone healing since the osteotomy is performed in the metaphysis and since locked plates do not hamper the periosteal blood supply. Due to the stability afforded by the pediatric condylar LCP and secure fixation of the patellar tendon as described by Novachek,[19] our patients did not require postoperative plaster immobilization. We could start immediate knee ROM exercises, to achieve 90° knee flexion by 6 weeks.

Partial weight-bearing commenced at 4 weeks and full weight-bearing ambulation by 8 weeks postoperatively.

Our current indications for DFEO + PTA include knee flexion deformity of 10°–30°, extensor lag of >15° and patella alta in children with crouch gait. We have not performed any soft-tissue procedures for hamstrings (fractional lengthening, semi tendinosis transfer or posterior knee capsulotomy) in association with the osteotomy, in contrast to other studies in the literature.[9,15,18] Besides the deleterious effects of hip extensor weakness and increased anterior pelvic tilt seen with injudicious hamstring lengthening,[10] we agree with Healy *et al.*[21] that DFEO + PTA not only restores knee extension through skeletal realignment but also restores functional hamstring length and velocity in most patients. We believe that not lengthening the hamstrings, not only preserves hip extensor function but also protects the sciatic nerve from stretch[21] and prevents iatrogenic knee hyperextension.[18]

One of the most worrisome complications after DFEO is the development of sciatic or peroneal nerve palsy, occurring in 3%–40% of cases.[9,14,21,22] We encountered this complication in only three limbs (5.76%) and all palsies recovered completely with no residual sequelae. We attribute our low rate of neurological complications to proper selection of patients (knee flexion deformity <30°), shortening a few millimeters of the posterior cortex while removing the bone wedge, trimming the posterior cortex of the distal fragment after displacing it posteriorly, avoiding simultaneous hamstring lengthening, and resting the knee in 15°–20° of flexion in the long knee brace in the immediate postoperative period.[14,21,22]

Our study is one of the first from India and among the few from international literature to report favorable outcomes following DFEO and PTA using the 90° pediatric condylar LCP in crouch gait. Overall, we observed a statistically significant improvement in the knee flexion deformity and extensor lag with an improvement in the muscle strength of quadriceps while maintaining the preoperative power of the hamstring muscles. We also observed a statistically significant improvement in functional parameters such as the GMFM-D and the FMS at 5 m, indicating gains in household mobility and function. The FMS at 50 m and 500 m did not show the significant change since the majority of patients were GMFCS Level III and IV with limited community ambulation. We report a significant improvement in the Koshino index from 1.4 to 1.0 postoperatively, indicating an excellent correction of patella alta.

Some of the limitations of our study were that it was nonrandomized, with a small sample size and a relatively shorter duration of followup. Instrumented gait analysis was not performed due to its limited availability and high costs, which could not be afforded by our patients. Finally, there was no control group to compare the effectiveness of this implant with other methods of osteotomy fixation.

Conclusion

The DFEO combined with PTA provides favorable clinical, functional, and radiological outcomes in children with crouch gait. The procedure has a short operative time with minimal blood loss and has a low complication rate. The newer 90° pediatric condylar LCP provides stable fixation and allows early mobilization and weight-bearing in children with cerebral palsy.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for 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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