Clinical outcome of hamstring lengthening to correct flexed knee gait in patients with spastic diplegia

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Background

Increased knee flexion during the stance phase of gait (flexed knee gait) is one of the most common gait abnormalities in spastic diplegia. Hamstring lengthening in ambulatory patients is widely considered to be the standard surgical procedure for the correction of increased knee flexion.

Aim

The aim of this work is to evaluate the results of fractional distal hamstring lengthening in correction of flexion knee gait in ambulatory children with spastic diplegic cerebral palsy.

Patients and methods

Between 2007 and 2011, twenty six patients with spastic diplegia with flexion knee gait were treated by fractional hamstring lengthening as a part of multi-level management. There were 17 (65.4%) boys and 9 (34.6%) girls in the series, all treated patients were diplegic with both lower limb affection. The mean age of the patients at the time of operation was 8.15 ± 1.826 (range 5 to 12) years, other procedures were needed in 11 patients to treat hip adduction and equinus deformities.

Results

At the end of a follow up period of 22.9 (12–36) months, a significant reduction in the mean popliteal angle was noted postoperatively as it was improved from a mean of 54.4 ± 4.87 (48–63) preoperatively to 27.2 ± 2.41 (22–30) after surgery. This relation was proved to be statistically significant $P \leq 0.001$. Much improvement in the knee flexion on standing was recorded after surgery, as the knee flexion on standing improved from 28.5 ± 4.85 (20–35) preoperatively to 3.7 ± 3.01 (0–10) postoperatively, also this was proved to be statistically significant, $P \leq 0.001$.

Twelve patients showed improvement by one level in Gross Motor Function Classification System levels (GMFCS) at end of follow up.

Three patients showed a complication of hyperextension in one knee during walking; the three patients were treated by combined medial and lateral hamstring lengthening.

Conclusion

Distal hamstring lengthening is an effective procedure in treatment of cerebral palsy patients with flexion knee gait in a short period of follow up but longer follow up is needed to assess the maintenance of the results.

Keywords:
cerebral palsy, flexed knee gait, hamstring lengthening

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Introduction

Combinations of bony and soft-tissue procedures are usually performed to correct complex lower-limb deformities and improve gait in ambulatory children with spastic diplegic cerebral palsy. Lower-limb deformities and gait disturbances are commonly managed with a single-event multilevel surgery [1–7].

The severity of the neurological involvement is best described in children with cerebral palsy by the Gross Motor Function Classification System (GMFCS) based on the description of self-initiated movement, the ability to sit and walk, and the need for assistive devices and mobility aids. [8]; descriptions and illustrations are shown in Fig. 1 [9].

Increased knee flexion during the stance phase of gait (flexed knee gait) is one of the most common gait

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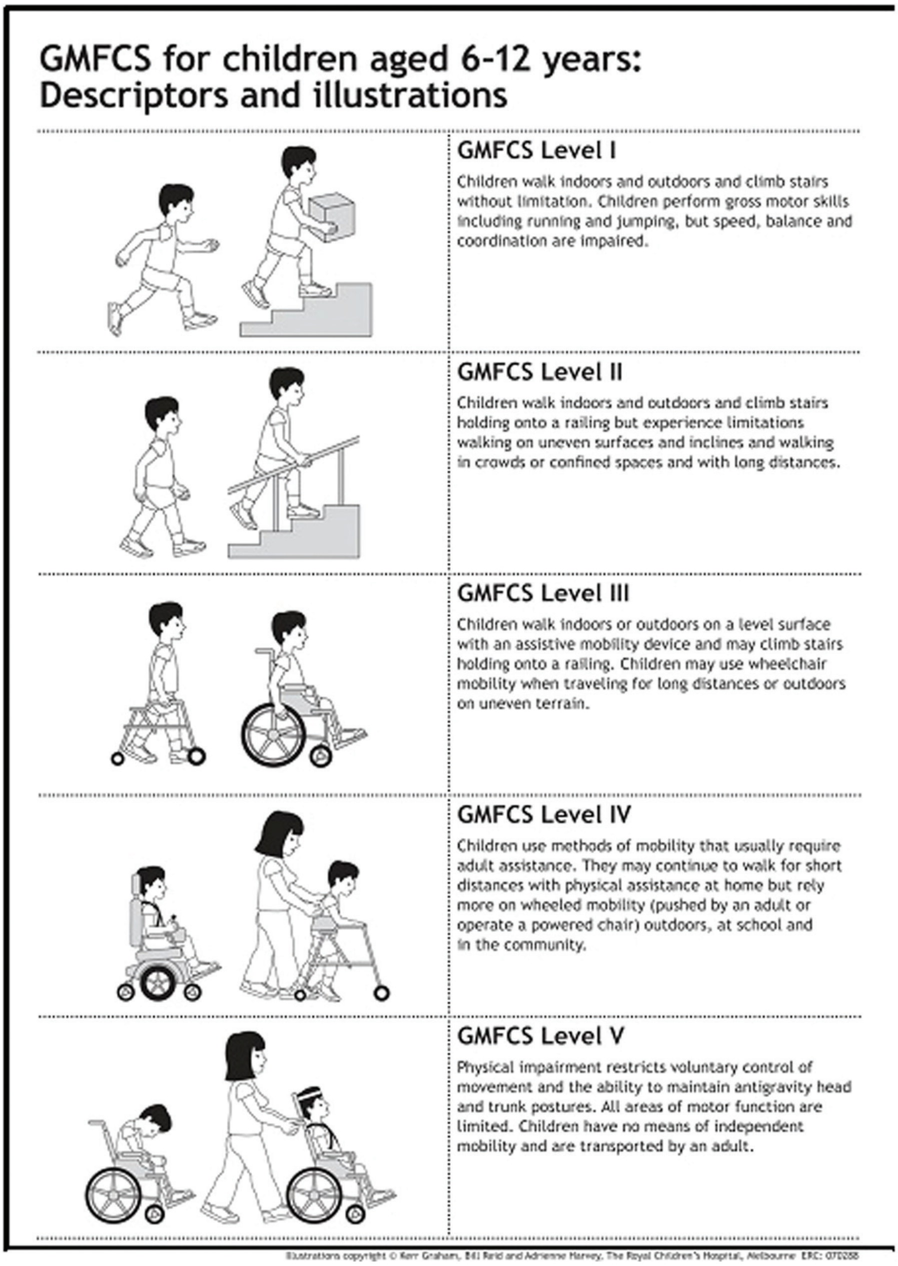
Figure 1



Description and illustrations of GMFCS [9]. GMFCS, Gross Motor Function Classification System.

abnormalities in spastic diplegia [10]. Rodda *et al.* [11] further classified flexed knee gait into four patterns: true equinus, jump knee, apparent equinus, and crouch.

One of the main factors leading to a flexed knee gait is the hamstring contracture [10,12–15]. Hamstring lengthening (HL) in ambulatory patients is widely considered to be the standard surgical procedure for the correction of increased knee flexion [15–19]. It is most often performed distally and can include the medial hamstrings alone or both medial and lateral hamstrings [20–22]. As muscle–tendon lengthening procedures are known to reduce muscle strength [23,24], the technique of lengthening at the musculotendinous junction is widely used to minimize loss of strength and accelerate recovery.

The aim of this work was to evaluate the results of fractional distal HL in the correction of flexion knee gait in ambulatory children with spastic diplegic cerebral palsy.

Patients and methods

Between 2007 and 2011, 26 patients with spastic diplegia with flexion knee gait were treated by fractional HL as a part of multilevel management. There were 17 (65.4%) boys and nine (34.6%) girls in the series; all treated patients were diplegic with affection in both lower limbs. The mean age of the patients at the time of operation was 8.15±1.826 (range: 5–12) years.

All patients were preoperatively assessed clinically for the popliteal angle and the GMFCS. Gait-video recording of all patients was performed in the coronal and sagittal planes, and was repeated at the end of the follow-up for comparison. Assessment of gait and the knee flexion on stance was carried out by clinical observation and by repeating the video recording before surgery and at the end of the follow-up. Complete neurological assessment of the patients was done and the operative plan was taken. Single-event multilevel correction was done in all patients.

A statistical description of the case series is depicted in Table 1.

Operative procedure

The operative technique that we employed entailed a midline posterior approach of the thigh through a 7 cm incision starting just proximal to the popliteal crease upwards (Fig. 2). All patients were operated under general anesthesia and in the prone position. We started by medial hamstring release, first by Z-lengthening of the semitendinosus and fractional lengthening of the semimembranosus fascia using two or three transverse incisions. Then we checked the popliteal angle by flexing the hip on the edge of the table; the popliteal angle more than 20° meant the correction was still insufficient after medial HL. In these cases the biceps femoris was lengthened with use of a fractional aponeurotic lengthening technique. Other procedures (32 procedures) were performed in 12 patients: bilateral adductor tenotomy was performed in five patients; bilateral equinus deformity was present in 11 patients, who were treated by using tendoachilles lengthening in three and the Baumann procedure in eight patients.

Follow-up methodology

Bilateral above-knee plaster cast with the knee in full extension was applied in all cases for 6 weeks, weight bearing was allowed immediately after the operation as tolerated by the patient, after which the cast was removed, followed by commencement of active exercise. Physiotherapy was started after removal of the cast and patients were fitted with above-knee night splints for 6 months to maintain knee extension. The patient was assessed 3 and 6 months after removal of the cast both clinically for the postoperative popliteal angle and the range of motion, the GMFCS, and by video assessment for the knee flexion gait.

Statistical analysis

Data were averaged for both sides and were compared before surgery with after surgery using paired *t*-tests performed by the SPSS program for windows, version 15 (Chicago, SPSS Inc., USA). Statistical significance was set at *P* value equal to 0.05.

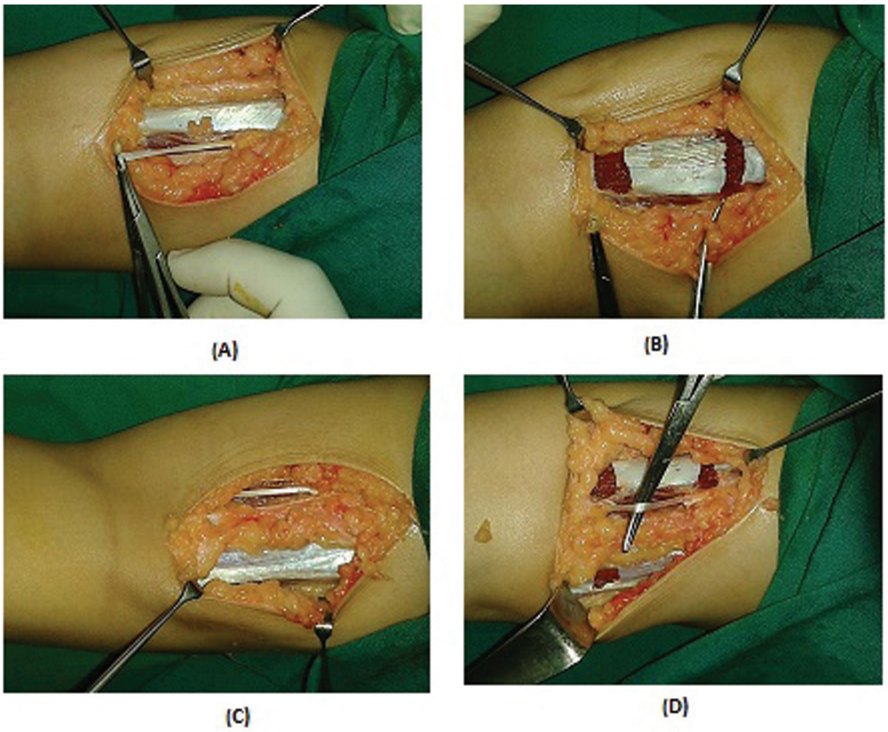
Consent

Informed consent has been taken from the parents of the patients submitted to this study and the protocol of this study has been approved by the ethical committee

Table 1 Statistical description of the case series

Variables		Mean (range) or [*n* (%)]
Age (years)		8.1538 (5–12)
Sex		
Male		17 (65.4)
Female		9 (34.6)
Gait		
Knee flexion		22 (84.6)
Scissoring		2 (7.7)
Crouch		2 (7.7)
Medial vs. combined medial an lateral hamstring lengthening		
Medial		12 (46.2)
Combined		14 (53.8)
Other procedures needed		
No		14 (53.8)
Yes		12 (46.2)
	Adductor tenotomy	5 (19.2)
	Tendoachilles lengthening	3 (11.5)
	Baumann	8 (30.8)
Follow-up period (months)		22.9 (12–36)

Figure 2



Operative photographs of combined medial and lateral hamstring lengthening: Z-pasty lengthening of the semitendinosus (a). Fractional lengthening of the semimembranosus fascia using two transverse incisions (b). Exposure of the biceps femoris apponeurosis (c). Fractional lengthening of the biceps fascia and repair of the semitendinosus tendon (d).

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Results

A total of 26 cerebral palsied patients with flexion knees due to hamstring contracture were treated by fractional HL. All patients were diplegic. In 12 (46.2%) patients other procedures were performed to correct other deformities; adductor tenotomy was performed in five (19.2%) patients to correct hip adduction deformity, the Baumann procedure was performed in eight (30.8%) patients, and tendoachilles lengthening was needed in three (11.5%) patients. At the end of a follow-up period of 22.9 (range: 12–36) months, a significant reduction in the mean popliteal angle was noted postoperatively as it improved from a mean of 54.4±4.87° (range: 48°–63°) preoperatively to 27.2±2.41° (range: 22°–30°) after the surgery. This relation was proved to be statistically significant (P<0.001)

Much improvement in the knee flexion on standing was recorded after surgery, as the knee flexion on standing improved from 28.5±4.85° (range: 20°–35°) preoperatively to 3.7±3.01° (range: 0°–10°) postoperatively; this also proved to be statistically significant (P<0.001).

Table 2 Statistical comparison of the patients data before and after surgery

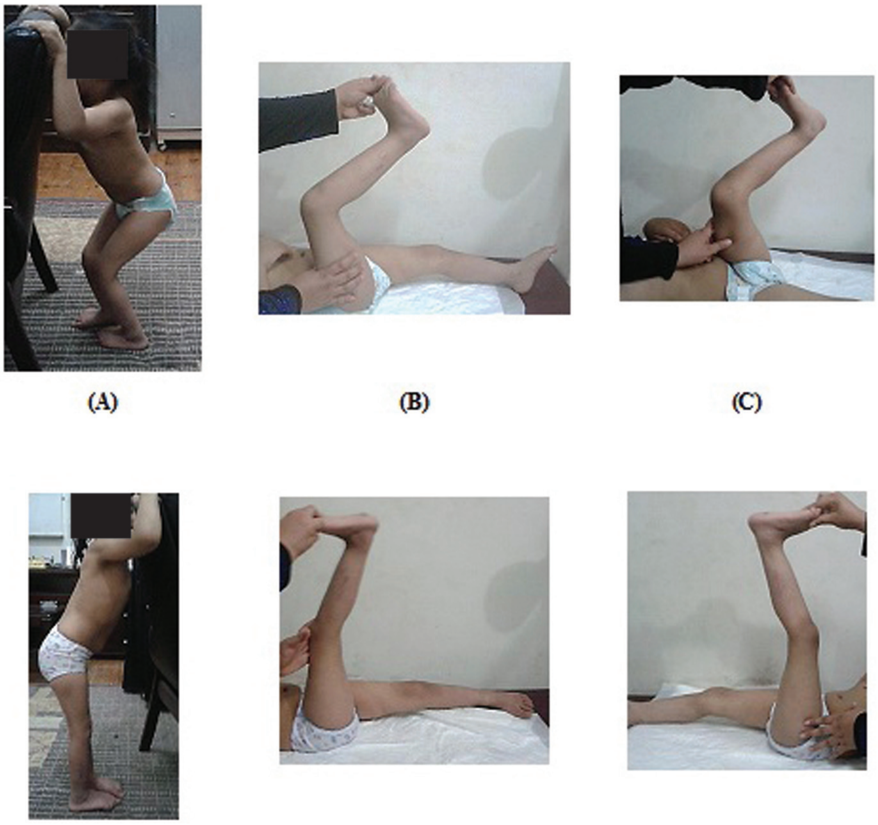
Surgery	Popliteal angle [mean (range)] (deg.)	GMFCS count [*n* (%)]	Knee flexion in standing [mean (range)] (deg.)
Before	54.4 (48–63)	I 4 (15.4) II 12 (46.1) III 10 (38.5)	28.5 (20–35)
After	27.2 (20–30)	I 9 (34.6) II 14 (53.9) III 3 (11.5)	3.7 (0–10)

GMFCS, Gross Motor Function Classification System.

The GMFCS improved, with five (19.2%) patients showing improvement from the GMFCS level II to GMFCS level I and seven (26.9%) patients showing improvement from the GMFCS level III to GMFCS level II at end of the follow-up (Table 2, Fig. 3).

Three patients showed a complication of hyperextension in one knee during walking; the three patients were treated by combined medial and lateral HL. These three patients were treated by antirecurvatum splint and physiotherapy to strengthen the hamstring muscles; two patients recovered but the third patient was not recovered till the end of his follow-up.

Figure 3



A 7-year-old girl with spatic diplegia with flexed knee gait; she walks using an assistive mobility device, CP walker (GMFCS III): preoperative photograph of the patient standing assisted with flexed knees (35°) (a). Preoperative photograph of the popliteal angle of the right knee (60°) and left knee (55°), respectively (b, c). Postoperative photograph of the patient standing assisted with full extension of the knees (d). Postoperative photographs showing improvement of the popliteal angle of the right (22°) and left knees (25°) (e, f). GMFCS, Gross Motor Function Classification System.

Discussion

In this series we noticed a statistically significant reduction in the mean popliteal angle from 54.42° before surgery to 27.15° after surgery. In addition, knee flexion on standing improved from 28.46° preoperatively to 3.65° postoperatively; this proved to be statistically significant. At the end of the follow-up (22.9 months), five (19.2%) patients showed improvement from the GMFCS level II to GMFCS level I and seven (26.9%) patients showed improvement from the GMFCS level III to GMFCS level II.

Our understanding of the existing literature is that the HL can be useful in improving the function and the gait in spastic diplegic patients who are ambulant but with knee flexion. Our results were, in fact, comparable with various short-term outcome studies that have demonstrated improvement in terms of knee extension during the stance phase and the popliteal angle following HL [16–20,25–29].

Chang *et al.* [17] reviewed 105 limbs in 61 children with cerebral palsy treated by distal HL, and reported on a significant improvement in popliteal angle, fixed knee flexion contracture, knee angle at foot contact, and midstance knee extension after HL, with an increase in the popliteal angle but no recurrence of the flexed knee gait on a longer follow-up. Damron *et al.* [25] reported on 117 cerebral palsies patients who underwent hamstring tenotomy by proximal semimembranosus release with distal semitendinosus and biceps femoris release. The range of motion was significantly improved and remained so for 4 years. Overall, 30% of nonambulatory patients improved at least one level in activity. In the series conducted by Husu and Li [30] 49 children with spastic cerebral palsy treated by distal hamstring elongation were reviewed. Forty patients had significant improvement in their gait pattern and 18 had improved motor function.

Kay *et al.* [19] compared the results of isolated medial and combined medial and lateral HL. Each group showed significant improvement in static and dynamic hamstring measures with no significant differences in the improvement range of motion and knee extension during the stance phase between the two groups.

Atar *et al.* [31] reviewed 30 patients who had distal hamstring release with the modified Green technique. An average improvement of 40° in the popliteal angle was noted at follow-up. Twenty-three patients improved their gait pattern. Nine patients improved by one level of walking ability.

In our series no recurrence was detected at the end of the follow-up; the same has been reported in the literature [17,19,25,30], whereas in the series by Atar *et al.* [31], using the modified Green technique, 12.5% recurrence rate was reported.

Genu recurvatum is a common adverse effect of HL [17–19,25,32] with higher prevalence in the group that is managed with combined medial and lateral HL, as reported by Kay *et al.* [19]; they reported on knee hyperextension in the stance phase in 24% of patients treated by combined lengthening compared with isolated medial lengthening patients (6%).

In this series genu recurvatum was noticed in three (11.5%) patients at the end of the follow-up; these patients were treated by combined medial and lateral HL.

Treatment of genu recurvatum is a challenge. In this series we treated this adverse effect by antirecurvatum orthosis and physiotherapy to strengthen the hamstring muscles. Genu recurvatum was resolved in two cases after 2 and 2.5 years, but the third patient showed residual genu recurvatum at the end of his follow-up (20 months) and could only be resolved by a longer follow-up. In the series reported by Dreher *et al.* [33], genu recurvatum was seen in 18 (35%) patients 1-year postoperatively. At a long-term follow-up, they noticed that genu recurvatum was resolved in many limbs, but 12% of the limbs showed residual genu recurvatum, indicating that overcorrection represents a problem following HL. Damron *et al.* [25] observed minor recurvatum at 1 year, which nearly disappeared after 3–5 years. Husu and Li [30] documented one patient with spastic quadriceps who had 15° of persistent genu recurvatum.

This study had some limitations. We recorded good results at this short period of follow-up but a longer follow-up is needed to document the long-term results as an increase in the popliteal angle was reported in the literature on longer follow-up [17].

We could not use the gait analysis as our institution does not own a gait lab, and we used the video recording in gait assessment and depended on our subjective observation.

Conclusion

Distal HL is an effective procedure in the treatment of cerebral palsy patients with flexion knee gait in a short period of follow-up but a longer follow-up is needed to assess the results.

Declaration of patient consent

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

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Nil.

Conflicts of interest

There are no conflicts of interest.

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