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Research Article

Lateral Hamstring Tendon Transfer around the Lateral Gastrocnemius Head and Medial Hamstring Lengthening to Correct Crouch Gait in Diaplegic Spastic Cerebral Palsy

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- Diplegia
- Crouch gait
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Abstract

Background: Hamstring muscles contracture is a major problem in the management of the cerebral palsy CP patient causing the crouch gait which is one of the most resistant conditions to treat.

Methods: Twenty patients (40 knees) with spastic cerebral palsy diaplegia, between 7 – 12 years of age, presented to The National Institute of Neuromotor System of Egypt, from January 2010 to January 2011. All of the patients were diplegic and community ambulators but having knee flexion deformity and walking with crouch gait. All received previous conservative treatment for cerebral palsy in the form of muscle relaxants and physiotherapy, but no previous surgery. Ten were males and ten were females. All were evaluated clinically for the presence of spasticity and/or contracture, knee flexion deformity, popliteal angle, hip extension strength, and type of gait. All underwent lateral hamstring transfer around the proximal head of origin of gastrocnemius, as well as medial hamstring lengthening by Z-plasty and fractionally. Both knees of each patient were operated upon in the same sitting.

Results: Clinical evaluation using a grading system revealed that 12 patients (60%) were classified as excellent, 6 patients (30%) as good, and 2 patients (10%) as fair. No poor cases were recorded. There was no complication. There was significant improvement in the result ($p > 0.05$).

Conclusion: Transfer of the biceps tendon to just above the knee around the lateral head of origin of gastrocnemius, combined with appropriate Z-plasty lengthening of gracilis and semitendinosus tendons and fractional lengthening of semimembranosus being retained in position, is effective in relieving crouch gait in cerebral palsy with spastic diplegia.

Level of Evidence: The study is type IV clinical evidence.

INTRODUCTION

Hamstring muscles contracture is a major problem in the management of the cerebral palsy CP patient, being among the primary factors in causing the crouch gait which is one of the most resistant conditions to treat in spastic cerebral palsy [1].

A rational modality in treating crouch gait is to transfer one of the distal hamstrings to just above the knee joint, and lengthen the other hamstrings. In such case, the deforming force is utilized for correction of knee flexion deformity as well as improving hip extension. The biceps femoris tendon is transferred by winding it around the lateral head of origin of the proximal gastrocnemius [2] and sutured to itself at a point which acts as a fulcrum for pulling the femur backwards, to correct knee flexion deformity and to function as hip extensor. The semitendinosus and gracilis tendons are Z-plasty lengthened. The semimembranosus is fractionally lengthened to help in the correction of knee flexion deformity, but retained without transfer to prevent genu-recurvatum. The effectiveness of the procedure weakens the hamstrings as knee flexors and potentiates their role in hip extension.

The objective of the study was to reveal the effectiveness of partial transfer of one of the distal hamstrings combined with appropriate lengthening of the remaining hamstrings in correcting crouch gait in CP diplegic, preventing pelvic tilt and hip subluxation, and avoiding the usual complication of genu-recurvatum associated with complete transfer of the hamstrings reported earlier [2].

PATIENTS AND METHODS

Twenty spastic cerebral palsy CP diplegic patients having knee flexion deformity and walking with crouch gait presented to The National Institute of Neuromotor System of Egypt, from

January 2010 to January 2011; underwent lateral hamstring transfer and medial hamstring lengthening; and were included in this study. The results in this group, after at least three years of follow-up, were reported in January 2014 using previous medical records, history, and physical examinations.

Inclusion criteria

Patients with cerebral palsy spastic diplegia, knee flexion deformity 20° – 60°, popliteal angle > 30°, and crouch gait were included.

Exclusion criteria

Patients with mental retardation (IQ < 70), visual impairment, hearing impairment, total body involvement TBI, and iliopsoas, rectus femoris, or gastrocnemius tightness were excluded.

Original Disease, Physical examination, and Treatment

All of the twenty patients had history of difficult delivery and incubation at the time of birth. All were spastic diplegic; no patient was hemiplegic or of the total body involvement (TBI) type. All were able to walk without support but with crouch gait; and were considered to be community level ambulators with Gross Motor Function Classification System GMFCS of level II. Each of them received non-operative treatment as physical therapy programs and skeletal muscle relaxant but no previous surgery. All had bilateral hamstring tightness with knee flexion deformity > 20° but < 60°, popliteal angle > 30°, but no iliopsoas, rectus femoris, or gastrocnemius tightness. The mean age at the time of surgery was 8.4 years (range, 7 –12 years). The patients were 10 males and 10 females.

Operative technique

The operation was performed under general anaesthesia using pneumatic tourniquet with the patient in the prone position. The two knees were approached in the same sitting by two teams of surgeons and nurses working together at the same time in order to minimize the tourniquet time. Two longitudinal parallel incisions were made in the back of each knee to expose its lateral and medial sides. The biceps, gracilis, semitendinosus, and semimembranosus were identified and exposed with care to avoid injury of the common peroneal nerve on the lateral side and the tibial nerve on the medial side. The proximal lateral head of gastrocnemius was identified and exposed. The biceps tendon was divided close to its insertion, transferred by winding it around the lateral head of gastrocnemius, and sutured around itself (Figure 1) using 0/1 vicryl sutures. The gracilis and semitendinosus tendons were Z-plasty lengthened by suturing them together proximally and distally using 0/1 vicryl sutures, and divided at their proximal and distal ends (Figure 2). The semimembranosus muscle was fractionally lengthened by dividing its aponeurosis transversely distally and semilunar proximally (Figure 3). The wound was closed in layers. An above-knee POP cast (AKC) with the knee straight and the ankle/foot plantigrade was applied.

Postoperative care

The POP cast was changed with removal of the skin stitches after 3 weeks. Another POP cast was applied for further 3 weeks.

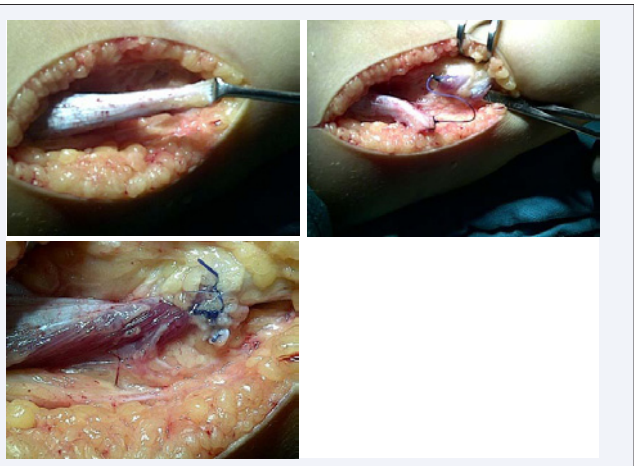

Figure 1 Exposure and division of the biceps femoris tendon *(left)*, transfer by winding around the lateral head of gastrocnemius *(middle)*, and suturing around itself *(right)*.

Figure 2 Z-plasty lengthening of combined sutured gracilis and semitendinosus tendons.

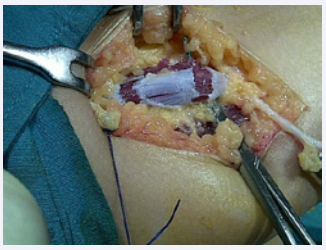

Figure 3 Fractional lengthening of semimembranosus aponeursis.

Physiotherapy program in the form of knee flexion/extension exercises, quadriceps strengthening exercises, and gait training was instituted after cast removal for further 1 – 3 months. Knee Ankle Foot Orthosis KAFO was applied during sleep or non-walking intervals.

Evaluation

All patients were assessed clinically; and a grading system, with a total score of 10 marks, was suggested. The preoperative values were compared to the postoperative ones regarding clinical evaluation which included the correction of knee flexion (2 marks), the decrease in the popliteal angle (2 marks), the increase in the strength of hip extension (2 marks), the

improvement of the crouch gait (2 marks), and the patient/parent satisfaction (2 marks).

The patients were graded into four categories as *excellent* with a total score of 9 – 10, *good* with a total score of 7 – 8, *fair* with a total score of 5 – 6, and *poor* with a total score < 5 (Table 1).

Intra-observer and inter-observer variability were studied. The overall intra-observer mean weighted kappa was χw = +0.48 (range SE χ = 0.008–0.055) and the overall inter-observer mean weighted kappa was χw= +0.53 (range SE χ = 0.012–0.044).

RESULTS

The twenty patients (40 knees) were followed-up at a mean of 3 years and 4 months (range, 3 – 4 years) after hamstring transfer surgery.

All had full correction of the knee flexion deformity which improved to 0° flexion, with the knee straight. All improved to the range of motion and functional strength exercises of the physiotherapy program. There was neither residual knee flexion deformity nor knee hyperextension or genu-recurvatum.

All had correction of the popliteal angle to < 20°,with 12 patients of whom 8 were males and 4 females < 10°, 6 patients of which 2 were males and 4 females 10° – 15°, and 2 female patients >15° – < 20°.

Eighteen patients had improvement in hip extension strength, tested while the patient in prone position using MRC scale 1–5, with 12 patients of whom 8 were males and 4 females having 2 grade improvement (up to 10°), and 6 patients of whom 2 were males and 4 females having one grade improvement (up to 5°). Two female patients had no grade improvement (0°), but also no deterioration of hip extension.

The crouch gait disappeared in 16 patients of whom 9 were males and 7 females, and improved as assessed by observing the decrease of hip flexion, the decrease of knee flexion during stance and swing, and by observing dorsiflexion or decrease of plantarflexion during swing, in 4 patients of whom one was male and 3 were females.

Eighteen patients and their parents, of whom 10 were males and 8 females, were satisfied. Only 2 female patients and their parents were accepting the situation but not dissatisfied, owing to the residual mild knee flexion.

Using the grading system, 12 patients (60%), of whom 8 were males and 4 females had > 9 marks and were classified as *excellent*; 6 patients (30%), of whom 2 were males and 4 females had 7 – 8 marks and were classified as *good*; 2 female patients (10%) had 6 marks and were classified as *fair*; and no patient had < 5 marks; so there were no poor cases (Table 2). There was no complication. There was significant improvement in the result (p> 0.05).

DISCUSSION

Crouch gait is the most resistant condition to treat in the diplegic spastic cerebral palsy [1-3]. Crouch complex consists of flexion at hip and knee and dorsiflexion at ankle [3]. Weakening of hamstrings to reduce knee flexion, which is the most important component of crouch, is the commonest technique used to treat this condition. Hoffinger and Abou Ghaida [4] (1993) showed that the hamstrings function as important hip extensor in CP diplegics as shown by dynamic electromyography EMG.

Partial distal lengthening of either medial or lateral hamstrings [5-8] total distal lengthening [9,10] and proximal hamstrings lengthening by fractional lengthening or z-plasty [11,12] were reported.

Partial hamstring lengthening usually leads to recurrence of knee flexion deformity [13]. Whereas, total lengthening is associated with incidence of pelvic tilt [3] due to weakness of hip extensors, and genu-recurvatum [5,8].

Other method of weakening of the hamstrings is by local injection of Botulinum toxin in the hamstrings [14]. The effect of the toxin is temporarily, lasting only for a few months. The toxin injection itself is costly and is used only in spasticity but not in contracture.

Ray and Ehrlich [1] (1979) transferred the tendons of semitendinosus and semimembranosus to the lateral inter-muscular septum and the tendon of Biceps femoris respectively, with good results in relieving knee flexion deformity. The procedure succeeded in correcting knee flexion deformity, but had little effect in improving hip extension.

Egger's operation, which was total transfer of distal hamstrings to the femoral condyles without leaving any muscle to flex the knee [15], improved pelvic tilt as it would function as hip extensor. However, genu-recurvatum was the commonest complication of this operation [2]. In the original Egger's operation, attachment of tendons to the posterior surface of the femoral condyles was technically difficult being in the deeper plane [2] and the presence of the popliteal vessels, genicular

Table 1: The scoring system.

Item	Score	
Knee Flexion Deformity	< 5°	2
	5° – 10°	1
	> 10°	0
Popliteal Angle	< 10°	2
	10° – 20°	1
	> 20°	0
Strength of Hip Extension	+ 2 grades	2
	+ 1 grade	1
	No improvement	0
Crouch Gait	Disappeared	2
	Improved	1
	Persistent	0
Patient/Parent Satisfaction	Satisfied	2
	Accepting	1
	Not accepting	0
Total Score		
Excellent	9 – 10	
Good	7 – 8	
Fair	5 – 6	
Poor	< 5	

Table 2: Evaluation of the result.

Case no.	Age (years)	Gender	Knee flexion deformity	Popliteal angle	zip extension strength	Crouch gait	Patient/Parent satisfaction	Total score	Grade
1	8	Male	0°	10° – 15°	+1	D	S	8	G
2	9	Male	0°	<10°	+2	D	S	10	E
3	7	Female	0°	>15° – < 20°	0	D	S	7	G
4	10	Male	0°	<10°	+2	D	S	10	E
5	9	Female	0°	10° – 15°	+1	I	A	6	F
6	12	Female	0°	10° – 15°	+1	D	S	8	G
7	10	Male	0°	<10°	+2	I	S	9	E
8	8	Female	0°	10° – 15°	+1	I	S	7	G
9	7	Female	0°	10° – 15°	+1	D	S	8	G
10	7	Male	0°	<10°	+2	D	S	10	E
11	9	Male	0°	<10°	+2	D	S	10	E
12	8	Male	0°	<10°	+2	D	S	10	E
13	8	Female	0°	<10°	+2	D	S	10	E
14	7	Male	0°	10°– 15°	+1	D	S	8	G
15	7	Female	0°	<10°	+2	D	S	10	E
16	8	Female	0°	>15°–< 20°	0	I	A	5	F
17	9	Male	0°	<10°	+2	D	S	10	E
18	8	Female	0°	<10°	+2	D	S	10	E
19	8	Female	0°	<10°	+2	D	S	10	E
20	9	Male	0°	<10°	+2	D	S	10	E

D: Disappeared. **I:** Improved.
S: Satisfied. **A:** Accepting.
E: Excellent. **G:** Good. **F:** Fair.

arterial anastomosis was the cause of significant bleeding in this operation.

In the current study, only the biceps femoris was transferred, the gracilis and semitendinosus were Z-plasty lengthened, the semimembranosus was appropriately lengthened fractionally but retained to prevent genu-recurvatum. The procedure will correct knee flexion and reduce the popliteal angle at the same time [1,13,16,17]. Moreover, the transferred tendon was attached indirectly to the posterior surface of the femoral condyles through the lateral head of origin of gastrocnemius, being itself attached to the lateral femoral condyle, acting as a fulcrum to pull the femur backwards, to improve hip extension and to prevent pelvic tilt or hip subluxation. There was neither residual knee flexion deformity nor genu-recurvatum. The surgery was practically the same as distal lengthening of hamstrings, taking no more operating time.

CONCLUSION

Transfer of one of the distal hamstring, namely the biceps femoris tendon to just above the knee around the lateral head of origin of gastrocnemius, combined with appropriate Z-plasty lengthening of gracilis and semitendinosus tendons and fractional lengthening of semimembranosus being retained in position, is effective in relieving crouch gait in cerebral palsy with spastic diplegia.

The operation is technically the same as any type of distal hamstrings transfer and lengthening. Serious complications of both hamstrings lengthening and transfer are avoided in this technique.

The encouraging criteria include correction of knee flexion deformity, decrease in the popliteal angle, increase of hip extension strength, and improvement of gait quality.

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