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Technical report

Re-exploration of the rectus femoris tendon to sartorius transfer in children with spastic cerebral palsy

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Background: The rational of rectus femoris tendon transfer is to use a spastic rectus femoris tendon as a knee flexor during swing phase of gait cycle. However, the concept of the rectus femoris tendon transfer has been challenged by the evidence of scar tissue formation along the transferred tendon route.

Objective: Examine the surgical technique for rectus femoris tendon transfer to the sartorius at the index procedure and report the findings at the anchoring site during the re-exploration.

Methods: Three knees were examined in two patients with spastic cerebral palsy who developed recurrent flexion contracture at 18 months after the rectus femoris tendon to sartorius surgery. They underwent femoral shortening procedures and re-exploration at the rectus femoris tendon to sartorius transfer site simultaneously to correct flexion contracture. The transferred tendon route was examined. The anchoring site at the sartorius was manually tested. The follow-up period after the re-exploration procedure ranged from 7-60 months (mean: 37 months).

Results: All three rectus femoris tendons were in a straight line, and glided smoothly on the new route with minimal scar tissue formation. The anchoring site at the sartorius was well healed, and the knee flexion was observed upon manual testing. Degree of knee flexion contracture ranged from 15 to 35 degrees (mean: 27 degrees) before re-exploration procedure. It was 5 to -5 degrees (mean: 0 degree) at the recent follow-up. All patients maintained their ambulatory status.

Conclusion: The present technique for rectus femoris tendon to sartorius transfer gave a straight-line transfer over smooth gliding path and provided a secure anchoring site. It converted the function of the transferred tendon from a knee extensor to a knee flexor and created minimal scar formation with smooth gliding path.

Keywords: Cerebral palsy, crouching gait, rectus femoris tendon transfer, re-exploration, spastic diplegia, stiffed-leg gait

Corrective surgery to reduce spasticity for children with spastic diplegia is a challenging task. The imbalance between the agonist and antagonist muscle groups results in joint contracture, leading many investigators to develop various muscle transfer procedures to gain the advantage from the spastic muscles. At the knee joint, the hamstring contracture causes constant flexion of the knee resulting in a crouching posture and a limited flexion-extension movement during the gait [1]. Hamstring lengthening alone may result in a gait with a stiffed leg pattern, especially during the swing phase secondary to exaggeration of the spasticity of the quadriceps [1-3]. Then, the rectus femoris tendon transfer procedure was developed and proven to improve knee flexion [2, 4-6]. However, there remain unresolved questions regarding the appropriate surgical techniques, the anchoring sites for rectus femoris tendon [4, 5, 7] and prevention of angulation of the transferred tendon and excessive scar formation [8-11]. The gross anatomic findings of the route of transferred tendon and its anchoring site would help us better understand the natural history of this procedure. We report the findings at the site where rectus femoris tendon to sartorius transfer procedure was performed.

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Materials and methods

Between 2004 and 2008, 36 cerebral palsy patients underwent rectus femoris tendon to sartorius transfer and hamstring lengthening as an index procedure. Three knees in two patients later developed recurrent flexion contracture due to incompliance with the rehabilitation guideline despite obtaining a full range of knee extension in the immediate post-operative period. The two patients underwent a femoral shortening osteotomy without extension or derotation to correct flexion contracture of the knee. Hence, the rectus femoris tendon transfer site was re-explored. Demographic data and indication of the procedure is shown in **Table 1**.

This study was done retrospectively. The hospital records were reviewed with the approval by Director, King Chulalongkorn Memorial Hospital.

Operative technique

For the index procedure, an anterior straight midline incision over the distal thigh was done. A subcutaneous tissue and deep fascia was opened in the same line with skin incision. A middle 1/3 slip of rectus femoris tendon was harvested from the underlying vasti and suprapatella pouch. The remaining sleeve of tendon was left for later wound closure. Then, the slip of rectus tendon was divided in half. Using the same incision, a soft tissue place was developed below the fascia of the medial side of the thigh. A sartorius muscle was identified and mobilized after the medial intermuscular septum was cut open. A muscle belly of the sartorius was brought up by a blunt instrument. Medial and lateral end of the rectus femoris tendon was hooked around the sartorius medially and laterally, respectively. Both ends were then passed through the sartorius muscle and sutured to themselves. The rectus femoris tendon now glided freely above the opening of the medial intermuscular septum and posterior to the knee joint axis. The incision was closed in layer starting from approximation of the sleeve of the rectus femoris. A long leg cast was applied for six weeks. Then, the physical therapy program was started by applying a ground reaction orthosis until the patient regained quadriceps strength (**Fig. 1** and **2**).

Table 1. Demographic data of the two patients that underwent re-exploration along with indications and details of index and re-exploration procedures.

Patient	Gender	Type	Age at the index procedure (years)	Indication of the index procedure	The index procedure	Age at the re-exploration procedure (years)	Indication of the re-exploration procedure	Procedure performed during re-exploration
1	Girl	Spastic Diplegia	9	Crouching gait	Bilateral rectus femoris tendon to sartorius transfer, hamstrings lengthenings, posterior joint capsule releases	10	Recurrent flexion contracture of the left knee	Left femoral shortening osteotomy
2	Girl	Spastic Diplegia	8	Crouching gait	Bilateral rectus femoris tendon to sartorius transfer, hamstring lengthenings, posterior knee joint capsule releases	9	Recurrent flexion contracture of both knees	Bilateral femoral shortening osteotomy

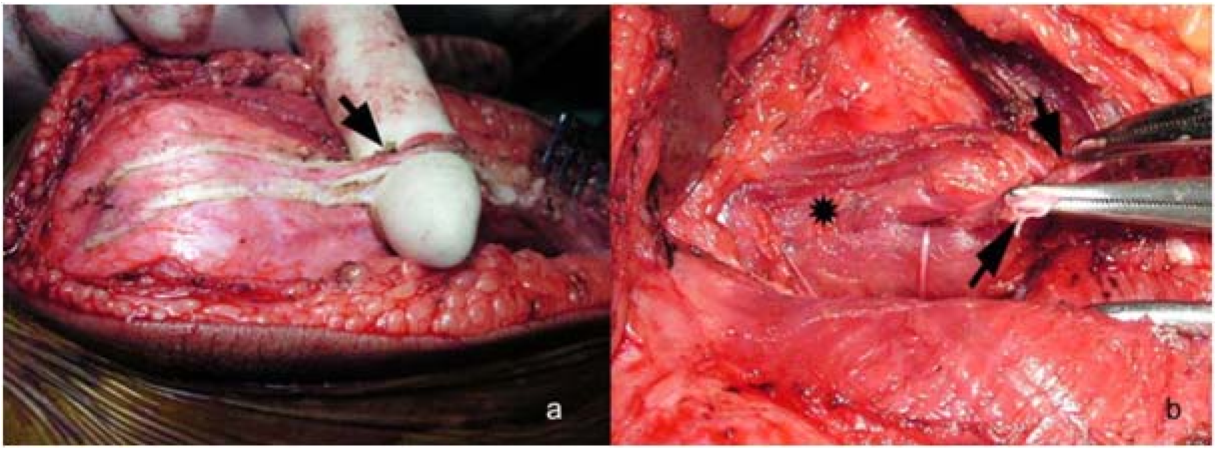

Fig. 1 The rectus femoris tendon to sartorius transfer procedure. **a:** an anterior midline longitudinal incision with a middle 1/3 of the rectus femoris tendon was dissected off the underlying suprapatella pouch and patella. **b:** Sartorius that is identified under the medial intermuscular septum. The rectus femoris tendon was divided in half. They were hooked around the sartorius medially and laterally then passed into the sartorius muscle to create a secure anchoring site. (Arrow = the rectus femoris tendon, asterisk= the Sartorius.)

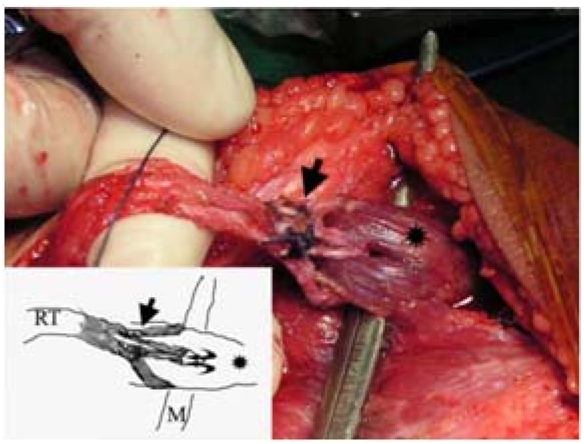

Fig. 2 The rectus femoris tendon to sartorius transfer procedure. The rectus femoris tendon was sutured with number 1 braided absorbable suture. The secure anchoring suture site on the sartorius is created. The inset picture represents a line drawing. Medial and lateral end of the rectus femoris tendon was hooked around the sartorius medially and laterally representing by curve arrows. (RT = rectus femoris muscle, M = Metzenbaum scissors, arrow = the rectus femoris tendon, asterisk= the sartorius).

During the re-exploration, a previous midline incision was utilized. The rectus femoris muscle and tendon were identified, and it was followed medially to the sartorius muscle. Both structures were mobilized carefully and the gross anatomic findings were examined. Then, the flexion contracture of the knee was corrected by femoral shortening osteotomy without extension or derotation. The rectus femoris tendon transfer was left undisturbed.

Results

Case 1. A 10 year-old girl developed a flexion contracture of the left knee 18 months after the initial procedure.

Case 2. A 9 year-old girl had bilateral flexion contracture of the knees 17 months after the initial procedure.

Detail of physical examination, range of movement and function status is shown in **Table 2**.

Table 2. Range of knee movement before and after the index and re-exploration procedure.

Pa-tient	Side	Range of movement of the knee at the index procedure (degrees)		Duration of follow up before the re-exploration procedure (months)	Range of movement of the knee at the re-exploration (degrees)		Duration of follow up after the re-exploration procedure (months)	Range of movement of the knee at recent follow up (degrees)		Ambulatory status at recent follow up
		Flexion	Extension		Flexion	Extension		Flexion	Extension	
1	Left	125	30	18	130	15	60	135	-5	Community ambulator with forearm crutches
2	Left	130	15	17	135	35	7	135	5	Independent ambulator with posterior wheel walker
	Right	130	45	17	135	30	7	135	0	

After the deep fascial layer was exposed during re-exploration procedure, minimal scar tissue around the tendon transfer route was observed. The route of the new tendon lay between the subcutaneous plane and the vastus medialis muscle. The rectus femoris muscle remained in a straight line between the rectus femoris and the vasti without excessive scar tissues (**Fig. 3**).

The suture site of the rectus femoris tendon to the sartorius muscle was then explored. A well-healed tendon anchoring to the sartorius muscle was visualized. (**Fig. 4**).

The flexion movement of the knee was observed by manual pull of the rectus femoris tendon. There was no evidence of cutting through or abnormal twisting of the sartorius. Both patients recovered uneventfully after the surgery. Upon follow-up, they were able to walk independently. By observational gait analysis, all knees had full extension in stance and were able to clear floor.

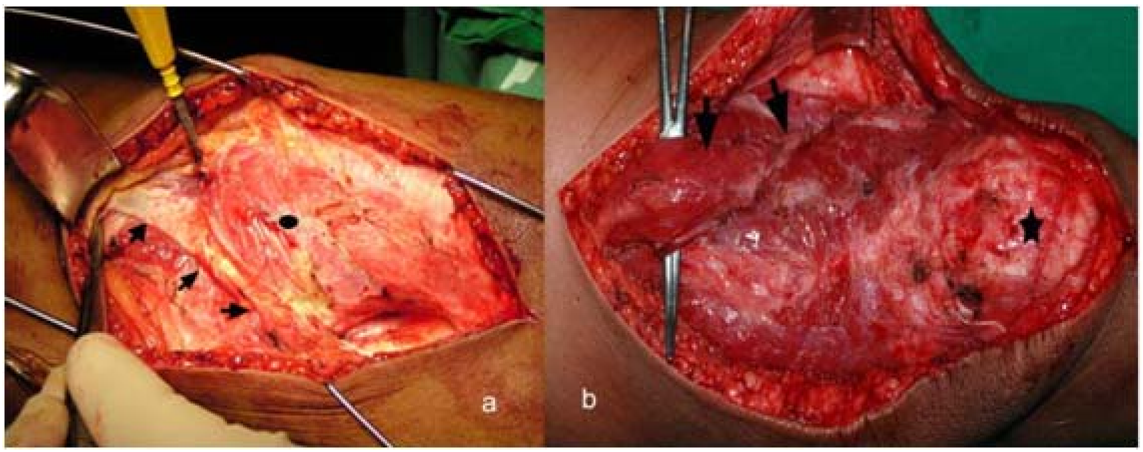

Fig. 3 Re-exploration procedure. **a:** The transferred rectus femoris tendon that was identified under the subcutaneous plane. Minimal scar tissue around the new tendon route was observed. The vastus medialis formed a gliding path for the transferred tendon. **b**: A top view showing the rectus femoris muscle tendon was in a straight line. No acute angulation was observed. (Arrow = the rectus femoris tendon, star = the patella, dot = the vastus medialis.)

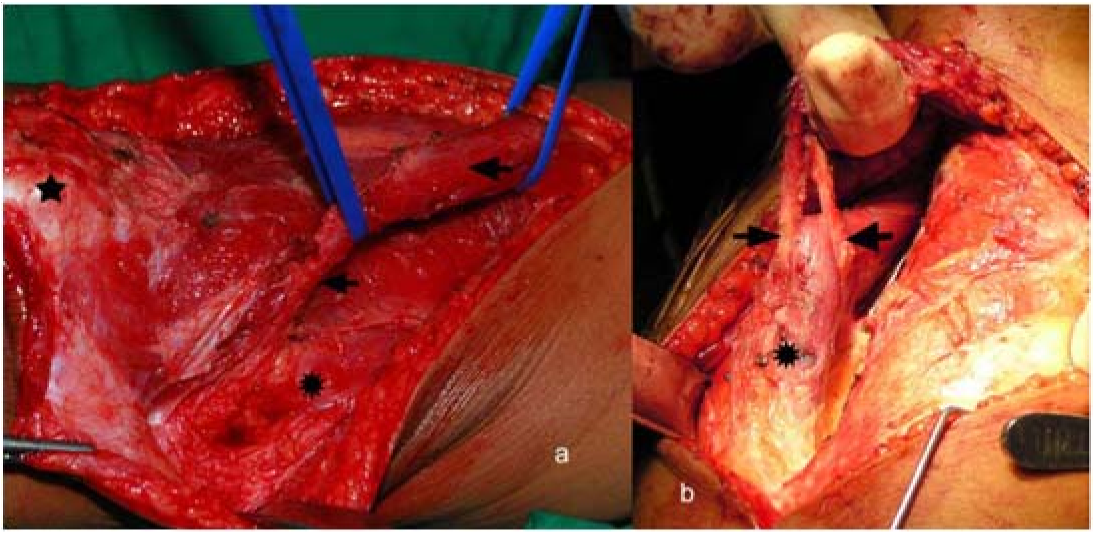

Fig. 4 Re-exploration procedure. **a:** A medial view showing the rectus femoris tendon with the anchoring site at the sartorius. **b:** both ends of the rectus femoris tendon was hooked around the sartorius and well healed creating a balance pulling force. (Arrow = the rectus femoris tendon, asterisk= the sartorius, star= the patella.)

Discussion

In children with spastic diplegia, crouching gait is frequently observed due to co-spasticity of the quadriceps and hamstring muscle [1, 2]. If hamstring muscle lengthening is performed alone, a stiff-legged gait may develop secondary to over extension of the knee due to constant quadriceps contraction throughout the swing phase without the antagonist effect of the hamstrings [1-3]. Surgery to release the distal part of the rectus femoris tendon alone has shown an improvement of the knee flexion in patients with cerebrovascular disease [12]. Subsequently, Gage [4] developed a rectus femoris tendon transfer to convert this abnormal spasticity of the quadriceps into a flexion moment of the knee. The author recommended the transfer of rectus femoris tendon to the stump of the semitendenosus, harvested in separate posterior incision, instead of the sartorius because he had trouble in anchoring the rectus femoris tendon to the fleshy muscle.

The concept and the results of this operation were later challenged by several investigators. Gold et al. [10] and Asakawa et al. [8, 9] reviewed the magnetic resonance imaging (MRI) done in patients receiving a rectus femoris to the semitendenosus transfer. The MRI showed a significant development of scar tissues around the transferred tendon. They were concerned with decrease in the range of the knee flexion generated by the rectus femoris to scar tissue formation. However, there were no reports on scar tissue formation directly observed during the surgery. Moreover, the MRI with three-dimensional geometry of muscle-tendon after transfer of the rectus through a subcutaneous tunnel demonstrated that the transferred muscle did not follow a straight course from the origin to the surgical insertion due to an angular deviation.

Thick connective tissues were observed near the location of angular deviation [9]. This may be attributable to the limited exposure to the rectus femoris tendon resulting in suboptimal mobilization of the rectus femoris to the sartorius if a transverse incision is used as recommended by Gage [4]. Consequently, the course of the transferred tendon forms an angle that reduces the gliding ability and increases scar tissue formation [9, 11]. Creating a route for the transferred tendon in a small subcutaneous tunnel worsens the range of motion. Therefore, the principle of the tendon transfer operation outlined by Green should be followed closely [13].

A muscle-actuated dynamic simulation study demonstrates that the scarred rectus femoris produce the range of knee flexion less than the rectus femoris tendon transfer to sartorius. It is recommended that the post-operative scarring to the surrounding tissue should be reduced to improve the range of knee joint flexion confirming our findings [14]. Based on the original technique of the rectus femoris to sartorius transfer, a short transverse incision above the superior patella pole was done, and the rectus femoris tendon was hooked to the medial half of the sartorius. Subsequent reports supported this rationale and demonstrated an increase of the range of the knee joint flexion in the three-dimensional gait analysis [6, 7].

In our case series, a single longitudinal incision was used. The route for the transferred tendon was between the subcutaneous tissue and the deep fascial layer. The incision could be extended up to the middle part of the thigh, if necessary. The rectus femoris was dissected until it was able to glide freely above the underlying vasti. The rectus tendon was transferred in a straight line as much as possible. A large opening of the medial intermuscular septum was created to provide a sufficient space. This technique may provide a gliding environment resulting in less adhesion compared with the subcutaneous tunnel technique. At the anchoring site, hooking the distal ends of the rectus tendon from both sides of the sartorius muscle was done to create a better tension balance.

On the surgical re-exploration, the scar tissues near the rectus femoris tendon were observed as shown in the MRI, but the amount of the scar tissues were not extensive enough to prevent the rectus femoris from working as a knee flexor as previous reported by Asakawa et al. [8, 9]. The transferred tendon was laid in a smooth curve rather than in an acute angle. At the anchoring site, the well-healed rectus femoris tendon was observed hooking around the sartorius muscle mass. This technique provided a sufficient anchoring power without any undesirable effects to the sartorius muscle. The suture site was strong enough to endure manual manipulation. The flexion movement of the knee was observed by pulling the rectus femoris tendon. This flexion movement was demonstrated clinically by the observational gait analysis [15, 16]. Post-operative immobilization of a six-week period was sufficient to allow the tendon to heal. As shown in **Table 2,** the objective data include the range of knee joint movement, the duration of follow-up and ambulatory status before and after the re-exploration procedure, but these data are hard to summarize by statistical measurement. We did not perform the laboratory gait analysis on these patients.

Conclusion

The rectus femoris transfer is a very useful procedure to increase knee flexion in children with cerebral palsy. The present transfer techniques have overcome several pitfalls experienced by other orthopedic surgeons. It is recommended that the risks of scar tissue formation by transferring the tendon in a straight line should be minimized to provide a sufficient space for the tendon to glide and to obtain a secure anchoring site. The procedure is performed with a single anterior incision that can be extended upward to the mid-thigh if necessary to provide an ample surgical exposure and create a smooth gliding path. Upon re-exploration, minimal scar tissue was observed and the tendon could be transferred directly to the soft and fleshy muscle with a favorable clinical result.

We have no conflict of interest to report.

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