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Reconstructive

Chronic Quadriceps Tendon Rupture Reconstruction with Sartorius Muscle Transfer: A Report of Five Cases

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Summary: Disruption of the knee extensor mechanism is an unfavorable situation because efficient mobilization requires a functioning knee extensor apparatus. The purpose of this retrospective study was to report our technique of sartorius muscle transfer for restoration of extension mechanism function and the outcomes of five patients. Patients with ruptured knee extensor mechanism secondary to trauma or knee arthroplasty-related issues were studied retrospectively. In all patients, sartorius muscle was transferred to restore the quadriceps tension deficit. Increase in the knee active range of motion, increase in the extensor mechanism power by one grade on Medical Research Council scale, and improvement in the extension lag were observed in all patients. The sartorius muscle transfer can be a reliable option to restore the knee extensor mechanism in chronic quadriceps tendon injuries. Our initial results are promising and showed improvement of the extensor mechanism muscle power, increased knee active range of motion, and decreased knee extension lag. The complications we observed did not impair the successful outcome of the sartorius transfer and were anticipated given the complexity of the studied cases. We encourage additional studies of sartorius muscle transfer to treat chronic quadriceps tendon injuries. *(Plast Reconstr Surg Glob Open 2021;9:e3785; doi: 10.1097/GOX.0000000000003785; Published online 23 August 2021.)*

INTRODUCTION

Quadriceps muscle activity is essential for stability and locomotion. Loss of integrity of knee extensor mechanism results in marked disability.[1] Quadriceps tendon (QT) rupture is relatively uncommon (1.3%–4%).[2,3] Sometimes diagnosis may require radiological evaluation.[4] Reconstruction of chronic quadriceps tendon injuries (CQTI) is challenging and has poor outcomes.[4,5] Various reconstruction techniques have been described, with relatively high failure rates reported with allografts and synthetic grafts.[6,7] The poor results with simple repairs necessitate augmentation with all CQTI surgical management.[8] Sartorius, biceps femoris, and semitendinosus muscle transfers are options for extensor mechanism reconstruction.[9]

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Received for publication June 8, 2021; accepted July 1, 2021.

DOI: 10.1097/GOX.0000000000003785

The sartorius is the most superficial muscle of the anterior thigh compartment, originating from the anterior superior iliac spine and inserting distally into the medial surface of the proximal tibia with an average length of 50 cm. It is supplied by six or seven vascular pedicles from the femoral artery. The descending genicular artery (1.77-mm diameter) is the most distal pedicle located on average 12.83 cm proximal to the knee joint.[10,11] (**See figure, Supplemental Digital Content 1,** which displays sartorius muscle anatomy showing the most distal pedicle supply by the descending genicular artery. Proposed skin incisions to access the quadriceps tendon and harvest the sartorius

The following organizations supported the institution of Drs. AHE and JDC and Mr. MGG: *Biocomposites, DePuy Synthes Companies, MHE Coalition, Orthofix, OrthoPediatrics, Pega Medical, Smith+Nephew, Stryker, and Zimmer Biomet. Drs. HMA and HHE have no financial interest to declare in relation to the content of this article.*

Disclosure: *Dr. JDC is a consultant for Bonesupport, Orthofix, Smith+Nephew, and Zimmer Biomet, receives fellowship support from Biocomposites, is on the MicroGenDX Advisory Board, and her spouse receives royalties from the University of Florida.*

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muscle. Copyright 2021, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore. Used with permission. **http://links.lww.com/PRSGO/B767**.) This study presents the sartorius muscle transfer technique for restoration of extension mechanism function.

MATERIALS AND METHODS

The institutional review board determined that this study was exempt from full review; informed consent was not required. The study conformed to the Declaration of Helsinki. A retrospective review was conducted for patients with CQTI who underwent sartorius muscle transfer between September 2014 and August 2018. Five patients were included. Primary outcomes included knee range of motion (ROM), QT strength, and extension lag improvement. Muscle strength was measured using the Medical Research Council (MRC) grading system.[12]

Surgical Technique

The patient was placed in a supine position, under general anesthesia with antibiotics and a sterile proximal thigh tourniquet. The previous anterior skin incision was used. In cases with multiple previous incisions, the most lateral incision was utilized. The extensor mechanism defect was exposed and debrided, and the patella was mobilized. Healthy QT tissue was preserved. The QT was mobilized by releasing adhesions. The gap was assessed with the knee in maximum extension. Krackow's stitches with number 2 Ethibond Excel polyester suture (Johnson & Johnson, New Brunswick, N.J.) were used in the QT to secure the proximal extensor mechanism.

The patella was prepared by drilling three longitudinal tunnels through the mid-portion of the patella using the 2.7-mm drill bit. A longitudinal 15-cm skin incision was made over the pes anserine extending proximally to harvest the sartorius muscle from its insertion with protection of the saphenous nerve. Careful blunt dissection was performed from distal to proximal with identification and protection of the descending genicular artery pedicle to the sartorius muscle. In all patients, this pedicle was found approximately 12–15 cm proximal to the knee joint. The sartorius muscle was passed smoothly through a subfascial tunnel created manually with no tight facial bands (Fig. 1). The transferred muscle was sutured using number 2 Ethibond, passed through the patellar tunnels, and tied to the inferior pole of the patella (Fig. 2). Augmentation of repair can be achieved using tensor fasciae latae, vastus lateralis fascia, mesh polypropylene, or tibialis anterior allograft. Meticulous hemostasis was maintained throughout the procedure. Surgical drains were placed, wounds were closed in layers, and sterile dressings were applied. The operated limb was placed in a well-padded posterior splint that maintained full knee extension.

Postoperative rehabilitation protocol was to maintain full knee extension for 6 weeks in a brace, followed by gradual increase in flexion by 30 degrees every 2 weeks using a hinged knee brace. Only closed chain exercise was permitted. (**See table, Supplemental Digital Content 2,** which displays postoperative rehabilitation protocol. **http://links.lww.com/PRSGO/B768**.)

RESULTS

The five patients (two women, three men) had a mean age of 61 years (range, 54–76 years). The mean follow-up duration was 20.4 months (range, 9–32 months). Table 1 shows the patient demographics, diagnosis, and procedures. Average time from the injury to the sartorius transfer was 22 months (range, 8–60 months). Three patients had prior failed attempts to repair/reconstruct the QT. All patients had marked quadriceps atrophy and required

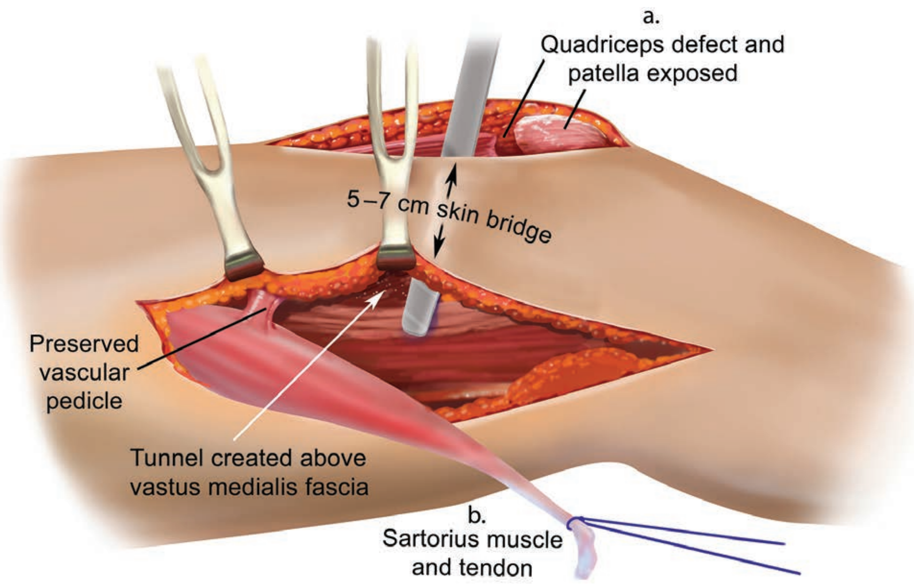

Fig. 1. Both skin incisions are made with a skin bridge of at least 5–7 cm to preserve skin viability. Quadriceps defect with patella exposed (a). Sartorius muscle is harvested with preserved vascular pedicle (b). Copyright 2021, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore. Used with permission.

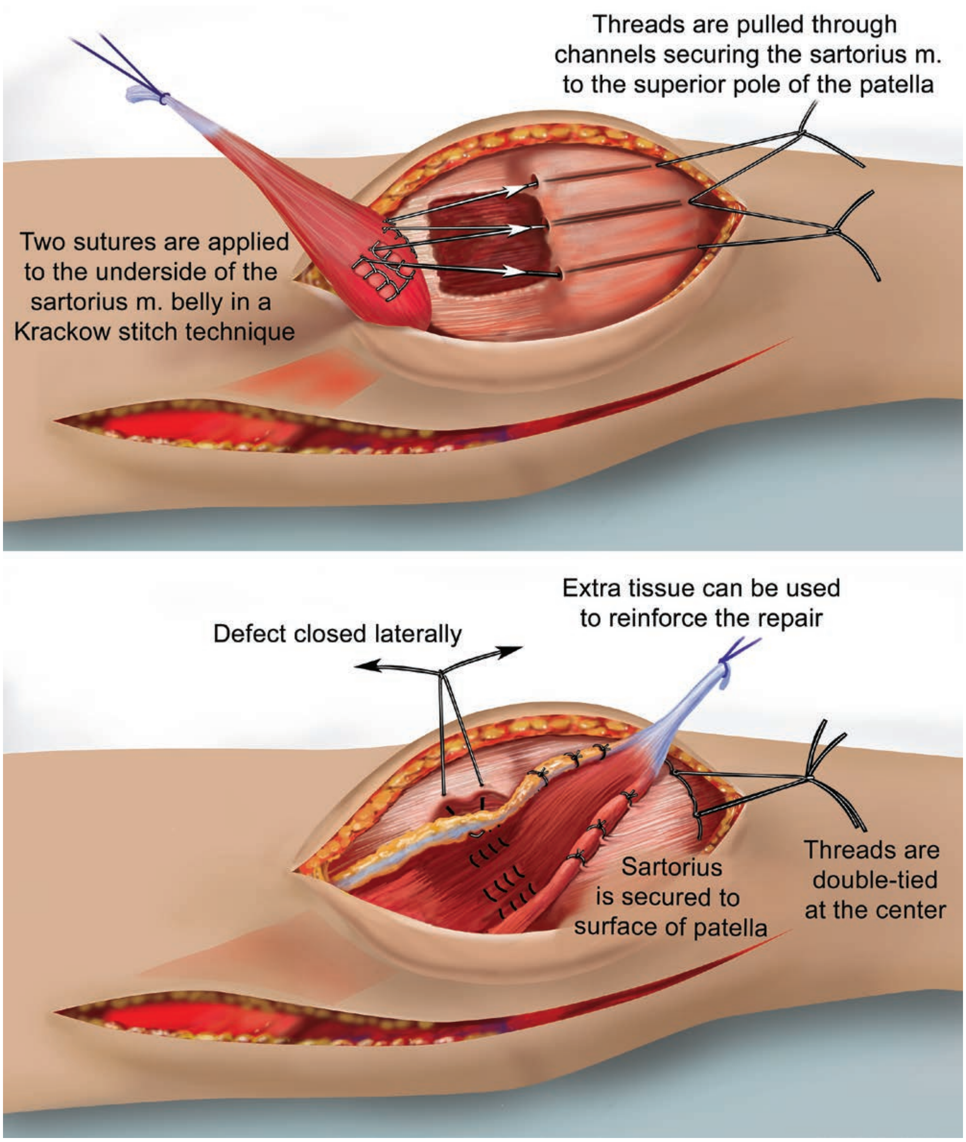

Fig. 2. The sartorius tendon is prepared. Sutures are passed through the predrilled patellar tunnels to secure the transferred muscle to the superior pole of the patella. Tighten the attachment with reinforcement proximally and distally. Copyright 2021, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore. Used with permission.

Table 1. Patient Demographics

Patient	Gender, Age (y)	BMI (kg/m^2)	Diagnosis	Side	Comorbidities	Procedure	Time to Flap (Mo)
1	Man, 54	30.3	Posttraumatic chronic QTR knee osteoarthritis, failed QT repair	L	HIV	Sartorius transfer, arthroscopic knee debridement	20
2	Man, 76	23.3	Posttraumatic QTR	L	Parkinson disease, aortic stenosis	Sartorius transfer, TFL transfer	12
3	Woman, 57	42.8	Post-TKA QTR followed by failed quadricepsplasty	L	Hypertension, morbid obesity	Sartorius transfer, QT repair	60
4	Woman, 61	28.2	Post-TKA QTR failed primary repair	L	DVT	Mesh polypropylene, quadricepsplasty, sartorius transfer	8
5	Man, 58	28.6	Post-TKA QTR failed allograft reconstruction	R	None	Sartorius transfer, TA allograft, VL fascia	12

BMI, body mass index; DVT, deep venous thrombosis; HIV, human immunodeficiency virus; L, left; QT, quadriceps tendon; QTR, quadriceps tendon rupture; R, right; TA, tibialis anterior tendon; TFL, tensor fasciae latae; TKA, total knee arthroplasty; VA, vastus lateralis.

Table 2. Outcomes following Sartorius Transfer

	Preoperative Assessment			Postoperative Assessment				
Patients	ROM	QS	Extension Lag	ROM	QS	Extension Lag	Complications	Follow-up (Mo)
1	40–120 degrees	3/5	40 degrees	0–125 degrees	4/5	0 degrees	POD 148: Medial thigh suture abscess required scar excision	17
2	45–120 degrees	3/5	45 degrees	10–130 degrees	4/5	10 degrees	POD 4: Hematoma required drainage POD 29: Wound necrosis managed with skin grafting	19
3	50–100 degrees	3/5	50 degrees	0–100 degrees	4/5	0 degrees	POD 34: Medial thigh wound necrosis required debridement and VAC	9
4	75– 110 degrees	3/5	75 degrees	5–120 degrees	4/5	5 degrees	POD 214: Patellar necrosis, patellar excision, proplopylene mesh reconstruction of patellar QT	25
5	45–120 degrees	3/5	45 degrees	10–120 degrees	4/5	10 degrees	POD 288: Prosthetic knee infection, revision TKA POD 564: Excision of extensor mechanism, revision TKA, sartorius flap used for soft-tissue coverage POD 791: Implant removal, arthrodesis	32

POD, postoperative day; QS, quadriceps strength; QT, quadriceps tendon; ROM, range of motion; TKA, total knee arthroplasty; VAC, vacuum-assisted closure.

a knee extension brace for ambulation. Local limb examination revealed intact neurovascular status in all patients. Imaging confirmed QT discontinuity in all cases.

All patients showed improvement in knee active ROM and extensor mechanism power by one grade on MRC scale (Table 2). All patients also had a decrease in extension lag. No patellar maltracking was observed during the follow-up period.

Patient 4 experienced patellar necrosis and underwent patellar excision and polypropylene mesh reconstruction of the quadriceps tendon (Table 2). Patient 5 had a periprosthetic infection that resulted in knee arthrodesis after failed revision arthroplasty. The sartorius was still viable and used as a flap. This was not considered as a failure of the sartorius muscle transfer.

DISCUSSION

Management of CQTI has not been discussed often in literature and represents a challenge for any surgeon. The sartorius muscle is a good option for QT reconstruction and has a faster adaptive rehabilitation because it is the most superficial muscle of the anterior thigh muscle group, acts in synergy with other muscles without unique function, and shares the same nerve supply of the quadriceps femoris muscle.[9,13]

In our series, the postoperative extension lag was remarkably reduced when compared with preoperative evaluation without mechanical failures. Pritsch et al[9] reported overall good outcomes for eight patients undergoing extensor mechanism reconstruction using only sartorius muscle transfer after massive tumor resection from the anterior thigh compartment. Limitations of the current study include the lack of a control group and that the results are based on a single surgeon's experience.

CONCLUSIONS

The sartorius muscle transfer can be considered a reliable option to restore the knee extensor mechanism in CQTI. Our initial results are promising and showed improvement of the extensor mechanism muscle power, increased knee active ROM, and decreased knee extension lag. The complications we encountered did not impair the successful outcome of the sartorius transfer and were anticipated given the complexity of the cases. Given the rarity of these cases, we encourage additional studies of sartorius muscle transfer to treat chronic quadriceps tendon injuries.

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REFERENCES

1. Ahmadiahangar A, Javadian Y, Babaei M, et al. The role of quadriceps muscle strength in the development of falls in the elderly people, a cross-sectional study. *Chiropr Man Therap.* 2018;26:31.
2. Ricciardi BF, Oi K, Trivellas M, et al. Survivorship of extensor mechanism allograft reconstruction after total knee arthroplasty. *J Arthroplasty.* 2017;32:183–188.
3. Clayton RA, Court-Brown CM. The epidemiology of musculoskeletal tendinous and ligamentous injuries. *Injury.* 2008;39:1338–1344.
4. Saragaglia D, Pison A, Rubens-Duval B. Acute and old ruptures of the extensor apparatus of the knee in adults (excluding knee replacement). *Orthop Traumatol Surg Res.* 2013;99(suppl 1):S67–S76.
5. Ormaza A, Moreta J, Mosquera J, et al. Chronic quadriceps tendon rupture after total knee arthroplasty augmented with synthetic mesh. *Orthopedics.* 2017;40:38–42.
6. Browne JA, Hanssen AD. Reconstruction of patellar tendon disruption after total knee arthroplasty: Results of a new technique utilizing synthetic mesh. *J Bone Joint Surg Am.* 2011;93:1137–1143.
7. Goldthwait JE. The direct transplantation of muscles in the treatment of paralytic deformities. *Trans Am Orthop Assoc.* 1897;s1-10:246–252.
8. Dobbs RE, Hanssen AD, Lewallen DG, et al. Quadriceps tendon rupture after total knee arthroplasty. Prevalence, complications, and outcomes. *J Bone Joint Surg Am.* 2005;87:37–45.
9. Pritsch T, Malawer MM, Wu CC, et al. Functional reconstruction of the extensor mechanism following massive tumor resections from the anterior compartment of the thigh. *Plast Reconstr Surg.* 2007;120:960–969.

10. Buckland A, Pan WR, Dhar S, et al. Neurovascular anatomy of sartorius muscle flaps: Implications for local transposition and facial reanimation. *Plast Reconstr Surg.* 2009;123:44–54.
11. García-Pumarino R, Franco JM. Anatomical variability of descending genicular artery. *Ann Plast Surg.* 2014;73:607–611.
12. Sapega AA. Muscle performance evaluation in orthopaedic practice. *J Bone Joint Surg Am.* 1990;72:1562–1574.
13. Walters BB, Varacallo M. Anatomy, bony pelvis and lower limb, thigh sartorius muscle. In: *StatPearls.* Treasure Island, Fla.: StatPearls Publishing; 2021.