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ORIGINAL ARTICLE

Reconstruction of chronic Patellar Tendon Rupture by Semitendinosus and Gracilis Tendons Autografts and Internal Brace Augment, retrospective study

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ABSTRACT

Background: Chronic patellar tendon rupture is rare but very disabling to the knee function. With proper reconstruction techniques, good knee function can be restored.

Aim: To evaluate the outcome of chronic patellar tendon rupture reconstruction by Semitendinosus-Gracilis autografts and internal brace augmentation.

Methods: It is a retrospective study; Level of evidence, 3. Reconstruction was performed for 5 patients with chronic patellar tendon rupture. age was 37 years in the Average time since injury was 13 months. active extension was not possible, a quadriceps strength of grade 2/5 and mean an IKDC score of 34. According to the IKDC Subjective Knee Evaluation, the 5 patients' knees were rated as severely abnormal. All 5 patients underwent reconstruction using a distally based Semitendinosus-Gracilis autograft with internal brace augmentation.

Results: Patients were followed up for 24 months. At 6 months, all patients had full active knee extension. 4 patients had quadriceps power of 5/5 and one patient had a power of 4/5. The IKDC score improved to an average of 82 (range 80–86), In 4 patients the knees were rated as normal while one knee was rated as near normal. All patients returned to preinjury activity levels.

Conclusion: Surgical reconstruction of chronic rupture of patellar tendon utilizing Semitendinosus- Gracilis autografts with internal brace augmentation yields excellent outcomes and can restore the function and biomechanics of the extensor mechanism of the knee to pre-injury levels.

Keywords: chronic patellar tendon rupture; Patellar tendon reconstruction; Hamstring tendons autografts; Internal brace augmentation.

INTRODUCTION

Patellar tendon ruptures caused by eccentric contraction of quadriceps muscles occur in males under the age of forty, and the injury is considered the third-most common trauma of the knee extensor mechanism [1]. The ideal management is surgical suturing within 2 weeks of trauma to avoid scar formation, wear, and loss of tendon sliding[2].

Patellar tendon traumatic ruptures are characterized by a rare incidence rate of 6.8 of 1,000,000 per year, with 78% of all injuries occurring in male patients at a mean age of 49 years[3]. An eccentric contraction of the quadriceps muscles at knee flexion angles greater than 45° is the main cause of most patellar tendon ruptures[4]. A force of 17.5 times body weight is estimated to cause a failure. The patella experiences the greatest forces at 60° of flexion, and ruptures are most common at the distal pole of the patella as the tensile load is marked at the insertion site[5].

Pathologic tendon rupture is usually associated with a low-velocity, indirect, minor traumatic episode. Predisposing causes are systemic diseases such as rheumatoid arthritis or lupus erythematosus, prior bone tendon bone harvest, or previous repeated steroid injections at the patellar tendon. On the other hand, a high-velocity injury such as a road traffic accident (RTA) can cause patellar tendon rupture in an otherwise healthy tendon[6].

Young and active people can be markedly negatively affected by injured patellar tendons,

resulting in an inability to actively preserve extension. The knee range of motion can be markedly altered due to patellar tendon healing problems whether loss of loss or tension. Surgical treatment of neglected patellar tendon ruptures is more challenging than that for acute injuries, and the results are less favorable[7].

Patients present late either due to neglect or missed or due to the severity of the associated injuries such as multiple open fractures that attract the attention of trauma surgeons and tend to delay care of associated soft tissue injuries. Various classification systems have been used to describe patellar tendon ruptures. Siwek and Rao divided these injuries into acute or chronic (more than two weeks)[7].

Our study aims to evaluate the outcome of chronic patellar tendon rupture reconstruction by Semitendinosus-Gracilis autografts and internal brace augmentation.

We hypothesized that the studded technique yields an excellent outcome and can restore the function and biomechanics of the extensor mechanism of the knee.

METHODS

Between January 2018 and January 2020, five patients with chronic patellar tendon rupture were referred to our sports medicine unit from the trauma unit in our institute after completion of their fracture management. This retrospective study was conducted after IRB approval (# 10255-29-3-2023). Written informed consent was obtained from all participants. The study was conducted according to the Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans. All patients were males. All patients were manual laborers. The average age was 37 years (range between 29 and 41 years). The time between injury and presentation ranged between 7 and 18 months (an average of 13 months). All patients were involved in road traffic accidents. Four patients had associated ipsilateral fracture tibia, one patient had ipsilateral closed fracture femur, one patient had ipsilateral torn anterior cruciate ligament (ACL) and one patient had ipsilateral combined torn ACL and lateral meniscus. (Table 1), (figure 1a, b, c)

At the presentation, all patients complained that they cannot actively extend their knees at all, have difficulty rising from a sitting position, have to use their arm to rise from the chair and feel that their knees are unstable.

During the physical examination, Prominent quadriceps wasting was present in all cases, and it ranged between 1 to 3 cm compared to the opposite side. A gap was palpated below the patella during active quadriceps contraction in the supine position. All patients had normal passive knee range of motion. All patients can not actively extend their knees in a sitting position at all (figure 2 a, b).

Patients cannot perform active straight leg raising in the supine position. The strength of the quadriceps was 2/5 in all patients. All patients cannot perform the one one-leg hop at all. IKDC evaluation of the knee for the 5 patients was severely abnormal, The IKDC score was 34 (range32-38), The Lysholm score was 36 (Range, 33-37) and the Kujala score was 31 (29-34) (Table 2).

Radiologically, a lateral view radiograph with the knee flexed 30° was taken and the Insal-Salvati ratio was estimated. This ratio was on average 1.8 (range 1.6–2.). In our institute MRI is the gold standard for diagnosis, to confirm the diagnosis and to diagnose associated injuries that if not addressed properly would adversely affect the overall final knee score (Figure 3 a, b). In the 5 patients, reconstruction was performed utilizing ipsilateral Semitendinosus and Gracilis tendons autograft with preservation of their native tibial insertions and augmentation by fiber tape internal brace. In two patients one with associated ACL tear, the other with ACL and lateral meniscus tears, after the reconstruction procedure we performed, all inside ACL reconstruction utilizing a semitendinosus tendon autograft from contra lateral knee and fixed with two tightropes and meniscus suture was performed at the same sitting.

Surgical technique

Before surgery, the patient's written consent was taken concerning the nature of the procedure and the possibility of V-Y quadriceps lengthening if needed. Surgery was performed under spinal anesthesia, a supine position, and a high thigh tourniquet. The tourniquet was inflated while the knee was in full flexion for not to limit patellar mobility during reduction. One gram of Vancomycin IV infusion was given before the tourniquet application.

A vertical midline incision is done from the upper pole of the patella to the tibial tubercle cutting through the cutaneous and subcutaneous layer through the deep fascia. The peritenon and the peritendinous flaps were dissected to expose the scarred patellar tendon portion which was debrided together with removing any retinacular redundancy. The superficial and deep aspects of the quadriceps tendon were released using a blunt elevator (Figure 4 a).

After the release of the scar tissue and adequate mobilization of the quadriceps tendon a trial to reduce the patella from the high riding position by a reduction clamp to a low position at

30^{O} of flexion under C arm control. The aim is to bring the lower pole of the patella to the anterior edge of Blumensaat's line. If this attempt failed a V-Y quadriceps lengthening is performed. (Figure 4 b)

The Semitendinosus (ST) and Gracilis tendons are harvested from the same incision using an open-end tendon stripper (Arthrex, Naples, FL), and are left distally attached. The tendons are cleaned of muscle and soft tissue and then whip-stitched separately using NO 0.0 fiber wire (Arthrex, Naples, FL) at the tendon-free end.

A 2.5 mm guide wire (Arthrex, Naples, FL) is passed horizontally 2 cm posterior to the tibial tubercle (TT). A 5 mm cannulated reamer (Arthrex, Naples, FL), is passed over the guide wire to create a bone tunnel (Figure4 c). A bone bed is created at the lower pole of the patella by a bone nibbler to prepare the proximal footprint of the patellar tendon. A 2.5-mm guide wire is used to drill 2 vertical tunnels at the medial and lateral thirds of the patella (Figure 4 d).

A central vertical socket is created at the central one-third of the patella by a 5 mm canulated reamer 20 mm deep over a guide wire. (Figure 5 a). Three NO 2 fiber wire sutures loops (Arthrex Naples Florida) are shuttled through the tunnels in the patella and are retrieved proximally with the loop ends at the distal pole of the patella. A fiber tape (Arthrex Naples Florida) is passed through the tibial tunnel and sutured through the retinacular remnants then through the quadriceps tendon then brought down to the tibial tunnel in a circumferential manner around the extensor apparatus (figure 5 b).

The (ST) tendon is passed through the transverse tunnel behind the (TT) from the medial to the lateral direction. The Gracilis tendon is passed along the medial aspect of the patellar tendon remnants. The two grafts are crossed over the patellar tendon remnants (figure 5 c).

The crossed tendons are passed through the medial and lateral fiber wire loops (figure 11) and sutured together by the NO 0.0 fiber wire then wedged in the central patellar socket by pulling on the central wire loop while the patella is held in 60° of knee flexion (figure 5 d).

While the knee is held at 60^{O} of flexion the fiber tape ends are tied together to provide stability to the construct but not to over constrain the knee. The fiber wire shuttling sutures at the proximal patella are tied together sequentially to secure the tendon grafts to the distal patellar pole (figure 5 e). The remnants of the native patellar tendon are sutured to the tendon grafts to reinforce the construct (figure 5 f). The range of motion is checked to ensure 90^{O} of knee flexion and not to constrain the patellar mobility.

The patellar retinacula are repaired by NO 0.0 fiber wire. A trial to repair the paratenon over the construct if feasible is performed. A suction drain is applied. The wound is closed in layers (figure 5 g, h). A hinged knee brace locked-in extension is applied.

Postoperative Rehabilitation.

A hinged knee brace locked-in extension is applied. After drain removal isometric quadriceps muscle contraction is strongly recommended as frequent as every 4 hours for 10 minutes. The patient was instructed for partial weight bearing with crutches as tolerated

At 6 weeks, the patient was instructed to sit at the edge of the bed and allow his knee to flex as tolerated. The goal is to reach 90^{O} of knee flexion at 9 weeks. Active quadriceps exercise was encouraged after 6 weeks to achieve full active knee extension at 9 weeks. At 12 weeks, quadriceps muscle strengthening started. At 4 to 5 months the patient is allowed to return to work.

STATISTICAL ANALYSIS

The results were presented as mean ± standard deviation. Comparisons between measures (mean ± SD) of multiple values (preoperative and follow-up visits after surgery) were done. All statistical analyses were performed with SPSS version 24.0. $P < 0.05$ was considered statistically significant.

RESULTS

All patients were followed up for a period of 24 months. Follow-up visits were at 2 weeks, 6 weeks, 3,4,5, and 6 months. Then at 3 monthly intervals thereafter. The average postoperative knee flexion at 3 months was 125° (range 120–130°). All 5 patients regained full active knee extension at 3 months (figure 6 a, b, c). At 6 months, 4 patients had 5/5 quadriceps power and one patient had 4/5 power. At 6 months, 4 patients regained quadriceps muscle mass compared to the other side, but one patient had quadriceps wasting of 1 cm.

At 6 months, MRI study was performed and confirmed graft viability and incorporation of the reconstructed patellar tendon plus viability of the reconstructed ACL in one patient and the healing of the torn lateral meniscus in the other patient. At 6 months, the average Insaal-Salvati ratio of 1.2 (range 1.1–1.3) (figure 7). Patients were evaluated according to IKDC, Lysholm, and Kujala scores. During the IKDC evaluation there were items in the score that were difficult for the patients to answer. For example, what is the highest level of activity you can perform without significant swelling in your knee. The patient answers were, we never performed Very strenuous activities like

jumping or pivoting as in basketball or soccer and we are not intending to do so in the future. The patients were rated as they were able to do moderate activities like moderate physical work, running or jogging and were given a score of 2 over 4 concerning this item and so on.

According to the IKDC scoring system, 4 patients had their knees graded as normal, while one patient was graded as near normal. The pre-operative IKDC score improved from 34 (range 32-38) to a postoperative average score of 82 (range 80–86). The Lysholm score improved from 36 (Range, 33-37) to 85 (range 84–88), and the Kujala score improved from 31 (29-34) to an average of 81 (range 79–84) (Table 3)

We had one superficial wound infection; this patient was accidentally discovered to be diabetic during routine preoperative investigations. The patient's initial trauma was a bad comminuted fracture tibia with a lacerated skin wound extending to his knee. Infection was controlled by diabetes control and proper antibiotic therapy; no wound drainage was needed.

Table 1: Patients' demographics

Case. Number	Age (years).	mode of injury	Duration since injury(months).	Associated injury	IKDC score	Lysholm score	Kujala score
1	36	RTA	18	None	34	35	32
2	31	RTA	11	ACL	32	34	31
3	41	RTA	15	None	36	36	34
4	29	RTA	9	Lat meniscus	30	33	29
				ACL tears			
5	39	RTA	16	None	38	37	33

RTA, roar traffic accident ACL, anterior cruciate ligament tear
Lat, lateral meniscus.

Table 2: Preoperative evaluation.

Case number	Active extension	Passive flexion	Quadriceps wasting	Quadriceps strength	Insall ratio	IKDC score
1	not possible	0–135°	2 cm	2	1.3	45
2	not possible	0-120°	2.5cm	2	1.7	40
3	not possible	0-130°	1.5cm	3	1.4	50
4	not possible	0-115°	3cm	2	2.2	37
5	not possible	0-125°	1.5cm	2	1.5	42

Table 3: Post-operative evaluation at final follow- up

Case number	Active extension	Passive flexion	Quadriceps wasting	Quadriceps Strength	Insall ratio	IKDC score	Lysholm score	Kujala score
1	Full	0-130°	nil	5	1.1	86	88	84
2	Full	0-125°	nil	5	1.2	82	86	80
3	Full	0-130°	nil	5	1.0	84	88	82
4	Full	0-120°	1cm	4	1.3	80	84	79
5	Full	0-130°	nil	5	1.1	86	88	84

Figure 1: Pre operative photo showing patient with (a) comminuted fracture tibia initial treatment by spanning external fixator (b) after fixator removal (c) open reduction and internal fixation via plate and screws.

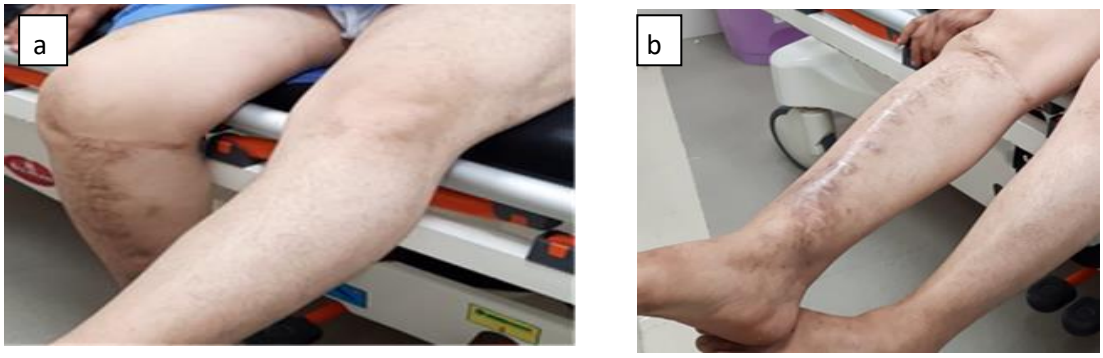

Figure 2: Pre operative photo showing (a) active knee extension is not possible (b) patient can extend his knee with the help of the other leg.

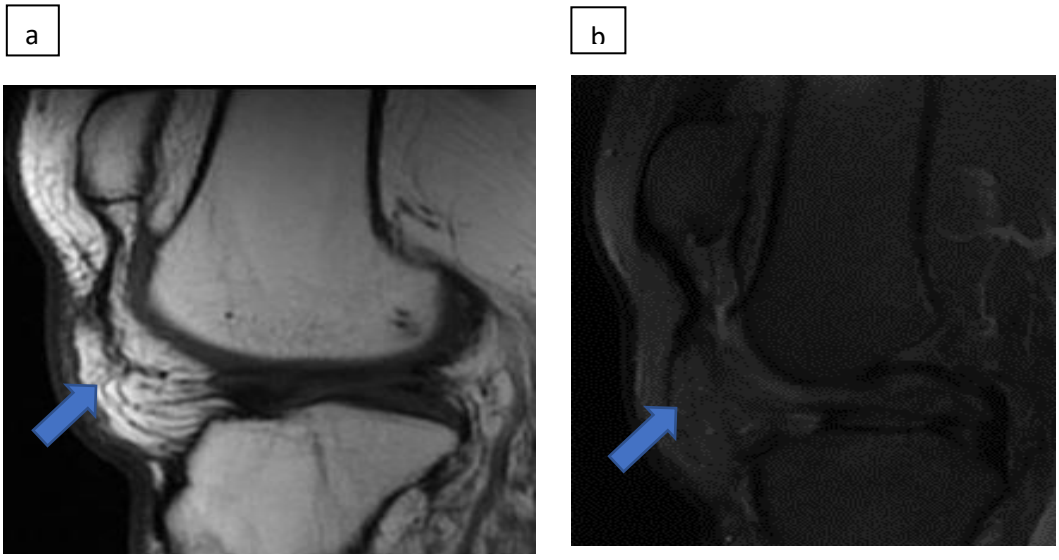

Figure 3: pre operative MRI showing chronic patellar tendon rupture at its distal attachment with poor quality tendon stump (blue arrow) and patella alta.

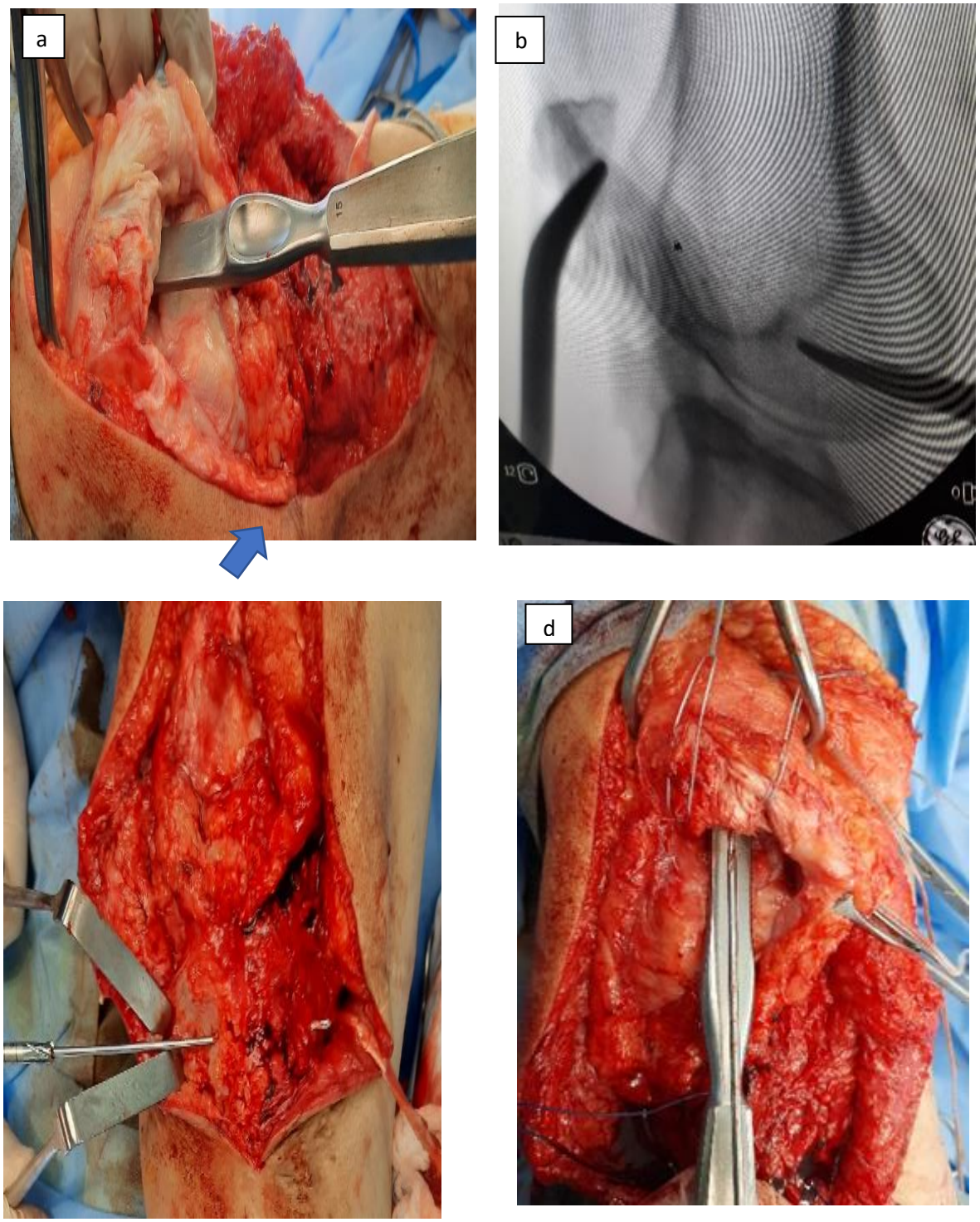

Figure 4: (a) Scar tissue removed and a Cobb elevator is used to remove adhesions around the quadriceps muscle and patella (blue arrow). (b) The patella was pulled down to an anatomic position by a reduction clamp under C- arm control. (c)A horizontal tunnel is created 2 cm behind the tibial tuberosity by a 5 mm cannulated drill over a guide wire (blue arrow). (d) A 2.5-mm guide wire is used to drill 2 vertical tunnels at the medial and lateral one-third of the patella. Two NO 2 fiber wire suture loops are shuttled through the tunnels in the patella and are retrieved proximally with the loop ends at the distal pole of the patella (black arrows).

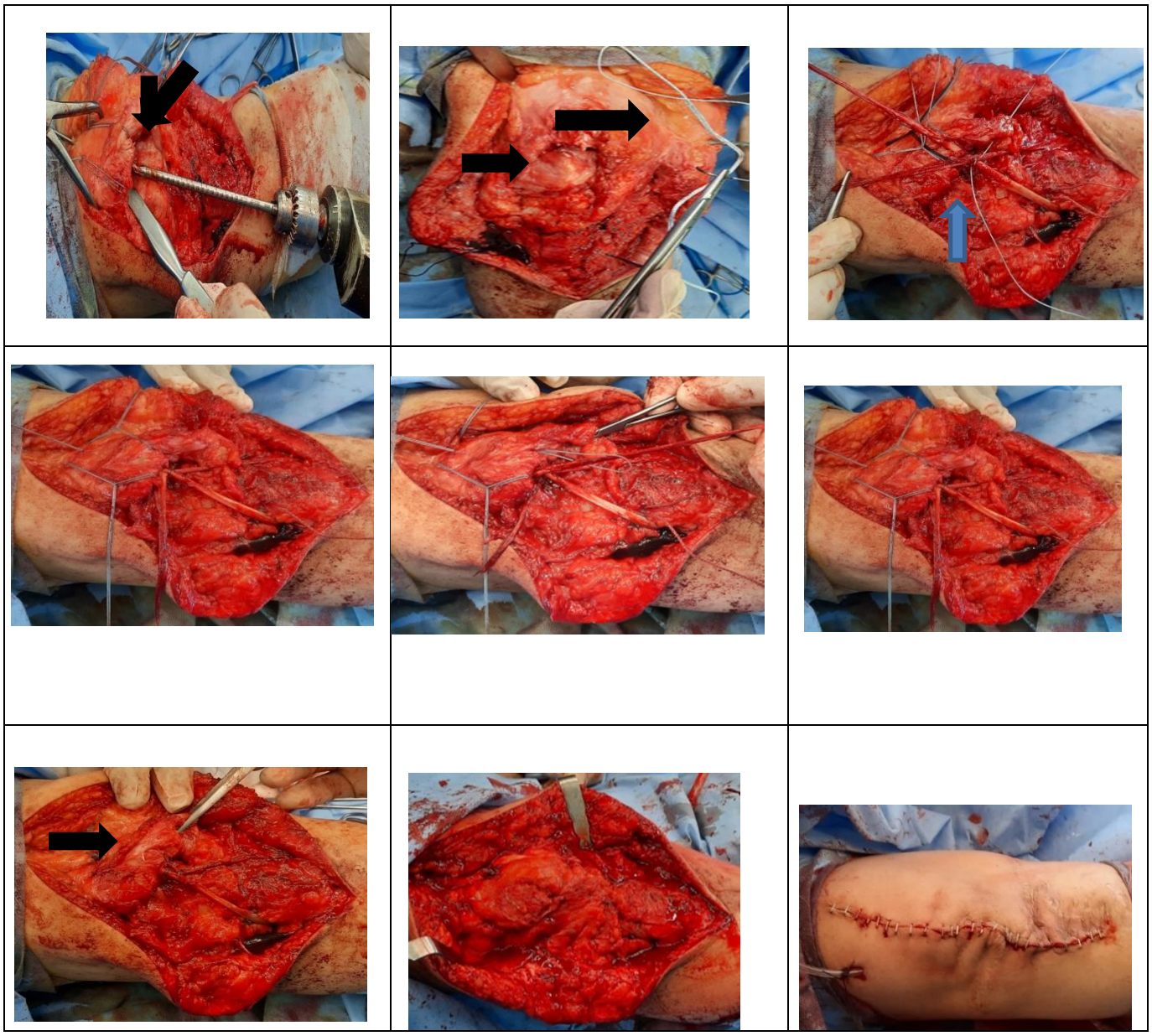

Figure 5 (a): A central vertical socket is created at the central one-third of the patella by a 5 mm canulated reamer (black arrow) 20 mm deep over a guide wire. (b): A fiber tape (black arrow) is passed through the tibial tunnel and sutured through the retinacular remnants then through the quadriceps tendon then brought down to the tibial tunnel. (c): The two grafts are crossed over the patellar tendon remnants ((blue arrow). (d): The crossed tendons are passed through the medial and lateral fiber wire loops (two black arrows). (e): The graft end is wedged in the central patellar socket (black arrow) by pulling on the central wire loop. (f) The fiber wire sutures at the proximal patella are sutured together (black arrow) in a sequential manner to secure the tendon grafts to the distal patellar pole. (g): The remnants (black arrow) of the native patellar tendon are sutured to the grafts. (h): A suction drain is applied; the wound is closed in layers.

Figure 6: At 6 months patient regained full knee flexion and active extension

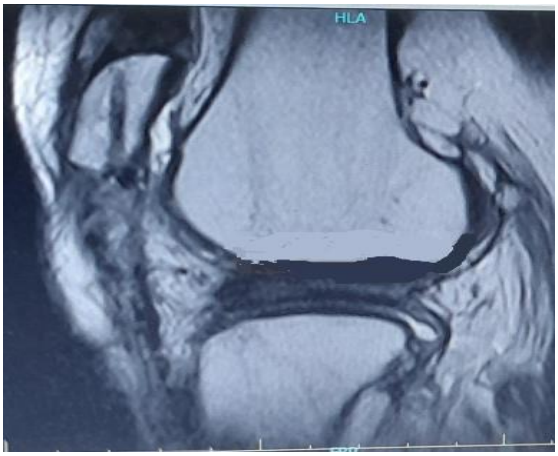

Figure 7: MRI photo at 6 months showing graft integrity and restoration of the anatomic position of the patella.

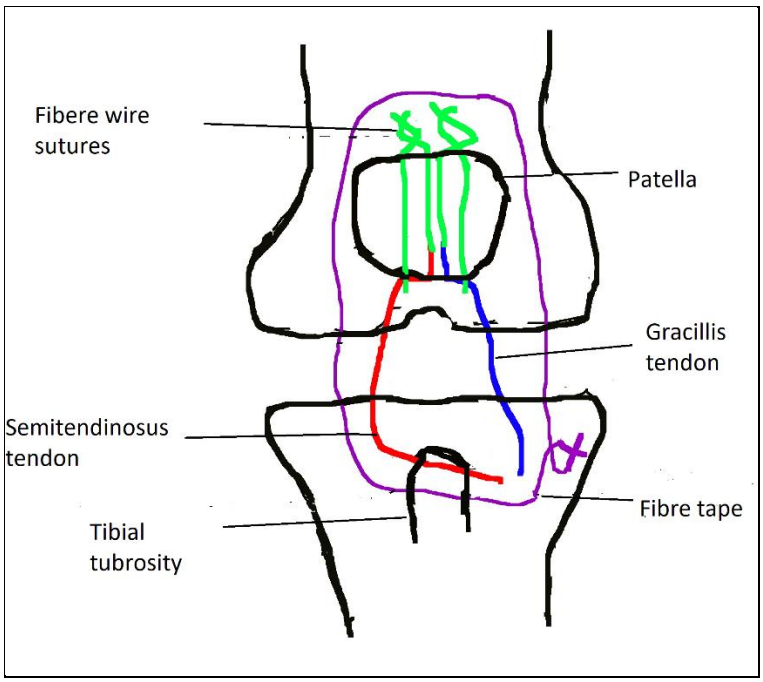

Figure 8: Schematic drawing shows the steps of the surgical procedure (the red color is the Semitendinosus tendon, the blue color is the Gracilis tendon, the green color is fiber wire sutures used to tie the grafts at the superior pole of the patella, the purple color is the fiber tape used to encircle the extensor mechanism).

DISCUSSION

Patellar tendon ruptures constitute the third most common injury to the extensor mechanism of the knee [6]. Most of these patients are seen for treatment immediately after injury and can undergo direct surgical repair with favorable results [9].

Late presentation in this case series was due to the drastic nature of the associated bony injuries that attracted the attention of the trauma team. All patients in this case series had associated fractures with multiple bony external and internal fixations. Patellar tendon reconstruction was performed after completion of the bony procedures and satisfactory bone healing.

To treat such complex injury there are many challenges we had to deal with. First, is quadriceps contracture and high-riding patella. Second, is the reconstruction of the patellar tendon with a very poor remaining tendon stump. Third, is adequate protection of the construct to withstand the huge loads on the extensor mechanism to start early range of motion, fasten tissue healing and to prevent knee arthrofibrosis.

Nonoperative management has limited indications and does not restore the function of the affected extremity. Late repair of chronic patellar tendon ruptures was first described in 1927, and several techniques have been described using various types of grafts including, hamstring, quadriceps, contralateral patellar tendon autografts, allografts, and synthetic grafts[10].

Allograft reconstruction has an increased risk of infection and weakness secondary to radiation of the tendon graft that reduces vascularity and cellularity when histologically compared to autografts[11].

Casey et al[12], in a series of four patients, managed chronic ruptures of the patellar tendon, the tendon remnants were sutured and protected with multiple strands of strong cerclage wire, in a figure-of-8 pattern, connecting the quadriceps tendon to the tibial tubercle. We can claim that the remaining tendon stump is usually very weak and insufficient for direct suturing and the need for tendon restoration is inevitable. Using stainless-steel cerclage wire can increase patients' irritation during rehabilitation due to hardware prominence or breakage and the need for a second surgery to extract the wire.

Nguene-Nyemb et al[11]. used the (ST) only and passed it in a single 6-mm horizontal patellar tunnel. They did not make a tibial tunnel and they sutured the (ST) graft to the remnants of the patellar tendon. We argue that this would not recreate the distal anchor point nor the length of the patellar tendon. The construct was not protected, this would slow down the rehabilitation, and extensor lag is highly possible.

Sundararajan et al[14] treated seven patients with chronic patellar tendon rupture using free Semitendinosus – Gracilis autografts for reconstruction. Grafts were passed through a single transverse patellar tunnel and a transverse tunnel

behind the tibial tuberosity. Again, they did not use any form of protection for the construct during the healing and incorporation phases of the graft, and this will certainly slow down the rehabilitation phase.

Ecker et al[15] were the first to describe the use of hamstring tendon autograft to reconstruct chronic patellar tendon injuries. They drilled 2 horizontal patellar and 2 tibial tunnels for graft passage. A cerclage wire was used to supplement the stability. In this technique, the risk of iatrogenic patella fractures due to double tunnels in the patella is very high plus a second surgery for wire removal.

Tsitskaris et al[16] in a case report used Semitendinosus-Gracilis grafts and fiber wire to augment the reconstruction. It allowed for a robust secure construct and did not require the removal of metalwork nor limit the degree of flexion as opposed to the use of cerclage wire described in other series.

Rothfeld et al [17] In 32 human cadaveric knees exposed to mid-substance patellar tendon injuries. They compared the results of repair using different modalities including suture repair without augmentation to suture repair with suture anchor internal brace augmentation and 18-gauge stainless steel cerclage wire augmentation and they concluded that Patellar tendon repair enforced with an internal brace was biomechanically higher to repair without augmentation and is similar to repair with augmentation with an 18-gauge stainless steel cerclage wire.

The use of suture anchors is a sound idea regarding less assault to the patella concerning the creation of full patellar tunnel and the equivalent graft to bone insertional strength compared to trans osseous tunnels, but all comes with cost. It is well known that the economic burden favors trans osseous tunnels that cost nothing over suture anchors that cost several hundreds of US dollars in our locality.

A biomechanical study was done by Ravalin et al [4] on 12 cadavers subjected to patellar tendon inferior pole tears. They compared the gap formation in different repair techniques. They showed significantly less gap formation with augmentation and a biomechanical difference once the gap becomes more than 3 mm. They found that an early-motion protocol benefits from a repair augmentation and gap formation less than 3mm.

Abdel-Aziz et al [18]. in a technical note described a technique to reconstruct the patellar tendon in which they used the semitendinosus tendon with preserved distal tibial attachment and a polyester tape is used to augment the repair in a circumferential manner.

In our technique, we used Semitendinosus and Gracilis tendons to increase the volume of collagen needed to reconstruct poor-quality tendon remains. They created a trough at the distal pole of the patella and laid the graft in the trough. In this way, they made surface contact between the distal pole and the graft. In our technique, after the creation of the trough at the distal patella, we made a socket 5mm in diameter and 20 mm in depth at the middle of the distal pole of the patella. The proximal end of the double graft was docked in the blind socket. We believe that bony incorporation of the graft in this way is better than simply Laing the graft against the bone.

The principle of repair augmentation was first described by Bunnell. The inclusion of a repair augmentation, whether purely mechanical or biological, increases the power of construction as proven by numerous biomechanical studies. Rehabilitation can be accelerated with a more powerful repair. It has been proposed that this tendon loading can play a role in healing across the repair site due to the mechanosensitive nature of the tendon structure[17].

In our technique, we used combined semitendinosus and gracilis autografts because they are easily available through the same incision with low morbidity and to provide more collagen fibers to compensate for the very poor tissue quality of the remaining patellar tendon stump. We preserved the tibial attachment of the grafts to preserve blood supply to the grafts and provide a strong distal anchor point to serve the purpose of accelerated rehabilitation after surgery.

We restored the anatomy and biomechanics of the patellar tendon by relying on two points of fixation near the native insertions of the patellar tendon. For proper restoration of the footprint of patellar attachment of the patellar tendon, the distal end of the patella was roughened and the two graft ends were laid in the bone trough created and fixed on both sides through trans osseous non absorbable sutures. We created a socket 5 mm in diameter and 20 mm in depth at the middle third of the distal end of the patella and wedged the graft in that socket, we believe this would increase bonny incorporation of the graft and add more strength to the construct,

Using internal brace augmentation, we were able to protect the reconstruct during the healing phases, we were able to prevent stress relaxation of the graft that would result in gap formation and extensor lag. We were able to start early rehabilitation protocol to speed up healing and prevent arthrofibrosis. A major advantage of suture tape is that it allows for smooth rehabilitation

without metal irritation, and it does not need another surgery to remove the hardware.

The real challenge during surgery in these complex cases is patella alta Bringing down the patella to an anatomic position would restore the patellar tendon length, which would adjust the patella-femoral joint contact loads to prevent post-operative patella-femoral osteoarthritis. Before surgery, written consent was taken upon approval to perform quadricepsplasty if we failed to bring the patella to an anatomic position during surgery. If a quadricepsplasty is performed, the quadriceps muscle is further weakened and an extensor lag may persist[10]. Fortunately, with the meticulous removal of scar tissue and release of adhesions around the quadriceps, it was possible to deal with this problem and we did not perform quadriceps plasty for any of our patients.

The next challenge is not to over constrain the knee joint to prevent post-operative knee stiffness that would be detrimental to knee function. We were keen during the final tying of the fiber tape ends together to ensure 90° of knee flexion.

At the final evaluation, four patients (80%) described their knees as normal and one patient (20%) described his knee as near normal according to the IKDC knee scoring system. Lysholm and Kujala's scores also revealed satisfactory outcomes. Quadriceps wasting improved slowly over time with comparable improvement in quadriceps power. At final evaluation, all patients regained full active knee extension, four patients regained quadriceps power of 5/5 (80%) and one patient 4/5 (20%). All patient returned to their pre-injury level of activity. 80% of the patients were very satisfied with the procedure while 20% were satisfied.

The study's limitations are the small sample size due to the rare nature of the injury. It took two years to collect five cases of that nature. Further prospective studies are needed with more sample size, randomization, and a control group.

CONCLUSION

Surgical reconstruction of chronic rupture of patellar tendon utilizing Semitendinosus- Gracilis autografts with internal brace augmentation yields excellent outcomes and can restore the function and biomechanics of the extensor mechanism of the knee to pre-injury levels and reverse a disabled to a functional knee.

COMPETING OF INTEREST

There was no conflict of interest regarding this study.

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