Knee extensor mechanism reconstruction with allograft: Surgical technique and rehabilitation protocol

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ABSTRACT

Primary patellar tendon rupture is a rare condition most commonly seen in active young adults. Even less frequent is the chronic or recurrent rupture of the patellar tendon, the latter being the one which poses a greater technical challenge when performing the surgical treatment. Our objective is to present a case where the surgical reconstruction of the knee extensor mechanism was performed using an allograft. The procedure took place after three initial surgeries to repair the patellar tendon failed, following a traumatic injury. Both the surgical technique and the rehabilitation protocol are described.

Key words: Knee extensor mechanism, recurrent rupture, allograft.

Level of Evidence: IV

Reconstrucción del aparato extensor de la rodilla con aloinjerto: técnica quirúrgica y protocolo de rehabilitación

RESUMEN

La rotura primaria del tendón rotuliano es un cuadro poco frecuente que afecta principalmente a adultos jóvenes activos. Aun menos frecuente es la rotura crónica o recurrente del tendón rotuliano, y es esta última situación la que plantea una importante dificultad técnica a la hora de realizar el debido tratamiento quirúrgico. El objetivo de este artículo es presentar a un paciente que fue sometido a la reconstrucción quirúrgica del aparato extensor mediante el uso de aloinjerto luego de haber pasado por tres cirugías fallidas para la reparación del tendón rotuliano tras sufrir una lesión traumática. Se describen tanto la técnica quirúrgica, como el protocolo de rehabilitación.

Palabras clave: Aparato extensor; rodilla; rotura recurrente; aloinjerto.

Nivel de Evidencia: IV

INTRODUCTION

The knee extensor mechanism consists of the quadriceps muscle, the quadriceps the patella, the patellar tendon and the tibial tuberosity. Primary patellar tendon rupture is a rare condition most commonly seen in active young adults under the age of 40. Its incidence is higher in patients with connective tissue diseases, who may sustain a rupture following minor trauma. It is most commonly caused by a violent contraction of the quadriceps muscle with the knee in a flexed position.[1,2]

The treatment for a complete rupture is surgery. Acute injuries are managed by tenorrhaphy, i.e., tendon-to-tendon suture. In some cases, transosseous suture and anchor fixation are used.[3] The course is usually favorable, and the time between injury and surgery is a factor affecting evolution. Chronic or recurrent disruptions are rare and require more complex surgical procedures due to the retraction of the extensor mechanism and to the loss of substance.

Received on 2-4-2019. Accepted after evaluation on 3-7-2019 • OSVALDO PATIÑO, MD • osvaldo.patino@hospitalitaliano.org.ar

How to cite this paper: Patiño O, Sánchez Saba, JE, Zicaro JP, Yacuzzi C, Costa Paz M, Bronenberg Victorica P. Knee extensor mechanism reconstruction with allograft: surgical technique and rehabilitation protocol. *Rev Asoc Argent Ortop Traumatol* 2020;85(1):74-81. https://doi.org/10.15417/issn.1852-7434.2020.85.1.959

CLINICAL CASE REPORT

A 24-year-old athlete with no relevant medical history sustained a patellar tendon rupture in his left knee following a fall from a ladder. He was initially treated at another center, where he underwent three surgical procedures with a poor postoperative course. The first surgery was a surgical repair of the patellar tendon using a tendon-to-tendon suture and one anchor. Two months after surgery, the patient sustained a new fall resulting in a new patellar tendon rupture. In this opportunity, two anchors were used in the patellar tendon repair surgery. During the postoperative month 6, the patient presented knee dysfunction and extension deficit as a result of a patellar tendon elongation. For this reason, he underwent a third surgery: a re-tightening and a new patellar tendon anchorage to the patella.

Five months after this new surgery, the patient came to our center. He complained of instability while walking up and down stairs, associated with a deficit to achieve full active extension of the knee. Physical examination revealed a loss of active extension of 30° associated with patella alta (Figure 1). The assessment of the knee X-rays (lateral view) produced an Insall-Salvati index of 2 (normal range: 0.8 to 0.12) compared to the healthy knee index of 1.2. MRI showed a patellar tendon disruption, 3cm from its tibial insertion, and patella alta and lateralization of the patella (Figures 2 and 3).

Due to the patient's pain, instability and inability to achieve a full extension, a new surgical treatment was indicated: knee extensor mechanism reconstruction with allograft.

Figure 1. Clinical image showing an active extension deficit of 30° with respect to the contralateral knee.

Figure 2. Comparative knee lateral X-rays. showing patella alta in the left knee with respect to the patellar height of the right knee (Insall-Salvati index of 2 and 1.2, respectively).

Figure 3. Patellar tendon disruption and associated patella alta. The TA-patella distance is 9cm.

Surgical technique

An extensor mechanism reconstruction with a massive bone allograft was performed. First, it was ascertained though an anterior approach that the injury involved the full extent of the tendon. The proximal tendon remnant was removed and an osteotomy of the anterior tibial tubercle was used as an allograft. Subsequently, the massive bone graft was allotransplanted. Distal fixation of the allograft tibial tubercle was achieved using two 4.5mm cortical screws and suturing the remnant distal allograft tendon with absorbable sutures. Proximal fixation of the tendon was achieved with two 5mm high resistance suture anchors in the inferior patellar pole and a suture between the remnant proximal tendon and the graft tendon using absorbable sutures and Krakow stitches as reinforcement (Figure 4). Following the reconstruction, a 3cm-patellar descent was achieved. The patient was managed with lower limb brace immobilization with the knee in extension (Figure 5).

Figure 4. A. Injury and patellar tendon remnant identification. **B.** Knee extensor mechanism allograft formed by the quadriceps the patella, the patellar tendon and the anterior tibial tubercle. **C.** Adequate graft size identification. **D.** Fixation of the allograft at the anterior tibial tubercle level with two 4.5mm cortical screws and suture of the remnant distal tissue to the allograft tendon with absorbable sutures. Proximal fixation of the tendon with two 5mm high resistance suture anchors in the inferior patellar pole and Krakow stitches as reinforcement.

Figure 5. Knee AP and lateral X-rays taken after the extensor mechanism reconstruction with allograft.

Rehabilitation protocol

The patient wore a brace from the upper thigh to the ankle with the knee in extension, and was prescribed crutch walking with no weight-bearing on his affected leg for 6 weeks. The rehabilitation protocol was divided into four phases according to the functional response in each one of them.

Phase I (weeks 1-6)

The priority of this phase is to protect the allograft with a brace locked in extension while maintaining a non-weight-bearing status and using a 2 point gait. The patient must wear the brace all day and night; after the first month, the brace can be removed at night. The patient must keep the affected leg elevated a few minutes several times a day. Cryotherapy must not be applied to the allograft site; if necessary, it may be limited to far-off areas. Once the surgical wound has healed and the suture stitches have been removed, passive lateral patellar range of motion (ROM) is started to prevent soft tissue adhesion. After 30 days, quadriceps electrical stimulation with symmetrical biphasic pulses is instituted; one electrode is placed in the proximal area and the other in the medial vastus muscle. After several sessions, the graft area is inspected to assess the treatment progression.

Phase II (weeks 6-12)

The patient assumes full weight-bearing, and patellar mobilization in all directions begins in this phase. Electrical stimulation sessions continue, twice daily for 20 minutes, at the patient's house. Then, isometric quadriceps contraction exercises are instituted, which facilitate motor unit recruitment.[4] In this phase, patient should gain knee flexion without stressing the graft, at an initial angle of 30°. It is key to properly teach the patient the whole protocol as well as the main red flags, as the protocol takes place in the patient's house. At the end of this phase, the patient begins with minimal weight-bearing, always using crutches.

Phase III (weeks 12-24)

Once the quadriceps activity has been deemed adequate, electrical stimulation sessions are discontinued, the patient only uses one crutch and starts to bear more weight on the affected limb until achieving full weight-bearing. At this time, no tendon pain nor effusion signs should be present. The patient begins aquatic therapy with full weight-bearing on the affected knee. The proprioceptive treatment is also instituted, first walking on an unstable surface and progressively increasing the exercise difficulty. In this phase, the main goal is to achieve 90° of flexion and progressively add proximal and distal resistance for gradually wider angles. The patient performs closed kinetic chain exercises (leg press machine) and open kinetic chain exercises. The physical therapist must observe every move to assess the biomechanical effectiveness and prevent compensations. Close to the end of week 24, the patient is directed to walk without crutches, progressively increasing the walking time and speed. In the presence of pain or effusion, reinstate phase II.

Phase IV(from week 24 onwards)

In this phase, the patient begins a progressive strengthening program with both open and close kinetic chain exercises. First, the patient performs eccentric exercises for the quadriceps and the rest of the lower limb muscles. Quadriceps stretching helps improving joint ROM. This phase includes plyometric exercises and functional activities of increasing difficulty. The patient undergoes proprioceptive reeducation and should have recovered normal ROM. Around week 32, the patient begins a regimen of alternating walking and jogging.

RESULTS

A new assessment is carried out two years after surgery, and functional scores are calculated. The patient presents no symptoms. The Visual Analogue Scale score was 0/10, the Knee Society Score was 95 and 100, the Lysholm score was 94 and the International Knee Documentation Committee score was 48.28. The patient has a biomechanically correct gait pattern and is able to perform daily life activities without difficulties, to use regular means of transport, to drive, to ride a bike, and to jog normally. Both knees ROM were measured with knee in extension and flexion with the patient in recumbent position, using a universal goniometer, and the muscle strength was measured with a Nicholas dynamometer. Results showed no extension deficit and an 8% flexion deficit when compared to the contralateral knee. In terms of the quadriceps muscle strength, there is an 8% deficit when compared to the contralateral muscle.

DISCUSSION

The recurrent rupture of the patellar tendon poses a treatment challenge to surgeons and rehabilitation specialists, given that the extensor mechanism function is difficult to restore. As most patients are young adults, it is important to achieve active terminal knee extension with a quadriceps strength similar to that of the uninjured side. Chronic disruptions may result in soft tissue retraction and patella alta, in which case the extensor mechanism reconstruction with allograft is the standard procedure.[5]

Chronic patellar tendon injuries are rare in young patients, and there is no literature consensus on optimal surgical management. There are only three reported cases. Savyasachi *et al*. described the successful use of allograft tissue in knee extensor mechanism reconstruction and highlighted the benefits of this procedure in restoring an adequate extension in young active patients.[6] Burks *et al*. reported the use of an allograft to reconstruct the extensor mechanism in a patient with severe knee extension deficit following an open patella fracture who achieved an adequate ROM and no extensor lag or pain after a two-year follow-up.[7]

Complex injuries of the extensor mechanism are more commonly seen in knee joint replacement surgeries, particularly in revision surgeries. This type of injuries do have more available literature regarding possible surgical treatments. Bonnin *et al*. indicated an incidence of 0.17-1% for patellar tendon rupture associated with total knee

arthroplasty and described several treatment options; however, all of them are associated with high failure rates.[8] Rosenberg *et al*. reported that complications following a patellar tendon repair are not uncommon and that the procedure rarely restores normal extension.[5] Burnett *et al*. reported that, regarding injured extensor mechanism in association with total knee arthroplasty, multiple techniques for reconstruction have been described; however, few have been able to restore a full extensor function, and the best outcomes are achieved through allograft reconstruction approaches.[9] Brown *et al*. studied the functional outcome of 50 extensor mechanism allograft reconstructions in patients with extensor mechanism disruption following total knee arthroplasty and found and a failure rate of 38%.[10]

We have failed to find in the Argentinian literature a suitable rehabilitation protocol to follow after this specific surgical procedure. Brown *et al*. described a protocol bearing similarities our protocol.[10] Their regimen included lower limb immobilization in extension for six weeks, only allowing minimal weight-bearing, always using crutches. This period includes isometric quadriceps contraction exercises. After week 6, passive ROM starts at 0° to 30° in a hinged knee brace advancing 10° per week. At postoperative week 12, the regimen allows for 90° knee flexion and the quadriceps strengthening exercises are progressively intensified.

In our case, we also began with a 6-week immobilization period with the knee in extension. After that first period, the rehabilitation was progressive, allowing for complete graft integration and avoiding its rupture or stretching during immature graft integration. The strategy of daily electrical stimulation was key to recover the quadriceps function and to exercise gentle tension on the reconstruction area.

The patient evolved without complications and is currently able to perform regular daily life activities and participates in non-contact sports activities.

CONCLUSIONS

The knee extensor mechanism reconstruction with allograft in a young patient who had sustained a complete disruption of the patellar tendon proved to be a satisfactory surgical alternative to the previous three failed surgical options. A precise surgical technique and an adequate rehabilitation protocol are indispensable to achieve a favorable outcome of this severe and rare condition.

Conflict of interests: Authors claim they do not have any conflict of interest.

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