

Chronic knee extensor mechanism lesions in total knee arthroplasty: a literature review

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Abstract

Knee extensor mechanism rupture is a serious complication of total knee arthroplasty (TKA). Its prevalence ranges from 1 to 10% and it is commonly observed as a chronic multifactorial pathology with the patellar tendon as the most common site of rupture.

Knee extensor mechanism reconstruction can be performed using allogenic or synthetic grafts. In the literature it is still not clear whether one of these techniques is superior to the other and the choice is usually tailored to the patient case by case. Allografts allow better restoration of the anatomical landmarks, whereas the mesh technique is more reproducible and the graft does not elongate over time. Allografts carry an increased risk of infection compared with synthetic reconstructions, while the mesh technique is cheaper and more readily available.

In this paper, we review the etiology, diagnosis and treatment of this pathology, drawing on the most recent literature.

Keywords: allograft reconstruction, chronic rupture, extensor mechanism, knee revision, prosthesis failure, synthetic graft.

Introduction

Extensor mechanism rupture is one of the most feared complications of total knee arthroplasty (TKA). Its

reported prevalence ranges from 1 to 10% and it is most commonly described as a chronic lesion (1-3). This complication is related to different factors, such as intra-operative procedures and patient characteristics (4). Extensor mechanism repair is a very challenging procedure with major implications for the good functioning of the TKA. Several techniques for extensor mechanism repair have been reported in the literature and different grafts have been utilized. In chronic lesions, knee extensor mechanism reconstruction can usually be performed using allogenic or synthetic grafts. Allografts can be fresh-frozen or freeze-dried; the Achilles tendon or the complete extensor mechanism are suitable grafts. The synthetic graft most commonly used is the Marlex mesh used in abdominal repair (5). In this paper we report the most common causes of extensor mechanism rupture after TKA and describe the most common repair procedures; we also describe the treatment that, on the basis of our own experience, we choose to perform.

Etiology

The extensor mechanism of the knee is composed of the quadriceps tendon, the patella and the patellar tendon. The patellar tendon is the most common site of rupture, and this is most likely to occur at the tibial insertion. Patellar tendon ruptures have been reported to account for between 0.17 and 0.55% of all TKAs (1). The injury mechanism can be a fall with a direct trauma or impingement on the prosthetic components (3). Quadriceps tendon rupture reportedly occurs after 0.1% of all TKAs, and it is definitely the least common cause of knee extensor mechanism failure (6). Patellar fracture can occur in the presence of either an un-resurfaced or a resurfaced patella. It is rarely associated with

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a traumatic event; indeed, in 88% of cases the etiology is atraumatic (fatigue strain). Predisposing factors for patellar fracture are (7-14): excessive lateral release, excessive bone removal, peg fixation and cementation, improper patellar tracking (malalignment), rheumatoid arthritis, patellar necrosis, surgical technique, and prolonged steroid use.

If the fracture is stable a non-surgical approach can be attempted; in displaced fractures, on the other hand, a surgical treatment is required. In cases in which surgical reconstruction is required, open reduction and internal fixation with tension band or cerclage wiring is the first choice of treatment, even though the post-treatment rate of failure and subsequent non-union may be as high as 90% (15).

The minimum force needed to break a healthy patellar tendon has been measured in biomechanical studies and found to be close to 17.5 times the individual's body weight (16). This is an impressive amount of force in relation to activities of normal daily living: climbing stairs generates only 3.2 times a person's body weight (17). Strain forces are found to be higher at the osteotendinous insertion than in the middle of the tendon, and thus more commonly produce avulsions than mid-substance lesions. Given the great strength of this tendon, ruptures tend to occur in degenerated tendons; this can be noted especially in the case of mid-substance lesions (18). Various Authors have described other health conditions predisposing to patellar tendon rupture, such as: local injections of corticosteroids (19), diabetes (19-21), microtrauma (20), rheumatic diseases (3), metabolic disorders (3), iatrogenic lesions (anterior cruciate ligament reconstruction with patellar tendon graft) (22), and systemic use of fluoroquinolones (23, 24).

In addition to these causes, when lesions occur in patients with TKAs we have to consider the soft tissue damage due to the previous surgical approach and procedure, which may have compromised the blood supply from the medial branch of the genicular artery and impaired the patellar bone quality. The medial genicular artery is the most damaged when using medial parapatellar arthrotomy, the most common approach in knee reconstruction surgery. In addition to this, microtraumatic damage of the patellar tendon has been described, attributable to impingement on the polyethylene insert (2).

Clinical examination and imaging

A good anamnesis is the first step in approaching an extensor mechanism rupture. Patients usually report pain followed by knee impotence, but no trauma. In the history-taking stage, the surgeon must investigate whether there have been previous episodes of pain, and establish whether the patient presents comorbidities that can affect the tendons and patella (diabetes, rheumatoid arthritis, corticosteroid injections, etc.). Clinically, on inspection, the knee is normally swollen, and sometimes the patella cannot be palpated because of edema resulting from the lesion. When the patellar tendon or the patella are involved in the lesion, the patient may show patella alta. In chronic lesions, intrarticular hematoma is often absent, but if it is present, we recommend evacuating the intra-articular fluid in a surgical theater because of the risk of infection. Liquid aspiration can be useful for differential diagnosis in uncertain cases. In cases of partial extensor mechanism rupture, extension may be possible, even with pain. In the presence of a complete tear, a lag sign can be observed and extension movements against gravity cannot be accomplished.

The first instrumental investigation should be a plain radiograph in three projections (anteroposterior, laterolateral and sunset view) in order to evaluate the bony landmarks of the knee and to exclude fractures around the prosthesis. The Insall-Salvati ratio must be calculated: this can be useful for comparing the position of the patella with its position on previous radiographs, and it can be suggestive of patellar tendon lesions. In these cases, it can prove useful to perform an ultrasound scan as this may show a hypo-echoic area within the proximal patellar tendon, and also because this examination can be executed dynamically. Its limitations, however, are its low reproducibility and subjectivity. We normally use computed tomography for diagnosing extensor mechanism rupture because the image quality it gives in the presence of a prosthesis is higher than that obtained with magnetic resonance imaging, and this allows us to better evaluate the quality of the bone around the TKA.

Allograft repair

The Achilles tendon with bone block or the whole knee extensor mechanism are the allografts normally

used for extensor mechanism repair. The choice of allograft depends on the residual tissue available, particularly the patellar bone stock. If the bone stock is inadequate or the patella is found to be difficult to mobilize a whole extensor mechanism allograft is indicated. Patients with an intact and mobile patella (the inferior pole can be brought down to within 2-3 cm of the joint line) are candidates for an Achilles tendon graft. Homologous tissue grafts allow better anatomical reconstruction of the extensor mechanism and the graft is usually completely incorporated into the host tissue (25). Allografts can be fresh-frozen or freeze-dried: the best results may be achieved with fresh-frozen allografts because of the greater strength of the graft (26). Emerson et al. were the first to describe an allograft reconstruction technique performed using a whole extensor mechanism (fresh-frozen or freeze-dried) (19, 27). Nazarian and Booth (21) then improved this technique in order to avoid the extensor lag of 20 to 40° lasted in almost 30% of the treated knees. They showed that the allograft should be tensioned in full extension.

In 2008 Malhotra et al. (20) described a new extensor mechanism reconstruction technique in which a composite allograft consisting of a patella-patellar tendon-tibial tubercle was used to repair the extensor mechanism in the presence of a good patellar bone stock. One problem encountered was delayed proximal graft healing at the bone-tendon interface.

Complete extensor mechanism allograft

This graft is composed of the proximal tibia, the patellar tendon, the patella and 5 to 8 cm of quadriceps tendon (28). In the literature, fresh-frozen grafts were reported to give better results compared with freeze-dried ones (19). We recommend checking the integrity and the appropriateness of the graft before surgery.

The skin incision should be performed on the previous scar, but if it is impossible to approach the whole extensor mechanism (i.e. sub-vastus, mid-vastus, mini incision, etc.), a new incision can be made following a new line, always respecting the basic principles for skin health and blood supply. The dissection is taken down along the midline to expose the extensor mechanism. The retinaculum dissection is performed through the extensor mechanism, creating medial and lateral flaps.

In every case, even if the diagnosis is a chronic rupture of the tendon and there are no clinical signs of infection, it is recommended to perform a bacteriological test.

The patella is then longitudinally osteotomized following the midline and carefully removed. If required, the bone should be used as autologous bone graft material. The midline incision is carried into the host quadriceps proximally and distally over the host tibial tubercle.

During this surgical step the allograft is prepared on a back table. Before creating any tibial trough the allograft tibial bone is marked and prepared as planned before surgery, to ensure a perfect press-fit. The length of the bone block should be from 5 to 8 cm above the articular surface of the allograft to the distal cut. The width and the depth of the block is approximately 1.5-2 cm. It is better to perform a conservative cut and then cut more if necessary. We mark an angle of 25° to 45° on the tibial proximal bone block and cut it carefully about 25 mm long to guarantee a good press-fit of the allograft (the same procedure is performed on the allograft tibial bone).

The allograft should subsequently be secured with two to three stainless steel wires. The bone shape created on the tibial allograft block ensures that it will engage the host bone during the tensioning. At this point, the quadriceps tendon is fixed with non-absorbable suture that will be used afterwards to tension the allograft. Once the allograft is tensioned, the steel wires are tightened and cut, then bent in a lateral position to avoid damage to the soft tissues. After surgery the knee is placed in full extension using a brace that allows wound control.

The full extension is maintained for eight weeks, avoiding full weight bearing. After this period, 30° of active flexion is achieved, placing the knee in a hinged knee brace, and patients can start weight bearing gradually. At 12 weeks, the maximum flexion is increased to 90°; gradually full flexion is gradually achieved before six months.

Achilles tendon allograft

As with the previous procedure, in Achilles tendon allograft reconstruction, the skin incision should be performed on the previous scar and can follow a new line only if this respects the basic principles for skin health and blood supply (29). A medial parapatellar

arthrotomy is performed and the patellar tendon is dissected from the surrounding soft tissues. The proximal extensor mechanism is dissected and mobilized proximally to obtain a better placement of the patella. The tibial metaphysis is prepared with a trough measuring approximately 2 cm in length and 1 cm in width and depth to receive the calcaneal bone block of the allograft. The position is chosen by placing the extensor mechanism in normal alignment. The calcaneal bone block is then cut to fit in the trough created in the tibia and then fixed in place with a cortical screw. A metal wire may be used to strengthen the bone-block fixation.

The Achilles tendon allograft is overturned on the joint capsule and sutured to the underlying extensor mechanism. The knee is positioned in complete extension and the allograft tensioned in a proximal direction and sutured to the quadriceps tendon (**Tab. 1**).

Marlex-Mesh reconstruction

This technique was first described by Browne and Hanssen in 2011 for the treatment of subacute or chronic knee extensor mechanism rupture (5). The reconstruction is performed with a synthetic graft folded in a sheet measuring 10 x 14 inches (25.4 x 35.6 cm) and sutured with heavy non-absorbable suture. A slot is prepared in the anterior aspect of the tibia in a position corresponding to the anterior tibial tuberosity, where the free end of the mesh graft is inserted into the medullary canal. It must be secured with cement and transfixed with a screw distal to the trough. In the case of a stable tibial component the free end of the graft should be fixed on the anteromedial aspect of the tibia using big non-absorbable sutures and tibial tunnels. The graft is then passed into the lateral aspect of the knee through the soft tissues and from deep to superficial.

Table 1. Literature results for reconstruction of the knee extensor mechanism.

Author	Analysis	Results
Crosset et al. (29)	Reconstruction of patellar tendon with an Achilles tendon allograft in total knee arthroplasty	In TKA the Achilles tendon was found to provide reliable reconstruction of a ruptured patellar tendon. Surgery indicated for patients with multiple prior operations
Barrack et al. (28)	14 patients with chronic extensor mechanism disruption treated with allograft reconstruction	Improvement of patients' functional status and satisfaction
Malhotra et al. (20)	Reconstruction (following patellar tendon loss) with an extensor mechanism composite allograft	Encouraging results in the management of a failed extensor mechanism after TKA
Springer and Della Valle (26)	Options for allograft reconstruction with an Achilles tendon bone block allograft or a whole extensor mechanism allograft	Current results with proper surgical technique show acceptable functional outcome after disruption of the extensor mechanism, a devastating TKA complication
Browne and Hanssen (5)	Surgical technique using synthetic mesh for patellar tendon reconstruction	Successful and durable technique in the majority of patients. No complications related to synthetic mesh use
Nam et al. (30)	Analysis of: patellar tendon disruption, quadriceps tendon rupture, patellar crepitus and soft-tissue impingement, periprosthetic patellar fracture, patellofemoral instability, and osteonecrosis of the patella	Treatment of these complications is often poor, and management of patient expectations is important

The patella and quadriceps tendon are mobilized, correctly positioned and then sutured to the graft in order to secure it to the lateral retinaculum, the vastus lateralis muscle and the quadriceps tendon. The vastus medialis muscle (VMO) then has to be mobilized and passed over the graft in a pants-over-vest manner, after which it has to be sutured, including the entire graft in the soft tissues and avoiding direct contact with the subcutaneous tissue (**Fig. 1**). This procedure is inexpensive and easy to perform and reportedly achieves good lag recovery without lengthening of the graft. Moreover, it allows the revision to be performed earlier as it is not dependent on allograft availability, and the risk of disease transmission is reduced (30).

Conclusions

In conclusion, extensor mechanism rupture is a highly complex and challenging complication of total knee arthroplasty. The first steps are to obtain a complete history and perform a correct clinical investigation; the history as told by the patient can be extremely

helpful for diagnosis, but it must be analyzed and confirmed by instrumental evaluation in order to locate and measure the lesion. In chronic lesions, repair is not suitable due to tissue loss and reconstruction is the only option. Reconstruction can be performed using an allograft or synthetic graft (mesh). The literature does not indicate whether either of these techniques is superior to the other and the choice must be made on the basis of the surgeon's preference.

Allografts allow better restoration of the anatomical landmarks but are associated with a longer period of integration and a physiological lengthening of the graft. Moreover, allografts are quite difficult to find and the technique is much more complex compared with use of a mesh. The mesh technique is more reproducible, easier to perform, and not subject to graft lengthening. Furthermore, allografts can be a vehicle for infections, whereas with meshes this risk is reduced. Finally, with the mesh technique the delay while waiting for a graft is reduced to zero. For these reasons, and also in view of the good results we have obtained in our own clinical practice, we prefer the mesh technique.



Fig. 1. Main steps in the Marlex mesh technique. A: 10 x 14-inch Marlex mesh sheet. B: Mesh sutured with heavy non-absorbable suture. C: Slot in the anterior aspect of the tibia. D: Mesh cemented into the intramedullary canal. E: Graft passed into the lateral aspect of the knee. F: Proximal suture of the extensor mechanism in a pants-over-vest manner on the graft.

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