Knee

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Extensor mechanism failure in total knee arthroplasty

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- Extensor mechanism failure in total knee arthroplasty (TKA) can present as quadriceps tendon rupture, patella fracture or patella tendon rupture.
- Component malrotation, excessive joint line elevation and previous lateral release are some of the risk factors contributing to extensor mechanism failure in TKA.
- Partial quadriceps tendon rupture and undisplaced patella fracture with intact extensor mechanism function can be treated conservatively.
- Extensor mechanism failure in TKA with disruption of the extensor mechanism function should be treated operatively as it is associated with poor function and extensor lag.
- It is recommended that acute repair of patella or quadriceps tendon rupture are augmented due to the high risk of re-rupture.
- Chronic ruptures of the extensor mechanism must be reconstructed as repair has a high failure rate. Reconstruction can be performed using autograft, allograft or synthetic graft.

Keywords: patella fracture in total knee arthroplasty; patella tendon rupture in total knee arthroplasty; quadriceps tendon rupture in total knee arthroplasty

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Introduction

Extensor mechanism failure is an uncommon but serious complication after primary or revision total knee arthroplasty (TKA). It is associated with significant morbidity and reduced quality of life due to extensor lag, instability, difficulty walking and/or pain. Its incidence is reported to be between 0.1% and 2.5% in all TKA but revision TKA is thought to carry a higher risk.[1–4]

Extensor mechanism failure can present as quadriceps tendon rupture, patella fracture (Fig. 1) or patella tendon rupture (Fig. 2) or avulsion which can occur either intraoperatively or postoperatively. Intraoperative failure of the extensor mechanism is usually related to gaining exposure to a stiff knee or over resection of the patella during patella resurfacing. Postoperative failures could be due to trauma, malrotation, chronic patella maltracking, and poor blood supply.[1] There are also other systemic factors predisposing to extensor mechanism failure, summarized in Table 1.

How to avoid extensor mechanism failure

Surgical exposure

Extensor mechanism failure can occur during surgical exposure of a stiff knee. When performing a medial parapatellar arthrotomy, it is important to leave a sleeve of periosteal tissue medial to the tibial tubercle and carefully elevate a maximum of 40% of the tibial tubercle to reduce the risk of patella tendon avulsion from its insertion. This will also allow a satisfactory repair during closure of the arthrotomy. If the knee is stiff preoperatively and access is difficult, it is our routine practice to consider a tibial crest osteotomy to avoid loss of extensor mechanism intraoperatively.[2,3,7]

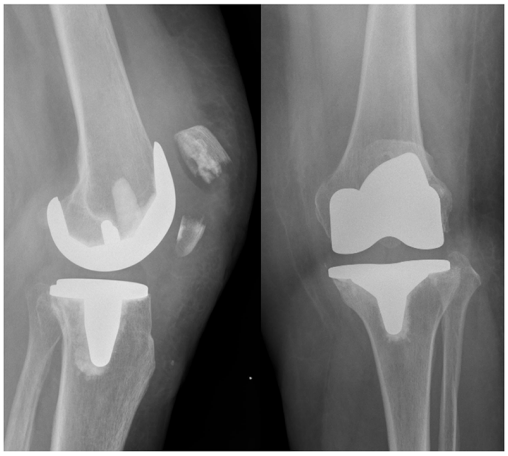

Fig. 1 Patella fracture after total knee arthroplasty.

Fig. 2 Patella tendon rupture after total knee arthroplasty.

Table 1. Risk factors for extensor mechanism failure following total knee arthroplasty[1–3,5,6]

Intraoperative
Gaining exposure to stiff knee causing quadriceps tendon rupture, patella tendon rupture or tibial tubercle avulsion
V-Y turn down
Over resection of patella causing patella fracture (must leave at least 12–15 mm bone)
Postoperative
Trauma
Compromised blood supply due to previous lateral release (damage to superior lateral genicular artery)
Multiply operated knee
Patella abnormalities (patella baja, alta)
Previous patella realignment procedure
Chronic patella maltracking
Component malrotation
Excision of fat pad
Infection
Metallosis
Other risk factors
Diabetes mellitus
Renal disease
Rheumatoid arthritis
Obesity
Osteopaenia/osteoporosis

Avoid compromising blood supply to the patella

There is evidence that previous lateral release of the knee increases the risk of extensor mechanism failure in TKA. This is due to compromised blood supply from injury to the superior lateral genicular artery. This can be avoided by staying as far lateral as possible to the patella when performing a lateral release.[8]

Lateral release is usually performed to improve patella tracking in TKA. Patella tracking can be assessed intraoperatively using the 'no thumb test'. Correct positioning of the TKA components will reduce the need for lateral release. Medialization, excessive valgus and internal rotation of the femoral component, internal rotation of the tibial component, lateralization of the patella button and overstuffing of the patellofemoral joint can all lead to patella maltracking and a requirement for lateral release.[9]

Several design changes in modern TKA implants such as medialized offset patella buttons, dome-shaped patellar components, a thinner trochlea flange and rotating platform tibial inserts have improved patella tracking in TKA and reduced the need for a lateral release.[10]

Injury to the superior lateral genicular artery can also happen during an extensile proximal exposure such as a V-Y turn down. A quadriceps snip or a tibial crest osteotomy can be used instead to improve exposure whilst avoiding injury to the superior lateral genicular artery.[2]

Avoid component malposition

Component malposition can increase the force going through the extensor mechanism, and the risk of extensor mechanism disruption. Excessive internal rotation of the tibial component displaces the tibial tuberosity laterally. Consequently, this increases the Q-angle, causing the patella to track abnormally, resulting in higher stress on the patella and the extensor mechanism. Similarly, internal rotation of the femoral component, medialization of the femoral component and lateralization of the patella button cause the patella to track on its lateral facet, leading to increased force on the extensor mechanism.[11–13] A computed tomography scan is useful to assess for component rotational profile prior to reconstruction of the extensor mechanism in TKA.[14]

Avoid joint line elevation

In over 36% of revision TKAs the joint line remains elevated by more than 5 mm.[15] Partington et al reported that elevation of the joint line occurred in 79% of revision TKAs and worsened clinical outcome with more than 8 mm of joint line elevation.[16] A biomechanical study using a validated musculoskeletal model demonstrated that 10 mm of joint line elevation would increase patellofemoral joint contact force by 60% of the body weight and 15 mm of joint line elevation would increase it by 90% during stair climbing.[15]

In revision TKA, there is likely to be femoral bone loss. Femoral bone loss should be addressed appropriately depending on its size using polymethyl methacrylate cement or augments to restore the joint line. Undersizing a femoral component to accommodate femoral bone loss will lead to joint elevation and must be avoided. The three-step technique described by Vince et al to re-establish the tibial platform, stabilize the knee in flexion, and finally stabilize the knee in extension, can be a valuable technique to ensure correct joint line position.[17]

Intraoperatively, there are several useful anatomical landmarks, including the fibula head, tibial tuberosity, lateral epicondyle and medial epicondyle.[18] However, the

measurements using these landmarks are variable, which negatively influences the use of these methods. Okzurt et al in a cadaveric study described different ratios using the transepicondylar width and the medial and lateral epicondyles to determine the anatomic location of the joint line in revision TKA surgery. The limitation of this method is that it is only useful with intact epicondyles.[19]

The joint line should be restored whenever possible and the maximum acceptable joint line elevation is 4 mm.[19] Preoperative planning using radiographs of the contralateral knee can help the surgeon to determine the exact native joint line before surgery.[20] In a TKA, the joint line position can be measured using Figgie's method on a lateral knee radiograph: the distance from the superior face of the tibial component to the top of the tibial tubercle.[21] Porteous et al modified the method using the distance between the most distal part of the femoral component and the top of the tibial tubercle.[18] If excessive joint line elevation is found preoperatively prior to reconstruction of a failed extensor mechanism in TKA, a revision TKA should be also performed to restore the joint line and prevent failure or recurrence.

Treatment options

Conservative treatment

Partial rupture, extensor lag of less than 20° and undisplaced patella fracture with intact extensor mechanism function can be treated conservatively in an extension splint or plaster for six weeks.[8,22] Conservative treatment may also be acceptable in elderly, low-demand patients. However, surgical treatment is recommended for more active patients as conservative treatment often leads to extensor lag and difficulty in walking. Surgical treatment will depend on the location of disruption and whether it is an acute or chronic disruption.

Acute

Patella tendon rupture

Patella tendon rupture most commonly occurs as an avulsion from its insertion at the tibial tubercle. A midsubstance tear is less common. Acute patella tendon rupture can occur intraoperatively whilst the surgeon is gaining exposure to a stiff knee or postoperatively following trauma.[2,3]

Acute rupture can be treated with direct repair using drill holes or suture anchors for avulsion of the tibial tubercle and end-to-end repair for midsubstance tears.[1,23,24] However, re-rupture rate is high in both cases and graft augmentation is recommended. Repair of the patella tendon is often bulky and achieving a tension-free wound closure can be difficult. In these cases, a rotational soft tissue flap such as a medial gastrocnemius flap to achieve soft tissue coverage may be required.[25] Management of acute and chronic patella tendon ruptures after TKA is summarized in Fig. 3.

Patella fracture

The majority of patella fractures after TKA occur in resurfaced patella. Only 0.05% of unresurfaced patella after TKA present with fracture.[26] Ortiguera and Berry[27] classified patella fractures after TKA based on three main criteria: integrity of extensor mechanism, fixation of patellar prosthesis and quality of bone stock.

Type 1 fractures (well-fixed component and intact extensor mechanism) can be treated conservatively in an extension splint with good to excellent results. Type 2 fractures are associated with disruption of the extensor mechanism with a stable or loose implant and should be treated operatively. Type 3 fractures are associated with a loose patella component but intact extensor mechanism. Asymptomatic Type 3 fractures can be treated conservatively. If symptomatic, the treatment options will depend on the patella bone stock. If there is adequate bone stock, the fracture can be fixed and the patella component removed or revised. Partial or total patellectomy will be required if the patella bone quality is poor. The remaining extensor mechanism is advanced distally and repaired. Patellectomy provides good pain relief but often leaves the patient with residual extensor lag and an unsatisfactory functional outcome.[27]

Based on the above principles, a treatment algorithm is recommended in Fig. 4.

Quadriceps tendon rupture

Complete quadriceps tendon rupture and those with an extensor lag of more than 20° should be treated surgically. Acute quadriceps tendon rupture after TKA can be treated with direct repair but is also associated with a high incidence of complication. A study by Dobbs et al[22] showed a complication rate of 42.3% in primary repair of quadriceps tendon rupture after TKA and 60% of patients with complete quadriceps tendon rupture had an unsatisfactory outcome after primary repair. The authors recommended graft augmentation in all surgical repairs of quadriceps tendons due to the high complication rate associated with primary repair alone.[22] A treatment algorithm for quadriceps tendon rupture after TKA is summarized in Fig. 5.

Chronic

Primary repair of the chronic extensor mechanism failure has a very high failure rate with unsatisfactory outcome and has therefore been abandoned.[2,22,23] Reconstructive and augmentation options include autograft, allograft, synthetic graft and medial gastrocnemius flap.[2,3]

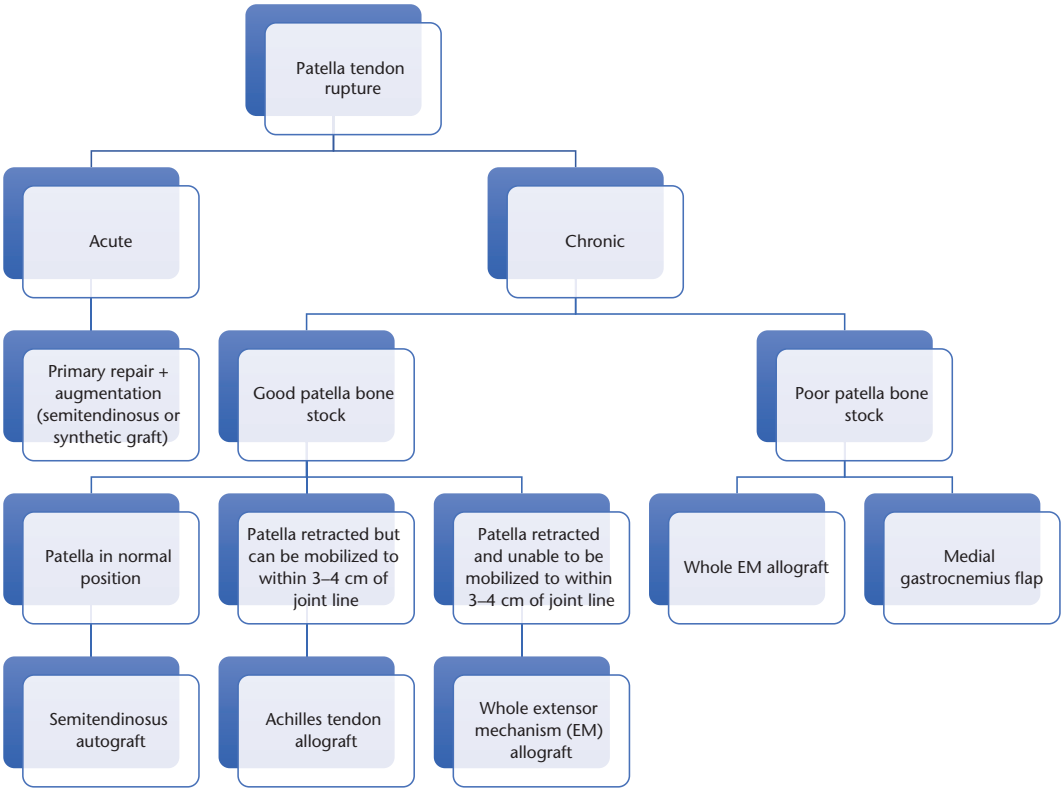

Fig. 3 Management of patella tendon rupture after total knee arthroplasty.

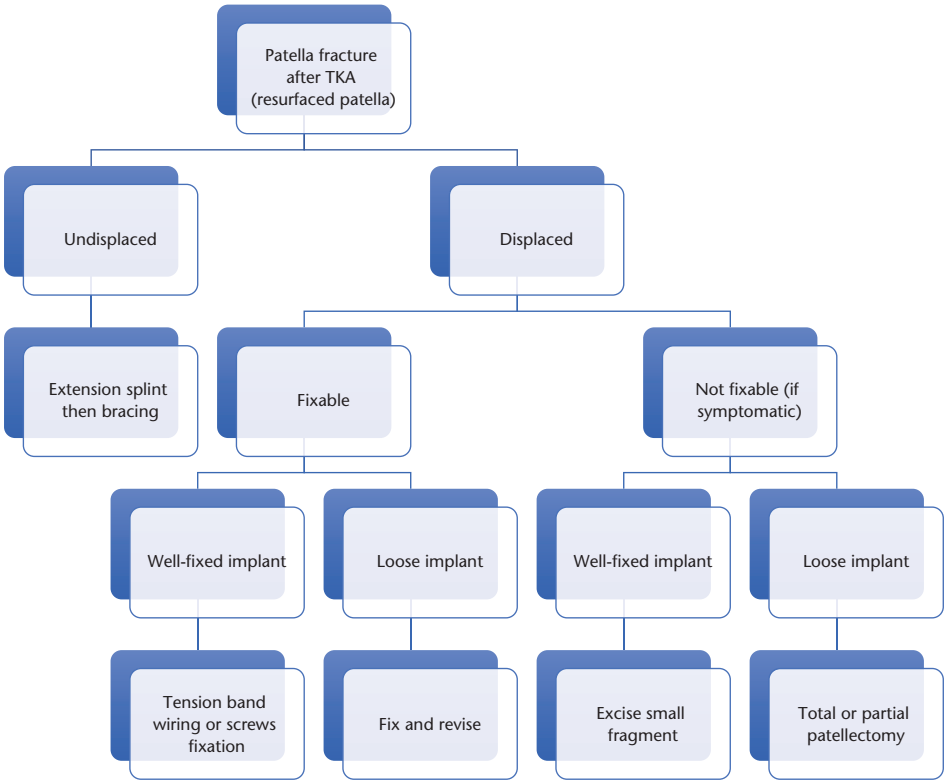

Fig. 4 Management of patella fracture after total knee arthroplasty (TKA).

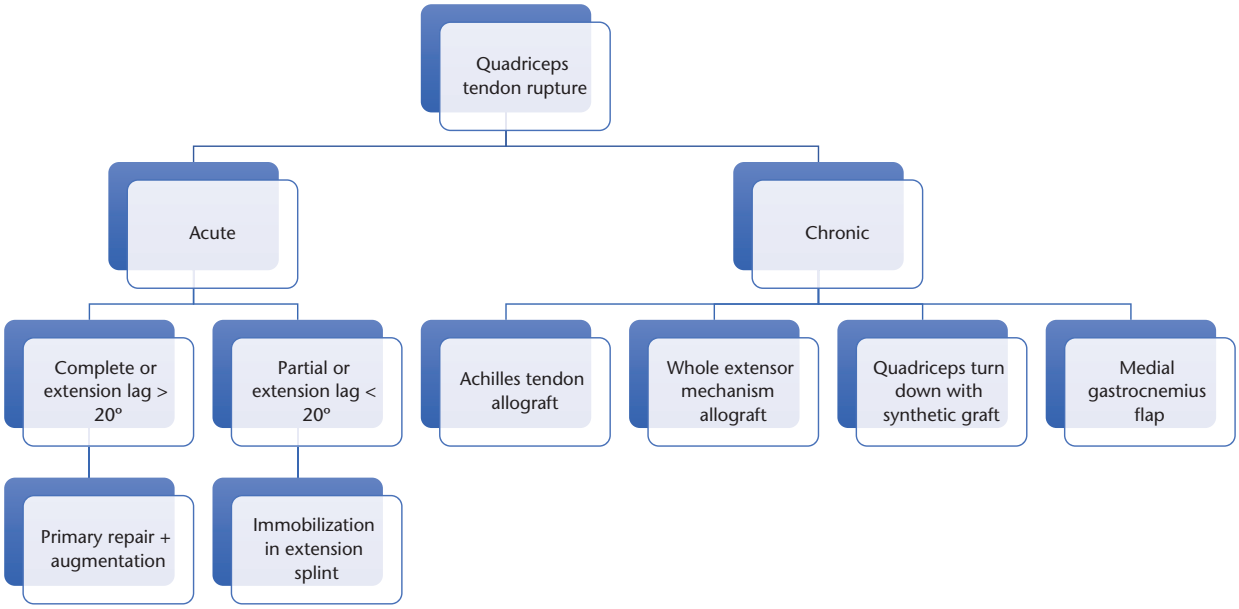

Fig. 5 Management of quadriceps tendon rupture after total knee arthroplasty.

Autograft

The semitendinosus tendon is the most commonly used autograft for reconstruction of chronic extensor mechanism disruption.[2,28] It can also be used as an augmentation for acute primary repair as discussed earlier.[22] The semitendinosus autograft can be used in reconstruction of patella tendon rupture or avulsion. It was first described by Cadambi and Engh.[28] The semitendinosus tendon can be harvested through a separate posteromedial incision. Its insertion as part of the pes anserinus is left attached and the tendon is traced proximally. The tendon is then detached proximally at the musculotendinous junction using a tendon stripper. The tendon is passed under the soft tissues to exit through the anterior incision. A transverse drill hole is made through the patella and the tendon is tunnelled through from a medial to lateral direction. The free end of the tendon is then sutured onto itself or the proximal tibia. If additional augmentation is required, a gracilis tendon can be used in a similar fashion.[28–30] However, the semitendinosus graft can only be used if the patella is not significantly retracted and there is good bone quality remaining in the patella.[2,3]

Allograft

The two most commonly used allografts in the literature are the Achilles tendon allograft (calcaneal bone–Achilles tendon) and the whole extensor mechanism allograft (Fig. 6) (proximal tibia-patella tendon–patella-quads tendon).[2,3]

Achilles tendon allograft is indicated for chronic patella tendon rupture or avulsion and chronic quadriceps tendon rupture.[31] In chronic patella tendon rupture, the patella needs to be mobilized to within 3–4 cm of the joint line. A trough is created in the proximal tibia medial and distal to the tibial tubercle to receive the calcaneal bone stock, which is secured with cerclage wires or screws. The Achilles tendon allograft is then pulled proximally to be secured onto the remaining patella tendon stump. In chronic quadriceps tendon rupture, there is often significant retraction proximally. The Achilles tendon allograft is particularly useful in this case due to its increased length.[2,3]

In cases where there is a deficient or absent patella, or significant retraction of patella where mobilization is not

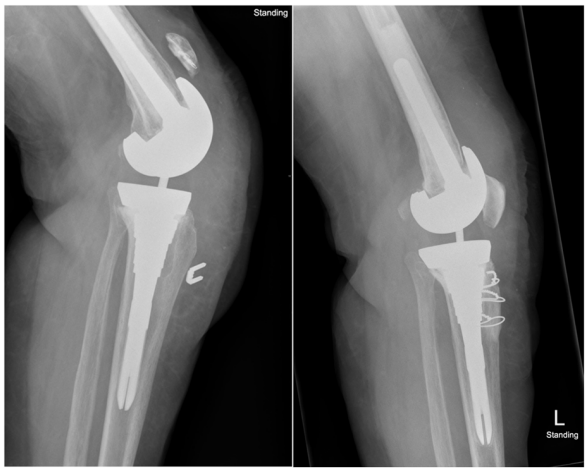

Fig. 6 Radiograph showing pre and postoperative reconstruction using extensor mechanism (EM) allograft.

adequate or significantly poor quality of extensor mechanism tissue, the whole extensor mechanism allograft is particularly useful.[2,3] This allograft can be also be used routinely for all extensor mechanism disruptions. This is performed through a midline incision and the existing extensor mechanism is divided into two halves (medial and lateral). Any existing patella will be bi-valved and resected. This provides the base to accept the allograft. The proximal tibia of the allograft is prepared into a rectangular shape and press fit through a contoured trough in the patient's proximal tibia. This is then secured using cerclage wires. To create maximal tension, the allograft is pulled proximally and the patient's quadriceps tendon is pulled distally using heavy sutures. They are sutured together with the quadriceps tendon overlying the allograft using heavy sutures. The remaining lateral and medial flaps of the extensor mechanism are then closed over and sutured to the underlying allograft. The allograft patella is not resurfaced as it is insensate. Allografts should also be non-irradiated and fresh frozen as freeze-dried allograft has inferior outcomes and a higher complication rate.[2] Reconstruction using whole extensor mechanism allograft (tibial bone stock, patella tendon, patella and quadriceps tendon) has been shown to improve extensor lag and functional outcomes, but it carries a high re-operation rate.[32,33]

Synthetic graft

Browne and Hanssen[34] described using a synthetic mesh (Marlex mesh, C.R. Bard, Murray Hill, New Jersey, USA) to reconstruct chronic patella tendon rupture. The mesh is fixed onto the proximal tibia through a small trough and secured with bone cement and screw fixation. The mesh is then tunnelled through the patella tendon and secured proximally with overlapping of the quadriceps tendon. Their study included 13 patients with chronic patella tendon rupture, all treated with mesh reconstruction. Nine out of 13 (69%) had good outcomes with < 10° extensor lag and no progressive loss of extension. Three had failures within six months and one had recurrent infection. The authors emphasized the benefits of using a synthetic material, which include cost, availability, immune reaction, disease transmission and stretching of allograft causing progressive extensor lag over time.[34] A subsequent publication by the same group demonstrated 84% of 77 patients who underwent extensor mechanism reconstruction using synthetic mesh have intact reconstruction with excellent functional outcome at a mean follow-up period of four years.[35]

Other synthetic grafts such as polyethylene terephthalate,[36] Dacron[37] and polypropylene mesh[38] have also been used as augmentation in complete quadriceps tendon repair after TKA with variable results.

Recent systemic reviews have shown equivalent success for allograft and synthetic mesh with a 25% failure rate in both. However, both reconstruction techniques carry a high risk of complications, including infection and failure with persistent extensor lag.[39,40]

Medial gastrocnemius flap

A gastrocnemius flap may be required for extensor mechanism reconstruction in cases where there is significant bone loss of the proximal tibia, making Achilles tendon allograft and extensor mechanism allograft not possible, or when additional soft tissue coverage is required around the anterior aspect of the knee.[26,41]

The medial gastrocnemius muscle is mobilised, leaving its proximal attachment. It is then brought anteriorly to cover the anterior aspect of the knee and sutured onto the underlying tissue. The tendon end of the flap is then repaired onto the quadriceps tendon.[2,25,41]

Jaureguito et al[41] reported overall good outcomes with improvement in range of movement and mobility, and reduction in extensor lag. In another study by Busfield et al,[25] seven patients had a mean extensor lag of 13.5° (range 0–50°) at an average of 21 months follow-up. All patients returned to independent mobility.

Other technical points

In all extensor mechanism repair or reconstruction, the repair or graft must be tensioned with the knee in full extension. The repair or reconstruction should not be assessed intraoperatively as it usually stretches out and can cause extensor leg if not tensioned in full extension. The knee is usually immobilized in an extension splint for six weeks, following which range of motion is gradually increased in a hinged knee brace.[2,3]

Conclusion

Extensor mechanism failure in TKA is associated with poor function and should be treated operatively. Non-operative treatment is reserved for those with an intact extensor mechanism function or in the elderly with low demand. Compromised blood supply to the patella, excessive joint line elevation and component malposition are some of the important risk factors contributing to extensor mechanism failure in TKA. Joint line and component malposition must be assessed preoperatively prior to extensor mechanism reconstruction as revision TKA may be required. Acute ruptures of extensor mechanism should be repaired with augmentation to reduce risk of failure. Management of patella fracture in TKA depends on its displacement, bone stock and stability of the implant. Reconstruction of the extensor mechanism can be performed with autograft, allograft or synthetic graft. However, the outcomes

of this techniques are poor, with a failure rate of up to 25% and high risk of complications.

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