

## Which ACL-Reconstruction Surgery Is Better? A Comparative Study of the Complications of the Bone-Patellar Tendon-Bone (BPTB) and Hamstring Tendon (4-Strand) Techniques (A Review of the Literature)

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**Abstract:** Anterior cruciate ligament (ACL) tear is one of the most knee injuries in professional athletes resulting in knee malfunction. ACL injury in mid-season is always a dilemma! Should the athlete leave the competitions and undertake ACL-reconstruction surgery or continue the sport using a functional knee brace? Based on the Noye's law, in one-third of these subjects, surgery is the best choice to save the knee to be able to return to the match in the future. One-third of the patellar tendon width and a graft including a mixture of the semimembranosus and gracilis tendons are two most commonly used allografts used in recent years all over the world. Although BPTB technique was the only gold standard method in the last decade, the new 4-strand technique with its benefits is now gradually being preferred in the world by some orthopedic surgeons. The current study intends to deliberately consider some common complications of each technique as well as its possible causes. The result of this literature search showed that each of these two common techniques has its own side effects with lower rate in 4-strand group.

**Key words:** Bone-Patellar Tendon-Bone • 4-Strand • ACL-Reconstruction

### INTRODUCTION

The ACL is the most commonly injured knee ligament and its injury occurs in the young and active population. The incident of ACL injuries is currently estimated approximately 200,000 annually, with 100,000 ACL reconstructions performed each year [1], mostly in athletes. Sporting activities are responsible in the majority of cases. It has been reported that one out of 3,000 individuals will suffer from some forms of ACL disruption, with 70% of acute ACL injuries occurring during a vigorous sporting activity such as basketball, football, skiing and soccer [2]. When an ACL injury occurs, the knee becomes unstable. This instability can be a problem because it makes patients more prone to developing arthritis and meniscus tears [3].

Treatment options for ACL injuries include both surgical and non-surgical treatments [4]. Patients may be able to function in their normal daily activities without a normal ACL, but athletes often face the decision to undergo surgery in order to return to their previous level of competition.

ACL-reconstruction prevents knees from further menisci injuries and joint degenerative diseases via restoring its mechanical stability [5]. Some current surgical methods included mini-arthrotomy open technique, two-incision arthroscopically assisted technique and one-incision endoscopic technique [6]. Arthroscopy is now the most common technique used in ACL-reconstruction and both live and artificial grafts are used in this surgery. Live grafts include the patellar tendon, hamstring tendons, achilles tendon, iliotibial tract and fascia lata [7, 8]. The donor sites of live grafts are either the patient (autograft) or another person (allograft) [7]. Patellar and hamstring tendons have been the most common grafts used during last years [9]. In the last two decades, while the middle one-third of the patellar tendon has been the best choice for ACL-reconstruction [10], it has now been dramatically shifted to the use of the hamstring tendons. This has mainly been due to complications such as the destruction of the extensor mechanism, anterior knee pain, patellar fracture, patellar tendon tear and finally patella baja. However, the hamstring grafts have also its own problems, such as weak fixation and reducing muscle

power following graft removal. As a summary, it can be concluded that little objective data are available in favor of being the hamstring graft better than the BPTB [11].

Since choosing the best graft for ACL-deficient athletes is so important and a comprehensive information is required regarding the athlete, the type of sport he/she is involved and the post he/she is playing, the current study tried to find objective data in favor/against each of the methods to be able to recommend the best technique to athletes for their safest and fastest return to their sporting activities.

**Complications of ACL-Reconstruction Surgery with the Use of the Bone-Patellar Tendon-Bone:** This most common reconstruction technique uses patellar tendon plus and part of bones of the inferior part of the patella and the superior part of the tibial tuberosity. Small (1986) reported 1.8% complication rate of this technique [12]. The most common complication of this method of surgery is patellar tendon rupture, patellar fracture and the graft rejection [13]. Although surgical technique improvements have reduced some of these complications, the rate of patellar fracture and tendon removal from the inferior part of the patella are still high [14, 15]. Those complications immediately following this type of surgery are patellar tendon sever inflammation, weakness of the quadriceps muscle, loss of knee full extension and the anterior knee pain [14, 16-18]. Patellar fracture occurs either during the surgery or after the surgery due to too much tensile force [19]. In addition to the complications happening earlier after the surgery, some complications also happen later on. For instance, tibial tuberosity fracture and tibial plateau fracture have been reported 6-7 months following the surgery [20, 21]. Tibial tuberosity fracture usually happen due to trauma resulting more tension is the tuberosity and tibial plateau fracture occur following damages of the tibial medullary canal [20, 21]. Patellar tendon avulsion is another complication, which occurs 6 weeks following the surgery [22, 23]. It should be noted that all complications mentioned here are related to the grafts obtained from the injured side leg.

Regarding the rupture of the patellar tendon following BPTB ACL-reconstruction surgery, much research has been carried out. A mechanical cause for this rupture is the most possible reason for this complication [24]. Lairungruang *et al.* (2003) compared the mean force tolerated by a normal patellar tendon (4365 N) with the tendon after removal of its middle third (2226) and concluded that this surgery reduced tendon strength to

half [25]. They also pointed out that removing more than one-third of this tendon would cause more deleterious effects for athletes.

Damages to the vascularity of the grafts may also be a main cause of its rupture. Bonamo *et al.* (1984) assumed that avascularity of the graft during harvesting due to cutting its vessels may cause graft death following its avascularity [26]. Hardin and Bach (1992) recommended orthopedic surgeon to use triangular bone plugs instead of rectangular ones to reduce the rate of avascularity and the graft rupture [22]. When the patellar tendon is torn, the operation site is very painful and the patients are not able to actively extend their knees [22]. A palpable defect will be seen in the inferior of the patella due to upward movement of the patella. They also show a weak and unstable knee due to the loss of knee extension.

The aim of patellar tendon repair is restoring extensor mechanism to its original condition to obtain maximum quadriceps function, protection of the vascularity of the graft and patellar tendon to prevent future osteoarthritic changes [27]. Graft augmentation allows applying an accelerated rehabilitation without applying sever tension on the musculotendinous junction and results in early restoration of the range of movement and less joint stiffness as well as it allows the therapists to be able to have more controlled force of the graft to expedite the repair [28].

Two other complications following BPTB ACL reconstruction are fracture of the upper part of the tibia and avulsion of the inferior part of the patella. Moen *et al.* (1998) reported a traumatic upper tibial fracture six week after the surgery [20]. Morgan and Steensen (1998) also reported a non-displaced fracture of the lateral tibial plateau due to a direct trauma seven months following the reconstruction [21]. An avulsion fracture of the distal part of the patellar tendon happened following a fall on a full flexed knee six weeks after the surgery. Researchers assumed a weak insertion of the patellar tendon due to avascular necrosis of this tendon and suffering from too much force on this area [22].

Some very rare BPTB technique complications have also been reported by researchers. These are hypoesthesia, dysesthesia, particularly at the lateral part of the leg as well as vascular damages [29-32]. These two problems may happen due to the bad scar formation following a longitudinal incision (vertical to the Langer's line) at the middle third of the patellar tendon and also injury to the infra patellar branch of the saphenous nerve. Since this is a pure sensory nerve, many patients are not

warned against this problem before the surgery [32] and they might suffer from numbness, neuroma and probably reflex sympathetic dystrophy syndrome [33, 34, 35]. A rate of 0.06 to 0.7 percent nerve damage has been reported following knee arthroscopy [31, 35]. Portland *et al.* (2005) reported 59% injuries to the infra patellar branch of the saphenous nerve following a vertical incision and 43% following the transverse incision in the infra patellar area. They recommended transverse incision for both the cosmetic and the lower rate of nerve damage to be more appropriate [37].

Vascular damages during knee arthroscopic surgeries are very rare (less than 1%). Only one pseudo-aneurism has been reported in literature following BPTB arthroscopic surgery, which happened in the inferior-medial genicular artery [38]. Manning and Marshall (1987) mentioned that too much destruction of the genicular artery plus its small branches cause separation of the vessel walls and produce pseudo-aneurism [39]. It can be diagnosed with a painful pulsating mass around the operated knee. MRI or magnetic resonance angiography (MRA) is the golden standard for diagnosis [40]. Treatment included removing the aneurism during an open surgery.

**Complications of Acl-reconstruction Surgery with the Use of the Hamstring Tendons:** Hamstring tendons are frequently used in ACL-reconstruction surgeries. Its unique biomechanical characteristics in double-loop hamstring graft, lower risk of grafting failure as well as its suitable fixation are all the reasons of dramatically increased rate of using this graft [41-46]. The lower rate of success in previous hamstring grafts related to the BPTB grafts might be due to its weak fixation and a single layer tendon instead of the double-loop graft. Much research proved that a double loop hamstring graft is much stronger than the 10-mm patellar tendon graft [47, 48]. Innovation of new fixation tools specifically designed for this technique has significantly increased the functional stability of these grafts. Although no research found in this area, it is commonly believed that the complications of this technique are much lower than BPTB method [44, 49, 50]. Less anterior knee pain, no knee extension loss, less knee pain during squat and less knee arthritis in the hamstring method are all the preferences of this technique when compared to BPTB [44, 49-51]. In a prospective study, Sajovic *et al.* (2006) found 50% knee osteoarthritis in subjects undergone BPTB technique relative to 17% osteoarthritis found in those undergone the double-loop hamstring technique [45].

Formation of knee cysts following ACL-reconstruction is very rare. The pathomechanics of cystic formation is unknown; however, accumulation of joint effusion in extracapsular space might be a cause for this complication. Imbalance between graft and tibia canal, necrosis of the grafts within the bone or extra movement of the graft within the canal might all postpone tendon-bone fixation and produce a cyst at the anterior part of the knee [52, 53].

There is also a risk of damaging the sciatic nerve due to its proximity to the medial hamstring tendons [54]. This is shown with paresthesia, numbness, neuroma and reflex sympathetic dystrophy reaction [16, 30, 37, 55]. Aglietti *et al.* (2004) reported a 25 Cm<sup>2</sup> anesthetic area behind the joint line in 50% of subjects undergone with the hamstring graft ACL reconstruction [56].

## CONCLUSION

There is still a debate in literature regarding choosing an ideal graft for ACL-reconstruction. Both the BPTB and the hamstring tendon graft techniques are supported by strong evidence. Both techniques have shown advantages and disadvantages following the surgery. While some believe a more stable knee following BPTB technique, others report a lower rate of the patello-femoral pain following the hamstring tendon techniques. As a result, there is no strong advantage of one technique over the other one and both have shown to be gold standard techniques for this surgery. In other words, there is a need for more high quality researches with more population, controlling the surgery procedure, the surgeons, the fixation method, the rehabilitation and the measurement systems to be able to prefer one technique to another one. It should also be mentioned that although no preference of one method to the other has been mentioned in terms of stability and functional outcomes, there is a tendency to shift to the hamstring method, mainly because of its lower rate of complications. Although there are some osteoarthritic changes in both surgical techniques, however, lower surgical side effects have shown the hamstring technique to be more accepted in athletic society.

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