Comparison of medium-term revision rates after autograft and allograft anterior cruciate ligament reconstruction

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AIM: *The present study investigates time until revision and revision rates, and their relationship with gender and age, among 267 patients with anterior cruciate ligament tears treated with autograft and allograft reconstructions.*
MATERIALS AND METHODS: *A retrospective evaluation was carried out based on data collected on 269 knees (bone-patellar tendon-bone autograft in 25, gracilis-semitendinosus autograft in 136, quadriceps autograft in two, allograft in 106) belonging to 267 patients who underwent an anterior cruciate ligament reconstruction between 2009 and 2018.*
RESULTS: *Of the 269 knees of the 267 patients (22 women and 247 men) operated on for an anterior cruciate ligament rupture, an autograft was used in 163, and nine of those required revision, while an allograft was used in 106 knees, and seven required revision. Revision surgery was necessary for six out of the 22 female patients and for only 10 out of the 247 male patients ($p<0.001$).*
CONCLUSION: *Each type of graft used for treatment is associated with certain advantages and disadvantages. Hamstring autografts and allografts were the most commonly used grafts during the anterior cruciate ligament reconstruction surgeries carried out at our clinics. The rate of re-rupture was quite low with use of both graft types, leading us to believe that the type of graft preferred for anterior cruciate ligament reconstruction surgery should be based on a common decision of the surgeon and patient.*

KEY WORDS: Allograft, Anterior cruciate ligament, Autograft, Loosening, Revision

Introduction

The knee joint consists of the tibiofemoral and patellofemoral joints, and is a ginglymus type of joint that can perform internal and external rotation movements aside from flexion and extension. The tendons in the knee are stretched during total extension, and rotation is not possible. The tendons relax after 20 degrees of flexion, and rotation begins, while almost 40 degrees of rotation can be achieved at 90 degrees of flexion. While the anterior cruciate ligament fibers are aligned in parallel to the femur during extension, they bend towards the lateral with increasing flexion, and the tibia rotates internally over the femur by almost 55 degrees. Accordingly, the graft is rotated during ligament reconstruction [1].

The cruciate ligaments are important components of the knee joint; they are intracapsular and are referred to as anterior and posterior cruciate ligaments based on their point of attachment to the tibia [2]. The anterior cruciate ligament starts from the anterio-lateral of medial tibial eminentia in the anterior intercondylar area, proceeds

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posteriolateral, folding around itself, and attaches to the posteromedial of the lateral femoral condyle. The anterior cruciate ligament is approximately 32 mm long and has a width of 7-12 mm; and while some authors have suggested that it consists of two separate bands, others state that there are three bands [3]. Depending to the point of tibial attachment, these bands are referred to as anteromedial, intermediate or posterolateral. Although located on a joint, the anterior cruciate ligament is extrasynovial. The anterior cruciate ligament innerves from the posterior joint branches of the tibial nerve, and its blood supply is provided by the middle genicular artery. Although rare, there have been cases of a congenital absence of the anterior cruciate ligament, resulting in instability of the knee joint [4].

The anterior cruciate ligament prevents the anterior translation of the tibia, while limiting internal rotation when the joint is in extension [5]. It also limits varus and valgus stresses, and is important for knee joint proprioception [6]. Knees with anterior cruciate ligament failure show chronic instability.

Almost 5 percent of patients referring with a complaint involving the knee joint require surgical treatment. Anterior cruciate ligament ruptures are among the most commonly seen knee injuries, and commonly develop as a result of a strain on valgus during the external rotation of the knee while the foot is fixed, or valgus strain due to rotation and sudden stopping, fast running or changing direction during athletic activities [7]. The anterior cruciate ligament is one of the most commonly injured structures resulting from falls from height or due to sporting activities, and spontaneous recovery from such a rupture is not possible. An acute traumatic hemarthrosis developing after a sports injury is accompanied by partial or total anterior cruciate ligament rupture in almost 70 percent of cases. On the other hand, anterior cruciate ligament ruptures accompanied by knee dislocations should be considered an orthopedic emergency [8]. Reconstruction of this ligament is particularly important in protecting the meniscus and preventing potential early-term osteoarthritic changes, and anterior cruciate ligament reconstruction surgery is the fundamental treatment is such cases [9]. Surgery becomes even more important when taking into account the fact that anterior cruciate ligament ruptures may lead to chondral injuries, meniscus ruptures, knee joint instability and early osteoarthrosis development due to repetitive injuries in conservatively monitored cases [10].

Anterior cruciate ligament reconstruction can be performed arthroscopically, with autografts, allografts and synthetic grafts being used for the reconstruction of ruptured anterior cruciate ligaments [11]. Successful outcomes have been reported in 90-100 percent of autograft and allograft reconstructions. Autografts used for anterior cruciate ligament reconstruction include bone-patellar tendon-bone autografts, and hamstring tendon (semitendinosus and gracilis), iliotibial band and quadriceps tendon autografts. Graft preference depends on surgical experience, surgical preference, status of donor region, patient's age, presence of comorbidities, activity status and patient preference [12].

As patellar tendon grafts are bone-tendon-bone grafts, they can be fixed more rigidly by showing better bone to bone recovery both in the femoral and tibial tunnel, and they also have better tensile characteristics than other types of grafts, allowing the early initiation of rehabilitation. However, they can be more disadvantageous as donor site morbidities are more frequent than in the case of other autografts. Bone-patellar tendon-bone grafts can also be disadvantageous as they may cause morbidities such as anterior knee pain (patellofemoral pain), patellar tendinitis, patellar tendon rupture, patella fracture, weakness of the knee extensor mechanism (weakness in quadriceps muscle strength) and loss of total extension. They also require long surgeries, and their localization and revision may be challenging. Bone-patellar tendon-bone autografts are preferred in high-performance athletes[13]. The biomechanics of quadrupled gracilis and semitendinosus tendon autografts are very similar to innate anterior cruciate ligament biomechanics, and offer advantages, being associated with a lower rate of donor site morbidity. As the integration of these autografts occurs through bone-soft tissue healing, it takes longer than bone-patellar tendon-bone autografts, and so postoperative rehabilitation is initiated at a later stage.

Following an anterior cruciate ligament reconstruction performed using hamstring tendon grafts, problems such as knee joint movement limitation and extension loss are minimal. Hamstring tendons (quadrupled gracilis and semitendinosus tendon autografts) are superior to patellar tendon autografts in terms of biomechanics and durability, and their stiffness is three times higher than the innate anterior cruciate ligament and twice as high as the patellar tendon.

The Quadriceps tendon is a graft with a wide cross-section, and is more frequently preferred in cases with multiple cruciate ligament ruptures, such as when there is a coexistence of anterior and posterior cruciate ligament ruptures, and due to a lower rate of donor site morbidity. Graft identification is weaker than in bone-patellar tendon-bone grafts, as there is a bone block at only one end of the graft [14].

Allografts, on the other hand, have the advantage of not requiring donor site surgery, which reduces the duration of the operation and eliminates donor site morbidities. They allow the use of unlimited grafts that are easily obtained in the desired size but increase treatment costs. Moreover, allografts come with risks in the form of immune reactions and infectious diseases. Postoperative rehabilitation is again initiated at a later stage, as these grafts require a long time for resorption and remodulation within bone tunnels. Allografts are more commonly used during revision surgeries. The currently used allografts include the tibialis anterior tendon, tibialis poste-

rior tendon, peroneus longus tendon, semitendinosus tendon, Achilles tendon, and the fascia lata and gracilis tendon.

As a result of such factors as obtaining thin grafts from the tendons, the presence of soft grafts or unreliable identification within the tunnel, heterograft reconstruction can also be carried out concomitantly using an allograft with a hamstring tendon autograft.

Synthetic grafts are less commonly used, as high rates of failure have been observed in anterior cruciate ligament reconstructions. Synthetic grafts are classified as permanent prosthetics (Gore-Tex, polyester, dacron, polytetrafluoroethylene, telos, trevira), frame prosthetics (carbon fiber, Leeds-Keio, ABC surgicraft) and support prosthetics (Kennedy LAD, PDS band)[15].

In the present study, we investigate the types of grafts used and the effects of gender and age on revision.

Materials and Methods

After receiving the approval of the ethics committee of our university (2018/4-13), a retrospective study was carried out based on the medical records of a total of 269 knees belonging to 267 patients whose records could be accessed from among the 303 patients operated on at our clinics for an anterior cruciate ligament rupture between 2009 and 2018. Among the patients excluded from the study were those with concomitant injuries of the same knee or a previous history of the knee surgery in the same knee in 24 patients. In addition, as the main aim of the study was to compare the outcomes achieved with autograft and allograft, 14 hybrid grafts combining autografts and allografts were also excluded from the study. The patients included to the study were required to have no previous history of knee surgery. A diagnosis of an anterior cruciate ligament rupture was confirmed based on an examination of outpatient clinic files and radiological investigation reports, and surgery notes were reviewed for all cases. The right and left knees of the patients were not evaluated separately. A left and right anterior cruciate ligament rupture occurring at different time points in two patients were treated as separate cases. Additionally, one patient had undergone two revision surgeries, of which only the first revision operation was included in the study while the second revision was excluded. The duration of postoperative follow-up varied between three months to eight years.

Surgical Technique

Following the general essential preoperative preparations, the affected lower extremity was tournicated, sterilized, stained and covered. Then, an entry portal was opened lateral to the patellar tendon and the joint was accessed by an arthroscope. The intraarticular region was observed and examined, and the suprapatellar region, medial joint space, intercondylar notch and lateral joint space were checked. Once the presence of an anterior cruciate ligament rupture had been confirmed, the graft (hamstring autograft, bone-patellar tendon bone autograft, quadriceps tendon autograft or allograft) was prepared and a notchplasty was performed. The tibial tunnel was opened with a drill after adjusting the tibial tunnel guide to 55 degrees. The femoral tunnel entry site was identified at the medial of the femur lateral condyle. The knee was moved to hyperflexion, the guidewire was removed from the femur lateral condyle and the femoral tunnel was opened with a drill. The prepared graft was passed through the tibial and femoral tunnel by endobutton and hanged to the lateral cortex of the femur, and then checked by scopy. A biointerference screw was inserted into the tibial tunnel for graft stabilization and a tenodesis of the tip of the graft to the tibia was carried out with a staple. The knee joint was moved to flexion and extension to check graft stabilization and notch impingement. The intraarticular area was washed, and a hemovac drainage tube was placed into the joint. All incisions were sutured according to their anatomical layers. After wound dressing, conservation was provided by an ROM walker and the operation was completed.

Postoperative Follow-Up and Rehabilitation

Intravenoz analgesics and antibiotherapy were initiated in the early postoperative period. The Hemovac drainage tubes were removed at the postoperative 24th hour and the wound was dressed. Physiotherapy was initiated on postoperative day 1, and the patients were discharged by ROM walker with partial load mobilization. The sutures were removed in the third week, and flexion of above 90 degrees and mobilization with a 50 percent load were allowed. The ROM walker was terminated in the sixth week and mobilization with a tolerated load and walking up and down stairs using a single walking stick were allowed. Patients were mobilized without support, and were allowed to run on a flat surface in the third month. Contact sports were allowed in the sixth month and patients were asked to return for a control visit at the postoperative first year.

Radiological Evaluation

Preoperative bilateral direct knee X-rays and MRI images were obtained in all cases, and preoperative patella tangencial and tunnel graphies were obtained when required. The presence of concomitant injuries on the same knee (fracture, chondral injury, meniscus rupture, collateral ligament rupture, posterior cruciate ligament rupture or knee dislocation) were evaluated in all cases. And all cases were evaluated postoperatively with bilateral knee X-

rays and from a control MRI obtained at the one-year control visit.

Statistical Analyses

The data was analyzed using the SPSS program; descriptive statistics were summarized as frequency distributions for qualitative data and as arithmetic mean, minimum, maximum and standard deviation values for quantitative data. The qualitative data was analyzed using non-parametric tests and a Chi-square test, and quantitative data were analyzed with parametric tests in the event of them being normally distributed, while non-parametric tests were used to analyze the non-normally distributed data. The data analysis was carried out with a Chi-Square test. P values of 0.05 were considered statistically significant.

Results

Of the 269 cases with an anterior cruciate ligament rupture included in this study (patients aged between 16 and 56 years), the majority were male (91.8%, 247 cases) while only 8.2 percent were female (22 cases) patients. Of all cases, 78.1 percent (210 cases) involved young, active adults aged 20-40 years. Adults older than 40 years accounted for 17.1 percent (46 cases) of the total, and only 4.8 percent (13 cases) of the cases were adolescents aged 16-20 years with active epiphyseal functions. The mean overall age of the patient group was 31.7 (±8.7) years.

Reconstruction was performed using an autograft in 60.6 percent (163) of cases and an allograft in 39.4 percent (106) of these 269 cases. Of all the used autografts, 25 (9.3%) were bone-patellar tendon bone, 136 (50.6%) were hamstring (semitendinosus and gracilis) tendons and two (0.7%) were quadriceps tendons.

Of the 247 grafts used on the male patients, 25 were bone-patellar tendon-bone autografts, 126 were hamstring autografts, two were quadriceps autografts and 94 were allografts, while 10 female patients underwent a hamstring autograft and 12 female patients received an allograft (Table I).

All of the bone-patellar tendon-bone autografts were used on male patients aged 21-40 years. While the majority (108 cases, 79.4%) of hamstring autografts were used on patients aged between 21 and 40 years, 25 were used in patients older than 40 years, and only two were used in patients younger than 20 years. One of the quadriceps autografts was used in a patient aged between 21 and 40 years, while the other was used in a patient aged older than 40 years. The majority of allografts (76 cases, 71.7%) were used in patients aged between 21 and 40 years, while 20 were used in patients older than 40 years and 10 were used in those younger than 20 years. The majority of the 13 grafts used on patients younger than 20 years were allografts (10 cases, 77%), while hamstring autografts were used in only two patients in this age group. The majority of the 210 operated cases in the 21-40 age group received a hamstring autograft (108 cases, 51.4%), while 36.1 percent (76 cases) received an allograft. Of the remaining cases in the 21-40 years age group, 12 percent (25 cases) received bone-patellar tendon-bone autograft, and one case received a quadriceps autograft. Among the cases older than 40 years, 54.3 percent (25 cases) received a hamstring autograft and 43.4 percent (20 cases) received an allograft, while only one patient received a quadriceps autograft.

Only 5.9 percent (16 cases) of 269 cases that underwent an anterior cruciate ligament reconstruction experienced a re-rupture and required a revision operation. The majority (253 cases) recovered and returned back to their normal levels of activity. While a revision was required in 27.3 percent (6 cases) of the 22 female patients, only 4 percent (10 cases) of the 247 male patients required revision *(Fisher's Exact Test; p=0.001)*. Furthermore, two of the six revision procedures performed on female patients were carried out within the first postoperative year, while four procedures were performed within one to five years. Of the 10 revisions made on male patients, three were carried out within the first postoperative year, five within one to five years and two procedures were required after five years.

In an analysis of the grafts used in revised patients requiring revision it was noted that, irrespective of the sub-

Table I - *Grafts used for anterior cruciate ligament reconstruction according to gender.*

Gender	Patellar T.	Hamstring	Quadriceps	Allograft	Total
Female	-	10	-	12	22
In-group %	-	45.5%	-	54.5%	100%
Overall %	-	3.7%	-	4.5%	8.2%
Males	25	126	2	94	247
In-group %	10.2%	51%	0.8%	38%	100%
Overall %	9.3%	46.8%	0.7%	35%	91.8%
Total	25	136	2	106	269
In-group %	8.5%	48%	0.7%	37.7%	100%
Overall %	9.3%	50.5%	0.7%	39.5%	100%

TABLE II - *Revision status based on the type of graft used for anterior cruciate ligament reconstruction*

Type of graft	No revision the first year	Revised within 1-5 years	Revised between 5 years	Revised after	Total
Bone-patellar tendon-bone autograft	25	-	-	-	25
Hamstring (semitendinosus-gracilis) autograft	127	-	8	1	136
Quadriceps autograft	2	-	-		2
Allograft	99	5	1	1	106
Total	253	5	9	2	269

type of graft, revision was required in nine out of 163 patients reconstructed with an autograft and seven out of the 106 patients reconstructed with an allograft. The analysis, which disregarded autograft subtypes, revealed no significant difference in terms of the rate of revision between autograft and allografts *(Yates corrected Chi-Square test; P=0.92)*. An analysis taking into account autograft subtypes also showed no significant differences between the subgroups *(Pearson Chi- Square; p=0.58).* Table II summarizes the subtypes of grafts and time to revision in patients who required a revision operation. While four out of the five cases requiring revision within the first postoperative year were in 21-40 years age group, one patient was older than 40 years. A total of seven of the nine patients who required revision within the postoperative one to five years were in 21-40 years age group, whereas one patient was older than 40 years and one was younger than 20 years. Among the patients who required revision after postoperative five years, one was in the 21-40 years age group and the other was older than 40 years. The rate of revision was not significantly different between the age groups (*Pearson Chi-Square test; p=0.82*). All cases requiring revision within the first one year had received an allograft. Of the nine re-rupture cases occurring within one to five years, eight had undergone a hamstring (semitendinosus and gracilis) autograft and one had received an allograft. Of the two cases requiring revision postoperative five year, one received a hamstring autograft and the other received an allograft (Table II).

Discussion

It is first worth noting that 91.8 percent (247 cases) of the patients in this study were male, and it is important to underline that, socio-culturally, men are more active than women in our population, being more engaged in competitive sports, and so exposed to a higher risk of anterior cruciate ligament rupture. The majority of anterior cruciate ligament ruptures (78.1%, 210 cases) were noted in young, active and athletic individuals aged between 20 and 40 years. This finding highlights the relationship between anterior cruciate ligament ruptures and sports injuries.

Strength is the leading basic biomechanical characteristic of a graft, which is important, as the graft used for reconstruction should have the same, or almost the same, strength as the innate anterior cruciate ligament. Stiffness of the graft, on the other hand, prevents graft failure, which may occur as a result of extension and flexion[16]. While bone-patellar tendon-bone autografts are three times stiffer, hamstring autografts have the same stiffness as the anterior cruciate ligament. The resistance of grafts to cyclic loads shows their essential strength, and these cyclic loads may cause graft failure over time. The strength of a graft does not depend on its diameter. Large grafts are associated with slow revascularization, and can cause intercondylar notch impingement, and the recovery time and revascularization of grafts are related to on their surface area. Grafts with large diameters and allografts show slow recovery, while hamstring grafts recover faster. Autografts are known to be more advantageous than allografts in terms of graft strength, stiffness and recovery potential. The present study showed that autografts are generally preferred in our clinics, being used in 60.6 percent (163 cases) of the operations carried out at our clinics for anterior cruciate ligament reconstruction. Allografts, on the other hand, are most commonly preferred in female patients (mostly due to cosmetic reasons) and in patients younger than 20 years (mostly in order to avoid donor site morbidity and cosmetic reasons). An allograft was used in 39.4 percent (106 cases) of the cases in our clinics, and was the preferred option in 77 percent of the cases younger than 20 years (10 cases) and in 54.5 percent of the cases involving women (12 cases). Another reason for allograft use is association with the decreases seen in the strength, stiffness and recovery potential of autografts with aging. In their study, Woo identified age as an important factor affecting the strength of a graft [17]. While allografts can be used in patients older than 40 years, hamstring tendon autografts (semitendinosus and gracilis) or bone-free central quadriceps tendons can be used in cases with an open epiphysis (<20 years). Allografts can be used for revision surgery in active patients aged 40 years and above who have gonarthrosis with patellofemoral joint problems, in patients with multiple ligament injuries, and in patients requiring anterior cruciate ligament reconstruction with a high tibial osteotomy [21]. In our clinic,

the use of allografts increases in patients over the age of 40 years. Patients in this age group experience a higher frequency of patellofemoral complaints. While allografts were used in 36.1 percent of patients aged between 21 and 40 years, this rate reached 43.4 percent in those aged over 40 years. In a study carried out in 1999, Gur recommended the use of hamstring and bone-free quadriceps tendon grafts in patients younger than 20 years, whereas hamstring autografts were used in only three of the 13 cases with an anterior cruciate ligament rupture in our clinics, with allografts used in the remaining 10 patients [18]. However, revision was carried out in only one female patient who had received an allograft. Allografts were more commonly preferred in adolescent patients due to cosmetic reasons and operational concerns.

Another important factor dictating graft preference is the time required for graft recovery. As the grafts used are free grafts that do not functionally vascularize, they gain the structure of a ligament after passing through a processes of avascular necrosis, cell migration and revascularization within 1-3 months following reconstruction. In the following 3-12 months, the process of remodeling against stress is completed. The graft reaches 50 percent of its original strength during the avascular necrosis process, which lasts for postoperative 3-6 months, and then reaches 80 percent strength over 9-12 months. Complete maturation takes longer, almost 1-3 years, in bone-patellar tendon-bone grafts. Bone recovery within the tibial and femoral tunnel can last from six weeks to six months. On the other hand, experiments on animals have shown that the integration of fixation using a staple can last for 8-12 weeks. The duration of recovery related to allografts was shown to be longer, requiring an additional 6-18 months [19]. Only 5.9 percent (16 cases) of the anterior cruciate ligament reconstructions carried out in our clinics required a revision operation following a re-rupture, of which, four occurred within the first year, and all were allografts. This indicates that recovery following an allograft is poorer and later than with autografts. Of the 12 cases that experienced a re-rupture after one year, nine were hamstring autografts and three were allografts. Only a few of the operations in our clinics involved female patients (8.2%, 22 cases), while revisions following a re-rupture were required in 27.2 percent (6 cases) of those cases. Of the six women who required revision, three had received allografts and three had received a hamstring autograft. We believe that women did not comply fully with the postoperative rehabilitation programs due to their domestic duties [20].

The advantages of allografts over autografts include the lack of morbidity risk associated with autogenous graft removal, and providing sufficient amount of graft where autografts are insufficient. The disadvantages include the potential transmission of infections (HIV, hepatitis, etc.), graft rejection, slow ligamentization, resorption of the graft in the bone tunnel and high costs [21]. Considering these advantages and disadvantages of allografts, it is understandable why hamstring autografts and allografts were more common in anterior cruciate ligament reconstructions in our clinics. In 89.9 percent (242 cases) of the 269 cases, hamstring autografts and allografts were used, while bone-patellar tendon-bone autografts were used only in 25 cases in the 21-40 years age group. This is because problems such as donor site morbidity, particularly anterior knee pain and the weakening of the extensor mechanism, are less tolerated by patients older than 40 years and younger than 20 years. Being associated with similar morbidities, quadriceps tendon autografts were used in only two cases, while no facial lata and Achilles tendon autografts were used on any patient in our study.

Conclusions

Anterior cruciate ligament ruptures represent an important healthcare problem, particularly among the young and active population who engage in competitive sports (mostly men), although the increased rate of postoperative re-ruptures among women requires further investigation. Anterior cruciate ligament reconstruction is a mandatory intervention aimed at preventing the degeneration of the knee joint and ensuring its stability. Each type of graft used for treatment is associated with its own specific advantages and disadvantages. Hamstring autografts and allografts were used most frequently in the anterior cruciate ligament reconstruction surgeries performed in our clinics, and the rate of re-rupture was quite low for both graft types. In this regard, the decision on which graft type should be used when anterior cruciate ligament surgery is required should be taken by the surgeon and the patient. Selection of the appropriate graft is the most important topic in anterior cruciate ligament reconstruction, as there is still no graft that is considered ideal.

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Riassunto

Lo studio riguarda 267 pazienti con lesione del legamento crociato anteriore, ricostruito con autotrapianto o con allotrapianto, prendendo in esame l'intervallo con la fase di revisione e il tasso di revisione stessa.

Si tratta dunque di uno studio retrospettivo sui dati raccolti circa 269 ginocchia di 267 pazienti sottoposti a ricostruzione del legamento crociato anteriore tra il 2009

e il 2018 (25 con autoinnesto rotula-tendine-osso; 136 con autotrapianto di gracile-semitendinoso; 2 con autotrapianto di quadricipite; 106 con allotrapianto).
Delle 269 ginocchia dei 267 pazienti (22 donne e 247 uomini) operati per rottura del legamento crociato anteriore, è stato adottato un autotrapianto in 163, e nove di questi hanno richiesto la revisione, mentre un allotrapianto è stato utilizzato in 106 ginocchia, con necessità di sette revisioni. La chirurgia di revisione si è resa necessaria per sei delle 22 pazienti donne e solo per 10 dei 247 pazienti uomini (p <0,001).
Ogni tipo di innesto utilizzato per la ricostruzione del legamento crociato presenta determinati vantaggi e svantaggi. Gli innesti e gli allotrapianti di Hamstring sono stati quelli più comunemente utilizzati presso i nostri reparti. Il tasso di rottura recidiva è stato piuttosto basso con l'uso di entrambi i tipi di innesto, portandoci alla conclusione che il tipo di innesto da preferirsi per la chirurgia di ricostruzione del legamento crociato anteriore dovrebbe essere basato su una decisione concordata tra chirurgo e paziente.

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