

Custom-made anterior cruciate ligament

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Abstract

Rupture of the anterior cruciate ligament (ACL) of the knee is one of the most common ligament injuries. It is most common in young, athletic patients, and its short- and long-term repercussions result in functional disability. The increasing development of ligamentoplasty using the crow's foot tendons: the medial rectus and the semitendinosus (DIDT), compared with ligamentoplasty using the patellar tendon, considered to be the "Gold Standard", and the quadriceps tendon, has led the various surgical and rehabilitation teams to compare these three techniques. Our work is a retrospective study of 66 patients with chronic knee instability secondary to ACL rupture. 33 patients underwent ligamentoplasty using a semitendinosus medial rectus graft (DIDT), 21 patients were treated with a patellar tendon graft using the Kenneth-Jones (KJ) technique and 12 patients were treated using the quadriceps tendon technique. Rehabilitation was started at 24 hours post-operatively, with support allowed, according to a well-coded protocol. Comparing these 3 techniques, patients in the DIDT and TQ group showed a less marked pain profile than those in the "patellar tendon" group. In all three groups, there was a significant improvement in the postoperative Lysholm and Tegner scores compared with the preoperative scores; this improvement was significantly greater in the DIDT group than in the KJ group (94.6 vs. 86.2). The three techniques (QT, KJ and DIDT) gave comparable long-term results, although the early postoperative effects, which differed from one technique to another, could be an interesting criterion in choosing the type of ligamentoplasty. In summary, in sensory terms QT > DIDT > KJ, in aesthetic terms QT = DIDT > KJ, and in functional terms QT = DIDT = KJ.

Measurement of preoperative and postoperative laximetry using a laximeter (KT-1000) represents an objective assessment of the outcome of surgery, which is necessary to demonstrate the superiority of one technique over another.

Keywords: Ligamentoplasty; ACL; DIDT; KJ; TQ.

1. Introduction

The growing interest in sport over the last few decades has resulted in a concomitant increase in the frequency of traumatic knee injuries, in particular rupture of the Anterior Cruciate Ligament (ACL) [1].

Its short-term repercussions are mechanical and functional instability affecting the patient's professional and active life. In the long term, it leads to degradation of the capsulo-menisco-cartilaginous structures, favouring osteoarthritis [2].

The aim of ACL ligamentoplasty is to correct the anterior laxity by reconstituting a new ligament in order to restore a stable, functional and pain-free knee that allows the patient to resume previous physical activity, in a durable manner, while limiting the long-term risk of osteoarthritis [3].

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Nowadays, the most commonly used transplants are hamstring (DIDT), patellar tendon (os-tendon-os) and quadriceps tendon, each of which has its own advantages and disadvantages [4].

Nevertheless, despite all these advances, results after ACL ligamentoplasty are not completely satisfactory. Indeed, around 37% of athletes do not return to their pre-injury level and more than 10% of patients suffer a repeat ACL rupture [4].

Patellar tendon (KJ) ligamentoplasty is considered the "Gold Standard", with its reputation for strength and reliability over time, while DIDT ligamentoplasty is traditionally valued for its low morbidity at the harvesting site, Quadriceps tendon (TQ) ligamentoplasty, on the other hand, differs from patellar tendon and DIDT ligamentoplasty in that it has a large tendon portion with a cross-sectional area close to that of the native ACL, with the possibility of adapting the size of the transplant to the patient's anatomy [5].

Interest of our study: To recognise the advantages and limitations of each surgical technique, and to adapt the choice of graft used to each patient.

2. Materials and methods

Our work is a single-centre retrospective study, spread over a period of 5 years and 10 months, from January 2017 to October 2022, collated in the Traumatology and Orthopaedics Department (Wing 4) at the Ibn Rochd University Hospital in Casablanca and including 66 patients with chronic knee instability secondary to ACL rupture.

Data were collected on a data processing form based on patient questioning, clinical examination, medical records and operative reports.

2.1. Inclusion criteria

- Arthroscopic ACL ligamentoplasty at our centre.
- Age greater than 16 years.
- Post-operative follow-up greater than one year.

2.2. Exclusion criteria

- The association of any other ligamentoplasty or ligament suture (PCL, LLI, LLE).
- Repeat ligamentoplasty.
- Associated tibial osteotomy.

In our series there were two operators: the first used the DIDT technique and the second used the KJ technique and the quadriceps tendon technique.

The results of surgery using the three techniques were assessed clinically, on the basis of the physical examination and the subjective signs reported by the patient. Functional results were assessed using the Lysholm-Tegner score.

Lxometry was not measured in our series due to lack of availability of the device in our department.

3. Results

3.1. Age

The mean age was 31.25 years, the youngest patient was 18 years old and the oldest was 50 years old.

3.2. Sex

In our series, 88.2% were men and 11.8% women, all procedures combined.

3.3. Knee affected

The right knee was affected in 63.63% of cases, and the left knee in 36.36% of cases.

3.4. Sports profile of patients according to the CLAS scale :

- 40 patients were recreational sportsmen and women, i.e. 60.6% of cases.
- 16 patients were competitive athletes, i.e. 24.24% of cases.
- 10 patients were active, i.e. 15.15% of cases.
- No patient was sedentary.

3.5. MRI of the knee:

MRI was used to confirm the diagnosis of ACL rupture in the knee and to establish a complete assessment of the injury. It was carried out in all our patients. Complete rupture of the anterior cruciate ligament was found in all our patients:

full-body rupture accounted for 57.6% of cases, absence of total visualization of the ACL for 19.7%, a tibial disinsertion lesion accounted for 16.2% of cases, and finally a femoral disinsertion lesion was found in 6.5% of cases.



Figure 1 MRI of the knee in sagittal section showing a complete rupture of the ACL

3.6. Type of graft

Our patients underwent surgery using three techniques depending on the type of graft: 33 patients underwent ligamentoplasty with DIDT grafting, i.e. 50% of cases (Figure 2), 21 patients with patellar tendon grafting using the Kenneth-Jones (KJ) technique, i.e. 31.81% of cases (Figure 3), and 12 patients with quadriceps tendon grafting, i.e. 18.18% of cases (Figure 4).



Figure 2 Technique DIDT Prélèvement et assemblage des deux tendons en 4 brins et leur suture les uns aux autres.



Figure 3 KJ bone-tendon transplant harvesting technique



Figure 4 Technique for harvesting the quadriceps tendon.

3.7. Arthroscopic phase

- Exploration Arthroscopic exploration of the affected knee revealed the following lesions:
- Damage to the medial meniscus in 15 patients, i.e. 22.72% of cases.
- Damage to the lateral meniscus in 11 patients (16.66% of cases).
- Chondral lesions in 7 patients (10.6% of cases).

Associated procedures: Only unstable meniscal lesions visualised under arthroscopy were treated as follows: - Partial meniscectomy in 11 patients (16.66%). - Meniscal suture in 7 patients (10.60%).

3.8. Preparation and cleaning of the notch

Once any associated lesions have been investigated and treated, the inter-condylar notch is cleaned of any remaining ACL residue using a Shaver and/or Basket forceps, and sometimes electric spraying.

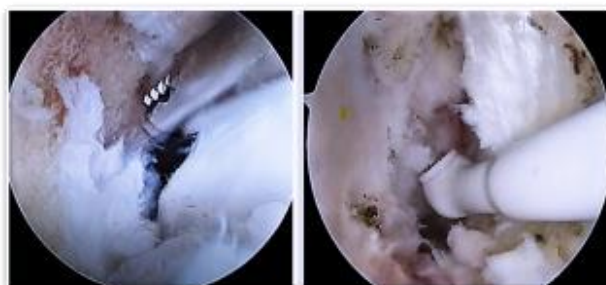


Figure 5 Resection of the ACL remnants using a Shaver and cleaning of the notch with a spray gun.

Operators use the "Biological ACL" concept to prepare the tibial tunnel, preserving as much of the native ACL as possible.



Figure 6 Arthroscopic view showing preservation of the remnants of the ACL at its tibial insertion: biological ACL.

3.9. Bone tunnels

The tibial tunnel was drilled "Out-In" using a sighting device at a 50° angle, with an average length of 26.4 mm, ranging from 25 to 30 mm, and an average diameter of 8 to 9 mm.

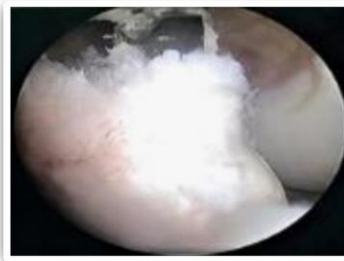


Figure 7 Arthroscopic view showing the emergence of the drill bit through the remnants of the preserved ACL.

The femoral tunnel was drilled "In-Out" (blind femoral tunnel technique), with an average length of 25.2 mm, ranging from 20 to 25 mm, and an average diameter of 8 mm.



Figure 8 Appearance of the femoral tunnel after drilling.

3.10. Inserting the new graft

Under arthroscopic control, the new ligament (graft) is inserted into the joint using a cat wire. Its two ends are inserted into the two tunnels.



Figure 9 Passage of the transplant through the tunnels replacing the old ACL.

3.11. Graft fixation

In our series, fixation was performed in all our patients (100% of cases) using resorbable interference screws.



Figure 10 Femoral and tibial fixation using resorbable interference screws.

The diameter of the screw chosen depended on the diameter of the tunnel drilled:

- 7 to 10 / 23 to 30 diameters for the tibia.
- 7 to 9 / 23 to 30 diameters for the femur.

3.12. End of procedure-Closure

This is performed after haemostasis (after releasing the tourniquet), after cleaning the joint and checking the tension of the neoligament. (Fig 11, 12, 13) Once stability has been tested, the wound is closed with a Redon drain, which is kept in place for 48 hours.



Figure 11 Arthroscopic view showing the final appearance of the transplant DIDT according to the biological ACL concept (left knee)

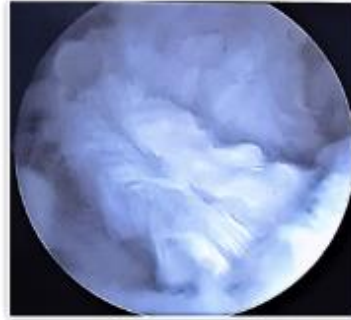


Figure 12 Final arthroscopic view of the bone-tendon transplant.



Figure 13 Final arthroscopic view of the quadricipital tendon transplant.

3.13. Post-operative follow-up

Standard radiographs were taken immediately postoperatively in all our patients in order to check the positioning of the bone tunnels.

With regard to pain assessment, 30% of patients operated on by DIDT were pain-free on average 8 days after the operation. This figure was 19.04% for patients operated on with KJ, and 25% for patients operated on with TQ. The average duration of pain in weeks was 2 weeks for DIDT, 4 weeks for KJ and 3 weeks for TQ.

3.14. Reeducation

- All patients benefited from a well-coded functional re-education programme, provided by the physiotherapy team affiliated to our department.
- Re-education began at 24 hours post-operatively, with the patient being allowed to bear weight, and continued throughout the hospital stay, which averaged 3 days.
- Rehabilitation was continued on an outpatient basis after discharge from hospital.
- The average time off work after the operation was one and a half months.

3.15. Functional results

- Residual post-operative pain was reported by 9 patients. 13.63% of the overall series, and 7 patients operated on using the KJ technique complained of pain at the harvesting site, 21.21% of cases.
- 3 patients (3.03%) complained of significant knee pain on moderate exertion, 2 patients (1.51%) operated on using the DIDT technique, and only 1 patient (1.51%) operated on using the TQ technique.
- Sensory disturbances, in particular hypoesthesia in the territory of the infra-patellar branches of the medial saphenous nerve (BIPNS), were found in 18 patients, i.e. 27.27% of cases (11 cases in the DIDT group, i.e. 61.11%, and 7 cases in the KJ group, 38.88%).
- The sensation of knee instability during sporting activity was described in only 5 patients, all three techniques combined, 3 patients operated on using the DIDT technique, and 2 patients operated on using the quadricipital tendon technique. The Pivot Shift Test and Lachman test were negative in all patients. The anterior drawer was present in one of our patients operated on using the DIDT technique.

- The KJ group demonstrated superior stability according to the anterior drawer test. Indeed, this test was found in 5 of our patients, 3 treated by the DIDT technique, and 2 treated by quadriceps tendon.

Amyotrophy of the homolateral quadriceps (figure 14) was found in 14 of our patients, i.e. 21.21% of cases, estimated at 2 cm of thigh circumference in relation to the estrolateral thigh (50% of cases in the KJ group compared with 28.57% of cases in the DIDT group, and 21.42% of cases in the TQ group). 2 patients had flexion stiffness after KJ (3.03% of cases), which recovered after 6 weeks of rehabilitation.



Figure 14 Appearance of quadriceps amyotrophy after 6 months.

3.16. Resumption of sporting activity

The return to sporting activity was 84.84% for the DIDT group after an average duration of 9 months. It was 90.47% for the KJ group with an average duration of 11 months. It was 83.33% for the TQ group with an average duration of 12 months.

The mean global preoperative score according to the Lysholm classification was 63.3. The overall postoperative score was 91 (Table 1). The average and poor results were explained by residual pain.

Table 1 Results of our series using the Lysholm system.

Results	Number of patients
Poor (0 à 63)	2
Fair (64 à 83)	13
Good / Excellent (84 à 100)	51
Total	66

To assess the level of sport, we used the Tegner rating, which consists of a scale of sporting and professional activity rated from 0 (professional disability) to 10 (competitive sport). We obtained an average Tegner score of 5.6 preoperatively, rising to 6.8 postoperatively.

In all three groups, there was a significant improvement in the postoperative Lysholm and Tegner scores compared with the preoperative scores.

At one year follow-up, the mean objective IKDC score was 92%.

3.17. Advantages and disadvantages of each technique :

3.17.1. DIDT technique

Advantage

- Load at higher resistance (4ST: 4090N).
- Integrity of the extensor apparatus.
- Adaptable length and thickness.
- If pedicled: double fixation.

- Mixed plasty possible: ALL ++.
- Easy to remove.
- Little morbidity
- Graft strength.
- A la carte" graft, with length and diameter adaptable to the knee.
- Small scar.

Disadvantages

- Slower bone-tendon consolidation.
- Enlargement of the tunnel by elastic effect (bungee-effect).
- Loss of sensitivity (saphenous nerve).
- Variable graft (length and thickness).
- Weakness in thigh flexion and dynamic control of tibial RI.
- Harvesting sometimes delicate.
- Haematoma may be present at the back of the thigh, with more or less clear bruising.

3.17.2. KJ technique

Advantage

- Biomechanics close to the native ACL.
- Bone/bone integration.
- Ideal tendon length.
- Mechanical properties if > 10mm.
- > BPTB Superior strength load (2977N vs. 2160N for native ACL)
- Easy to prepare
- Often used in revisions

Disadvantages

- Frequent anterior pain.
- Quadricipital weakness.
- Loss of prepatellar tenderness.
- Structural vulnerability of the extensor apparatus (patella fracture, LP rupture) FP syndrome.
- Patellar tendonitis
- Loss of extension power
- A risk of loss of flexion
- Pain on kneeling in 16% of cases

3.17.3. TQ technique

Advantage:

- Biomechanics close to the native ACL.
- Higher resistance load (2174N).
- Highly versatile (diameter, length, bone pad).
- Partial bone/bone integration.
- Less anterior pain.
- No loss of sensation.
- Often used in revision.
- Few consequences other than scarring.

Disadvantages

- Anatomical variation.
- Risk of large scar tissue formation.
- Patella fracture (if bone pad).
- FP? syndrome.
- Weak extensor apparatus.

- A risk of pain at the harvesting site, requiring caution in rehabilitation.
- Quadriceps amyotrophy.
- Large unsightly scar.

3.18. CHOICE: on what criteria?

3.18.1. Patients :

Sport, demand, work, age.

History/availability.

3.18.2. Clinical

- Laxity: AP, PS.
- Associated injuries (App ext, MCL/LCL).
- Muscular strength - Osteoarthritis / chondropathy.
- Background:
- Surgical revision.
- Associated gestures (meniscal suture, OTV).
- Multi-ligament.

Transplant

- Iatrogenic lesion of the harvest?
- Mechanical properties of the graft?
- surgeon +++ :
- Habits
- School

4. Discussion

The treatment of ACL ruptures has undergone a major boom thanks to the emergence of several ligamentoplasty techniques, and the development of these techniques under arthroscopy, allowing better control of the positioning of the graft and more effective treatment of associated meniscus or cartilage injuries. The most popular implant is the central third of the patellar tendon with its 2 bone plates, patellar and tibial. It has excellent load-bearing capacity, high rigidity and solid bone-to-bone implantation, allowing the graft to integrate more quickly into the tunnels. Its main disadvantage is possible pain at the harvesting site and dysfunction of the patellofemoral joint [5].

The use of semitendinosus and medial rectus tendons, combined to form a 2- or 4- bundle graft, is also very common. This implant is very rigid, with twice the load-bearing capacity of the native ACL, but fixation is more difficult and the incorporation period is longer, exposing the graft to sliding forces. During this period, rehabilitation and activities must be carried out with caution, as patients are at greater risk of developing anterior laxity [6,7].

Reconstruction of the anterior cruciate ligament (ACL) using the QT technique continues to be one of the fastest-growing ACL techniques in the world. The clinical advantages of the QT technique - including robust and predictable graft sizing, superior biomechanics, equal or better clinical outcomes, low morbidity and improved aesthetic outcome, are now supported by a number of clinical and biomechanical studies, as well as systematic reviews [7].

The patellar tendon seems to be used more often in men practising competitive sports. The DIDT is more often used in recreational athletes.

In the 1999 SFA retrospective study [8], the KJ was mainly indicated in men practising a sport with contact pivot, whereas the DIDT was more often indicated in women practising a sport without contact pivot.

In the study by Freedman et al [9], the KJ group included a significantly higher proportion of men than in the DIDT group. Full weight-bearing protected by 2 canes is authorised by most surgeons for KJ. For DIDT, the patient was authorised to walk with immediate partial support, the flexion of which must not exceed 80° for 3 to 4 weeks. As a result, DIDT penalises patients in terms of function and walking comfort.

Few studies had compared the results of TK vs TQ, with comparable results on scores, laxity, functional recovery with a clear superiority of TQ over KJ on pain [12].

- DIDT vs TQ: Few data, Comparable: scores, TQ: less nerve damage [13].
- DIDT vs TQ vs KJ: [14].
- Sensory terms QT > DIDT > KJ
- Aesthetic terms QT= DIDT > KJ
- functional terms QT= DIDT = KJ.

Most surgeons recommend splinting, usually until the knee is fully locked. There did not appear to be any difference in the length of time the brace was used between the different procedures. Post-operative mobility did not appear to be influenced by the type of procedure (KJ, DIDT, TQ). However, knee flexion was influenced by the association of external plasty, which slowed flexion gain by one to 2 weeks compared with DIDT or KJ alone. This is explained by the trophic and analgesic consequences of the associated extra-articular procedure [14].

DIDT and TQ cause less pain than KJ, as confirmed by our clinical experience. In a study carried out by Feller et al(10), pain was less frequent in the DIDT group at 2 weeks post-operatively, while at 8 weeks post-operatively there was no difference between the two techniques. Rose et al[11] found less pain in the DIDT group at 6 and 12 weeks post-operatively.

Quadriceps amyotrophy is all the greater when the transplant has been taken at the expense of the extensor system (KJ, TQ). Gradually, the deficits are reduced, in parallel with the resumption of physical activity and then sport [15,16].

Our clinical experience supports this observation. According to several authors, the resumption of sporting activity is not modified by the surgical technique adopted. In our series, the rate of return to sport was equivalent between the 3 groups DIDT, KJ, TQ [17,19].

5. Conclusion

The 3 techniques (KJ, DIDT and TQ) give comparable long-term results and no graft shows a clear advantage. However, the early post-operative effects, which differ from one technique to another, may constitute an interesting criterion in the choice of the type of ligamentoplasty, although there does not appear to be any obvious difference.

Indeed, an a la carte ACL requires surgeons to master several techniques at the same time, in order to choose the right implant according to age, sex, activities, history and associated injuries.

However, our relatively short follow-up period and small sample size are not sufficient to draw firm conclusions. The measurement of preoperative and postoperative laximetry using a laximeter (KT-1000) represents an objective assessment of the outcome of surgery, which is necessary to demonstrate the superiority of one technique over another.

Based on the results of this work, we recommend the DIDT technique for children and elderly subjects, DIDT or TQ for knee patients, combined plasty for at-risk patients with chronic laxity and in high-level athletes, and the TQ technique for revisions.

This work could be used as a basis for a study with more hindsight and a larger sample size.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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