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Original Scientific Paper

A NEW TECHNIQUE FOR COMBINED ANTERIOR CRUCIATE AND ANTEROLATERAL LIGAMENT RECONSTRUCTION USING QUADRICEPS AND PLANTARIS TENDONS

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SUMMARY – Anterior cruciate ligament (ACL) reconstructions with quadriceps tendon (QT) grafts are gaining popularity, both in primary and revision procedures. Recently, the role of the anterolateral ligament (ALL) of the knee in improving rotational knee stability has been emphasised and concurrent ACL and ALL reconstruction is advocated. In this paper, a new technique utilising the QT and the plantaris tendon (PLT) for combined ACL and ALL reconstruction is analysed. Patients that underwent combined ACL and ALL reconstruction using QT and PLT grafts in a 3-years period were prospectively analysed. A total of 9 patients with 6 months minimum follow-up were assessed with Lachman and Pivot shift clinical tests, International Knee Documentation Committee (IKDC) score, Knee injury and Osteoarthritis Outcome Score (KOOS), Lysholm score, and Tegner activity scale. One patient had reconstructed ACL re-rupture at the final follow-up visit, leaving 8 patients with a mean follow-up of 19±8 months. There was a significant improvement in anteroposterior and rotational stability in all the patients. The IKDC, KOOS, and Lysholm scores improved as well. The Tegner activity scale increased postoperatively, however, it did not reach preinjury values. QT and PLT grafts are valuable alternatives for currently used grafts in combined ACL and ALL reconstructive procedures. This new technique is a reasonable option in ACL revision surgery and a good alternative in primary ACL and ALL reconstruction, especially when hamstring grafts are not advised or they are missing.

Keywords: *Anterior cruciate ligament, Anterolateral ligament, Quadriceps tendon, Plantaris tendon*

INTRODUCTION

Combined reconstruction of the anterior cruciate ligament (ACL) and anterolateral ligament (ALL) is a reasonable option for patients with symptomatic ACL-deficient knees[1]. The indications are well described and different surgical techniques using various grafts are available[2]. The majority of these techniques utilise hamstring tendon autografts[3]. On the other hand, the QT graft has become very popular in ACL reconstruction, especially in ACL revision procedures[4]. Furthermore, in the case of ACL revision, it is strongly recommended to perform concomitant reconstruction of the ALL[5]. However, techniques of combined ACL and ALL reconstruction using QT are scarce[6]. For this reason, we developed a new

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technique of combined ACL and ALL reconstruction utilising QT and plantaris tendon (PLT) grafts. In this study, a new surgical technique of combined ACL and ALL reconstruction is introduced, and clinical outcomes, as well as the patients' subjective outcomes, are presented.

MATERIALS AND METHODS

Patients that underwent combined ACL and ALL reconstruction for primary or revision procedure using QT and PLT from March 2019 to March 2022 were prospectively analysed. All patients had a documented history of knee injury and clinically verified ACL-deficiency. Magnetic resonance imaging (MRI) of the knee was mandatory for the confirmation of the ACL rupture and, in cases of revision surgery, the characteristics of prior femoral and tibial tunnels. Also, MRI was used to identify PLT, since PLT has an absence rate of 9% in the Croatian population[7,8]. Preoperatively, Lachman and Pivot shift tests were documented, and patients were assessed with KOOS score, IKDC evaluation form, Lysholm score and Tegner activity scale.

Surgical technique

All surgeries were performed in a single orthopaedic institution by two senior orthopaedic surgeons using the same surgical procedure. First, the PLT was harvested through the proximal approach as previously described and a minimum of 30 cm of tendon length was considered adequate for the success of the procedure[2,9] (Figure 1). The QT graft was harvested through a longitudinal skin incision beginning at the base of the patella or a transverse skin incision 1 cm proximal to the base of the patella. A 2/3 tendon thickness, 10 mm wide and 8 to 9 cm long QT graft with or without bone block from the patella was retrieved (Figure 2).

The ACL-ALL graft was prepared on a separate table (Figure 3). Free ends of the QT and PL grafts were sutured with nonabsorbable sutures each (#2 Fiberwire, Arthrex). Next, PLT was folded in two and doubled PLT graft was sutured on the femoral side of the QT graft with absorbable sutures (#2-0 Vycril, Ethicon).

Arthroscopy was performed in a standard fashion addressing any additional pathology. The common ACL-ALL femoral tunnel was prepared in an outside-in manner taking care of proper positioning of

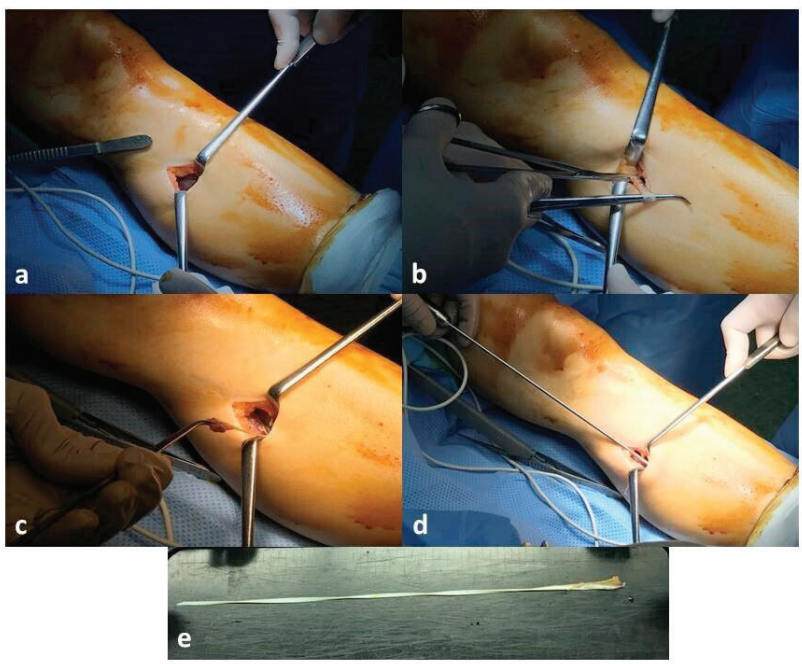

Figure 1. Intraoperative images of the PLT harvesting through proximal approach (a). The PLT is identified between the soleus and gastrocnemius muscles, pulled out and cut at the myotendinous junction (b). The PLT is then bluntly mobilised in the distal direction (c) and harvested with a closed tendon striper (d). Final PLT specimen (e).

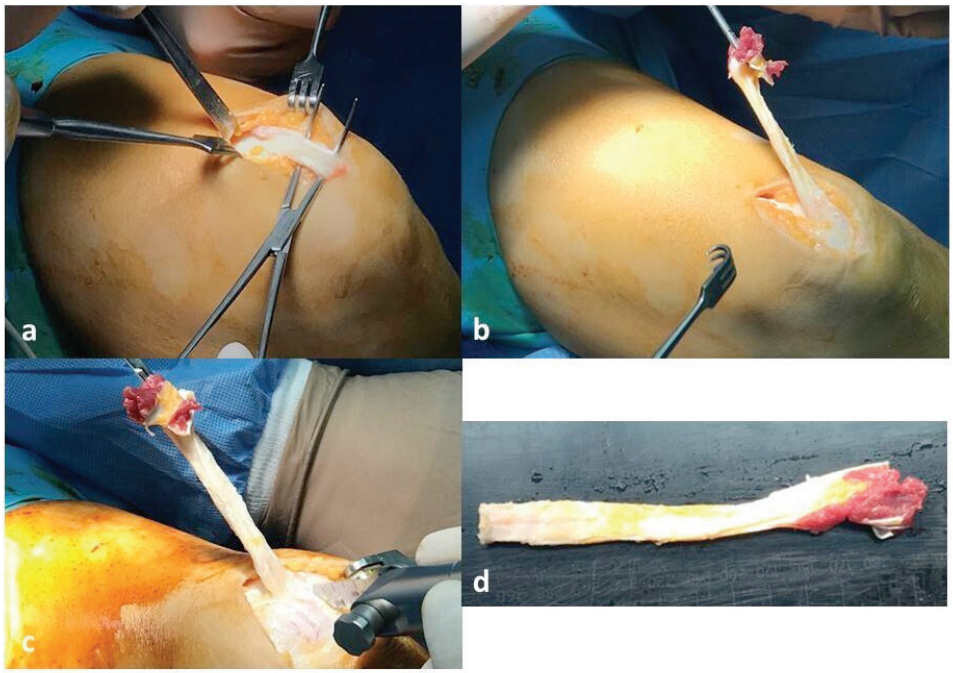

Figure 2. Intraoperative images of the QT harvesting through a longitudinal skin incision. Two 10 mm wide longitudinal incisions are made in the middle third of the QT tendon and a superficial 2/3 of the tendon is identified (a). The QT graft is cut proximally through stab incision (b) with a bone block from the proximal part of the patella (c). Final QT specimen (d).

Figure 3. Final ACL-ALL graft construct. The ACL graft is made of QT and the ALL graft is made of PLT. The PLT is secured with sutures on the femoral side of the ACL graft. Both grafts share a common femoral tunnel.

the tunnel entrance for the ALL femoral footprint approximately 5 mm proximal and 5 mm posterior to the lateral femoral epicondyle and tunnel exit on the inner wall of the lateral femoral condyle at the centre of the ACL femoral footprint. The ACL tibial tunnel was also drilled in an outside-in manner aiming for the ACL tibial footprint. Finally, the ALL tibial tunnel was prepared through one stab incision midway through Gerdy's tubercle and fibular head and 1 cm distal to the joint line[3]. The ACL-ALL graft was passed through the ACL femoral tunnel into the ACL tibial tunnel with the remaining portion of the doubled PLT graft remaining outside the femoral tunnel. The common ACL-ALL graft was secured in the common femoral tunnel with an interference screw (BioComposite Interference Screw, Delta, Arthrex). The ACL graft was secured in the tibial tunnel with the interference screw (BioComposite Interference Screw, Delta, Arthrex) and the knee in 20° of flexion. The ALL graft consisting of the doubled PLT graft was passed below the iliotibial band, through the ALL tibial tunnel, and secured under tension with an interference screw (BioComposite Interference Screw, Delta, Arthrex) and the knee locked in full extension. There was no drainage and no bracing after the surgery.

Postoperative follow-up

The patients were advised to follow certain general rehabilitation guidelines but there was no strict rehabilitation protocol imposed.

Each patient was scheduled for visits 2 weeks, 2, 4, and 6 months after the surgery and at the final follow-up. Lachman and Pivot shift tests were documented on each visit and the KOOS score, IKDC evaluation form, Lysholm score, and Tegner activity scale were evaluated at the time of the final follow-up visit.

RESULTS

There were a total of 9 patients that underwent combined ACL and ALL reconstruction using QT and PLT, (4 female), with the mean age of 27 years (± 9.5 SD). For eight patients this procedure was revision ACL surgery. The mean follow-up was 19 months (± 8 SD) (Table 1.).

The mean ACL graft diameter was 9 mm (± 1 SD) and the mean ACL graft length was 9 cm (± 1 SD). The mean PLT length was 33 cm (± 4 SD) (Table 2.).

Preoperatively, 3 (33,3%) patients had grade 2 Lachman test and 6 (66,7%) patients had grade 3 Lachman test. Furthermore, 3 (33,3%) patients had grade 2 Pivot shift test and 6 (66,7%) patients had grade 3 Pivot shift test. At the six month visit 8 (88,9 %) patients had grade 0 Lachman test and 1 (11,1 %) patient had grade 1 Lachman test (Table 2.). At the same visit, all patients had grade 0 Pivot shift test. One patient had a knee injury one year after surgery and verified ACL re-rupture and for that reason did not complete outcome scores at the time of the final follow-up. The rest of the patients had the values of

Table 1. Details of patients included in this report.

Patient	Sex	Age (at time of surgery)	Type of procedure	Follow up in months
1	F	28	revision	30
2	F	23	revision	28
3	F	15	revision	28
4	M	24	revision	20
5	M	42	revision	19
6	F	22	revision	19
7	M	38	revision	18
8	M	18	primary	6
9	M	37	revision	6

Table 2. Results of clinical tests and graft characteristics of each patient.

Patient	Lachman test		Pivot shift test		QT graft length (in cm)	QT graft diameter (in mm)	PLT length (in cm)
	Preoperative	Postoperative	Preoperative	Postoperative			
1	3	0	3	0	11	9	30
2	3	0	3	0	12	8	31
3	3	0	3	0	11	8	30
4	2	0	3	0	9	7.5	30
5	3	0	3	0	8	9.5	34
6	3	0	2	0	9	9.5	34
7	2	0	2	0	9	10	33
8	2	0	2	0	9	10	42
9	3	1	3	0	8	7,5	36

Lachman and Pivot shift tests documented six months after surgery at the time of the final follow-up.

There was an increase in mean overall KOOS score from 58 (± 13 SD) to 71(± 21 SD). The IKDC score increased from an average of 52 (± 14 SD) to 68 (± 12 SD) and Lysholm score increased from an average of 62,5 (± 8 SD) to 76,1 (± 15 SD). The preinjury Tegner activity scale score was 8 on average (± 1 SD) and decreased to 3 on average (± 2 SD) after the injury. At the final follow-up the average, the Tegner activity scale score was 5 (± 1 SD).

DISCUSSION

Objective and subjective results of this study demonstrate that combined ACL and ALL reconstruction using QT and PLT is a valuable procedure in restoring anteroposterior and rotational knee stability in primary and revision ACL surgery.

Although ACL revision surgery is well documented and discussed, combining ALL reconstruction in this procedure has recently been advised[10]. However, combining ACL revision surgery using QT and ALL reconstruction using PLT tendon has not been described yet.

The QT is gaining popularity in both primary and revision ACL surgery because its clinical and outcome results are comparable to those of hamstrings grafts[11]. The QT graft has better biomechanical properties than the bone-patellar tendon-bone (BTB) graft, with the QT maximum load to failure of 2185,9 N (± 758,8 SD), compared to the BTB graft maximum load to failure being 1580,6 N (± 479,4 SD)[12]. The QT graft can be obtained either with a bone block from the patella or without it and with full or partial thickness of the tendon[13,14]. In this study, we used a partial thickness QT graft since there is no significant difference in outcomes and complication rates between partial and full thickness QT grafts[15].

The plantaris muscle is considered rudimentary and unlike other tendon grafts, taking PLT has almost no effect on knee function. PLT is the longest tendon in the human body and it has been used as a graft in different reconstructive procedures[16]. Recently, doubled PLT has been described as the ALL graft in concomitant procedure with ACL reconstruction using tripled semitendinosus graft[22]. The PLT has excellent biomechanical properties, studies have shown that the mean maximal force of a single strand PLT is between 161 and 197 N[17,18]. More recently, we published a biomechanical study of doubled PLT with a mean maximal force of 220.3 ± 108 N[19,20]. When compared with biomechanical properties of native ALL with a mean load to failure of about 180 N, the biomechanical properties of doubled PLT seem sufficient to replace it as a reconstruction graft[20-22].

In this study, the majority of the patients preoperatively had severe anteroposterior instability (grade 3 Lachman test) and severe rotational instability (grade 3 Pivot shift test) all of which were successfully resolved by using QT and PLT for combined ACL and ALL reconstruction Although our follow up time is short, at the end almost all patients had no anteroposterior instability with negative Lachman tests in 8 patients. More importantly, there was almost no rotational instability at the end of follow up with negative Pivot shift tests in 8 patients. We believe this is due to the addition of the ALL in the reconstruction procedure.

The described technique is also suitable for patients undergoing primary ACL reconstruction when the use of hamstrings tendons is not recommended due to various reasons [23,24]. In the present study, one patient participated in judo, a sport where strong knee flexors have an important role in grappling techniques, and therefore hamstrings tendons were not suitable for ACL and ALL grafts. Moreover, since hamstrings are agonists of ACL, using QT and PLT as grafts in such primary ACL reconstruction procedures enables intact hamstrings to protect the ACL graft[25].

In ACL revision procedures, QT is the best graft choice if primary reconstruction used either hamstrings tendons or BTB graft. In this way, the use of contralateral autografts or allografts is avoided. In the present study, 8 patients had revision ACL reconstruction, combined with ALL reconstruction, after failed primary ACL reconstruction with hamstrings tendons. The mean QT graft diameter in the study was 9 mm which is the size of the graft large enough to be placed even in enlarged bone tunnels usually encountered after hamstrings graft reconstruction. Moreover, there was no need for additional surgery and filling of bone tunnels. Since hamstring tendons have been utilised in primary ACL reconstruction, adding PLT solves the graft source for ALL reconstruction in these cases.

The limitation of this study is the small number of patients with the outcomes presented through subjective tests; therefore, we cannot give definitive remarks regarding the safety or the efficacy of using QT and

PLT autografts for combined ACL and ALL reconstruction. Another limitation is a short follow-up period. However, we believe that the present study is justified based on a need for new approaches when it comes to tendon autografts for ACL revision surgeries.

It can be concluded that the combination of QT and PLT in ACL and ALL reconstruction provides a strong graft construct with good biomechanical properties for both ACL and ALL. According to our results, this is an effective procedure that restores anteroposterior and rotational knee stability in primary and revision ACL surgery.

ACKNOWLEDGMENTS

None.

LIST OF ABBREVIATIONS

ACL – anterior cruciate ligament
ALL – anterolateral ligament
BTB – bone-patellar tendon-bone
IKDC - International Knee Documentation Committee
KOOS - Knee injury and Osteoarthritis Outcome Score
MRI – magnetic resonance imaging
PLT - plantaris tendon
QT – quadriceps tendon
SD – standard deviation

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

CONSENT FOR PUBLICATION

This manuscript has consent of all patients for the use of their data and images. The authors obtained the written consent of all patients for the publication of the data and images that appear in the article.

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Sažetak

REKONSTRUKCIJA PREDNJEG KRIŽNOG LIGAMENTA I ANTEROLATERALNOG LIGAMENTA KOLJENA TETIVAMA KVADRICEPSA I PLANTARISA

M. Josipović, J. Vlaić, J. Serdar, I. Levaj, M. Šimunović, D. Nizić i M. Jelić

Rekonstrukcija prednjeg križnog ligamenta (ACL) presatkom tetive kvadricepsa (QT) kod primarnih i revizijskih zahvata postaje sve učestalija. Nedavno je istaknuta uloga anterolateralnog ligamenta (ALL) u poboljšanju rotacijske stabilnosti koljena te se zagovara istodobna rekonstrukcija ACL-a i ALL-a. U ovom radu analizirana je nova kirurška tehnika kombinirane rekonstrukcije ACL-a i ALL-a koja koristi QT i tetivu plantarisa (PLT). Prospektivno su praćeni pacijenti kojima je učinjena udružena rekonstrukcija ACL-a i ALL-a presadcima QT i PLT u razdoblju od 3 godine. Ukupno je analizirano 9 pacijenata s minimalno 6 mjeseci praćenja. Koristili su se klinički testovi Lachman i Pivot shift te upitnici procjene ishoda: *International Knee Documentation Committee (IKDC), Knee injury* and *Osteoarthritis Outcome Score (KOOS)*, Lysholm i Tegnerova ljestvica aktivnosti. Kod svih pacijenata je došlo do značajnog poboljšanja u anteroposteriornoj i rotacijskoj stabilnosti. Rezultati IKDC, KOOS i Lysholm upitnika također su se poboljšali. Tegnerova ljestvica aktivnosti se postoperativno poboljšala, ali nije dosegla vrijednosti prije ozljede. Jedan je pacijent zadobio rerupturu ACL-a u vrijeme posljednjeg pregleda, ostavljajući 8 pacijenata s prosječnim praćenjem od 19±8 mjeseci. Presadci QT i PLT vrijedna su alternativa za trenutno korištene presatke u zahvatima udružene rekonstrukcije ACL-a i ALL-a. Ova nova tehnika razumna je opcija u revizijskim zahvatima rekonstrukcije ACL-a i dobra alternativa u primarnoj rekonstrukciji ACL-a i ALL-a, osobito kada se ne preporuča koristiti tetive fleksora koljena ili one nedostaju.

Ključne riječi: *prednji križni ligament, anterolateralni ligament, tetiva kvadricepsa, tetiva plantarisa*