Difference of ligamentization according to graft type after anterior cruciate ligament reconstruction: Quantitative assessment using Ultra short eho time-T2* mapping

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INTRODUCTION:

The semitendinosus tendon (ST) is often used as a graft for anterior cruciate ligament (ACL) reconstruction; however, in pediatric cases, maturation of the grafted tendon is delayed, and the reoperation rate is higher than that in adults. Recently, the quadriceps tendon (QT) has attracted considerable attention. In our previous research, the QT was characterized by a high failure load and had a significantly higher collagen fibril diameter among pediatric patients than the ST. QT has been reported to have various advantages as a tendon graft for use in ACL reconstruction.

The graft may gradually become a ligament, and multiple phases occur in stages in a complex manner. However, whether ligamentization in the QT compared to ST grafts differs remains unclear. Although magnetic resonance imaging (MRI) is the mainstream method for observing ligamentization, we focused on an imaging method called Ultra short echo time (UTE)-T2*mapping that has recently attracted attention. The relaxation time T2* should reflect the T2* relaxation of collagen-bound water in tendons and ligaments and is ideal for capturing tissue changes in the ligamentization of reconstructed ACLs. By acquiring multiple echoes, we can evaluate the UTE-T2* relaxation time of tendons and ligaments, which cannot be evaluated by conventional MRI based on gradient echo because the T2* value of collagen-bound water is less than submilliseconds. Therefore, the UTE T2* technique is an excellent tool for observing ligamentization of reconstructed ACL.

In our previous studies, the T2* value increased rapidly up to 6 months postoperatively and then decreased slowly after peaking (11.9 ± 2.4 ms).

We hypothesized that the use of QT grafts would lead to faster tissue maturation than that of ST grafts. This study aimed to investigate any differences in ligamentization between the groups using ST and QT for grafts after ACL reconstruction by UTE-T2*mapping.

METHODS:

Our Medical Ethics Review Committee approved this study. Patients who underwent ultrashort echo time-MRI after primary ACL reconstruction between 2019 and 2022 were included in this study. The patients were divided into two groups with eight patients comprising each group as follows: ST group (10 women; average age 18.4 ± 4.5 years) and QT group (4 men, 6 women; average age 19.0 ± 10.8 years).

All the patients were treated by a single orthopedic surgeon. In all cases, the graft was created using a single bundle of the quadriceps, semitendinosus, semitendinosus, and gracilis tendons. A femoral tunnel was created at the center of the anatomical ACL footprint using the inside-out method with an original rounded rectangular dilator. The tunnel on the tibial side was created in a circular shape at the center of the anatomical ACL footprint. The femoral side of the graft was fixed using a cortical device (Tight Rope, Arthrex, USA). After the graft was pretensioned several times, the tibial side was fixed with a tibial fixation implant (Tension-Loc; Arthrex, USA). All patients underwent rehabilitation using a standardized postoperative protocol.

The slices in the UTE-T2* map for measuring the T2* values were selected by referring to the slices in which the reconstructed ACL was more distinct on the oblique sagittal T2-weighted image. The UTE-T2* values for the intra-articular region of the reconstructed ACLs were measured at the proximal, middle, and distal sites based on the method previously reported by Okuda et al. The values for the intraosseous regions of the reconstructed ACLs were measured at one site each in the tibia and femur. One orthopedic surgeon used a 5-mm^2 circle to manually segment the regions of interest within areas unaffected by artifacts. All measurements were performed three times, and the average value was used as the UTE-T2* value for each region.

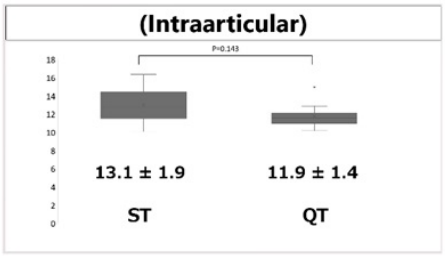
The Mann–Whitney U test was used to compare the T2* values of the QT and ST groups. Statistical significance was set at $P < 0.05$.

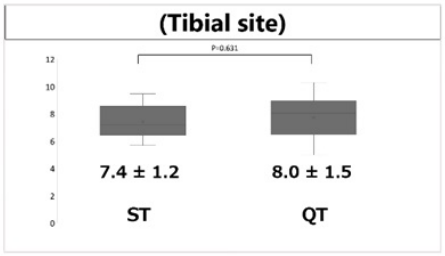
RESULTS:

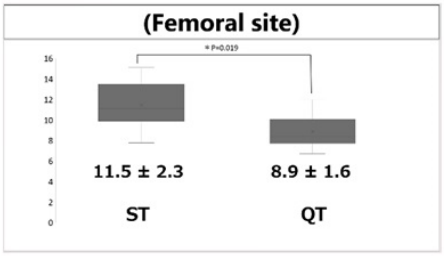
In the ST group, the UTE-T2* values 6 months postoperatively were 13.1 ± 1.9 ms (intra-articular region), 7.4 ± 1.2 ms (tibial site), and 11.5 ± 2.3 ms (femoral site), while those in the QT groups were 11.9 ± 1.4 ms (intra-articular region), 8.0 ± 1.5 ms (tibial site), and 8.9 ± 1.6 ms (femoral site). The QT group had significantly lower values within the femoral tunnel (P=0.019).

DISCUSSION AND CONCLUSION:

At 6 months after ACL reconstruction, the T2* values in the QT group were lower than those in the ST group within the femoral tunnel. This suggests that QT may accelerate ligamentization within the femoral tunnel.


(Intraarticular)
P=0.143
18
16
14
12
10
8
6
4
2
0
13.1 ± 1.9
11.9 ± 1.4
ST
QT


(Tibial site)
P=0.631
12
10
8
6
4
2
0
7.4 ± 1.2
8.0 ± 1.5
ST
QT


(Femoral site)
* P=0.019
16
14
12
10
8
6
4
2
0
11.5 ± 2.3
8.9 ± 1.6
ST
QT