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Comparison of collagen-type composition by layer and physical maturity in quadriceps tendon

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There is no COI to disclose for this presentation.

Introduction

- Using quadriceps tendon (QT) as the autograft has been attracting to reduce the re-operation rate after anterior cruciate ligament (ACL) reconstruction.

- Since the QT anatomically has a three-layered structure, there are two options when selecting the autograft: partial harvest of first and second layers of full harvest of all layers.

- The postoperative results of using a partial- or full-layer QT as the autograft are controversial.

- The percentage of type I collagen, the main component of tendon tissue, is related to the physical strength.

Purpose

To reveal the differences in collagen content by layer and physical maturity in the QT.

Materials and Methods

63 QT samples of 21 patients

- who undergone knee surgery
- with agreement for this study

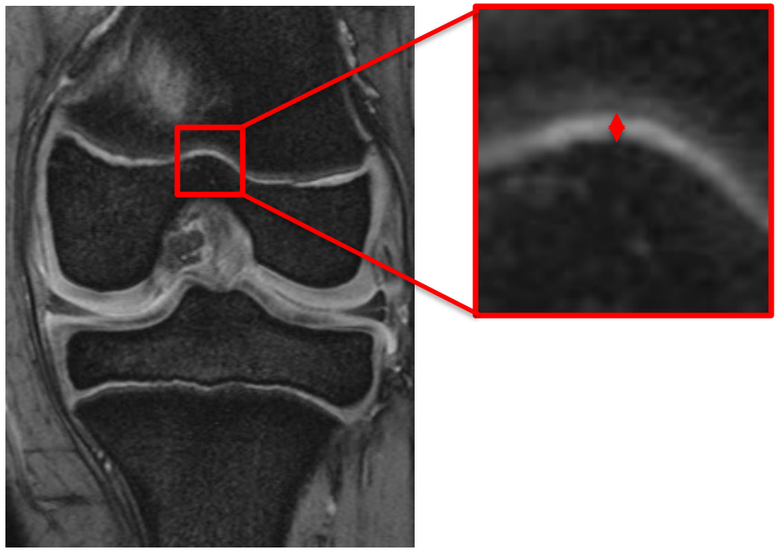
> 20 years

< 20 years

EP > 1.5 mm

EP < 1.5 mm

EP: epiphyseal patency



EP was measured at distal mid femur in coronal section of MRI.

immature group

12 QT samples of 4 patients

- 11.5 ± 2.9 years
- 3 males and 1 female

young group

24 QT samples of 8 patients

- 15.9 ± 1.9 years
- 6 males and 2 females

adult group

27 QT samples of 9 patients

- 34.3 ± 11.4 years
- 8 males and 1 female

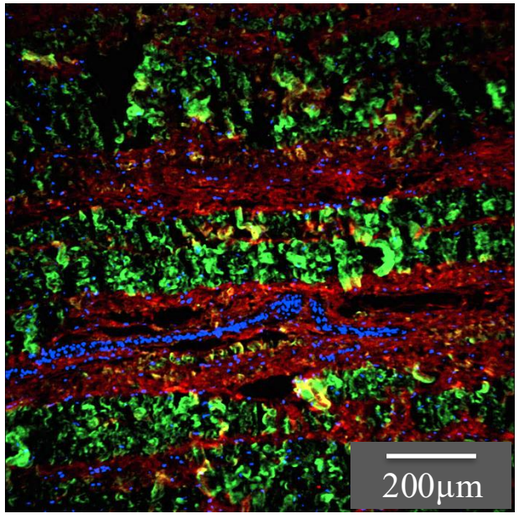
Materials and Methods

☐ Immunostaining and confocal microscopy

- ✓ Type I and type III collagen were immunostained in green and red, respectively.
- ✓ The observation was conducted using confocal microscopy.

☐ Quantitative evaluation and statistical analysis

- ✓ The area occupied by type I and type III collagen was measured, and the positive area ratio was calculated using image analysis software (type I + type III = 100 %).
- ✓ Comparisons between and within groups were made using one-way ANOVA, Kruskal-Wallis test, and Friedman test.



type I

type III

DAPI

Results

	immature	young	adult	*p* value		
				immature vs. young	immature vs. adult	young vs. adult
Sex (male:female)	3:1	6:2	8:1	1.000	1.000	0.577
Age (years)	11.5 ± 2.9	15.9 ± 1.9	34.3 ± 11.4	0.634	< 0.001	< 0.001
Height (cm)	149.4 ± 20.7	165.8 ± 8.4	172.0 ± 2.9	0.074	0.009	0.541
Weight (kg)	41.2 ± 15.8	60.1 ± 7.9	75.1 ± 13.2	0.106	0.037	0.147

Results

Group	immature	young	adult	*p* value (between group)
1st layer	98.5 (96.3-100.0)	85.2 (68.6-98.3)	89.9 (74.5-98.5)	0.098
2nd layer	94.6 (79.4-100.0)	76.5 (55.0-92.5)	84.6 (53.0-99.4)	0.068
3rd layer	76.6 (7.4- 99.9)	73.6 (48.8-98.9)	89.0 (76.2-99.3)	0.076
***p* value (between layer)**	0.526	0.212	0.895	

There is no differences in collagen contents of the QT by the layer or patient's physical maturity.

Discussion

- Correlation between the collagen composition of tendon tissue used as autografts in ACL reconstruction and postoperative re-injury has attracted attention.

- Type I collagen is mechanically strong, and a high content of it indicates greater overall tissue strength.
  - Based on the results of this study,
    QT may not differ in mechanical strength by layer or patient's physical maturity.

- In a systematic review, both full and partial thickness of QT autografts were effective for ACL reconstruction with comparable postoperative outcomes.
  - The trend was similar to that inferred from the results of this study.

Discussion

- Improvement of knee extensor strength is important for return to sports after ACL reconstruction.

- Improvement in knee extensor strength after reconstruction with full-thickness QT is poorer than with partial-thickness QT.

For a safe return to sports, we need to look at factors other than the characteristics of the autografts.

Limitations

- The sample size was small, and many samples were obtained from males.
- The relationship between the results of mechanistic tests and actual clinical outcomes and collagen composition is unknown.
- Failure to consider the process of ligamentization that occurs after ACL reconstruction.
- The obtained samples were taken from a different site than the parenchyma of the autografts.

Conclusion

No differences in collagen content in the QT were apparent between the layer or patients' physical maturity.

References

1. Cordasco FA, et al. Quadriceps tendon anterior cruciate ligament reconstruction in skeletally immature patients: 3-year clinical and patient-reported outcomes. Am J Sports Med. 2024;52:2230-6.
2. Gagliardi AG, et al. Outcomes of quadriceps tendon with patellar bone block anterior cruciate ligament reconstruction in adolescent patients with a minimum 2-year follow-up. Am J Sports Med. 2020;48:93-8.
3. Harris NL, et al. Central quadriceps tendon for anterior cruciate ligament reconstruction. Am J Sports Med. 1997;25:23-8.
4. Lippe J, et al. Anatomic guidelines for harvesting a quadriceps free tendon autograft for anterior cruciate ligament reconstruction. Arthroscopy. 2012;28:980-4.
5. Slone HS, et al. Quadriceps tendon autograft for anterior cruciate ligament reconstruction: a comprehensive review of current literature and systematic review of clinical results. Arthroscopy. 2015;31:541-54.
6. Engel J. Versatile collagens in invertebrates. Science. 1997;277:1785-6.
7. Asai K, et al. Differences in cellular and microstructural properties of the semitendinosus muscle tendon between young and adult patients. J Orthop Sci. 2022;27:478-85.
8. Kimura M, et al. Growth-related changes in the ultrastructure of the quadriceps tendon. Knee. 2023;42:357-63.
9. Dedouit F, et al. Age assessment by magnetic resonance imaging of the knee: a preliminary study. Forensic Sci Int. 2012;217:232.e1-7.
10. Yoshioka K, et al. Endothelial PI3K-C2α, a class II PI3K, has an essential role in angiogenesis and vascular barrier function. Nat Med. 2012;18:1560-9.
11. Mizuno Y, et al. Differences in collagen types in the semitendinosus, quadriceps, and patellar tendons: A report using samples from an 11-year-old patient. Knee. 2023;42:339-46.
12. Mizuno Y, et al. Collagen-type composition in the semitendinosus, quadriceps, and patellar tendons of a 22-year-old patient: A case report. Cureus. 2024;16:e61324.
13. Mizuno Y, et al. One-year changes in collagen type in semitendinosus tendons: A case study using tissues obtained from a growing patient. Cureus. 2024;16:e67564.
14. Ajay C, et al. No difference between full thickness and partial thickness quadriceps tendon autografts in anterior cruciate ligament reconstruction: a systematic review. Knee Surg Sports Traumatol Arthrosc. 2019;27:105-16.
15. Rosalia L, et al. Impact of Quadriceps Tendon Graft Thickness on Electromechanical Delay and Neuromuscular Performance After ACL Reconstruction. Orthop J Sports Med. 2023;11:23259671231201832.