

# Vascularity Assessment of Quadriceps Tendon Donor Site After Anterior Cruciate Ligament Reconstruction Using Ultrasound with Superb Microvascular Imaging (SMI)

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**INTRODUCTION:** Quadriceps tendon (QT) is an increasingly popular graft choice for anterior cruciate ligament reconstruction (ACL-R) <sup>1</sup>. Ultrasound with Superb Microvascular Imaging (SMI) is a novel microvascular imaging technology capable of visualizing a slower and smaller blood flow relative to conventional doppler modalities. Evaluation of vascularity has been performed to assess the healing response <sup>2</sup>. Therefore, vascularity assessment using SMI would be helpful to understand the healing response of QT donor site after ACL-R. The objectives of this study were 1) to assess the vascularity changes of QT donor site and compare to the contralateral, nonoperative site, 2) to assess and compare healing responses of different areas of QT donor site following ACL-R at various pre- and postoperative timepoints.

**METHODS:** Patients who were pre- and post ACL-R using QT autograft were included in this study. Those who had contralateral ACL-R using QT autograft and had additional surgery for meniscal pathology or manipulation following primary ACL-R, were excluded. Ultrasound examination was performed before ACL-R, and 2, 4, 6, 9, 12, and 24 months after ACL-R using a 18-5 MHz linear ultrasound transducer (Aplio i800, Canon medical systems, Japan). Participants were positioned supine with the knee at 20° of knee flexion. Short axis images of QT were acquired at 0, 15, 30, and 45 mm proximal to the superior pole of the patella. QT vascularity was assessed using SMI (Figure 1). To quantify the amount of the vascularity signal within the QT, the area ratio of the vascular signal was evaluated with respect to the total area of QT using Image J software <sup>3</sup>. QT vascularity ratio between donor and contralateral sites was compared using Wilcoxon signed-rank test. Vascularity ratio among each timepoint or each assessment location was compared using a Friedman test or a Kruskal-Wallis test followed by Bonferroni correction for post-hoc analysis. Statistical significance was set at  $p < 0.05$ .

**RESULTS:** No QT defects were observed at any timepoints and no QT ruptures occurred during study period. In total, 70 pre- and postoperative timepoints of 42 individuals (22 male, 20 female) with a mean age of  $25.1 \pm 7.6$  years were included for analysis. Contralateral limb had almost no vascularity signal at any timepoint. No significant difference between donor and contralateral sides was seen preoperatively and 24 months postoperatively. Significantly greater vascularity within the donor site was observed compared to contralateral, nonoperative QT at 2 months (all assessment locations), 4 months (all assessment locations), 6 months (0, 15, and 30 mm proximal to the superior pole of the patella), 9 months (0 mm), and 12 months (0 and 15 mm) following ACL-R. Vascularity ratio 6 to 12 months after ACL-R was greater at 0 or 15 mm than at 30 and/or 45 mm proximal to the superior pole of the patella (Figure 2). In addition, vascularity ratios 4 months after ACL-R were significantly greater than other timepoints (Figure 3).

**DISCUSSION:** The most important finding of this study was that vascularity near proximal patellar was observed up to 12 months postoperatively and QT donor site completely healed 24 months after ACL-R. Surgeons may consider careful closure of the donor site defect especially near the proximal pole of the patella. Furthermore, greatest vascularity was seen 4 months after ACL-R. According to literature on patellar tendon donor site, vascularity 2 months after ACL-R was greater than other timepoints by conventional Doppler ultrasound <sup>2</sup>. Although SMI was not used in the literature, QT donor site may heal slower than patellar tendon donor site. However, QT has been known to have less donor-site pain than patellar tendon <sup>4</sup>. Donor site vascularity may not be correlated with donor site pain. Furthermore, QT donor site may be most vulnerable up to 4 months postoperatively, surgeons may use their own judgement when utilizing e.g., biodex system postoperatively.

**SIGNIFICANCE/CLINICAL RELEVANCE:** Healing response near proximal patella was seen up to 12 months postoperatively and QT donor site completely healed 24 months after ACL-R. SMI was useful in assessing the healing response of QT donor site after ACL-R.

## REFERENCES:

1. Winkler, et al. KSSTA 2022.
2. Seijas, et al. KSSTA 2015.
3. Takeuchi, et al. KSSTA 2021.
4. Mouarbes, et al. AJSM 2019.

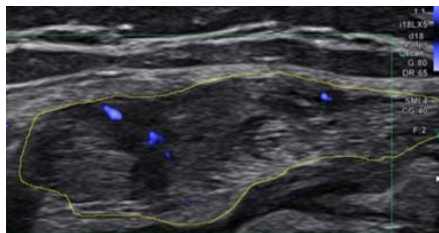


Figure 1. Vascularity assessment of the quadriceps tendon (QT) using superb microvascular imaging (SMI). SMI illustrates vascularity signals (blue area) within the QT (yellow line). Peritendinous structure was excluded in this study. The amount of the vascular signal was assessed using a quantified ratio of vascularized area with respect to total area of QT (vascularity ratio).

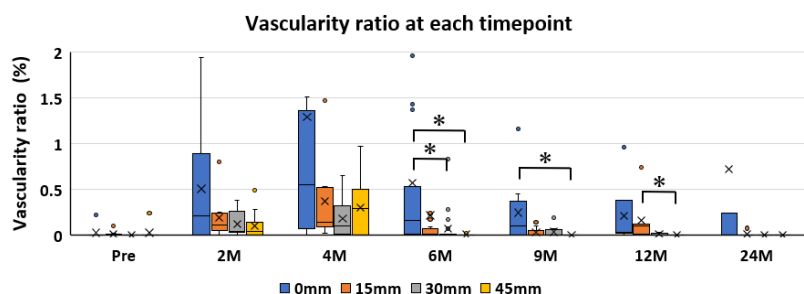


Figure 2. Vascularity ratio at each timepoint. \*: significant difference ( $p < 0.05$ ).

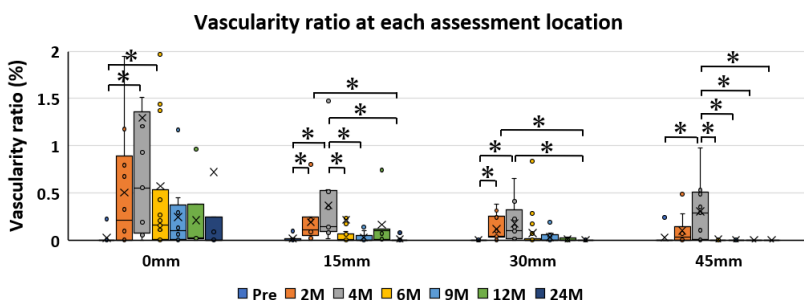


Figure 3. Vascularity ratio at each assessment location. \*: significant difference ( $p < 0.05$ ).