Reliability and Repeatability of Diffusion Tensor Imaging (DTI) Scalar Metrics in Pathological Patellar Tendons

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Summary

DTI may hold promise for capturing pathological changes in patellar tendons. Inter-rater reliability of DTI was found to be excellent. Between-day repeatability in pathological tendons, however, requires further study prior to implementation.

Introduction

Patellar tendinopathy and bone-patellar tendon-bone autograft (BPTB) harvest for anterior cruciate ligament reconstruction are tendon injuries that impact long-term knee health [1,2]. Diffusion tensor imaging (DTI) is a non-invasive magnetic resonance imaging (MRI) based approach with the potential to assess tendon microstructure, offering further insights into tendon pathophysiology and its clinical relevance. This study aims to determine the inter-rater reliability and test-retest repeatability of DTI metrics in pathological (PATH) and contralateral (CON) patellar tendons.

Methods

Ten participants (5 patellar tendinopathy [25.6(6.2) yrs, 74.5(14.3) kg, 1.7(0.12) m] 5 BPTB [22.8(1.7) yrs, 71.2(11.9) kg, 1.7(0.12) m, 24.6(19.9) months since surgery]) received two bilateral knee MRI scans (3T SIGNA Premier, GE 18-channel transmit/receive knee coil) within a 7-day period. 3D CUBE proton density weighted images (0.5^3 mm^3 isotropic resolution, TR/TE = 1000/33.1 ms) and DTI (SE-EPI, axial oblique aligned with tendon, 1.5×1.5 mm^2 resolution, 3 mm thickness, TR/TE = 4008/60.8 ms, b = 800s/mm^2, 30 encodings, four B=0, 2 averages, AIR Recon DL processing (high)) were acquired. Preprocessing and linear tensor fitting were performed. Two raters segmented the day-1 scans, and one rater segmented the retest scans. The tendon was then trisected into medial, lateral, and central regions of equal width, and axial diffusivity (λ_1), mean diffusivity (MD), and fractional anisotropy (FA) were extracted (Figure 1). Intraclass correlations (ICCs) for inter-rater reliability and test-retest repeatability were calculated for each metric separated by limb (PATH and CON).
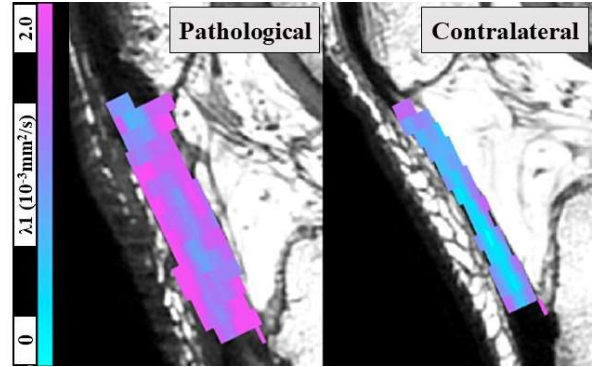

Figure 1: Diffusion scalar map of λ_1 overlaid on proton density MRI from a participant 8-months after BPTB autograft harvest.

Results and Discussion

Excellent inter-rater reliability was observed for all DTI scalar metrics in all regions. Repeatability was moderate to good in CON tendons, but poor to moderate in PATH tendons. This discrepancy may be due to potentially greater daily microstructural fluctuations in PATH tendons. Using non-linear tensor fitting may address this discrepancy. PATH tendons also had higher diffusivity and lower FA (poorer tissue organization), possibly reflecting loosely packed collagen fibers and greater extracellular matrix spacing commonly observed in healing tendons (Table 1).

Conclusions

DTI appears to capture microstructure changes in pathological patellar tendons; however, between-day stability of pathological tendons requires further investigation.

Acknowledgments

References

[1] Nutarelli S et al. (2023). *Ortho J Sports Med*, **11(6)**.

[2] Huang W et al. (2020) *J Orthop Translat*, **22**: 14-25.

Table 1: Means and intraclass correlation (ICC) ranges (over medial, lateral, and central regions) of DTI scalar metrics (λ_1, MD, and FA) for inter-rater reliability and test-retest repeatability by pathological (PATH) and contralateral (CON) tendon.

DTI Metrics	Mean (Standard Deviation)			Inter-Rater Reliability ICC Ranges		Test-Retest Reliability ICC Ranges	
	Tendinopathy (N=5)	BPTB (N=5)	CON (N=10)	PATH	CON	PATH	CON
λ_1 (10^{-3}mm^2/s)	1.06 (0.11)	1.23 (0.26)	0.99 (0.19)	0.92-0.98	0.90-0.95	0.26-0.52	0.70-0.80
MD (10^{-3}mm^2/s)	0.83 (0.10)	0.94 (0.23)	0.75 (0.18)	0.89-0.97	0.90-0.95	0.28-0.43	0.63-0.82
FA	0.35 (0.05)	0.38 (0.11)	0.43 (0.12)	0.96-0.99	0.98-0.99	0.40-0.72	0.55-0.83