# Diffusion Tensor Imaging of the Anterior Cruciate Ligament

Epworth Research

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## Introduction

While conventional MRI remains the gold standard in knee imaging, it cannot as yet reliably assess ligament or tendon microstructure. This limitation is significant in orthopaedic and sports medicine, particularly in evaluating the Anterior Cruciate Ligament (ACL) grafts after surgery; or the triage, and following up, of non surgical candidates for emerging rehabilitation protocols (eg. Cross Bracing Protocol).

## Aim

Perform Diffusion Tensor Imaging (DTI) tractography (a technique used predominantly in neuroradiology) to analyse the ACL of the knee in healthy volunteers. This would assess whether this technique would be viable to assess ACL injuries, ACL graft maturation, and ACL healing.

## Methodology

The study was performed on a GE Architect 3T MRI magnet, at Epworth Geelong. Rigorous pre-procedural screening was performed, as per normal standard care for clinical MRI studies.

Imaging of the knee was acquired using a standard knee coil, and the FOCUS (Field-of-view Optimized and Constrained Undistorted Single-shot) DWI sequence. The following base values were selected:

**NEX (Number of Excitations):** 2
- This means the scan was repeated twice to improve the image quality
- Repeating the scan helps to get a clearer picture by reducing random noise

**Image Resolution:** 2mm, in-plane 0.78 x 0.78 mm
- This describes the resolution of the image
- Each voxel (a 3D pixel) of the image is 0.78 mm by 0.78 mm in size, and the thickness of each slice of the image is 2 mm

**B-value:** 400
- The b-value is a parameter in DTI that controls the sensitivity of the scan to diffusion
- A b-value of 400 means the scan is set to a level that balances detail and sensitivity to movement of water molecules

## Results

DTI tracks the movement of water molecules in biological tissues. It does this by assessing the Brownian motion of water molecules. As water molecules in ligaments are constrained, the direction in which they can diffuse is similarly constrained. From the data acquired, a colour tractography map can then be produced using either deterministic or probabilistic algorithms. The colours correspond to the direction in which fibres run.

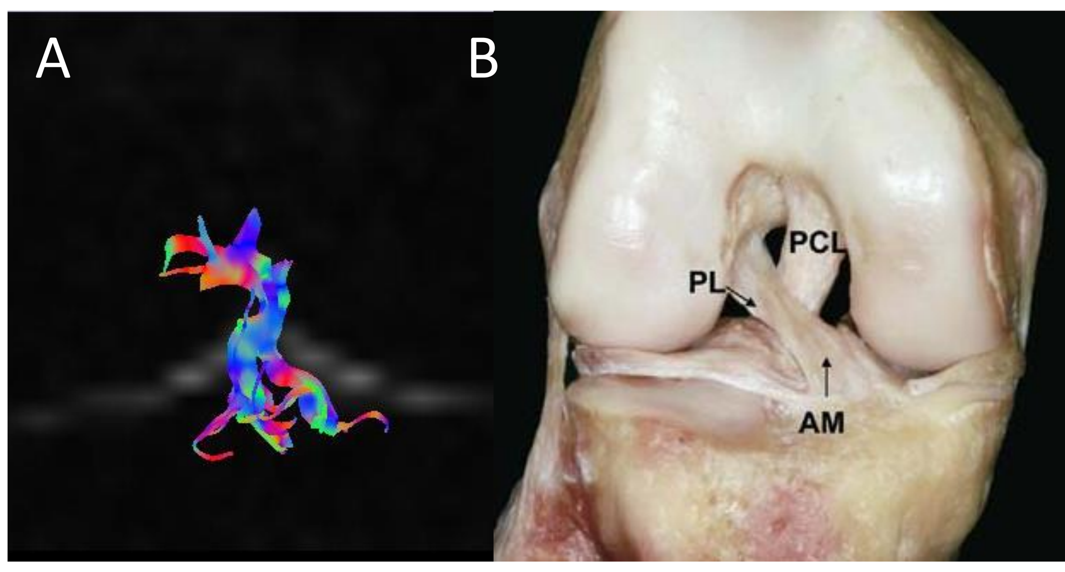


Figure 1a. Coronal DTI Tractography NEX 2; b400
Figure 1b. Coronal cadaver specimen. AM = Anteromedial bundle; PL = posterolateral bundle.
image courtesy of musculoskeletalkey.com/double-bundle-anterior-cruciate-ligament-reconstruction-3

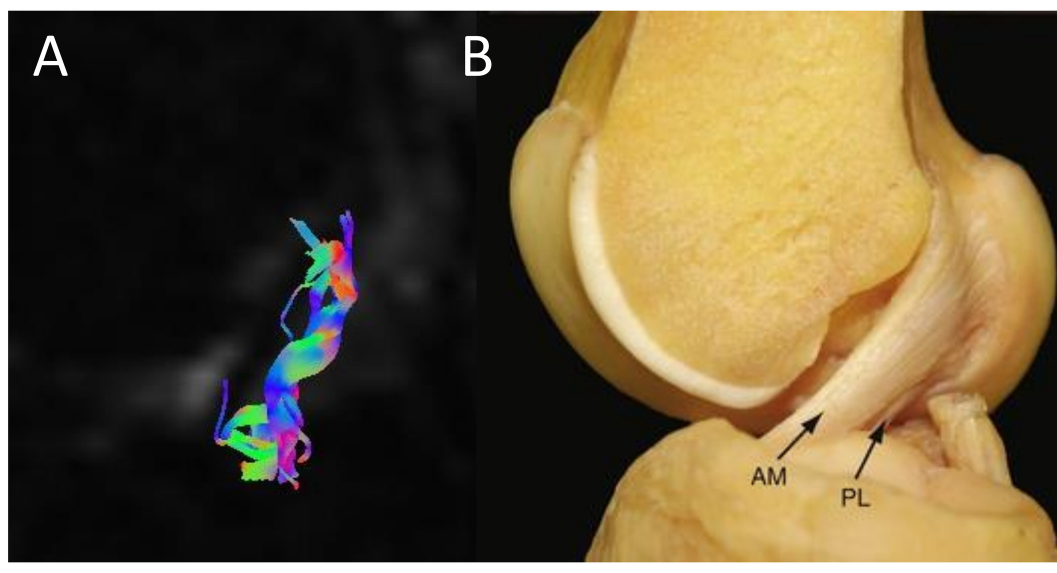


Figure 2a. Sagittal DTI Tractography. NEX 2; b400
Figure 2b. Sagittal cadaver specimen.
(image courtesy of clinicalgate.com/double-bundle-anterior-cruciate-ligament-reconstruction/)

In the coronal-oriented DTI image (Figure 1A), the posterolateral bundle is identified as predominantly red, with the anteromedial bundle predominantly blue. Both follow the expected anatomic path when compared to the cadaver specimen in Figure 1B.
In the axial-oriented DTI image (Figure 2A), the two bundles can again be identified, corresponding to the expected anatomic path (Figure 2B).
In these images, the green fibres most likely correspond to the interface between the two bundles.

## Conclusions

This project successfully produced DTI tractography of the ACL. While DTI's utility in neuroradiology is well established, we have shown that DTI has potential utility in musculoskeletal imaging by distinguishing the two bundles of the ACL.

In addition to the visual representation of musculoskeletal microstructure, quantitative data can also be extracted in DTI.

As such, this opens up new possibilities in evaluating injury and response to injury.

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