

Predicting cartilage morphology from bone using a statistical shape model

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Background

Patient-specific computational models of the knee offer the potential to improve the diagnosis and treatment of disorders such as patellofemoral pain and osteoarthritis. The first step in creating a patient-specific model of the knee is to segment medical imaging data to accurately reconstruct the geometry of the bone and cartilage. Segmentation of cartilage currently requires high resolution, volumetric MRI and a trained expert to produce an accurate result. This process is both time-consuming and expensive, and is one of the rate-limiting steps preventing the uptake of computational models in a clinical setting.

By exploiting the relationship between the bone and cartilage morphology, we present a novel method for predicting cartilage morphology from bone data. This will enable the rapid generation of cartilage morphology using sparse imaging data, such as plain film x-ray.

Method

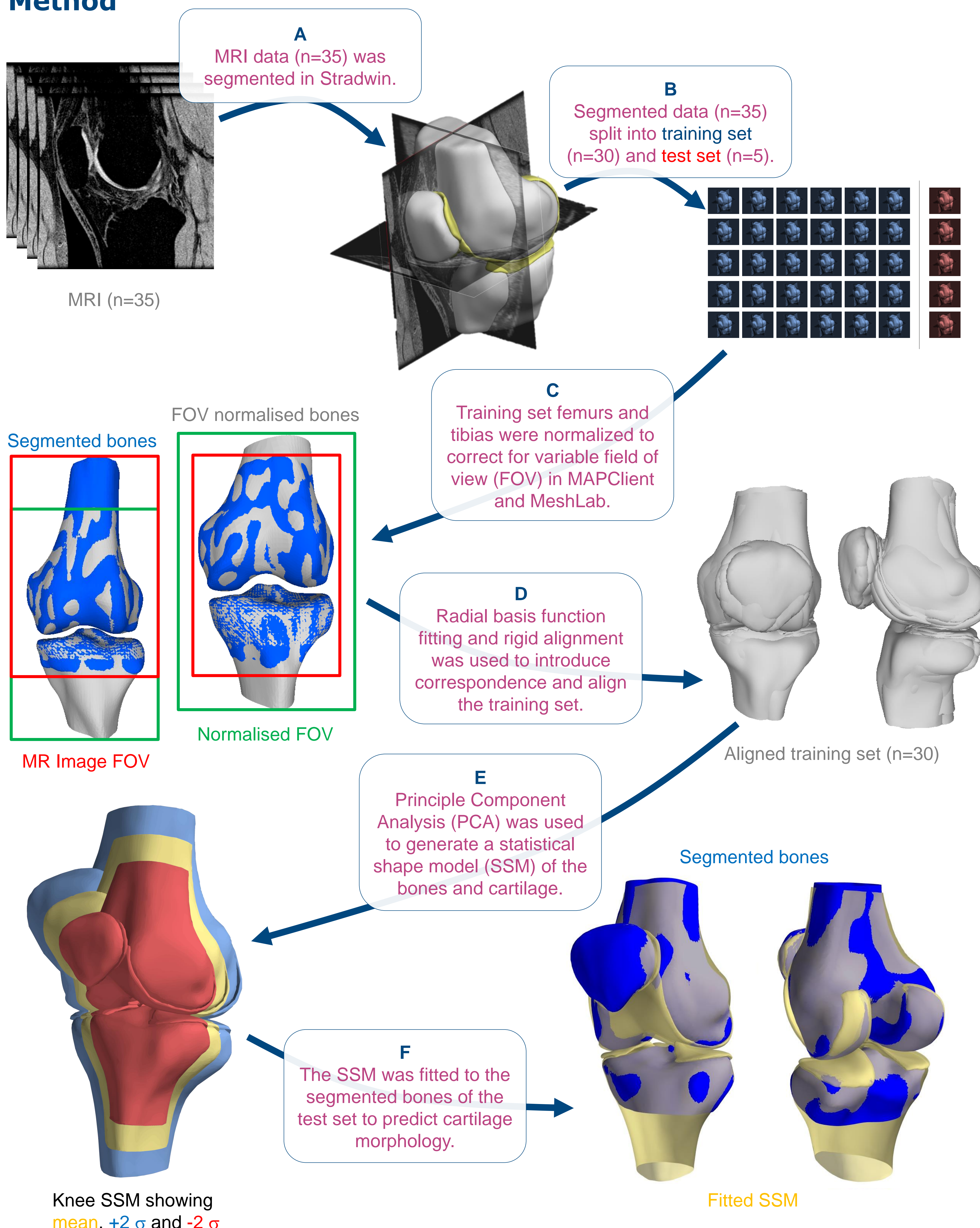


Figure 1: Overview of the workflow for generating an SSM and for predicting cartilage morphology from bone.

Results & Discussion

The mean error in the predicted cartilage meshes was largest in the medial tibial (0.89 ± 0.127 mm) and smallest in the lateral tibia (0.71 ± 0.095 mm) (Table 1).

The highest errors were distributed near the boundaries of the cartilage: up to 6.82 mm error when predicting the femoral cartilage in the test data.

Table 1: Average errors and DICE scores between predicted and manually segmented cartilage morphologies across test set (n=5).

Cartilage	Max error	RMS error	Mean error	DICE score
Femoral	6.82	0.97	0.76	0.72
Patellar	3.61	0.89	0.72	0.78
Lateral tibial	4.14	0.90	0.71	0.78
Medial tibial	3.76	1.01	0.89	0.73

Cartilage predictions were best near the load bearing areas and worst at the boundaries (Figure 2).

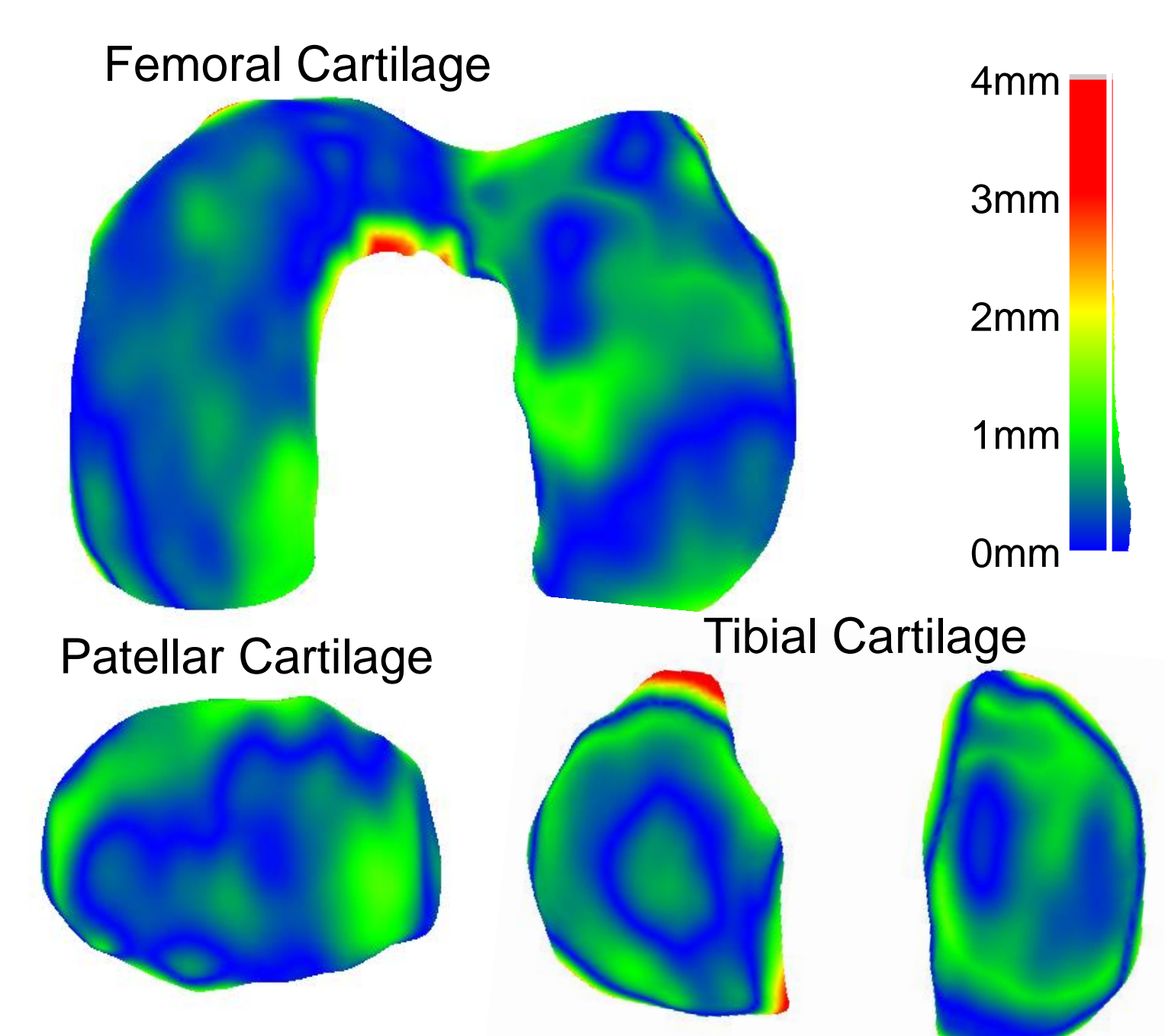


Figure 2: Absolute error distribution between predicted and manually segmented cartilage for example subject.

Summary

The method shows promise for predicting patient-specific cartilage from sparse data, and performed reasonably despite a small training set of n=30. Further training is expected to improve the performance of this method.

References

1. Besier TF et al. (2015). *Med Sci Sports Exerc*, **47**(11), 2416-2422.
2. Zhang J et al. (2014). *Biomed Sim.* **8789**, 182-192.

Acknowledgements

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