

# MRI of Maturation-Related Changes in Collagen Network of Human Femoral Cartilage

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## INTRODUCTION

The depth-wise variation of T2 relaxation time in healthy articular cartilage is sensitive to the orientational changes in the collagen network [1]. Juvenile animal tissue with a different degree of maturation has been reported to show a varying number of low and high T2 laminae that correspond to histologically verified structures of varying collagen orientation [2,3,4]. Such laminae have also been reported for in vivo T2-weighted images of juvenile human cartilage [4]. In this study, we determined the number of visible collagenous zones across the distal femoral compartment from T2-weighted images of human subjects from childhood to late adolescence.

## MATERIALS AND METHODS

Six adolescent human subjects (age 4.6-16.7 years) underwent a clinical MRI study of the knee. The patients were not diagnosed for any developmental cartilage disorder or arthritis. Two patients had an osteochondritis dissecans lesion. The MRI study included (but was not limited to) a sagittal T2-weighted fast spin echo sequence (TR=3700-4200ms, TE=86-91ms, matrix 384x224, FOV=16x16cm, 3 or 4mm slice thickness, 1mm slice separation). From this series, the cartilage surfaces across the femoral compartment were reviewed for the number of visible low and high intensity laminae using a division scheme as modified from Eckstein et al [5]. The occasionally visible very thin low intensity lamina at the articular surface was excluded from the assessment since its visibility varied significantly depending on the amount of synovial fluid, joint curvature and partial volume effect, and its visibility is not likely related to maturation itself.

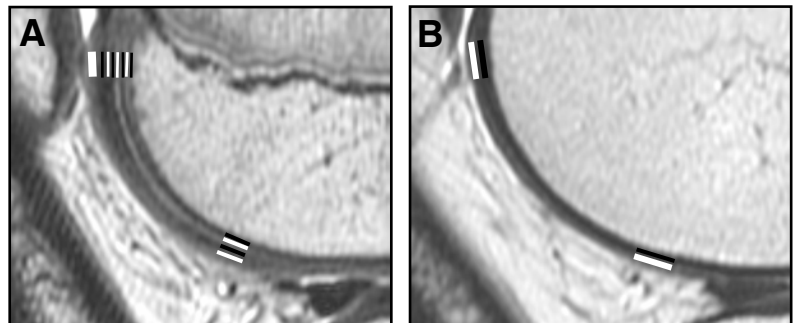
## RESULTS

The number of visible low and high intensity laminae varied between one to eight depending on the age and topographical location of the joint (Fig. 1 and 2). For the femoral condyles, at early childhood the cartilage is characterized by a more homogeneous appearance (1 lamina), showing more laminae at about 10 years of age, and reaching the bi-lamina appearance of mature adult cartilage close to 12 years. For trochlear cartilage, one to eight laminae were already seen at about 5 years of age, persisting to at least 12 years of age. Depending on the topographical location, the tissue has reached the appearance of mature adult cartilage at the age of about 14-16 years. A systematic thinning of the cartilage layer was also observed in the course of maturation, as the deep layers of cartilage transform to bone tissue.

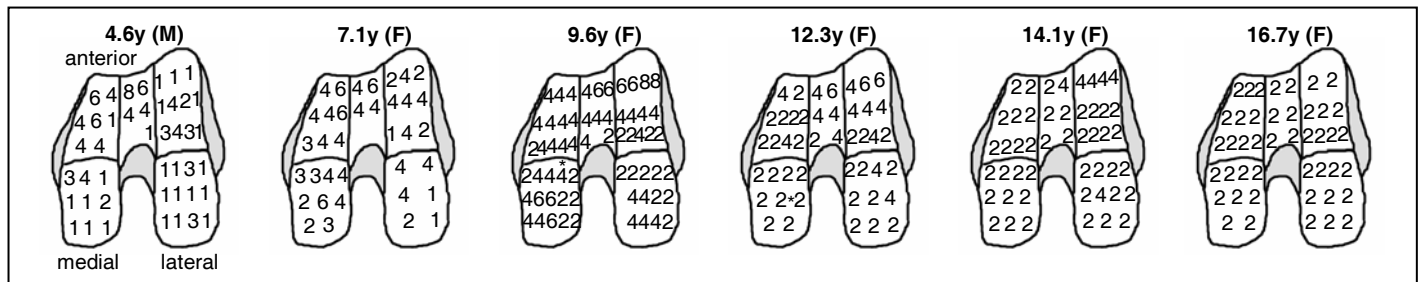
## DISCUSSION

To our knowledge, this is the first report on the systematic evaluation of MRI-visible collagen zones across the distal femur. Cartilage shows a homogeneous MR appearance at an early age [6]. Cartilage undergoes a significant amount of microscopically validated collagen remodeling [7], which is also evidenced by the changing lamina appearance of MRI in the course of age as presented in this study. The cartilage thickness gradually decreases with maturation, and the developing cartilage is converted to bone. This should be taken into account when evaluating maturing cartilage.

According to the present MRI assessment of collagen-related laminae, cartilage at different parts of the joint appear to mature at different periods. Developing cartilage probably adapts to the prevailing loading conditions that are likely to play an important role in cartilage development. The maturation process appears to have begun in the trochlea prior to condyles, which may be due to the different weight-bearing conditions associated with crawling.



**Fig. 1:** Representative T2-weighted images of varying numbers of laminae in the lateral trochlea of 9.6 year-old (A) and 16.7 year-old (B) subjects. Number of laminae are visualized by black and white lines.



**Fig. 2:** Varying number of collagen laminae at different age as visualized by T2-weighted MRI. "\*" indicates a joint area with an osteochondritis dissecans lesion. The age and sex of the subjects are indicated.

## REFERENCES

- [1] Nieminen MT et al. Magn Reson Med 2001; 46:487-93.
- [2] Xia Y et al. J Magn Reson Imaging 2003; 17:365-374.
- [3] Nissi M et al. Osteoarthritis Cartilage, in press.
- [4] Gründer W. NMR Biomed 2006; 19:855-76.
- [5] Eckstein F et al. Osteoarthritis Cartilage 2006; 14:974-83.
- [6] Varich LJ et al. Radiology 2000; 214 :705-9.
- [7] Rieppo J et al. Transact Orthop Res Soc 2004;29:549.