

Effect of high tibial osteotomy on patellar cartilage health: a dGEMRIC study

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INTRODUCTION High tibial osteotomy (HTO) is a treatment for medial tibio-femoral (TF) osteoarthritis (OA) whose objective is to change joint biomechanics. HTO changes the alignment of the leg from varus to slightly valgus in order to reduce loading on the medial TF cartilage. This operation has been shown to alter mechanics in both the TF and patellofemoral (PF) joints^{2, 4}. Changes in TF cartilage following the surgery, most notably regrowth of cartilage in the medial compartment, have been reported using arthroscopy^{3, 6} and Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC)⁷, however it is not clear how the procedure affects the PF joint. The objective of this study was to determine how the mechanical change produced by HTO affects cartilage health in the PF joint.

METHODS Seven subjects were recruited prior to their HTO surgery for medial tibio-femoral OA. All subjects gave informed consent. Titanium hardware, which causes less artifact than stainless steel, was used to permit follow-up scanning. Scans were performed within one month before surgery, and at 6 months and 12 months follow-up on a 3T Philips Achieva scanner.

A standard dGEMRIC protocol was used. Subjects were given a double dose of Gd-DTPA²⁻ intravenously and walked for 10 minutes immediately following injection. Two hours following injection, eight single slice inversion recovery scans were performed (TI: 1800, 1200, 700, 400, 200, 150, 100, 50 ms). At follow-up, the imaged slice was selected to match the pre-op image.

T1s were calculated for each pixel (dGEMRIC index, ms) using image processing software (IGOR). The patellar cartilage was then segmented, and medial and lateral compartments were defined (excluding the central region of the cartilage area). Outliers were removed (>1500, <100 ms) and means computed for each compartment and the whole cartilage. A repeated-measures ANOVA was performed on the means to determine if there was a difference in dGEMRIC index between the time points.

The average number of outliers was less than 1% (range 0.1-6.7%). For one subject, the 1800 ms scan had to be omitted for both the 6- and 12-month follow-ups due to motion.

RESULTS Mean dGEMRIC index was lower in the medial compartment than in the lateral compartment in four subjects at all time points. In five of the seven subjects, dGEMRIC index was decreased in both compartments at 6 months compared to the pre-op value. At 12 months, two of these five subjects showed further decreases in dGEMRIC index (one in the medial compartment, one in the lateral). In one case (lateral compartment), there was a subsequent increase in dGEMRIC index to greater than the pre-op level, and in all other cases there was some increase in dGEMRIC index, but to less than the pre-op level.

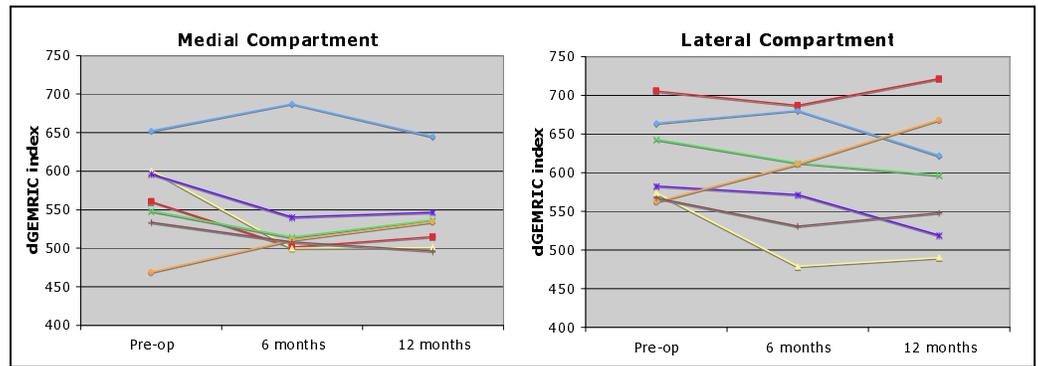


Figure 1: Medial and lateral compartment dGEMRIC indices at three time points. Each colour corresponds to one subject. Higher dGEMRIC index indicates healthier cartilage.

One subject showed an increase in dGEMRIC index at 6 months, and a decrease in dGEMRIC index at 12 months to lower than pre-op levels in both compartments. One subject showed an increase in dGEMRIC index at both 6 and 12 months in both compartments. While there were changes in dGEMRIC index, there were no statistically significant results in either compartment or the patellar cartilage as a whole.

DISCUSSION The variety of dGEMRIC changes produced by HTO surgery may reflect subject-specific mechanical changes produced by the surgery. While few longitudinal studies have been done using dGEMRIC, and it is not clear what constitutes a clinically significant change in dGEMRIC index, some case studies have been reported. Our findings of dGEMRIC index decreases following HTO surgery in 5 of 7 subjects are consistent with one case study that found that GEMRIC index in the TF joint decreased by 50 to 150 ms at first follow-up following PCL injury, and return to near normal by 6 months⁸. Similarly, in one case, the dGEMRIC index of lateral TF cartilage following HTO decreased by 9.7% at three months and returned to normal at six months⁷. We saw a smaller average decrease in dGEMRIC index at 6 months of 4.7% and 3% in the medial and lateral PF compartments respectively (not significant), but these studies assessed different joints at different time points. In one study, the median dGEMRIC index for OA cartilage was 550 ms, and the median for normal cartilage was 670 ms⁵. It may be that some of this PF cartilage, especially the medial compartment, was already somewhat degraded. dGEMRIC has been shown to be repeatable within 10-15%¹.

We chose to study the PF joint because its mechanics are changed by the procedure and because dGEMRIC analysis can be performed more easily than at the TF joint. While the TF joint is of great interest in HTO, metal artifact from the osteotomy plate and screws limits our ability to perform dGEMRIC at this joint, especially at 3T. Also, the tibia is significantly disrupted in the HTO surgery, and therefore the patella may better represent the effect of mechanical change alone on cartilage health.

These results, when combined with measurements of joint mechanics¹, will provide a model with which the effects of a change in joint mechanics on cartilage can be studied *in vivo* in humans.

1. Burstein, *MRM*. 2001, 2. d'Entremont, *ORS* 2007, 3. Fujisawa, *Orthop Clin North Am*. 1979, 4. Hill, *ORS*.2005, 5. McKenzie, *JMRI* 2006, 6. Odenbring, *Clin Orthop*. 1992, 7. Yamashita, *OARSI* 2008, 8. Young, *JBJS Am* 2005