

Factors Influencing Patellofemoral Cartilage Degradation Change Over Time Following Patellar Dislocation

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INTRODUCTION: Adolescents who experience a patellar dislocation have an elevated risk of developing patellofemoral post-traumatic osteoarthritis (PTOA) [1]. Patellofemoral cartilage degradation has been identified shortly after dislocation [2], followed by a phase of partial recovery [3]. The rest of the continuum from injury to patellofemoral OA has not been well characterized. The current study used quantitative MRI for longitudinal evaluation of patellofemoral cartilage following a dislocation to identify factors contributing to cartilage degradation beyond the initial phase of injury.

METHODS: Adolescents who experienced a traumatic patellar dislocation participated in quantitative MRI at two time points. The average time from injury to baseline evaluation was 45 ± 35 days. Follow up evaluations occurred from 181 to 429 days after the first evaluation (average = 210 ± 51 days). The analysis only includes knees with no other injuries or surgical treatment between the two evaluations. The population included 20 knees from 18 subjects, with 16 evaluated after a first dislocation. Four knees were evaluated following a recurrent dislocation after the first was treated conservatively. Demographic characteristics at the first evaluation were: age = 16.9 ± 1.6 years, body mass index (BMI) = 24.1 ± 3.9 kg/m², 12 females, and 8 males. The study was approved by the IRB.

Parameters of patellofemoral anatomy and alignment were measured from a 3D non-fat saturated turbo spin echo MRI scan with a 0.5 mm slice thickness. Landmarks were identified on MRI slices to quantify trochlear depth (lateral trochlear inclination), position of the tibial tuberosity (tibial tuberosity to trochlear groove distance), patellar height (Caton-Deschamps index), patellar size (superior to inferior patellar length), and patellar alignment (bisect offset index and patellar tilt).

Cartilage was assessed from MRI T1ρ relaxation times. Long T1ρ relaxation times indicate a relatively weak cartilage matrix due to a low concentration of proteoglycans. Mapping T1ρ relaxation times to patellofemoral cartilage has been described in detail previously [2-4]. Cartilage was segmented from a 3D fat saturated Dual Echo Steady State (DESS) MRI scan and separated into medial, central and lateral regions on the patella and within the trochlear groove. Cartilage T1ρ relaxation times were quantified from fat saturated Magnetization-prepared Angle-modulated Partitioned-k-space Spoiled gradient-echo Snapshots (MAPSS) scans. T1ρ relaxation times were mapped to the cartilage regions from the DESS scans and averaged within each region.

T1ρ relaxation times were compared between the baseline and follow up evaluations with paired t-tests. For the baseline and follow up evaluations, multivariable linear regressions correlated anatomy, alignment and demographic parameters against T1ρ relaxation times for all regions. Non-normal distributions of residuals were addressed with Spearman correlations based on ranks, while heteroscedasticity was addressed with weighted least squares regressions. Comparisons were also made between males and females with t-tests. Statistical significance was set at p < 0.05.

RESULTS SECTION: The only significant change in T1ρ relaxation times from the baseline to follow up evaluations was a decrease at the medial patella (p = 0.027, Fig. 1). At baseline, T1ρ relaxation times were positively correlated with Caton-Deschamps index and inversely correlated with patellar length and BMI for various regions of patellofemoral cartilage (Table 1). T1ρ relaxation times were also longer for females than males at the central and lateral patella (p < 0.04). At follow up, cartilage T1ρ relaxation times were positively correlated with patellar length (opposite of baseline) and inversely correlated with bisect offset index. T1ρ relaxation times were also longer for males at the lateral patella (p = 0.004).

DISCUSSION: The parameters related to patellofemoral cartilage properties based on T1ρ relaxation times changed dramatically between evaluations. Similar to prior studies, the analysis showed cartilage recovery at the medial patella [3,4], which is the site of impact against the lateral femur during a patellar dislocation. Low BMI, a high patella (Caton-Deschamps Index), and being female have also been related to long patellofemoral cartilage relaxation times following dislocation previously [2,4]. The current study adds a small patella as a parameter correlated with long relaxation times shortly after dislocation. On the contrary, for the same knees 6-14 months later, parameters associated with larger size and patellar constraint (males, large patella, small bisect offset index) were correlated with long relaxation times.

SIGNIFICANCE/CLINICAL RELEVANCE: The acute phase of injury following patellar dislocation includes an impact injury to cartilage and an inflammatory response. Knees are typically braced for a few weeks following injury. For the next 6-12 months, cartilage partially recovers from impact, inflammation recedes, and patients return to function. As the biological and biomechanical environments change, so do the factors influencing cartilage, indicating a potential biomechanical-biological interaction. Measures associated with smaller stature and patellar instability (high patella) are related to cartilage degradation in the early phase following injury. Conversely, after 6-14 months of conservative treatment, parameters associated with larger stature and patellar constraint are related to cartilage degradation and potentially risk of PTOA. The continuum from initial injury through progressive degradation to OA needs to be understood to identify patients at highest risk of OA and develop cartilage preservation strategies.

REFERENCES: 1. Sanders et al. Am J Sports Med 45:1012-1017. 2. Farrow et al. Am J Sports Med 51:3714-3723. 3. Elias et al. Cartilage 13:19476035221102570. 4. Elias et al. Orthop J Sports Med 13:23259671251334634.

ACKNOWLEDGEMENTS: Department of Defense, Peer Reviewed Medical Research Program Discovery Award W81XWH2010040, Arthroscopy Association of North America Research Grant #2204.

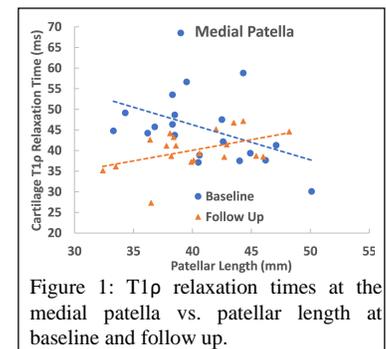


Figure 1: T1ρ relaxation times at the medial patella vs. patellar length at baseline and follow up.

Table 1: Parameters significantly correlated with T1ρ relaxation times (msec)

Time Point	Region	Parameter	r ²	β	p-value
Baseline	Med Pat	Pat Length	0.24 [#]		0.027
Baseline	Cen Pat	Pat Length	0.55*	-0.57	0.002
Baseline	Cen Pat	BMI		-0.43	0.013
Baseline	Lat Pat	Pat Length	0.57*	-0.49	0.006
Baseline	Lat Pat	BMI		-0.50	0.005
Baseline	Cen Trochlea	CDI	0.34	0.58	0.007
Baseline	Lat Trochlea	CDI	0.42	0.65	0.002
Follow Up	Med Pat	Pat Length	0.21	0.46	0.041
Follow Up	Med Trochlea	Bisect Offset	0.22	-0.47	0.039
Follow Up	Cen Trochlea	Bisect Offset	0.56	-0.75	<0.001
Follow Up	Lat Trochlea	Pat Length	0.34	0.58	0.007

Pat: Patella, Med: Medial, Cen: Central, Lat: Lateral, CDI: Caton-Deschamps Index, BMI: body mass index, β: Standardized beta coefficient

*r² for the multivariable regression including two significant variables

[#]Spearman regression