Comparing Patient-Reported Outcomes and Knee Health 10 Years Post-ACLR Using WORMS and Quantitative MRI

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Background:

■ **PTOA after ACL injury and even after ACLR**

Post-traumatic osteoarthritis (PTOA) is known to have the potential to develop after anterior cruciate ligament (ACL) rupture.

■ **Evaluation after Surgery**

Patient-reported outcomes (PROs)
PROs are commonly used for post-operative evaluations after ACL reconstruction.

Whole-Organ Magnetic Resonance Imaging Score (WORMS) [1]
Semi-quantitative assessment of the whole knee joint.

T1rho/T2 mapping [2]
Qualitative assessment of postoperative cartilage degeneration, such as T1rho and T2 mapping, which can detect early cartilage degeneration, has been reported after ACLR. [3, 4]

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Background:

However,

it is unclear whether PROs reflect the progression of knee joint degeneration, i.e., osteoarthritis progression, especially when evaluating long-term results.

■ Aim of this study

To investigate the relationship between subjective PROs and the health status of the knee joint using MRI, including the WORMS score and quantitative MRI evaluations, T1ρ and T2 values, in patients 10 years post-ACL reconstruction.

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Methods: Participants

Prospective study [5, 6]
76 patients were enrolled
July 2011 - September 2014

↓

Recruiting in 2024
Bilateral MRI

↓

13 patients
participated in
the 10-year follow-up

MRI acquired bilaterally using a 3.0 T GE Signa Premier scanner (GE Healthcare, Waukesha, WI) with two 16-channel medium flex receive-only coils (NeoCoil, Pewaukee, WI, USA).

☐ Bilateral 3D proton-density fat-saturated fast-spin-echo (3D PDFS FSE, i.e., Cube)
[TR/TE, 1,200/27 ms; echo train length, 32; matrix, 512 × 512 pixels; field of view (FOV), 16 cm; slice thickness, 0.6 mm (interpolated into 0.3 mm)]

→ **modified WORMS**

☐ Bilateral Magnetization-Prepared Angle-Modulated Partitioned k-Space Spoiled Gradient Echo Snap-shots (MAPSS) sequences
[time of spin-lock: 0, 10, 40, 80 ms; TE: 0, 12.8, 25.7, 51.4 ms; FOV, 14 cm; matrix, 256x256; slice thickness, 4 mm; spin-lock frequency, 500 Hz]

→ **$T_{1\rho}$ and T_2**

PROs:
Knee Injury and Osteoarthritis Outcome Score **(KOOS)**
ACL-Return to Sport after Injury **(ACL-RSI)** scale
Marx activity scale **(MARX)**: physical activity levels

Cartilage segmentation: T1rho and T2 mapping

Postprocessing was done using in-house developed software

with **Matlab** (Mathworks, Natick, MA, USA) integrated with

Elastix library for image registration. [2, 3, 4]

Using the mean values in each of 6 cartilage regions;

medial femur (MF), medial tibia (MT),

lateral femur (LF), lateral tibia (LT),

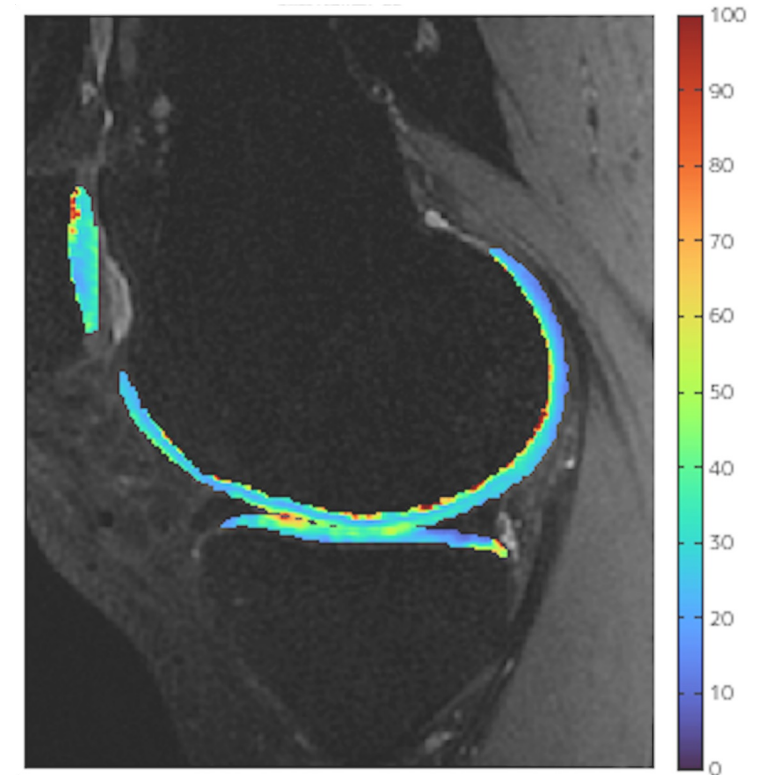**patella (PAT), and trochlea (TRO).**

Primary analyses
Spearman test was performed to investigate the correlations between
- PROs and the WORMS total score
- PROs and T1rho/ T2 values

Secondary analysis
Spearman test was performed to investigate the correlations between
- T1rho/ T2 values and the WORMS total score

Statistical significance was set at $p < .05$.   UCSF

Results: Demographics

Characteristics (n=13)			
Sex[*]		Male	9 (69.2%)
		Female	4 (30.8%)
Age at surgery (years)[‡]			32.4 ± 5.4
BMI (kg/m^2)[‡]			24.2 ± 2.6
Side[*]		Right	7 (53.8%)
		Left	6 (46.2%)
Time from injury to surgery (days)[†]			42 (38 - 74)
Surgery	Graft[*]	Hamstring autograft	8 (61.5%)
		Posterior tibialis allograft	5 (38.5%)
	MM[*]	Intact	11 (84.6%)
		Partial menisectomy	2 (15.4%)
		Repair	0 (0%)
	LM[*]	Intact	8 (53.8%)
		Partial menisectomy	4 (30.8%)
		Repair	1 (7.7%)
Follow-up period[†]			124 (121 - 140)

[*] Data expressed as count (percentage %).
[‡] Data expressed as mean ± standard deviation.
[†] Data expressed as median (Interquartile range)

PROs (n= 13)		median (IQR)
KOOS	Symptoms	78.6 (71.4 - 92.9)
	Pain	97.2 (88.9 - 97.2)
	ADL	98.5 (97.1 - 100)
	Sports/Rec	90 (80 - 100)
	QOL	75 (62.5 - 75)
ACL-RSI		64.5 (44.7 - 71)
Marx activity scale		6 (4 - 9)

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Results: PROs and WORMS total score

Correlations with the WORMS total score

PROs	rho	p-value
KOOS symptoms	0.42	0.15
KOOS pain	0.66	0.016
KOOS ADL	0.01	0.97
KOOS Sports/Recriation	0.15	0.62
KOOS QoL	-0.07	0.81
ACL-RSI	0.64	0.020
Marx activity score	-0.18	0.55

ACL-RSI and KOOS Pain had positive correlations with the WORMS total score.

Favorable PROs ↔ Structural OA progression

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Results: PROs and T1rho/T2 values

T1rho values	MF		LF		MT		LT		PAT		TRO	
PROs	rho	p-value	rho	p-value	rho	p-value	rho	p-value	rho	p-value	rho	p-value
KOOS symptoms	0.00	0.99	0.28	0.35	0.17	0.57	-0.15	0.62	0.38	0.20	-0.29	0.34
KOOS pain	0.37	0.21	0.57	0.043	0.12	0.69	0.00	1.00	0.22	0.46	-0.02	0.94
KOOS ADL	0.30	0.31	0.20	0.50	-0.28	0.35	-0.40	0.17	-0.06	0.83	0.02	0.95
KOOS Sports/Rec	0.29	0.33	0.33	0.26	-0.18	0.54	-0.18	0.56	0.10	0.73	-0.01	0.99
KOOS QoL	0.15	0.63	0.36	0.22	-0.28	0.35	0.10	0.75	0.50	0.09	-0.15	0.62
ACL-RSI	0.47	0.11	0.38	0.20	0.16	0.59	-0.09	0.77	0.21	0.49	0.26	0.39
Marx activity score	0.34	0.26	-0.01	0.98	-0.45	0.12	-0.61	0.028	-0.31	0.30	0.06	0.85

T2 values	MF		LF		MT		LT		PAT		TRO	
PROs	rho	p-value	rho	p-value	rho	p-value	rho	p-value	rho	p-value	rho	p-value
KOOS symptoms	0.25	0.40	0.39	0.19	0.28	0.35	-0.30	0.31	0.06	0.86	-0.46	0.12
KOOS pain	0.78	0.0027	0.38	0.19	0.64	0.021	0.27	0.38	-0.07	0.81	-0.19	0.52
KOOS ADL	0.20	0.50	-0.37	0.21	-0.10	0.73	-0.17	0.57	-0.54	0.059	-0.15	0.63
KOOS Sports/Rec	0.36	0.22	-0.11	0.72	0.13	0.66	-0.03	0.92	-0.33	0.27	-0.27	0.36
KOOS QoL	0.35	0.24	-0.11	0.72	-0.05	0.88	0.27	0.37	0.07	0.81	-0.37	0.21
ACL-RSI	0.82	0.0011	0.40	0.17	0.43	0.14	0.02	0.94	-0.05	0.87	0.26	0.38
Marx activity score	-0.27	0.37	-0.64	0.020	-0.31	0.29	-0.20	0.51	-0.64	0.020	0.17	0.56

Favorable PROs (KOOS pain and ACL-RSI) ↔ Progression of the Cartilage degeneration

High activity ↔ Preventing the Cartilage degeneration

Results: T1rho/T2 values and WORMS

Correlations with the WORMS total score

Regions	T1rho		T2	
	rho	p-value	rho	p-value
Medial Femur (MF)	0.55	0.051	0.79	0.0022
Lateral Femur (LF)	0.47	0.11	0.58	0.041
Medial Tibia (MT)	0.29	0.32	0.82	0.0012
Lateral Tibia (LT)	-0.19	0.53	0.11	0.72
Patella (PAT)	-0.07	0.81	-0.15	0.61
Trochlea (TRO)	0.10	0.73	0.23	0.44

The WORMS total score was not associated with **T1rho** values in any of the regions. However,

the WORMS total scoe correlated positively with **T2 values** in MF, MT, and LF.

Structural OA progression ↔ Progression of the Cartilage degeneration (T2 value)

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Discussion

Higher scores in ACL-RSI and KOOS pain were associated with worse knee conditions, indicating potential progression of knee OA without perceived pain or fear during sports.

This suggests the need for caution in using patient-reported evaluations at long-term outcomes to assess structural knee health.

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Conclusion

In patients 10 years post-ACL surgery,

favorable patient-reported outcomes did not necessarily reflect the actual structural health status of the knee joint.

Instead, there was a positive correlation between worse joint conditions and scores in ACL-RSI and KOOS pain.

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