Characterization of Bone Marrow Edema Patterns among Patients with Segond Fracture in the Setting of Acute Anterior Cruciate Ligament Injury: A Comparative MRI Study

Sharif Garra, Zachary Li¹, Naina Rao², Luilly Vargas³, Jordan Eskenazi⁴, Erin F Alaia, Michael J Alaia¹, Eric Jason Strauss, Laith M Jazrawi⁵

¹NYU Langone Orthopedic Center, ²NYU Langone, ³NYU Langone Medical Center, ⁴NYU Langone Health, ⁵Center For Musculoskeletal Care

INTRODUCTION:

The incidence of Segond fracture ranges from 2%-29% and its presence is considered to be indicative of a higher energy mechanism compared to an isolated anterior cruciate ligament (ACL) injury. While several prior studies have investigated the anatomic distribution of bone edema on magnetic resonance imaging (MRI) following ACL injury, there has been limited characterization of bone edema among patients with a concomitant Segond fracture. The purpose of this study is to investigate the anatomic distribution of bone marrow edema on MRI among patients who sustained a Segond fracture compared to those with an isolated ACL tear.

METHODS:

A retrospective study was performed on patients who presented with an acute isolated ACL tear following a sports activity injury between 2012 and 2022. Inclusion criteria were patients aged 18 to 40 years old at the time of injury and had an injury which occurred during participation in sports activity. Exclusion criteria were the following: 1) previous ipsilateral knee surgery or history of ACL injury; 2) ACL reconstruction was performed more than 90 days after the day of injury; 3) unknown date or mechanism of injury; 4) MRI obtained more than 30 days after injury. Two blinded readers (a musculoskeletal radiologist and a senior orthopaedic resident) reviewed all knee MRIs to assess bone marrow edema using the Whole-Organ Magnetic Resonance Imaging Score (WORMS). The area of each subcompartment was scored based on the WORMS bone bruise subscale from 0-3: 0 (no marrow abnormality), 1 (abnormality <25% of subregion area), 2 (25%-50%), or 3 (>50%). Patients' demographics, sports activity at injury, and type of meniscus injury were collected from the patient charts. Bone edema was compared between groups using Pearson's Chi squared testing. Bivariate linear regression was used to evaluate the relationship between each compartment and medial or lateral meniscus injury.

RESULTS:

There were 522 patients in the final analysis, of which 28 patients (5.4%) were identified to have a Segond fracture. Overall, the mean age was 28.2 ± 5.9 years, the cohort was 54.3% males, and the mean BMI was 25.1 ± 4.0 , and there were no significant differences in demographics comparing those with and without Segond fracture (p>0.05). The Segond group demonstrated significantly greater rates of WORMS grades 2 and 3 in the central lateral femoral condyle, as well as the anterior, central, and posterior lateral tibial plateau. Furthermore, the Segond group demonstrated significantly greater rates of WORMS grades 2 and 3 in the central lateral femoral condyle, as well as the central lateral femoral condyle (R=0.034, p=0.019) and central tibial plateau (R=0.093, p=0.033) were significantly correlated with lateral meniscus tears, while the edema in the posterior medial femoral condyle was correlated with medial meniscus tears (R=0.127, p=0.004).

DISCUSSION AND CONCLUSION:

Patients who present with ACL tear and a concomitant Segond fracture demonstrate significantly more extensive bone marrow edema in both the medial and lateral compartments of the knee compared to patients with an isolated ACL tear. These findings suggest that the Segond fracture may be indicative of a higher energy injury mechanism, and a potentially more serious injury.

Figure 1. Subdivision of the latenal compartment of the knee in the sagittal view based on the WORMS scale. LFa; latenal denoral condyte naterior, LFc; latenal femeral condyte center, LFp, latenal femoral condyte posterior; LTa, latenal tibia	TABLE 1 Comparison of Bone Edema Distribution between Patients with and without Segond Fracture				TABLE 2 Comparison of Bone Edema Distribution between Parients with and without Segood Prastare			d without	Figer 2 Comprises a distribution shows values within compression for using pricess with and values logical darws.	Figure 3. Bone edema location correlation heat map.
plateau anterior; LTe, lateral tibial plateau center; LTp, lateral tibial plateau posterior.		Segond Fracture (n=28)	Isolated ACL Tear (p=494)	p-value		Segond Fracture (n=28)	Isolated ACL Tear (n=494)	p-value		to contral a standard and a
	Lateral compariment edems, n (%)*				Lateral comportment edema, n (%)*			-		conceal to 💿 🖉 🦿
	Anterior LFC Anterior tibial platers	1 (3.6) 4 (14.3)	1 (0.2) 6 (1.2)	0.105	Anterior LFC Anterior tibial plateau	1 (3.6) 4 (14.3)	1 (0.2) 6 (1.2)	0.105	11 11 11 11 11 11 11 11 11 11 11 11 11	mtp_ant 🔹 🔴 🧬 🧬
	Central LFC	18 (64.3)	137 (27.8)	<,001	Central LFC	18 (64.3)	137 (27.8)	<.001	The second secon	mtp_central • • • • • • • •
	Central tibial plateau	9 (32.1)	11 (2.2)	<,001	Central tibial platean	9 (32.1)	11 (2.2)	<.001	Transforders base	cororal mtp + + + + + + + + + + + + + + + + + + +
	Posterior LFC	1 (3.6)	4 (0.8)	0.242	Posterior LFC	1 (3.6)	4 (0.8)	0.242		second
LEn	Posterior tibial plateau	27 (96.4)	290 (58.8)	<,001	Posterior tibial plateau	27 (96.4)	290 (58.8)	<.001		to at · · · · · · · · · · ·
LFa /	Medial compartment edema, n (Medial compertment edemo, n (* Anterior MEC	(s)* 1 (3.6)	4 (0.8)	0.242		to central
LFC	Anterior MFC Anterior tibial plateau	1 (3.6)	4 (0.8) 4 (0.8)	0.242	Anterior tibial plateau	2 (7.1)	4 (0.5) 4 (0.8)	0.042		coronal mfc • • • • • • • • • • • • •
Lrc	Central MPC	2 (7.1) 2 (7.1)	5 (1.0)	0.049	Central MFC	2 (7.1)	5(1.0)	0.049		to post • • • • • • • • • • • • •
	Central tibial plateau	1 (3.6)	3 (0.6)	0.199	Central tibial plateau	1(3.6)	3 (0.6)	0.199	11 11 11 11 11	coronal_tp • • • • • • • • • • • • • • • • • • •
	Pesterior MFC	0 (0.0)	5 (1.0)	1	Posterior MFC	0(0.0)	5(1.0)	>.999		coronal_ctp • • • • • • • • • • • • • • • • • • •
T T T	Posterior tibial plateau	17 (60.7)	209 (42.4)	0.076	Posterior tibial plateau	17 (60.7)	209 (42.4)	0.076		mic_ant · • • • • • • • • • • • •
	Coronal view edema, a (%)*				Coronal view edema, n (%)*					mfc_central • • • • • • • • • • • • • • •
LTa LTc LTp	Lateral femur	14 (50.0)	101 (20.5)	<,001	Lateral ferror Lateral tibial platera	14 (50.0) 14 (50.0)	101 (20.5) 55 (13.4)	<.001 <.001		mtc post · · · · · · · · · · · · · · · · · · ·
	Lateral tibial plateau	14 (50.0)	55 (13.4)	<.001	Central tibial plateau	9 (32.1)	31 (6.3)	<.001		fic_ant
State of the state	Central tibial plateau Medial ferror	9 (32.1)	31 (6.3) 2 (0.4)	<.001	Medial forur	1(3.4)	2 (0.4)	0.153		RC past
	Medial berrar Medial tibial plateau	1 (3.6) 2 (7.1)	2 (0.4) 9 (1.8)	0.153	Medial tibial plateau	2 (7.1)	9(1.8)	0.113		
	MOULD (COLD process) 2 (7.1) 9 (7.8) 0.113 "Edema answeed as gade 2 or 3 (727%) using the Whale-Organ Magnetic Resonance Imaging Secret (WOMS) manyor absorbably subscale Abbreviations: LPC Internal femoral condyle, MPC medial femoral condyle				*Edema assessed as grade 2 or 3 (~25%) using the Whole-Organ Magnetic Resonance Imaging Score (WORMS) marrow absormability subscale Abbreviations: LPC Interal femoral condyin, MPC mediat fenoral condyin					-1 -0.8 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1