Clinical Diagnostic Study of Syndesmotic Instability Using a 3-Dimensional Weight-Bearing CT Distance Mapping Algorithm

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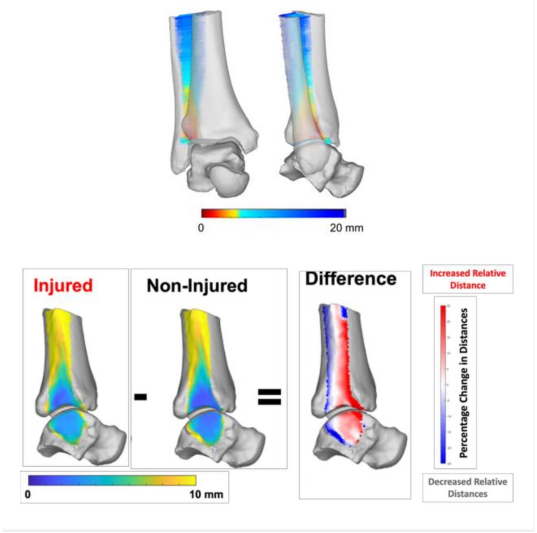
INTRODUCTION: Up to 33 % of ankle sprains progress to chronic instability, often owing to undetected syndesmotic injury. MRI offers high soft-tissue sensitivity but lacks functional, load-bearing assessment and incurs higher costs. We evaluated a novel 3-D distance-mapping algorithm applied to weight-bearing CT (WBCT) to quantify tibiofibular diastasis. We hypothesised that this technique would improve diagnostic accuracy and pinpoint the most informative anatomical levels.

METHODS: Thirty-two skeletally mature patients with unilateral chronic ankle instability underwent bilateral WBCT followed by arthroscopic evaluation and surgical stabilisation. Semi-automated segmentation and a custom MATLAB script calculated tibiofibular distances and volumes at 1, 3, 5 and 10 cm above the tibial plafond. Medial and lateral gutter distances were subdivided equally into anterior and posterior halves. Contralateral ankles served as internal controls. Paired t-tests compared injured and uninjured sides. ROC analysis assessed diagnostic performance, and optimal cut-offs were derived with the Youden index.

RESULTS: Mean age was 35.3 ± 17.5 years; mean BMI 29.2 ± 8.6 kg/m². Eighteen patients (56 %) had syndesmotic injury.Injured ankles displayed significant tibiofibular widening at 1 cm (33.5 %) and 3 cm (27.4 %) versus controls ($P < 0.05$), with no difference at 5 or 10 cm. ROC AUC was 0.77 (95 % CI 0.64–0.90) at 1 cm and 0.70 (0.54–0.86) at 3 cm; a 1-cm cut-off of 2.12 mm yielded 89 % sensitivity and 64 % specificity, with a mean injured-control distance gap of 0.20 mm. Tibiofibular volume was significantly greater at 1, 3 and 5 cm ($P < 0.05$). Medial and lateral gutter measurements did not differ, and demographics were not associated with injury status.

DISCUSSION AND CONCLUSION: WBCT distance mapping delivers a rapid, objective assessment when conventional methods falter, detecting diastasis below 0.5 mm in subtle or equivocal cases. Early recognition of occult laxity can sharpen surgical indications and help avert progression to chronic instability. In our series, 3-D WBCT identified syndesmotic widening as small as 0.2 mm under physiologic load, with the strongest diagnostic power 1 cm above the tibial plafond (AUC 0.77; 89 % sensitivity at a 2.12-mm threshold). These results parallel cadaveric data at 1–3 cm, though clinical accuracy is tempered by soft-tissue restraints and partial-thickness tears. Volumetric analysis corroborated distance findings through 5 cm, whereas medial and lateral gutter metrics remained non-discriminatory. The principal limitation is the modest sample size; additional constraints include the retrospective, single-center design. To our knowledge, this is the first clinical study to deploy WBCT distance mapping for diagnosing subtle syndesmotic instability, and larger multi-center cohorts are warranted to validate thresholds and refine its clinical role.



	CONTROLS		INJURED (SYNDESMOTIC INJURY)		INJURED VS. CONTROLS	
	MEAN	STD DEV.	MEAN	STD DEV	% DIFFERENCE	P VALUE
Minimum Distance (mm) at 1 cm	2.06	0.65	2.75	0.60	33.5%	0.001
Minimum Distance (mm) at 3 cm	2.45	0.76	3.12	0.96	27.35%	0.01
Minimum Distance (mm) at 5 cm	7.20	1.51	7.93	1.91	10.14%	0.115
Minimum Distance (mm) at 10 cm	10.83	2.61	11.65	3.06	7.57%	0.277
Volume (mm^3) at 1 cm	645.20	211.12	740.34	204.49	14.75%	0.031
Volume (mm^3) at 3 cm	2334.04	539.52	2695.14	659.61	15.47%	0.017
Volume (mm^3) at 5 cm	5117.29	1171.16	5806.25	1396.19	13.46%	0.044
Volume (mm^3) at 10 cm	14193.05	4208.88	14731.32	4847.76	3.79%	0.721
Medial gutter (anterior) min. distance (mm)	1.82	0.45	1.81	0.51	-0.55%	0.933
Medial gutter (posterior) min. distance (mm)	1.73	0.55	1.82	0.56	5.2%	0.6
Lateral gutter (anterior) min. distance (mm)	1.79	0.31	1.84	0.34	2.79%	0.542
Lateral gutter (posterior)min. distance (mm)	1.86	0.30	1.88	0.35	1.08%	0.999