Reconciliation Between Lateral Radiographs and Axial Computed Tomography Regarding Posterior Malleolus Fracture Anatomy and Medial Malleolus Involvement

Lenox Hill Hospital

Alexandra Black DPM, Jered Stowers, DPM, Stuart Katchis MD, Lon Weiner MD, William Spielfogel, DPM, FACFAS

Statement of Purpose

Fracture anatomy of the posterior malleolus fragment (PMF) in a trimalleolar injury has significant variation dependent on mechanism of injury and concomitant pathology. Plain film radiographs are performed during early workup of ankle trauma and play a pivotal role for closed reduction, surgical planning and post-operative management. Pre-operative computed tomography (CT) is a useful tool to further analyze fracture anatomy. The purpose of this study is to compare X-ray and CT in order to create consistent parameters to characterize PMF morphology.

Literature Review

Previous studies have evaluated size, displacement, comminution, and medial extension when comparing imaging techniques for PMF pathology. Reliability of radiographic assessment of PMF anatomy has been assessed showing that plain films do not consistently give the necessary information for surgical planning, necessitating use of CT in the setting of trimalleolar ankle fractures[1]. Poor inter/intra-reader reliability was measured concerning PMF size and characteristics as compared to CT[2]. Posteromedial involvement is often missed on plain film radiography[3]. Based on our review of the literature, PMF height and articular surface on lateral X-ray have not been compared to width and depth of the posterior fragment on axial CT. To date, these variables have not been studied as a predictor of medial extension or presence of posteromedial involvement. The aim of this study is to set consistent parameters when comparing the two modalities and establish correlations of fracture pathology for surgical planning.

Methodology & Procedures

- We studied 23 patients with trimalleolar ankle fractures identified from January 2008 until January 2018
- 4 variables pertaining to the PMF fragment were measured in *millimeters* on the PACS system at our institution (See Figure 1):
    1. PMF fragment height on lateral X-ray
    2. Articular surface length on lateral X-ray
    3. Medial-lateral width on axial CT
    4. Anterior-posterior depth on axial CT
- Pearson correlations were calculated for all pairwise combinations (See Results)
- PMFs were classified according to Haraguchi[4] and Bartinocek[5]
- We noted medial extension and presence/absence of medial malleolus fracture

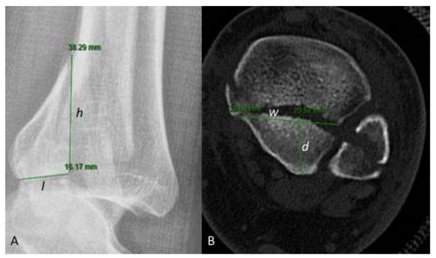
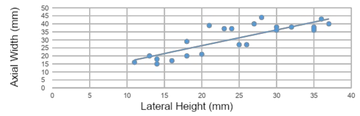


Fig. 1. (A) A lateral X-ray showing depth and height of the PMF. (B) An axial CT showing medial-lateral width and anterior-posterior depth of the PMF.

Results

Table 1

		Lateral *h*	Axial *w*
Lateral *h*		1	.834†
	Sig (2-tailed)		.000
	N	23	23
Axial *w*		.834†	1
	Sig (2-tailed)	.000	
	N	23	23

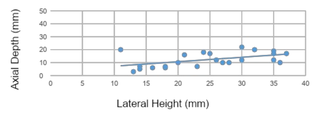


†Correlation is significant at the 0.01 level (2-tailed)

Correlation coefficient for posterior malleolus **fragment height** on lateral radiographs and **medial-lateral width** on axial computed tomography.

Table 2

		Lateral *h*	Axial *d*
Lateral *h*		1	.506[1]
	Sig (2-tailed)		.014
	N	23	23
Axial *d*		.506[1]	1
	Sig (2-tailed)	.014	
	N	23	23



†Correlation is significant at the 0.05 level (2-tailed)

Correlation coefficient for posterior malleolus **fragment height** on lateral radiographs and **anterior-posterior depth** on axial computed tomography.

Fig. 2). Bartinocek type I – a posterior malleolus fracture classified as an extraincisural fragment with intact fibular notch, unable to be classified according to the Haraguchi system.

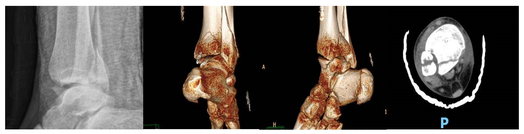
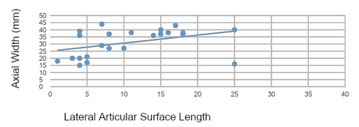


Fig. 3) Bartinocek II/ Haraguchi I - triangular fragment involving posterolateral aspect of tibial plafond without medial extension

Fig. 4) Bartinocek III/ Haraguchi II - a two-part posteromedial fragment with medial extension

Table 3

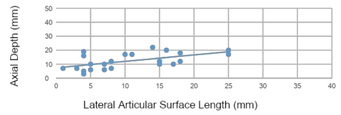
		Lateral *l*	Axial *w*
Lateral *l*		1	.409
	Sig (2-tailed)		.052
	N	23	23
Axial *w*		.409	1
	Sig (2-tailed)	.052	
	N	23	23



Correlation coefficient for posterior malleolus fracture **articular surface** on lateral radiographs and **medial-lateral width** on axial computed tomography.

Table 4

		Lateral *l*	Axial *d*
Lateral *l*		1	.477[1]
	Sig (2-tailed)		.021
	N	23	23
Axial *d*		.477[1]	1
	Sig (2-tailed)	.021	
	N	23	23



†Correlation is significant at the 0.05 level (2-tailed)

Correlation coefficient for posterior malleolus fracture **articular surface** on lateral radiographs and **anterior-posterior depth** on axial computed tomography

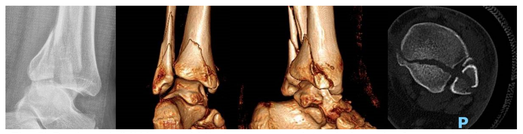


Fig. 5) Bartinocek IV/ Haraguchi II - large posterolateral triangular fragment with medial extension

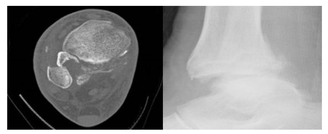


Fig. 6) Bartinocek II/ Haraguchi type III – a small-shell type with posterolateral fragment that extends into the fibular notch.

Analysis & Discussion

X-ray Versus CT Imaging

- Three of the tables have significant values, while only PMF height vs medial-lateral width is strong, p=0.01 (See Table 1)
- We propose a threshold for PMF height as a useful tool for anticipating medial extension and posteromedial involvement based on the plain film: *a minimum of 25 millimeters in fracture height on lateral view on X-ray will likely demonstrate medial extension of the PMF fragment*

Medial Malleolus Involvement

- Medial malleolus fracture (MMF) pattern was present in 19/23 patients
- Of the 19 MMFs, 13 presented with a PMF with medial extension
- 74% of patients with MMF avulsions exhibited complete PMF involvement

Classification Systems[4,5]

- 10/23 (43%) exhibited BIII, HII fracture pattern (See Figure 4)
- 8/23 (35%) exhibited BII, HI (See Figure 3)
- 3/23 (13%) exhibited BIV, HII type (See Figure 5)
- 1 patient with BI (shell-type fragment) did not classify according to Haraguchi (See Figure 2)
- 1 patient presented with fracture resembling BII, HIII (See Figure 6)
- Haraguchi (2D analysis) does not account for variation in the fracture with medial extension (HII), which may have two fragments (BIII) or one large posterolateral triangular piece (BIV), while Bartinocek (3D analysis) accounts for greater variation in fracture pattern, including osteoporotic, comminuted fragments, which was not observed in this study

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