Computerized Tomography Measurement of Syndesmotic Reduction in Intra-Articular Tibial Plafond Fractures

Amanda Crowell, DPM[a], Kerianne E. Spiess, DPM AACFAS[b], and Andrew J. Meyr, DPM FACFAS[c]

[a]Resident, Temple University Hospital Podiatric Surgical Residency Program, Philadelphia, Pennsylvania
[b]Ocean County Foot and Ankle Surgical Associates, Toms River, New Jersey
[c]Clinical Associate Professor and Residency Program Director, Department of Podiatric Surgery, Temple University School of Podiatric Medicine and Temple University Hospital, Philadelphia, Pennsylvania (AJMeyr@gmail.com)*
*Please don't hesitate to contact AJM with any questions/concerns. He's happy to provide you with a .pdf of this poster if you email him.

Statement of Purpose and Literature Review

Intra-articular fractures involving the ankle joint complex may be associated with significant patient morbidity, particularly if involving disruption and instability of the syndesmotic ligaments. Although this has been relatively well-established within the literature with respect to rotational ankle fractures [1,2], the association and impact of syndesmotic disruption and malreduction on intra-articular tibial plafond fractures (i.e. pilon fractures) is relatively unknown [3-5].

The diagnosis of syndesmotic instability has traditionally been performed through intra-operative stress examination [6], however, there has been a trend with the contemporary literature to identify syndesmotic malreduction with the use of computed tomography (CT) [7-10]. In fact, a recent study has identified good reliability among several different assessment methods for post-operative syndesmotic reduction in ankle fractures with the use of CT scans [10]. **The objective of this investigation was to measure syndesmotic reduction in intra-articular fractures of the tibial plafond.**

Methodology

Following approval by our IRB, a retrospective CPT procedure code and ICD-9 diagnosis code search were performed within our institution to identify patients with a pilon fracture who had undergone a preoperative CT scan. Returned results were then reviewed for our specific inclusion (age 18-90 years, presence of skeletal maturity, presence of an intra-articular tibial plafond fracture [open or closed inclusive], and performance of a preoperative CT scan) and exclusion (other forms of ankle fracture [i.e. rotational ankle fractures], presence of skeletal immaturity, no preoperative CT scan, and age less than 18 years or greater than 90 years) criteria.

Measurements of syndesmotic reduction were subsequently performed on all CT scans meeting inclusion criteria based on three methods described and reviewed by Warner et al (Figure 1)[10]. All measurements were performed with Centricity™ RIS-IC software (General Electric Company, Fairfield, CT, USA) which measures to a precision of 0.1mm and 1.0º.

Descriptive statistics were calculated and consisted of the mean, standard deviation (SD), and range. Comparative statistical analyses were subsequently performed to normative published data and employed the independent Student's t-test [6-10]. A level of statistical significance was set a p = 0.05.

Results

We identified 20 fractures in 20 subjects who met inclusion/exclusion criteria. Thirteen subjects (65.0%; 13/20) were male. The mean ± standard deviation (range) age was 39.75 ± 12.78 years (18-66). Eighteen (90.0%; 18/20) injuries involved a fracture to the fibula in addition to the tibial plafond.

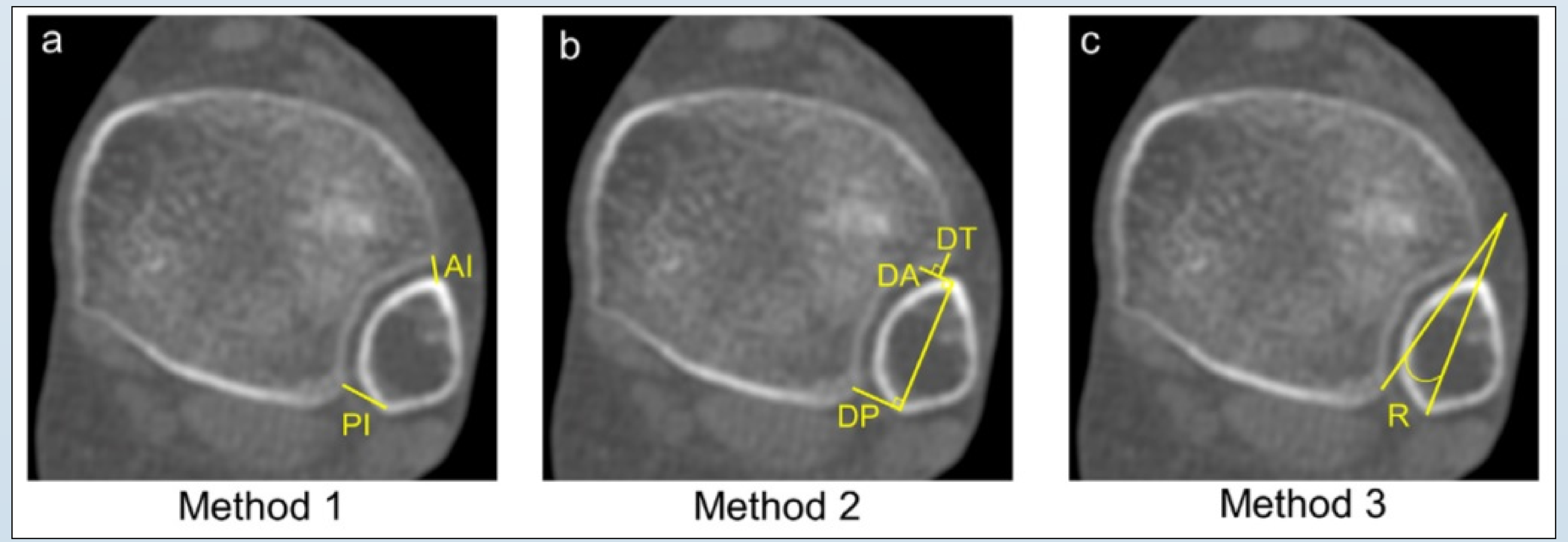
With respect to the first method of measuring syndesmotic reduction, we observed a mean ± standard deviation (range) anterior incisura (AI) distance of 3.74 ± 2.06mm (0.6-9.6mm). This was significantly different from the 155 normal ankles in the Warner et al study, the 155 ankles with a rotational ankle fracture in the Warner et al study, and the 64 normal ankles in the Lepojarvi et al study. This was not a significantly from the 100 normal ankles in the Nault et al study [6-10].

We observed a mean ± standard deviation (range) posterior incisura (PI) distance of 6.69 ± 2.32mm (3.4-13.0mm). This was significantly different from the 155 normal ankles in the Warner et al study, the 155 ankles with a rotational ankle fracture in the Warner et al study, the 64 normal ankles in the Lepojarvi et al study, and the 100 normal ankles in the Nault et al study [6-10].

With respect to the second method of measuring syndesmotic reduction, we observed a mean ± standard deviation (range) direct anterior distance of 4.47 ± 2.24mm (1.4-10.0mm), direct posterior distance of 8.54 ± 2.84mm (5.6-18.2mm), and direct translation distance of 3.04 ± 1.24mm (0.9-6.5mm). A statistically significant difference was observed between our observed direct anterior distance and the values observed in the Warner et al study of 155 normal ankles and 155 ankles with a rotational ankle fracture. We did not observe a statistically significant difference between our observed direct posterior distance and the values observed in the Warner et al study of 155 normal ankles nor the 155 ankles with a rotational ankle fracture. And we did not observe a statistically significant difference between our observed direct translation distance and the values observed in the Warner study of 155 normal ankles nor the 155 ankles with a rotational ankle fracture [10].

With respect to the third method of measuring syndesmotic reduction, we observed a mean ± standard deviation (range) fibular rotation angle of 7.50 ± 3.89º (1-15º). A statistically significant difference was observed between our observed measurement and the Warner et al study of 155 normal ankles, the Warner et al study of 155 ankles with a rotational ankle fracture, and the Dikos et al study of 30 normal ankles. A statistically significant difference was not observed between our observed measurement and the Nault et al study of 100 normal ankles [6-10].

Figure 1: Measurement of syndesmotic reduction



Measurements of syndesmotic reduction were performed on all CT scans meeting inclusion criteria based on three methods described and reviewed by Warner et al [29]. All involved axial images 1 cm proximal to the tibial plafond. The first method measures the distance (in mms) from both the anterior and posterior tibial incisura (Fig 1a). The second measures isolated diastasis and compression of the anterior and posterior aspects of the fibula relative to the tibia (in mms) and anterioposterior translation of the fibula relative to the tibia (in mms) (Fig 1b). And the third measures isolated rotation of the fibula with respect to the tibia (in degrees) (Fig 1c).

(Figure reproduced from Warner SJ, Fabricant PD, Garner MR, Schottel PC, Helfet DL, Lorich DG. The measurement and clinical importance of syndesmotic reduction after operative fixation of rotational ankle fractures. J Bone Joint Surg Am. 2015 Dec 2; 97(23): 1935-44).

Specific Measurement of Syndesmotic Reduction	Original Data (n=20)	Published Normative Data	Statistical Comparison*
Method 1 Anterior Incisura distance (mm)	3.74 ± 2.06 (0.6-9.6)	-Warner et al unaffected (n=155): 4.46 ± 0.97 (2.50-9.53) -Warner et al affected (n=155): 5.11 ± 1.63 (1.67-10.69) -Nault et al (n=100): 4 ± 1 (1.5-6.4) -Lepojarvi et al (n=64): 2.8 ± 0.09 (0.9-5.3)	p=0.0087* p=0.0008* p=0.3914 p=0.0004*
Method 1 Posterior Incisura distance (mm)	6.69 ± 2.32 (3.4-13.0)	-Warner et al unaffected (n=155): 8.80 ± 1.66 (4.94-12.81) -Warner et al affected (n=155): 9.10 ± 2.39 (4.01-10.69) -Nault et al (n=100): 8 ± 1.7 (2.1-11.5) -Lepojarvi et al (n=64): 5.1 ± 0.15 (2.7-9.1)	p<0.001* p<0.001* p=0.0039* p<0.001*
Method 2 Direct Anterior distance (mm)	4.47 ± 2.24 (1.4-10.0)	-Warner et al unaffected (n=155): 5.51 ± 1.26 (1.81-10.00) -Warner et al affected (n=155): 5.88 ± 1.73 (1.12-10.12)	p=0.0021* p=0.0011*
Method 2 Direct Posterior distance (mm)	8.54 ± 2.84 (5.6-18.2)	-Warner et al unaffected (n=155): 8.88 ± 1.74 (4.88-14.33) -Warner et al affected (n=155): 9.14 ± 2.47 (4.42-19.22)	p=0.4505 p=0.3164
Method 2 Direct Translation distance (mm)	3.04 ± 1.24 (0.9-6.5)	-Warner et al unaffected (n=155): 3.01 ± 1.04 (-0.78-6.06) -Warner et al affected (n=155): 2.76 ± 1.76 (-2.30-8.99)	p=0.9057 p=0.4918
Method 3 Fibula Rotation angle (degrees)	7.50 ± 3.89 (1-15)	-Warner et al unaffected (n=155): 13.22 ± 5.22 (0.70-30.70) -Warner et al affected (n=155): 11.95 ± 7.34 (-14.10-29.40) -Nault et al (n=100): 8.7 ± 3.1 (1.1-15.1) -Dikos et al (n=30): 12.7 ± 6.7 (0.5-29.5)	p<0.0001* p=0.009* p=0.1332 p=0.003*

Discussion

To our knowledge this is the first investigation of syndesmotic reduction in pilon fractures, and as such, it is likely to raise more questions than it is to answer. Although some statistically significant differences were observed, it is unclear what, if any, the clinical significance might be attributed to these findings. A good example of this is with respect to the first method of measuring syndesmotic reduction, the anterior and posterior incisura distance. Our observed measurement of both the anterior and posterior incisura distance in pilon fractures was statistically less than the measurements performed by Warner et al, not statistically different than the measurements performed by Nault et al, and statistically greater than the measurements performed by Lepojarvi et al [26-29]. This finding literally runs the gamut of possible observations! Further, it is difficult to assess these findings from a clinical perspective as the observed differences are measured on the order of millimeters. Although the measurement of anterior and posterior incisura distance has been demonstrated to be reliable [29], we are not aware of the establishment of any normal/abnormal thresholds for this measurement or any correlation of these measurements to functional outcome measures.

<u>We would presume to postulate three potential conclusions based on these specific results</u>:

-Based on the observed statistically significant differences in the specific results of this investigation, it is possible that there might be an unrecognized component of syndesmotic malreduction in pilon fractures.

-It could also be that these measurements, although seemingly reliable for measuring syndesmotic reduction in rotational ankle fractures, may not be accurately or reliably measuring syndesmotic reduction in pilon fractures. This could be a result of the fracture patterns and comminution that often accompany pilon fractures. We observed that there were times when it was difficult to identify the consistent anatomic landmarks required for these measurements in the setting of tibial comminution.

-Or finally, it could be that these measurements, although seemingly reliable for measuring syndesmotic reduction in rotational ankle fractures, have little to no clinical significance for either rotational ankle fractures or pilon fractures as the range of normal values reported in the literature is relatively broad and have not been associated with functional outcome measures.

In conclusion, this investigation is the first to our knowledge to study syndesmotic reduction parameters of pilon fractures with computed tomography. Although we do not definitively conclude that these results indicate that there is a component of syndesmotic malreduction in pilon fractures, they at the very least open the door to this possibility and will hopefully lead to future investigations on the topic.

References

[1] Warner SJ, Fabricant PD, Garner MR, Schottel PC, Helfet DL, Lorich DG. The measurement and clinical importance of syndesmotic reduction after operative fixation of rotational ankle fractures. J Bone Joint Surg Am 97(23): 1935-44, 2015.
[2] van Blijmen N, Denk K, van Kampen A, Jaarsma RL. Long-term results after ankle syndesmosis injuries. Orthopedics 38(11): e1001-6, 2015.
[3] Assal M, Ray A, Stern R. Strategies for surgical approaches in open reduction internal fixation of pilon fractures. J Ortho Trauma 29(2): 69-79, 2015. [4] Lee YS, Chen SW, Chen SH, Chen WC, Lau MJ, Hsu TL. Stabilisation of the fractured fibula plays an important role in the treatment of pilon fractures: a retrospective comparison of fibular fixation methods. Int Orthop 33(3): 695-9, 2009.
[5] Song Z, Zue HZ, Zhang K, Li Z, Zhuang Y, Yang N. Pathogenesis and treatment strategies for pilon fractures with ankle dislocation. J Foot Ankle Surg 54(5): 815-20, 2015.
[6] Pakarinen H, Flinkkila T, Ohtonen P, Hyvonen P, Lakovaara M, Leppilahti J, Ristiniemi J. Intraoperative assessment of the stability of the distal tibiofibular joint in supination-external rotation injuries of the ankle: sensitivity, specificity, and reliability of two clinical tests. J Bone Joint Surg Am 93(22): 2057-61, 2011.
[7] Nault ML, Hebert-Davies J, Laflamme GY, Leduc S. CT scan assessment of the syndesmosis: a new reproducible method. J Orthop Trauma 27(11): 638-41, 2013.
[8] Lepojarvi S, Pararinen H, Savola O, Haapea M, Sequeiros RB, Ninimaki J. Posterior translation of the fibula may indicate malreduction: CT study of normal variation in uninjured athletes. J Orthop Trauma 28(4): 205-9, 2014.
[9] Dikos GD, Heisler J, Choplin RH, Weber TG. Normal tibiofibular relationships at the syndesmosis on axial CT imaging. J Orthop Trauma 26(7): 433-8, 2012.
[10] Warner SJ, Fabricant PD, Garner MR, Schottel PC, Helfet DL, Lorich DG. The measurement and clinical importance of syndesmotic reduction after operative fixation of rotational ankle fractures. J Bone Joint Surg Am 97(23): 1935-44, 2015.