

Radiographic evaluation of the ankle syndesmosis

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Background: Radiographic measurements to document ankle anatomy have been suggested in recent literature to be inadequate. Focus has been put on stress views and computed tomography; however, there are also issues with these modalities. An orthogonal view that could be used both statically and dynamically could help determine syndesmotic stability. The purpose of this study was to determine a parameter on a normal lateral ankle radiograph that will increase the reliability of standard radiography in diagnosing syndesmotic integrity.

Methods: Three orthopedic surgeons reviewed 80 lateral ankle radiographs. Thirty of those radiographs were reviewed on a second occasion. Rotation of the radiographs was determined by evaluating the overlap of the talar dome. Four radiographic parameters were measured 1 cm above the tibial plafond: fibular width, tibial width, and anterior and posterior tibiofibular intervals.

Results: Seventy-two radiographs were determined by consensus to be adequate. Means and ratios were documented to determine the relationship of the fibula to the tibia. Interrater reliability ranged from moderate to near-perfect, and the intrarater reliability was documented for each ratio. The anterior tibiofibular ratio was shown to be strong to near-perfect. It demonstrates that 40% of the tibia should be seen anterior to the fibula at 1 cm above the tibial plafond.

Conclusion: The anterior tibiofibular ratio provides an orthogonal measure for the syndesmosis that, in conjunction with those parameters previously documented, could clinically and economically improve the diagnosis of syndesmotic disruptions.

Contexte : Selon la littérature récente, les mesures radiographiques utilisées pour documenter l'anatomie de la cheville seraient inadéquates. L'accent a été placé sur les clichés de cheville en position de stress et sur la tomomodensitométrie, mais ces modalités présentent également des inconvénients. Une vue orthogonale utilisée en position statique et en position dynamique pourrait aider à évaluer la stabilité syndesmotique. Le but de cette étude était de déterminer quel paramètre de la radiographie latérale normale de la cheville accroîtrait la fiabilité de la radiographie standard pour le diagnostic de l'intégrité syndesmotique.

Méthodes : Trois chirurgiens orthopédistes ont passé en revue 80 radiographies latérales de la cheville. Trente de ces radiographies ont été interprétées une deuxième fois. La rotation des radiographies a été déterminée par l'évaluation du chevauchement du dôme talien. Quatre paramètres radiographiques ont été mesurés à 1 cm au-dessus du plafond tibial : la largeur du péroné, la largeur du tibia et les intervalles tibiofibulaires antérieur et postérieur.

Résultats : Soixante-douze radiographies ont consensuellement été jugées adéquates. Les moyennes et les ratios ont été notés pour établir le rapport péroné-tibia. La fiabilité inter-examineur a varié de modérée à quasi-parfaite et la fiabilité intra-examineur a été documentée pour chaque ratio. Le ratio tibiofibulaire antérieur s'est révélé être un paramètre solide à quasi-parfait. Il démontre que 40 % du tibia devrait être visible à l'avant du péroné à 1 cm au-dessus du plafond tibial.

Conclusion : Le ratio tibiofibulaire antérieur constitue une mesure orthogonale pour la syndesmosse qui, en conjonction avec les paramètres précédemment documentés, permettrait d'améliorer le diagnostic des troubles syndesmotiques aux plans clinique et économique.

Ankle sprains and fractures are among the most common musculoskeletal injuries.^{1,3} It is essential that we have the most up to date and relevant information at our disposal when we are treating such injuries. Over the past 20–30 years, radiographic evaluation of the ankle has been thoroughly investigated. There have been radiographic measurements established to document ankle anatomy; in 1983, Pettrone and colleagues⁴ examined 146 displaced ankle fractures and determined significant prognostic features.⁴ The objective measurements that were used in their study continue to be used in today's research as well as in clinical practice. There are components of the ankle, however, that are poorly described by our standard diagnostic imaging.

Once an ankle is deemed to require radiography, the standard is to complete anteroposterior (AP), lateral and mortise views. When critically analyzing those images, the most clinically important soft tissue component of the ankle is the syndesmosis. The syndesmosis is a ligamentous complex that includes 4 ligaments: the anterior inferior tibiofibular ligament, the posterior inferior tibiofibular ligament, the interosseus tibiofibular ligament/membrane and the inferior transverse tibiofibular ligament. It unites the distal tibia and fibula, and injuries to the syndesmosis can lead to severe acute and chronic morbidity.^{1,2}

Radiographic parameters to determine a syndesmotom injury have historically been described in the AP and mortise views. On a mortise view, the medial joint space should be less than 4 mm, and the superior joint space should be within 2 mm medially of its width laterally. Tibiofibular overlap on the AP view should be greater than 10 mm, and the space between the medial wall of the fibula and the incisural surface of the tibia should be less than 5 mm.^{1–3} Recent literature has suggested, however, that evaluation of the syndesmosis on static AP and mortise views is not adequate to determine if there is a syndesmotom injury pre-sent.^{4–11} It has been suggested that current diagnostic criteria used specifically for syndesmotom injuries are of minimal value and that further criteria should be developed.^{5,6,9}

Ankle arthroscopy, computed tomography (CT) or magnetic resonance imaging (MRI) have been suggested as alternatives to standard radiography to ensure proper diagnosis of syndesmotom injuries;^{7–10,12} however, none of these options is clinically or economically practical. A potential solution is to add an orthogonal parameter on the lateral radiograph to those being used in the AP and mortise views, thereby increasing their effectiveness. Orthogonal views are used as a diagnostic tool for most other fractures. Although the lateral ankle radiograph has been evaluated for many years in the fracture setting, it is only recently that specific parameters are being developed on that view. The purpose of this study was to determine a parameter on a normal lateral ankle radiograph that would increase the reliability of standard radiography in diagnosing syndesmotom integrity.

METHODS

Three orthopaedic surgeons (A.F., C.M., C.S.) reviewed 80 lateral ankle radiographs. Thirty of those radiographs were reviewed on a second occasion more than 2 months later. The radiographs were retrospectively gathered through the Picture Archiving and Communication System (PACS) system at our institution. We obtained ethics approval through the Health Research Ethics Authority.

We considered radiographs to be acceptable based on what would be acceptable in an intraoperative environment: radiographs centred at the talar dome, demonstrating neutral rotation/superimposition of the talus. Inclusion criteria were patients who were skeletally mature with absence of radiographic disease, as documented by a radiologist. We excluded films that demonstrated prior ankle surgery, fractures or end-stage ankle arthrosis.

We documented 4 measurements: tibial and fibular widths (TW, FW), the anterior tibiofibular interval (ATFI, defined as the anterior cortex of the fibula to the anterior cortex of the tibia) and the posterior tibiofibular interval (PTFI, defined as the posterior cortex of the tibia to the posterior cortex of the fibula; Fig. 1). Measurements were documented 1 cm above the centre of the tibial plafond.^{8,12} Ratios were determined in order to assess the positional relationship of the tibia relative to the fibula.

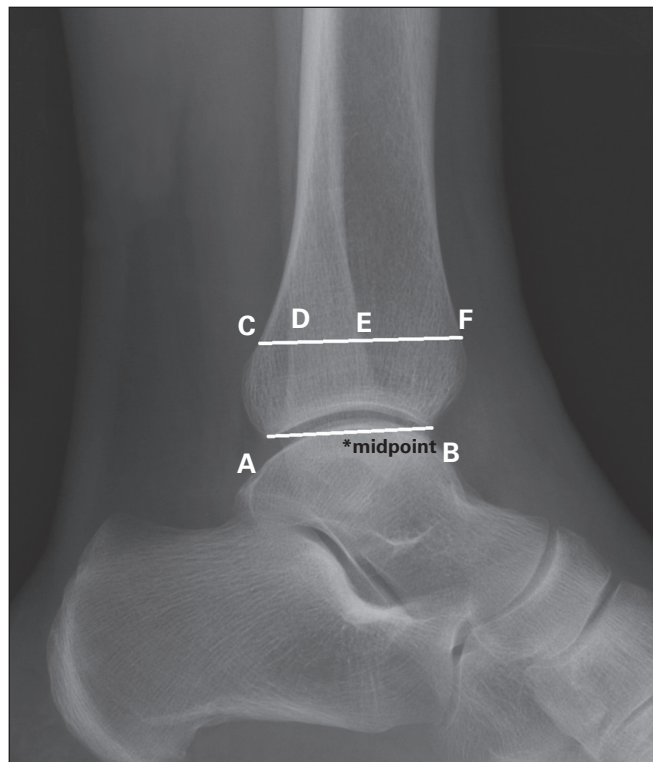


Fig. 1. Lateral ankle radiograph. The line segment A–B shows the tibial plafond, C–D shows the posterior tibiofibular interval, D–E shows the fibular width, E–F shows the anterior tibiofibular interval, and C–F shows the tibial width. All measurements were made 1 cm above the midpoint of the tibial plafond.

Statistical analysis

Statistical analysis was completed using SPSS software version 19 (SPSS Inc.). We used descriptive statistics, intraclass correlation with inter- and intraobserver reliability and an independent *t* test with Pearson correlation to assess associations between age, sex and side. Intraclass correlation was interpreted as poor at 0–0.2, fair at 0.3–0.4, moderate at 0.5–0.6, strong at 0.7–0.8 and near perfect at greater than 0.8.¹³

RESULTS

Eighty radiographs were selected; 8 were excluded based on our given criteria. The 72 remaining radiographs were from 35 men and 37 women with a mean age of 44 years; 33 showed the right ankle and 39 showed the left ankle (Table 1). Descriptive statistics are shown in Table 2.

Four ratios to describe the relationship of the tibia and fibula were determined: PTFI:TW, ATFI:TW, PTFI:(PTFI+FW) and ATFI:(ATFI+FW). The respective means ± standard deviations were 0.17 ± 0.06, 0.39 ± 0.09, 0.27 ± 0.06, 0.46 ± 0.07. We conducted an independent sample *t* test using Pearson correlation to determine the association between each ratio and age, sex and side (Table 3).

We documented the inter- and intrarater reliability for each ratio (Tables 4 and 5). The interrater reliability ranged from moderate to near perfect (0.599–0.862), and intrarater reliability was strong to near perfect for ATFI:TW, moderate to near perfect for PTFI:TW, strong to near perfect for PTFI:(PTFI+FW) and poor to strong for ATFI:(ATFI+FW).

DISCUSSION

The syndesmosis is the most significant ligamentous complex of the ankle.^{1–3} Disruption can lead to instability, pain and arthrosis.^{1–3,14,15} Functionally, malreduced syndesmotic injuries have demonstrated worse outcomes on the Short Form Musculoskeletal Assessment, which looks at general health, and on the Olerud/Molander questionnaire, which is ankle-specific.¹⁴

Recent literature demonstrates that the validity and reliability of our classic diagnostic criteria is not optimal.^{4–11} Nielson and colleagues⁶ and Hermans and colleagues⁷ compared the standard radiographic measurements for ankle fractures with MRI findings. They found that radiographic measurements for syndesmosis injury did not correlate with MRI findings. In 2004, Beumer and colleagues⁵ demonstrated that, although previously used parameters to

Table 1. Demographic and clinical characteristic of patients whose radiographs were reviewed

Characteristic	No. of patients*
Side	
Right	33
Left	39
Sex	
Female	37
Male	35
Age, mean (median) [range] yr	44 (44) [14–91]

*Unless otherwise indicated.

Table 2. Descriptive statistics

Statistic	ATFI:TW	PTFI:TW	PTFI:(PTFI+FW)	ATFI:(ATFI+FW)
Mean	0.39	0.17	0.27	0.46
Median	0.39	0.17	0.27	0.46
SD	0.09	0.06	0.06	0.07

ATFI = anterior tibiofibular interval; FW = fibular width; PTFI = posterior tibiofibular interval; SD = standard deviation; TW = tibial width.

Table 3. Pearson correlation

Variable	Measure, <i>r</i>			
	ATFI:TW	PTFI:TW	PTFI:(PTFI+FW)	ATFI:(ATFI+FW)
Side	-0.018	-0.180	-0.155	0.006
Sex	-0.094	0.187	0.109	-0.162
Age	0.075	-0.205	-0.129	0.161

ATFI = anterior tibiofibular interval; FW = fibular width; PTFI = posterior tibiofibular interval; TW = tibial width.

Table 4. Interrater reliability

Measure	Mean (95% CI)
ATFI:TW	0.599 (0.379–0.751)
PTFI:TW	0.772 (0.643–0.860)
PTFI:(PTFI+FW)	0.850 (0.707–0.919)
ATFI:(ATFI+FW)	0.862 (0.399–0.949)

ATFI = anterior tibiofibular interval; CI = confidence interval; FW = fibular width; PTFI = posterior tibiofibular interval; TW = tibial width.

Table 5. Intrarater reliability

Observer	Measure, mean (95% CI)			
	ATFI:TW	PTFI:TW	PTFI:(PTFI+FW)	ATFI:(ATFI+FW)
1	0.720 (0.264–0.896)	0.688 (0.190–0.885)	0.796 (0.454–0.925)	0.745 (0.328–0.906)
2	0.747 (-0.171–0.934)	0.828 (0.629–0.921)	0.749 (0.453–0.885)	0.678 (-0.215–0.904)
3	0.917 (0.790–0.965)	0.992 (0.982–0.996)	0.977 (0.946–0.990)	0.224 (-0.060–0.607)

ATFI = anterior tibiofibular interval; CI = confidence interval; FW = fibular width; PTFI = posterior tibiofibular interval; TW = tibial width.

diagnose syndesmosis injury have been useful, there remains no optimal tool for diagnosis.

It has been suggested that MRI, CT or arthroscopy should be used to ensure adequate diagnosis and treatment;^{7-10,12} however, if it is possible to diagnose syndesmotric disruption with plain film radiography, significant cost and morbidity could be spared. Stress examination is another method that has been used to diagnose syndesmotric disruption;^{9,15-17} however, use of the mortise and AP views have continued to be the foundation for diagnosis.^{9,15,16} It has been demonstrated that we should be putting more emphasis in the sagittal plane,^{2,12,16-18} but ultimately, there is a need for new radiographic parameters to better delineate the syndesmosis.

Prior to analyzing the abnormal syndesmosis, however, it is essential to understand and document how a healthy syndesmosis is represented. We have therefore described the anterior tibiofibular ratio (ATFR), which characterizes the ATFI:TW ratio described previously. It has been documented in the literature on a number of occasions that sagittal movement of the fibula relative to the tibia can represent a syndesmotric injury;^{2,7,9,12,16-19} however, to our knowledge only 2 studies^{12,19} have attempted to determine specific criteria for diagnosis on the lateral view. In 2013, Grenier and colleagues¹⁹ concluded that the tibiofibular joint can be accurately assessed on the lateral view when looking at the sagittal relationship of the tibia and the fibula. They described the anteroposterior tibiofibular ratio (APTF), which they calculated based on a line from the anterior tibial physeal scar to the intersection of the physeal scar and the anterior cortex of the fibula, relative to a continuation of that line to the posterior tibial cortex. Although they were able to use the physeal scar as a radiographic marker for measurement, we believe it to be an indistinct landmark that could introduce inconsistency.¹⁹ In 2012, Dikos and colleagues¹² determined that the interval of the anterior fibula to the anterior tibia is a reliable marker based on comparison with axial CT images. In addition, they determined that there are significant anatomic variations dependent and independent of sex. When the anterior interval was expressed as a ratio to the fibular width, those sex differences were controlled, and the independent variations were primarily seen with regards to fibular rotation, specifically in the AP plane.¹² We believe that a ratio on the lateral radiograph would control for the sex and anatomic variations.

We evaluated 72 ankles free of disease and calculated a ratio that represents a normal positional relationship of the fibula relative to the tibia. Our results reveal that the ATFR should be equal to 39% \pm 9% (i.e., approximately 40% of the tibia should be anterior to the anterior fibular cortex, 1 cm above the tibial plafond). Intrarater reliability was strong to very strong with a moderate interobserver reliability. When analyzing the ATFR, there was no significant difference shown with regard to age, sex or side.

Limitations

Limitations of our study include those inherent to a retrospective design; our radiographs were not randomly chosen and, therefore, there may be a selection bias. The quality of the radiographs may represent an issue with providing accurate measurements; however, this limitation is also present in the clinical setting. Ensuring appropriate and quality radiographs will facilitate the detection and treatment of correct pathology. In addition, there may be a discrepancy when determining the ratio in the sterile operating room setting without the ability to use digital rulers, and the amount of variance described from patient to patient may limit the effectiveness of the ratio. These are 2 areas that are outside the scope of the present study; however, a prospective analysis with an increased population size, including the ability to appropriately identify the ATFR and relate it to functional outcome, would be of great benefit moving forward.

CONCLUSION

The ATFR is a radiographic measure on the lateral view of the ankle that will add to the current diagnostic tools that delineate the ankle syndesmosis. The measure has to be validated on ankles with a disrupted syndesmosis; however, we have shown the ATFR to be an easily calculated and reproducible measure that is suitable for determining the normal relationship of the tibia and fibula. The ATFR provides an orthogonal measure for the syndesmosis that, in conjunction with those parameters previously documented, could clinically and economically improve the diagnosis of syndesmotric disruptions.

Affiliations: All authors are from the Department of Orthopaedic Surgery, Memorial University of Newfoundland, St. John's, Nfld.

Competing interests: None declared.

Contributors: S. Croft, A. Furey and C. Moores designed the study. S. Croft, A. Furey, C. Stone and C. Moores acquired the data, which S. Croft, A. Furey, C. Stone and R. Wilson analyzed. S. Croft and A. Furey wrote the article, which all authors reviewed and approved for publication.

References

- Zalavras C, Thordarson D. Ankle syndesmotric injury. *J Am Acad Orthop Surg* 2007;15:330-9.
- Scheyerer MJ, Helfet DL, Wirth S, et al. Diagnostics in suspicion of ankle syndesmotric injury. *Am J Orthop* 2011;40:192-7.
- Browner BD. *Skeletal trauma: basic science, management, and reconstruction*. Philadelphia (PA): Saunders/Elsevier; 2009.
- Pettrone FA, Gail M, Pee D, et al. Quantitative criteria for prediction of the results after displaced fracture of the ankle. *J Bone Joint Surg Am* 1983;65:667-77.
- Beumer A, van Hemert WL, Niesing R, et al. Radiographic measurement of the distal tibiofibular syndesmosis has limited use. *Clin Orthop Relat Res* 2004; (423):227-34.
- Nielson JH, Gardner MJ, Peterson MG, et al. Radiographic measurements do not predict syndesmotric injury in ankle fractures: an MRI study. *Clin Orthop Relat Res* 2005; (436):216-21.

7. Hermans JJ, Wentink N, Beumer A, et al. Correlation between radiological assessment of acute ankle fractures and syndesmotic injury on MRI. *Skeletal Radiol* 2012;41:787-801.
8. Nault ML, Hebert-Davies J, Laflamme GY, et al. CT scan assessment of the syndesmosis: a new reproducible method. *J Orthop Trauma* 2013;27:638-41.
9. van den Bekerom MP. Diagnosing syndesmotic instability in ankle fractures. *World J Orthop* 2011;2:51-6.
10. Franke J, von Recum J, Suda AJ, et al. Intraoperative three-dimensional imaging in the treatment of acute unstable syndesmotic injuries. *J Bone Joint Surg Am* 2012;94:1386-90.
11. Gardner MJ, Demetrakopoulos D, Briggs SM, et al. Malreduction of the tibiofibular syndesmosis in ankle fractures. *Foot Ankle Int* 2006;27:788-92.
12. Dikos GD, Heisler J, Choplin RH, et al. Normal tibiofibular relationships at the syndesmosis on axial CT imaging. *J Orthop Trauma* 2012;26:433-8.
13. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33:159-74.
14. Sagi HC, Shah AR, Sanders RW. The functional consequence of syndesmotic joint malreduction at a minimum 2-year follow-up. *J Orthop Trauma* 2012;26:439-43.
15. Jenkinson RJ, Sanders DW, Macleod MD, et al. Intraoperative diagnosis of syndesmosis injuries in external rotation ankle fractures. *J Orthop Trauma* 2005;19:604-9.
16. Stoffel K, Wysocki D, Baddour E, et al. Comparison of two intraoperative assessment methods for injuries to the ankle syndesmosis. A cadaveric study. *J Bone Joint Surg Am* 2009;91:2646-52.
17. Candal-Couto JJ, Burrow D, Bromage S, et al. Instability of the tibiofibular syndesmosis: Have we been pulling in the wrong direction? *Injury* 2004;35:814-8.
18. Xenos JS, Hopkinson WJ, Mulligan ME, et al. The tibiofibular syndesmosis. Evaluation of the ligamentous structures, methods of fixation, and radiographic assessment. *J Bone Joint Surg Am* 1995;77:847-56.
19. Grenier S, Benoit B, Rouleau DM, et al. APTF: anteroposterior tibiofibular ratio, a new reliable measure to assess syndesmotic reduction. *J Orthop Trauma* 2013;27:207-11.

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