# Radiographic Evaluation of Ankle Syndesmosis using Anterior Tibiofibular Ratio (ATFR) and Anteroposterior Tibiofibular Ratio (APTF): A Pilot Study

**Jeremy D. Iturriaga, MD, DPAFP, DPBO*, Lucille P. Detoyato, MD, FPOA***

* Western Visayas Medical Center
Department of Orthopaedics
Iloilo City, Philippines

DOI: 10.29322/IJSRP.12.09.2022.p12919
http://dx.doi.org/10.29322/IJSRP.12.09.2022.p12919

Paper Received Date: 13th July 2022
Paper Acceptance Date: 29th August 2022
Paper Publication Date: 6th September 2022

***Abstract***
**Objectives:** To determine the ankle syndesmosis radiographically using Anterior Tibiofibular Ratio (ATFR) and Anteroposterior Tibiofibular Ratio (APTF) of selected tertiary government hospital employees.

**Methods:** Four observers namely two consultants and two residents, were employed randomly using a simple randomization, from a pool of six consultants and thirteen residents in order to measure the ATFR and APTF ratio of the lateral ankle radiographs. Forty lateral ankle radiographs were initially assessed in a specific order. Another assessment was done three weeks after the first observation by the same observers but with rearranged order of the previously assessed radiographs. Single blinding was applied to observers.

**Results:** There were twenty subjects included in this study with a total of 40 lateral ankle radiographs, which was based on the inclusion and exclusion criteria. ATFR mean is 0.41 and the APTF ratio mean is 0.90. Paired t-test results showed no significant difference when comparing the right and left ankle among different observers for both ATFR and APTF ratio. Likewise, the t-test comparing sexes showed no significant difference for all observers on both ATFR and APTF ratio.

**Conclusion:** This study was able to determine the Anterior TibioFibular Ratio and AnteroPosterior TibioFibular ratio of Filipino subjects. Furthermore, ATFR and APTF ratio are both reliable and reproducible tools in the measurement of the ankle syndesmosis.

***Index Terms***- ATFR, APTF ratio, Ankle syndesmosis, Radiograph

## I. INTRODUCTION

The integrity of the ankle mortise relies on the relationship of the distal tibia and fibula around the ankle, where the syndesmotic ligament complex is found and works to resist rotational, translational as well as axial force. Injuries to the ankle can have an associated disruption to the ankle syndesmosis, although injury to the syndesmosis alone may occur.

In the study of Vucivekic et. al in 1980, syndesmosis injuries arise in approximately 10% of all patients with ankle fractures although some report showed even up to 13 per cent of syndesmotic injuries found in ankle fractures. Still other authors suppose that the incidence may even be as high as 40 % in athletes, and syndesmotic disruption can even occur in such a simple ankle sprain.

As stated by Heckman in 2015, the relationship between the tibia and fibula centers on the syndesmosis where the fibula lies in the incisura of the lateral aspect of the tibia. There are important ligaments that stabilizes the syndesmosis and these are the anterior-inferior tibiofibular ligament (AITFL), the posterior-inferior tibiofibular ligament (PITFL), and the interosseous ligament which is confluent with the interosseous membrane above.

In an article published by Ramsey and company in 1976, where cadaveric investigation was assessed and it showed that disruption and widening of the ankle syndesmosis results in shifting of the talus laterally. A 1 mm of lateral talar shift reduces the contact area of the

talus to the tibial plafond by as much as 42%. Thus, it is considered important to accurately reduce syndesmotic disruption to prevent poor functional outcome.

In 1989, a journal published by Harper et, al. described the radiographic relationships of the distal tibiofibular syndesmosis which was considered to be the normal values. These includes the following: first, the tibiofibular clear space (TFCS) on the AP and mortise view which is less than 6 mm; next, the tibiofibular overlap (TFO) on the AP view of more than 6 mm or 42% of the fibular width, and (3) tibiofibular overlap on the mortise view of more than 1 mm.

Aside from radiography, there are other clinical diagnostic tests used to diagnose syndesmotic injuries including CT scan, even MRI and Arthroscopy but these tests are considered costly economic wise especially in our setting.

In 2013, Grenier et. al, published a study of a new radiographic measurement using lateral view of ankle in normal adults: the anteroposterior tibiofibular ratio (APTF) to determine the reliability of standard lateral ankle radiograph in diagnosing syndesmotic integrity. In the same year, Croft et. al, also made a study of the lateral ankle using anterior tibiofibular ratio (ATFR) that will add to the current diagnostic tools that delineate the ankle syndesmosis.

The purpose of this study will be to validate the ATFR and the APTF ratio on a normal lateral ankle radiograph among Filipinos that would increase the reliability of standard radiography in diagnosing syndesmotic integrity and to aid in intraoperative decision making on fixation of the syndesmosis.

**Objectives**

**General Objective:**
To determine the ankle syndesmosis radiographically using Anterior Tibiofibular Ratio (ATFR) and Anteroposterior Tibiofibular Ratio (APTF) of selected WVMC employees at Western Visayas Medical Center (WVMC).

**Specific Objectives:**
1. To determine the ATFR of selected WVMC employees.
2. To determine the APTF ratio of selected WVMC employees.
3. To determine if there is a significant difference of ATFR and APTF ratio of the left and right ankle among selected WVMC employees among selected observers

## II. DATA COLLECTION

This study was designed to determine the Anterior Tibiofibular Ratio and Anteroposterior Tibiofibular ratio among selected WVMC employees using lateral radiography of the ankle. This research is a Prospective Cross-Sectional, Correlational study which was conducted at Western Visayas Medical Center from December 2020 until January 2021.

The study population were Western Visayas Medical Center employees who had no prior history of injury to the ankle. A simple randomization using a randomization platform was utilized from an internet website “randomizer.org” from a pool of 1075 employees. Subjects signed an informed consent form approved by the ethics committee of our institution. For subjects who refused to give consent, randomization with replacement was employed. All subjects wore lead protection during the radiological imaging procedure.

**Inclusion Criteria**
Radiographs included in this study met all of the following criteria:
1) patient is aged 21 years old or older,
2) patient had no documented ankle joint disease or condition,
3) a true lateral ankle view showing superimposition of the talar domes are visible
4) senior radiologic technicians will be assigned to take the X-ray

**Exclusion Criteria**
Radiographs excluded in this study were those who have any of the following:
1) Poorly taken radiograph including blurry films or with artifacts,
2) Patient who underwent prior ankle surgery,
3) Patient who had history of trauma to the ankle,
4) Pregnant subjects

**Withdrawal Criteria**
A. Withdrawal of the Subject by Principal Investigator

1) Principal investigator may remove or withdraw a subject at any time in his discretion in circumstances wherein the safety of subject is compromised or the subject is non-compliant.

B. Voluntary Withdrawal by the Subject

1) subject who wishes to withdraw from the study at any given time for which he or she has previously gave consent.

**Sample Size**

A total of twenty subjects were included in this study, which produced 40 lateral ankle radiographs as recommended by Harrison et. al., (2001) in conducting a validation or reliability study of a new radiological method, particularly in line-drawing radiographic procedures. Harrison et. al., (2001) recommended the following:

1. At least three observers should be used. This will create three pairs for an analysis of interobserver reliability.
2. Between 30 to 60 radiographs should be used. This provides enough comparisons of measurements to provide meaningful results.
3. All observers should measure all radiographs at least twice with a time delay. This will provide at least three sets of intraobserver data.
4. ICCs for both interobserver and intraobserver reliability should be provided; any additional tests are welcome.

**Description of the Study Procedure**

Four observers, two (2) Orthopaedic consultants and two (2) Orthopaedic residents, were employed randomly using a simple randomization platform from an internet website "randomizer.org", from a pool of six (6) consultants and thirteen residents measured the ATFR and APTF ratio of the lateral ankle radiographs. Forty lateral ankle radiographs were initially assessed by the observers in a specific order. Another assessment was made three weeks after the first observation by the same observers but with rearranged order of the previously selected and assessed radiographs. Single blinding was applied to observers. The radiographs were evaluated with the use of Picture Archiving and Communication System (PACS).

**Statistical Tool**

Data was analyzed using SPSS version 25. 95% confidence interval will be used. A paired t test was used to compare the right and left measures and the correlation was assessed by a Pearson test.

**Table 1. Level of acceptability as clinical measure by Portney and Watkins (2000)**

| ICC | Fleiss (1986) | P&W (2009) |
|---|---|---|
| 0.99 | Excellent | Clinical Measures |
| 0.96 | | |
| 0.90 | | |
| 0.89 | | Good |
| 0.80 | | |
| 0.75 | | |
| 0.50-74 | Good | Poor to moderate |

## III. Results and Discussion

**Results**

There were twenty subjects included in this study with a total of 40 lateral ankle radiographs, which was based on the inclusion and exclusion criteria. 12 subjects were males. The mean age of the subjects was 34.3 (22 – 51) years old. ATFR mean is 0.41 (sd 0.06651) with a range of 0.26-0.68 (Table 3). For the APTF ratio, the mean is 0.90 (sd 0.077) with a range of 0.75-1.20 (Table 3.).

The paired t-test comparing the right and left ankle was not significantly different among observers, (right ATFR for observers A and B is 0.123 and 0.931 for observers C and D). Same is true with the APTF ratio which revealed a not statistically significant difference for all observers (right APTF ratio for observers A and B is 0.259 while 0.325 for observers C and D (Table 8). The t-test comparing sexes showed no significant difference for all observers on both ATFR and APTF (Table 9).ow it is the time to articulate the research work with ideas gathered in above steps by adopting any of below suitable approaches:

**Table 2. Clinical and Demographic Characteristics of Subjects**

| Sidedness | Number of Subjects |
|---|---|
| Right | 20 |

| | |
|---|---|
| Left | 20 |
| Sex | |
| Male | 12 |
| Female | 8 |
| Mean Age | (34.3) 22-51 |

**Table 3. Descriptive Statistics**

| | ATFR | APTF |
|---|---|---|
| Mean | 0.41 | 0.90 |
| SD | 0.06651 | 0.077 |
| Range | 0.26-0.68 | 0.75-1.20 |

**Table 4. Paired t-Test for Sidedness**

| APTF | | ATFR | |
|---|---|---|---|
| Observer A and B | Observer C and D | Observer A and B | Observer C and D |
| 0.259 | 0.325 | 0.123 | 0.931 |

**Table 5. Paired t-Test for Sex**

| APTF | | ATFR | |
|---|---|---|---|
| Observer A and B | Observer C and D | Observer A and B | Observer C and D |
| 0.214 | 0.449 | 0.051 | 0.914 |

**Discussion**

It has been known that an injury to the ankle syndesmosis leads to incongruency of the mortise and can give rise to ankle instability, pain and arthritis. Hence, judicious restoration of ankle syndesmosis is a must in order to prevent long term complications.

Several textbooks and other literatures recommend radiographic measurements in evaluating the syndesmosis on AP and mortise view of the ankle. Nonetheless, Beumer in 2004 believed that these parameters were not optimal to asses ankle syndesmosis. To reliably evaluate the syndesmosis, CT scan and MRI are indeed better option as well as considered to be superior to plain radiograph. On the contrary, intraoperative CT scan evaluation is not generally available to some surgeons. In this regard, Grenier et. al, in 2013 and Croft and colleagues in 2015, established new radiographic parameters; the AnteroPosterior TibioFibular ratio (APTF) and Anterior TibioFibular Ratio (ATFR) respectively to establish newer criteria for evaluation of syndemosis.

Anatomic variations due to race can contribute to differences in radiographic measurements. On this account, the author evaluated lateral view of forty ankle radiographs using the APTF and ATFR by Grenier et. al, and Croft et. al, respectively. The APTF ratio is a ratio based on the line made from anterior physeal scar of the distal tibia to the anterior fibular cortex that bisects the physeal scar, and carrying on of that line to the posterior cortex of the distal tibia. Whereas the ATFR describes the ratio of the anterior tibiofibular interval to the tibial width which was described earlier.

In 2013, Grenier et. al, described a new radiographic measurement of ankle syndesmosis utilizing the true lateral view radiograph of the ankle that can be used in the intraoperative evaluation of syndesmosis: the Anteroposterior Tibiofibular Ratio (APTF). The APTF ratio was 0.94 + 0.13 with a range of 0.63 – 1.31. They concluded that this ratio is a new reliable method for radiographically measuring the distal tibiofibular joint anatomy. This study showed APTF ratio of 0.90 + 0.08 with a range of 0.75 – 1.2.

Meanwhile, Croft and colleagues in 2015, also evaluated lateral ankle radiographs utilizing 4 measurements namely tibial width (TW), fibular width (FW), anterior tibiofibular interval (ATFI) and posterior tibiofibular interval (PTFI). By using these measurements, four ratios: PTFI:TW, ATFI:TW, PTFI: (PTFI + FW) and ATFI: (ATFI + FW) were utilized to describe the tibia and fibula relationship were evaluated. Of the 4 ratios, the authors found out that the ATFR (ATFI:TW) ratio has better Intraclass correlation coefficient. They found that the ATFR is equal to 39% + 9% of the tibia should be anterior to the anterior fibular cortex. On that account, they recommended the ATFR as a measure in conjunction with other parameters for evaluation of syndesmotic disruptions. This study

noted that ATFR of 0.41 + 0.07 with a range of 0.26 – 0.68 or 41% + 7% of the tibia is anterior to the anterior fibular cortex when measured 1 cm above the center of tibial plafond.

## IV. Conclusion and Recommendation

In conclusion, APTF and ATFR are both radiographic measurements on the lateral ankle that will add to other imaging and diagnostic studies for evaluation of ankle syndesmosis. In addition, these ratios can further assess the intra-operative reduction of ankle syndesmosis. There was no significant difference of both ratios when it comes to sidedness of the ankle. In addition, both of these ratios are quick and simple to perform and reliable measures as well.
Reliability study such as the ICC or Intraclass correlation coefficient should also be included on further studies, as it is one of the descriptive statistics that allows testing the reliability of the study among groups of data.

Further evaluation of these ratios should be conducted to pediatric age population, as well as larger population should be determined since this is a pilot study conducted only in this center.

## Acknowledgment

First and foremost, I would like to thank the Lord Jesus Christ, for the gift of life, strength, wisdom and good health He bestowed upon me.
My sincerest gratitude to my mentors, Dr. Ronnie Payba, Dr. Margarito Morano, Dr. Raoul Cañonero, Dr. Cesar Cuenca and Dr. Lucille Detoyato for imparting knowledge and skills as I coursed through the training program.
Special thanks to Dr. Lucille Detoyato, my research adviser and Dr. Kris Francisco for their guidance and support to complete this undertaking.
I also take this opportunity to thank my co-residents for their encouragements and support. Also, I wish to thank Miss Divina De los Reyes, the Department's secretary for her valuable support.
Finally, my very special appreciation to my wife Rosalie, my children Lee Summer, Luis Sebastian, Leon Silas and the rest of my Family for their love, undying support and unending encouragements to complete my task.

## References

1. Bauer, A. S., Bluman, E. M., Wilson, M. G., & Chiodo, C. P. (2009). Injuries of the distal lower extremity syndesmosis. Current Orthopaedic Practice, 20(2), 111-116.
2. Beumer; W L W van Hemert;R Niesing;C A C Entius;A Z Ginai;P G H Mulder;B A Swierstra (2004). Radiographic Measurement of the Distal Tibiofibular Syndesmosis Has Limited Use Clinical Orthopaedics and Related Research. 423():227-234
3. Bucholz, R. (2015). Court-Brown C, Rockwood C. Rockwood and Green's Fractures in Adults.
4. Croft, S., Furey, A., Stone, C., Moores, C., & Wilson, R. (2015). Radiographic evaluation of the ankle syndesmosis. Canadian Journal of Surgery, 58(1), 58.
5. Dattani, R., Patnaik, S., Kantak, A., Srikanth, B., & Selvan, T. P. (2008). Injuries to the tibiofibular syndesmosis. Bone & Joint Journal, 90(4), 405-410.
6. Del Buono, A., Florio, A., Boccanera, M. S., & Maffulli, N. (2013). Syndesmosis injuries of the ankle. Current reviews in musculoskeletal medicine, 6(4), 313-319.
7. Dikos, G. D., Heisler, J., Choplin, R. H., & Weber, T. G. (2012). Normal tibiofibular relationships at the syndesmosis on axial CT imaging. Journal of orthopaedic trauma, 26(7), 433-438.
8. Dubin, J. C., Comeau, D., McClelland, R. I., Dubin, R. A., & Ferrel, E. (2011). Lateral and syndesmotic ankle sprain injuries: a narrative literature review. Journal of chiropractic medicine, 10(3), 204-219.
9. Grenier, S., Benoit, B., Rouleau, D. M., Leduc, S., Laflamme, G. Y., & Liew, A. (2013). APTF: anteroposterior tibiofibular ratio, a new reliable measure to assess syndesmotic reduction. Journal of orthopaedic trauma, 27(4), 207-211.
10. Harper, M. C., & Keller, T. S. (1989). A radiographic evaluation of the tibiofibular syndesmosis. Foot & ankle, 10(3), 156-160.
11. Harrison, D. E., Harrison, D. D., Cailliet, R., Janik, T. J., & Holland, B. (2001). Radiographic analysis of lumbar lordosis: centroid, Cobb, TRALL, and Harrison posterior tangent methods. Spine, 26(11), e235-e242.
12. Heckman, J. D., McQueen, M. M., Ricci, W. M., Tornetta, P., & McKee, M. D. (2015). Rockwood and Green's fractures in adults. Wolters Kluwer Health,.
13. Hopkinson, W. J., Pierre, P. S., Ryan, J. B., & Wheeler, J. H. (1990). Syndesmosis sprains of the ankle. Foot & ankle, 10(6), 325-330.
14. Lin, C. F., Gross, M. T., & Weinhold, P. (2006). Ankle syndesmosis injuries: anatomy, biomechanics, mechanism of injury, and clinical guidelines for diagnosis and intervention. Journal of Orthopaedic & Sports Physical Therapy, 36(6), 372-384.
15. Magan, A., Golano, P., Maffulli, N., & Khanduja, V. (2014). Evaluation and management of injuries of the tibiofibular syndesmosis. British medical bulletin, 111(1), 101-115.
16. Morshed, S. (February 2014). Current Options for Determining Fracture Union. Advances in Medicine Volume 2014, Article ID 708574 Portney, L.G. and Watkins, M.P. (2000) Foundations of clinical research: Applications to practice. 2nd Edition, Prentice Hall Health, Upper Saddle River
17. Ostrum, R. F., De Meo, P., & Subramanian, R. (1995). A critical analysis of the anterior-posterior radiographic anatomy of the ankle syndesmosis. Foot & ankle international, 16(3), 128-131.
18. Ramsey, P. L., & Hamilton, William (1976). Changes in tibiotalar area of contact caused by lateral talar shift. JBJS, 58(3), 356-357
19. Sowman, B., Radic, R., Kuster, M., Yates, P., Breidiel, B., & Karamfilef, S. (2012). Distal tibiofibular radiological overlap: does it always exist?. Bone and Joint Research, 1(2), 20-24.
20. Takao, M., Ochi, M., Oae, K., Naito, K., & Uchio, Y. (2003). Diagnosis of a tear of the tibiofibular syndesmosis: the role of arthroscopy of the ankle. Bone & Joint Journal, 85(3), 324-329.
21. Van Den Bekerom, M. P., Oostra, R. J., Alvarez, P. G., & Van Dijk, C. N. (2008). The anatomy in relation to injury of the lateral collateral ligaments of the ankle: a current concepts review. Clinical anatomy, 21(7), 619-626.
22. Xenos, J. S., Hopkinson, W. J., Mulligan, M. E., Olson, E. J., & Popovic, N. A. (1995). The tibiofibular syndesmosis. Evaluation of the ligamentous structures, methods of fixation, and radiographic assessment. JBJS, 77(6), 847-856.

AUTHORS

**First Author** – Jeremy D. Iturriaga, MD, DPAFP, DPBO, Western Visayas Medical Center Department of Orthopaedics, dr.jeremyiturriaga@gmail.com
**Second Author** – Lucille P. Detoyato, MD, FPOA, Western Visayas Medical Center Department of Orthopedics, lucilmd@gmail.com