

## Original Article

# Radiographic assessment of AO 44-B1 and -B2 ankle fractures

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## Abstract

**Objective:** To verify if there is a type of image that guides the surgeon in recommending surgical treatment for ankle fractures and assess whether this decision is associated with the evaluator's age and experience, considering surgeons of different nationalities.

**Methods:** We analyzed 3 different presentations of radiographic images of ankle fractures in 36 patients: anteroposterior and lateral views, true anteroposterior and lateral views, as well as the 3 grouped images. Images were assessed randomly and independently by 89 professionals of different nationalities, ages, and experience.

**Results:** Among professionals from Ecuador, Argentina, Mexico, and Chile, surgery recommendations were more frequent when images were presented in true anteroposterior and lateral views. For professionals from Peru, Venezuela, Bolivia, Paraguay, Brazil, Colombia, Uruguay, and Guatemala, as well as globally, recommendations for surgery were more frequent when grouped images of the 3 positions were presented. In all countries and globally, we verified lower frequencies of surgery recommendations when presenting only anteroposterior and lateral views.

**Conclusion:** In most countries, surgery recommendations were more frequent when grouped images of all 3 views were presented. On the other hand, the highest frequencies of surgery recommendations were observed when images were presented only in true anteroposterior and lateral views. Surgery recommendations were not associated with the experience (years since graduation) of the evaluating physician.

**Level of Evidence IV; Prognostic Studies; Case Series.**

**Keywords:** Ankle fractures/epidemiology; Radiography/methods; Observer variation; Reproducibility of Results; Attitude of health personnel.

## Introduction

Ankle fractures are among the most frequent injuries of the musculoskeletal system and correspond to approximately 9% of all fractures<sup>(1)</sup>; the radiographic study of these pathologies represents 10%-12% of all radiographs captured in emergency settings, resulting in significant expenses<sup>(2-12)</sup>.

Radiographic assessment is essential in ankle fractures. The Ottawa ankle rules represented an attempt to reduce the recommendation of imaging examinations. However, the small dose of radiation and low cost of radiographic procedures favor the performance of such tests<sup>(6)</sup>. Radiographic views classically requested for diagnosing ankle fractures are anteroposterior (AP), AP with internal rotation of 20° (true AP), and lateral. However, many studies have challenged the need for

3 radiographic images when diagnosing ankle fractures<sup>(2,4,9,10)</sup>. Various authors have suggested that 2 views may be enough for diagnosing this pathology<sup>(2,4,9,11)</sup>. These studies suggest that only the AP and lateral views could be used for diagnosing fractures<sup>(2,10)</sup>. Conversely, other authors recommend only the true AP and lateral views, since these could provide "95% precision" in the diagnosis of ankle fractures when compared to the 3-view series<sup>(4,9)</sup>. In most of these studies, the combination of 2 images was compared to the standard 3-image series, selected according to the researcher's preference.

This work aimed to verify if there is a type of image that leads the surgeon to recommend surgical treatment of ankle fractures and to assess whether the surgeon's decision is associated with his or her age and experience, considering surgeons of different nationalities.

Study performed at the Hospital Santa Teresa, Petrópolis, RJ, Brazil.

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## Methods

This study was approved by the Institutional Review Board and registered on the Plataforma Brasil database under CAAE (Ethics Evaluation Submission Certificate) number: 82503418.6.0000.5245.

This is an observational cross-sectional study was performed between March 01 and June 30, 2019, involving 89 evaluating professionals and 36 patients with ankle fractures treated at a tertiary hospital. Patients were randomly selected and no sampling analysis was performed.

Inclusion criteria were: patients over 18 years old, diagnosed with 44-B1 and -B2 supination external rotation ankle fractures, who had radiographic images in 3 views in the studied period. Exclusion criteria were: patients with open fractures (since these are normally caused by more intense trauma and may present different patterns), patients with history of previous ankle fractures or of fractures due to metabolic or tumor-derived alterations.

For achieving the aim of this study, radiographic images were randomly and independently assessed by 89 professionals of different nationalities, ages, and experience (time since graduation). Inclusion criteria for evaluators were: physicians graduated more than 1 year before in orthopaedics and traumatology and who were registered at orthopaedic associations in their countries of work. Exclusion criteria for evaluators were: physicians who did not work with traumatology and who did not belong to any orthopaedic association.

Three different presentations of radiographic images of the ankles of 36 patients were shown to the evaluators.

Each of the 36 cases was presented to the evaluators as follows:

- Presentation 1: radiographic image of the ankle in AP and lateral views;
- Presentation 2: radiographic image of the ankle in AP with internal rotation of 20° (mortise) and lateral views;
- Presentation 3: radiographic image of the ankle with all 3 grouped images (AP, mortise, and lateral).

The 108 presentations were independently provided to the evaluators in a random order via a digital platform under control of the researchers only. For each presentation, the evaluator indicated his or her decision of surgical or conservative treatment. Once the evaluator chose a type of treatment, the program did not allow changes to previously assigned answers. This was determined so as the evaluator could not change his or her opinion when identifying the case in presentations containing all 3 images. We did not control the time spent by each evaluator examining the radiographic images.

## Statistical analysis

Data on the evaluators (age, time since graduation, and country of work) and their answers regarding surgery recommendations for each of the 180 evaluations formed the database for our research.

Quantitative variables (age and time since graduation) were described using minimum and maximum values, means, medians, standard deviations, and coefficients of variation. The variability of a quantitative variable distribution was considered low if; moderate and high if: for each of the 3 presentations; results of the selected outcome (surgery recommendations) were presented in tables and graphs as absolute and percentage frequencies (relative surgery recommendation index).

We used the Mann-Whitney test for comparing ages and time since graduation of professionals who recommended surgery or not, since the distribution of these variables in this study was not normal. The normality of data distribution regarding age and time since graduation was verified by a Shapiro-Wilk test.

Since variables were not normally distributed, the correlation between quantitative variables was assessed by Spearman's rank correlation coefficient, and the significance of the correlation coefficient was tested.

All discussions were performed with a maximum significance level of 5% (0.05).

## Results

### Profile of the professionals

Table 1 presents the distribution of frequencies regarding the evaluators' countries of work and main age statistics, per country and globally (Figure 1). The sample contains professionals from 12 countries in South, Central, and North America, of which Brazil and Mexico are the most represented countries (33.7% and 15.7% of the sample, respectively) (Table 1).

Table 2 presents the distribution of frequencies regarding the evaluators' countries of work and main statistics of time since graduation, per country and globally (Table 2, Figure 2).

### Decisions of the professionals

Table 3 demonstrates the distribution of frequencies of professional recommendations to operate on the evaluated cases and the relative surgery recommendation index, per country, type of presented image, and globally. Figure 3 presents, for each type of presented image and globally, frequencies and relative indices of surgery recommendations, per country and globally.

Considering professionals from Ecuador, Argentina, Mexico, and Chile, surgery recommendations were more frequent when images were presented in true AP view. For professionals from Peru, Venezuela, Bolivia, Paraguay, Brazil, Colombia, Uruguay, and Guatemala, as well as globally, surgery recommendations were more frequent when the 3 grouped images were presented. For all countries and globally, we verified the lowest frequencies of surgery recommendations when only the normal AP view was presented (Figure 3).

Only in 2 out of 108 evaluations (1.9%), we verified a significant association between the decision to operate and the age of the evaluating physician. In both cases, physicians who decided on surgical treatment were significantly more experienced than

**Table 1.** Distribution of frequencies of evaluators' countries of work and main age statistics, per country and globally

| Country   | Number of cases | Age of the professionals |         |      |        |                    |                          |
|-----------|-----------------|--------------------------|---------|------|--------|--------------------|--------------------------|
|           |                 | Minimum                  | Maximum | Mean | Median | Standard deviation | Coefficient of variation |
| Argentina | 8               | 27                       | 54      | 40.8 | 41     | 8.7                | 0.21                     |
| Bolivia   | 2               | 33                       | 36      | 34.5 | 35     | 2.1                | 0.06                     |
| Brazil    | 30              | 28                       | 62      | 41.0 | 40     | 8.7                | 0.21                     |
| Chile     | 3               | 32                       | 63      | 43.7 | 36     | 16.9               | 0.39                     |
| Colombia  | 9               | 33                       | 52      | 40.0 | 39     | 6.7                | 0.17                     |
| Ecuador   | 2               | 44                       | 45      | 44.5 | 45     | 0.7                | 0.02                     |
| Guatemala | 1               | 28                       | 28      | 28.0 | 28     | -                  | -                        |
| Mexico    | 14              | 27                       | 58      | 39.4 | 39     | 10.2               | 0.26                     |
| Paraguay  | 3               | 28                       | 42      | 33.3 | 30     | 7.6                | 0.23                     |
| Peru      | 4               | 32                       | 82      | 54.3 | 52     | 21.5               | 0.40                     |
| Uruguay   | 1               | 34                       | 34      | 34.0 | 34     | -                  | -                        |
| Venezuela | 12              | 30                       | 58      | 36.3 | 33     | 8.6                | 0.24                     |
| Global    | 89              | 27                       | 82      | 40.1 | 38.0   | 10.0               | 0.25                     |

**Table 2.** Distribution of frequencies of evaluators' countries of work and main statistics of time since graduation, per country and globally

| Country   | Number of cases | Time since graduation |         |      |        |                    |                          |
|-----------|-----------------|-----------------------|---------|------|--------|--------------------|--------------------------|
|           |                 | Minimum               | Maximum | Mean | Median | Standard deviation | Coefficient of variation |
| Argentina | 8               | 3                     | 29      | 13.0 | 12     | 9.0                | 0.69                     |
| Bolivia   | 2               | 2                     | 5       | 3.5  | 4      | 2.1                | 0.61                     |
| Brazil    | 30              | 2                     | 34      | 13.1 | 13     | 9.0                | 0.69                     |
| Chile     | 3               | 4                     | 39      | 16.0 | 5      | 19.9               | 1.25                     |
| Colombia  | 9               | 2                     | 22      | 8.8  | 6      | 7.3                | 0.83                     |
| Ecuador   | 2               | 10                    | 15      | 12.5 | 13     | 3.5                | 0.28                     |
| Guatemala | 1               | 2                     | 2       | 2.0  | 2      | -                  | -                        |
| Mexico    | 14              | 2                     | 33      | 11.8 | 9      | 10.0               | 0.85                     |
| Paraguay  | 3               | 1                     | 12      | 5.0  | 2      | 6.1                | 1.22                     |
| Peru      | 4               | 4                     | 50      | 21.3 | 16     | 21.1               | 0.99                     |
| Uruguay   | 1               | 5                     | 5       | 5.0  | 5      | -                  | -                        |
| Venezuela | 12              | 3                     | 28      | 7.8  | 6      | 6.7                | 0.86                     |
| Global    | 89              | 1                     | 50      | 11.5 | 7      | 9.8                | 0.85                     |

**Table 3.** Distribution of frequencies of evaluators' surgery recommendations on the evaluated cases and relative surgery recommendation indices, per country, type of image, and globally

| Country   | Presenting image in normal anteroposterior view |                                   |                                       | Presenting image in true anteroposterior view |                                   |                                       | Presenting all 3 images |                                   |                                       | Global      |                                   |                                       |
|-----------|-------------------------------------------------|-----------------------------------|---------------------------------------|-----------------------------------------------|-----------------------------------|---------------------------------------|-------------------------|-----------------------------------|---------------------------------------|-------------|-----------------------------------|---------------------------------------|
|           | Evaluations                                     | Number of surgery recommendations | Relative surgery recommendation index | Evaluations                                   | Number of surgery recommendations | Relative surgery recommendation index | Evaluations             | Number of surgery recommendations | Relative surgery recommendation index | Evaluations | Number of surgery recommendations | Relative surgery recommendation index |
| Argentina | 288                                             | 182                               | 63.2%                                 | 288                                           | 224                               | 77.8%                                 | 288                     | 204                               | 70.8%                                 | 864         | 610                               | 70.6%                                 |
| Bolivia   | 72                                              | 42                                | 58.3%                                 | 72                                            | 56                                | 77.8%                                 | 72                      | 57                                | 79.2%                                 | 216         | 155                               | 71.8%                                 |
| Brazil    | 1080                                            | 663                               | 61.4%                                 | 1080                                          | 713                               | 66.0%                                 | 1080                    | 740                               | 68.5%                                 | 3240        | 2116                              | 65.3%                                 |
| Chile     | 108                                             | 55                                | 50.9%                                 | 108                                           | 72                                | 66.7%                                 | 108                     | 69                                | 63.9%                                 | 324         | 196                               | 60.5%                                 |
| Colombia  | 324                                             | 183                               | 56.5%                                 | 324                                           | 201                               | 62.0%                                 | 324                     | 210                               | 64.8%                                 | 972         | 594                               | 61.1%                                 |
| Ecuador   | 72                                              | 57                                | 79.2%                                 | 72                                            | 62                                | 86.1%                                 | 72                      | 57                                | 79.2%                                 | 216         | 176                               | 81.5%                                 |
| Guatemala | 36                                              | 9                                 | 25.0%                                 | 36                                            | 7                                 | 19.4%                                 | 36                      | 13                                | 36.1%                                 | 108         | 29                                | 26.9%                                 |
| Mexico    | 504                                             | 273                               | 54.2%                                 | 504                                           | 329                               | 65.3%                                 | 504                     | 322                               | 63.9%                                 | 1512        | 924                               | 61.1%                                 |
| Paraguay  | 108                                             | 72                                | 66.7%                                 | 108                                           | 71                                | 65.7%                                 | 108                     | 76                                | 70.4%                                 | 324         | 219                               | 67.6%                                 |
| Peru      | 144                                             | 102                               | 70.8%                                 | 144                                           | 106                               | 73.6%                                 | 144                     | 115                               | 79.9%                                 | 432         | 323                               | 74.8%                                 |
| Uruguay   | 36                                              | 20                                | 55.6%                                 | 36                                            | 17                                | 47.2%                                 | 36                      | 24                                | 66.7%                                 | 108         | 61                                | 56.5%                                 |
| Venezuela | 432                                             | 283                               | 65.5%                                 | 432                                           | 332                               | 76.9%                                 | 432                     | 345                               | 79.9%                                 | 1296        | 960                               | 74.1%                                 |
| Global    | 3204                                            | 1941                              | 60.6%                                 | 3204                                          | 2190                              | 68.4%                                 | 3204                    | 2232                              | 69.7%                                 | 9612        | 6363                              | 66.2%                                 |

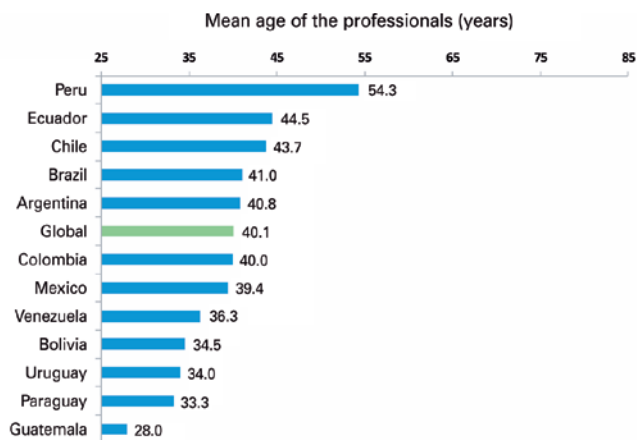


Figure 1. Mean age of professionals per country (ascending order).

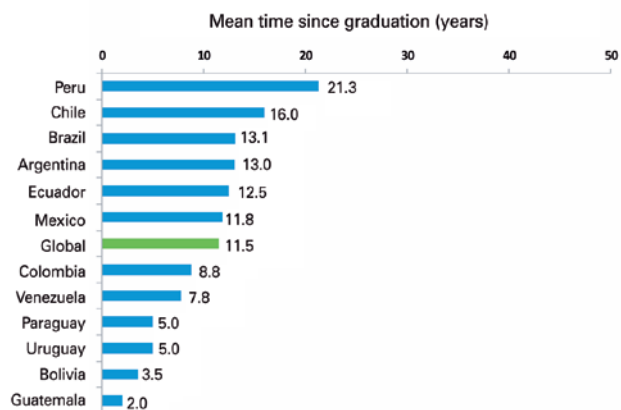


Figure 2. Mean time since graduation for professionals in each country (ascending order).

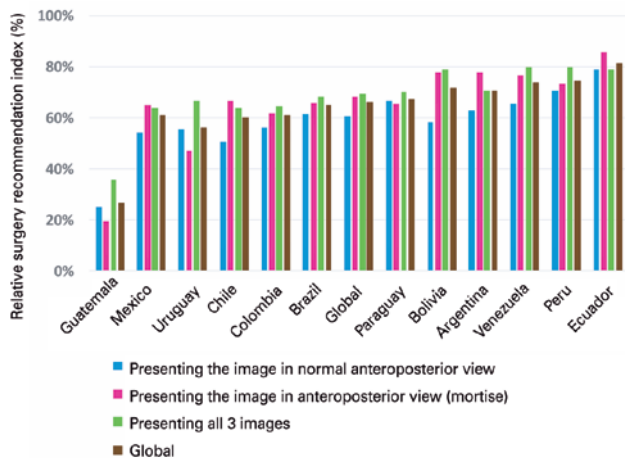


Figure 3. Relative surgery recommendation indices per country and type of presented image and globally.

those who decided on conservative treatment. In the other evaluations and globally, we did not verify a significant association between the decision to operate and the age of the evaluating physician (p-values over 5% in the Mann-Whitney test when comparing age distributions of those who decided to operate and those who decided not to). As the association between the decision to operate and the age of the evaluating physician was present only in a nonrelevant fraction of the cases (1.9%), we concluded that the decision to operate was not significantly associated with the age of the evaluating physician.

In 5 out of the 108 evaluations (4.6%), we verified a significant association between the decision to operate and the time since graduation of the evaluating physician. In these 5 cases, professionals who decided on surgical treatment were significantly more experienced than those who decided on conservative treatment. In the remaining evaluations and globally, we did not verify a significant association between the decision to operate and the time since graduation of the evaluating physician (p-values over 5% in the Mann-Whitney test when comparing time since graduation of those who decided to operate and those who decided not to). Since the association between the decision to operate and the time since graduation of the evaluating physician was observed with a nonrelevant frequency (4.6% of the evaluations), we concluded that the decision to operate was not significantly associated with the time since graduation of the evaluating physician.

Additionally, we investigated whether the total number of surgery recommendations (regarding the 3 presentations and globally) was correlated with the professional's age and time since graduation. Because data were not normally distributed, correlations were assessed using Spearman's rank correlation coefficient. Correlations presented on Table 4 are small and not significantly different from zero (p-values of significance over 5%).

Table 4. Correlation analysis between the number of surgery recommendations by the evaluator and his or her age and time since graduation

| Correlation coefficient between variables in lines and columns (p-value of significance of the correlation coefficient) | Age             | Time since graduation |
|-------------------------------------------------------------------------------------------------------------------------|-----------------|-----------------------|
| Number of surgery recommendations by the evaluator for the presentation of lateral and normal anteroposterior images    | 0.06<br>(0.559) | 0.09<br>(0.400)       |
| Number of surgery recommendations by the evaluator for the presentation of lateral and true anteroposterior images      | 0.06<br>(0.534) | 0.12<br>(0.246)       |
| Number of surgery recommendations by the evaluator for the presentation of all 3 images                                 | 0.07<br>(0.534) | 0.09<br>(0.427)       |
| Total number of surgery recommendations by the evaluator                                                                | 0.06<br>(0.563) | 0.11<br>(0.320)       |

## Discussion

According to the literature, various studies have demonstrated different numbers of views that would be required for diagnosing ankle fractures<sup>(1,4,9,10,16)</sup>.

In emergency departments, radiographic examinations of the ankle represent 10%–12% of all requested radiographs<sup>(2–12)</sup>.

Auletta et al.<sup>(13)</sup> reported that 50% of ankle radiographs were not necessary and other studies demonstrated that they are unnecessary<sup>(3,14,15)</sup>. Cockshott et al.<sup>(2)</sup> stated that fractures were present in only 29% of the radiographed patients. Auletta et al.<sup>(13)</sup> found fractures in 30% of patient radiographs and Brandser et al.<sup>(11)</sup> found a 28% fracture prevalence.

In our study, we observed that ankle fractures should be diagnosed and classified for their correct treatment, and the ideal setting would include 3 radiographic images: AP, true AP, and lateral views.

This study demonstrated that, even in different medical scenarios (different countries), most evaluators opted for using 3 images of ankle fractures for recommending surgical treatment. However, images in true AP and lateral views, when compared with the 3 grouped images, also provided more information such as: type of fracture, classification, and surgical treatment.

Cockshott et al.<sup>(2)</sup>, in a review with 242 ankle radiographs, observed that the AP and lateral views detected all fractures and that true AP images did not provide additional information. Wallis<sup>(9)</sup>, when analyzing 945 ankle radiographs, found 128 fractures (13.5%). This author studied AP and lateral radiographs and compared them with true AP images; although 4.7% of the cases presented fractures that had not been detected in the AP radiograph, he determined that true AP images would not be necessary because the undiagnosed fractures were fibula avulsion fractures that would not alter the established line of treatment. Brandser et al.<sup>(12)</sup> compared images used for diagnosing ankle fractures and combined individual results for comparing the performance of 2 and 3 images.

Vangsnæs et al.<sup>(4)</sup> examined 123 cases of ankle fractures and compared fracture detection using true AP and lateral views with the 3 images. They observed 95% “precision” with this combination and reported that the choice of the true AP and lateral views over the AP and lateral views was a decision of the authors for performing the study. Brage et al.<sup>(10)</sup> studied intra and interobserver agreement in the classification of 99 ankle fractures using 2 and 3 images and found that agreement was better with 2 images. The authors recommended the use of the true AP and lateral images for classifying ankle fractures. However, authors did not focus on the fracture diagnosis.

Brandser et al.<sup>(11)</sup> observed that the combination of both images (AP and true AP) was similar for diagnosing fractures and did not find a reason for choosing one over the other. However, they analyzed only the fracture diagnosis and did not verify whether the 3 images were necessary for classifying fractures or deciding on treatment.

This study demonstrated that, globally, surgeons recommended surgery more frequently when provided with 3

images (69.7% of surgery recommendations when 3 images were provided). However, this is not the standard for groups of surgeons in all countries, since when observing the surgery recommendation indices in each separate country, some differences were verified. When comparing the surgery recommendation indices regarding images in AP, lateral, and true AP views, we observed that, in general, these were higher when the true AP image was shown (68.4% vs 60.6% when the normal AP image was shown). It is important to note that this study aimed to assess surgery recommendations for each image and did not study classification and diagnosis.

For the first time in the literature, physicians from 12 different countries participated in evaluations of ankle fracture images, allowing us to identify and alert for differences between indices of surgery recommendation between countries. Considering evaluators from Ecuador, Argentina, Mexico, and Chile, surgery recommendations were more frequent when true AP images were presented. For professionals from Peru, Venezuela, Bolivia, Paraguay, Brazil, Colombia, Uruguay, and Guatemala, as in the global results, surgery recommendations were more frequent when images in all 3 views were presented. In all countries and globally, we verified the lowest frequencies of surgery recommendations when the image was in normal AP view. The variety of patterns in different countries demonstrates the need to provide as many images as possible.

This study also identified that the decision to operate was not significantly associated with the age and time since graduation of the evaluator. The total number of surgery recommendations by each professional, in all 3 presentations and globally, was also not correlated with his or her age and time in the profession.


An important limitation of this work was the difficulty in obtaining larger samples of evaluators in some countries. It is worth noting that the study recruitment was widely distributed in all participating countries, but adherence was lower than the expected or needed. By dividing the sample with 89 evaluators per country of work of the evaluator, we had small subsamples for some countries, hampering an unbiased statistical inference from our results. However, this does not prevent our results from being used in comparison with other studies with larger subsamples. Moreover, the results of the global analysis presented more validity and provided important conclusions, since this analysis was performed with a broader (89 evaluators) and diverse sample, contemplating many countries of origin.

Another limiting factor of this study was the absence of a categorization of evaluators into 2 groups: those with training on ankle and foot surgery and those who were general trauma specialists.

## Conclusion

In most countries, surgery recommendations were more frequent when images of all 3 views were presented. However, the highest frequencies of surgery recommendations were observed when only true AP and lateral images were presented.

Surgery recommendations were not associated with the time since the surgeon's graduation.

**Authors' contributions:** Each author contributed individually and significantly to the development of this article: PJL \*(<https://orcid.org/0000-0003-4967-7576>) Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, data collection, bibliographic review, survey of the medical records, formatting of the article, approved the final version; FF \*(<https://orcid.org/0000-0002-6495-3383>) Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, statistical analysis, bibliographic review, approved the final version; WDB \*(<https://orcid.org/0000-0003-1838-1473>) Interpreted the results of the study, participated in the review process, statistical analysis, bibliographic review, approved the final version; LEA \*(<https://orcid.org/0000-0002-8488-184X>) Interpreted the results of the study, participated in the review process, bibliographic review, formatting of the article, approved the final version. All authors read and approved the final manuscript. \*ORCID (Open Researcher and Contributor ID) .

## References

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: A review. *Injury*. 2006;37(8):691-7.
2. Cockshott WP, Jenkin JK, Pui M. Limiting the use of routine radiography for acute ankle injuries. *Can Med Assoc J*. 1983;129(2):129-31.
3. Stiell IG, Greenberg GH, McKnight RD, Nair RC, McDowell I, Reardon M, et al. Decision rules for the use of radiography in acute ankle injuries. Refinement and prospective validation. *JAMA*. 1993;269(9):1127-32.
4. Vangsness CT Jr, Carter V, Hunt T, Kerr R, Newton E. Radiographic diagnosis of ankle fractures: are three views necessary? *Foot Ankle Int*. 1994;15(4):172-4.
5. Brand DA, Frazier WH, Kohlhepp WC, Shea KM, Hoefler AM, Ecker MD, et al. A protocol for selecting patients with injured extremities who need x-rays. *N Engl J Med*. 1982;306(6):333-9.
6. Stiell IG, McKnight RD, Greenberg GH, McDowell I, Nair RC, Wells GA, et al. Implementation of the Ottawa ankle rules. *JAMA*. 1994;271(11):827-32.
7. Stiell IG, McKnight RD, Greenberg GH, Nair RC, McDowell I, Wallace GJ. Interobserver agreement in the examination of acute ankle injury patients. *Am J Emerg Med*. 1992;10(1):14-7.
8. Stiell IG, McDowell I, Nair RC, Aeta H, Greenberg G, McKnight RD, et al. Use of radiography in acute ankle injuries: physicians' attitudes and practice. *CMAJ*. 1992;147(11):1671-8.
9. Wallis MG. Are three views necessary to examine acute ankle injuries? *Clin Radiol*. 1989;40(4):424-5.
10. Brage ME, Rockett M, Vraney R, Anderson R, Toledano A. Ankle fracture classification: a comparison of reliability of three X-ray views versus two. *Foot Ankle Int*. 1998;19(8):555-62.
11. Brooks SC, Potter BT, Rainey JB. Inversion injuries of the ankle: clinical assessment and radiographic review. *Br Med J (Clin Res Ed)*. 1981;282(6264):607-8.
12. Brandser EA, Berbaum KS, Dorfman DD, Braksiek RJ, El-Khoury GY, Saltzman CL, et al. Contribution of individual projections alone and in combination for radiographic detection of ankle fractures. *AJR Am J Roentgenol*. 2000;174(6):1691-7.
13. Auletta AG, Conway WF, Hayes CW, Guisto DF, Gervin AS. Indications for radiography in patients with acute ankle injuries: role of the physical examination. *AJR Am J Roentgenol*. 1991;157(4):789-91.
14. Hall FM. Overutilization of radiological examinations. *Radiology*. 1976;120(2):443-8.
15. Abrams HL. Sounding board The "overutilization" of x-rays. *N Engl J Med*. 1979;300(21):1213-6.
16. De Smet AA, Doherty MP, Norris MA, Hollister MC, Smith DL. Are oblique views needed for trauma radiography of the distal extremities? *AJR Am J Roentgenol*. 1999;172(6):1561-5.