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Should the Tibiotalar Angle Be Measured Using an AP or Mortise Radiograph? Does It Matter?

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ABSTRACT

Understanding the tibiotalar angle (TTA) is key to planning for deformity correction. The TTA is an important radiographic tool to determine alignment or malalignment of the ankle and hindfoot. Two methods of measuring the TTA have been described: the midline TTA (MTTA) and the lateral TTA (LTTA). The aim of this study was to compare the 2 angles as measured on mortise and anteroposterior (AP) radiographs in a series of normal and pathological cases. A radiographic review was performed of sequential ankle AP and mortise radiographs taken between January 2016 and September 2017 across 4 specialist orthopedic centers. Patients were categorized into a normal group, where patients had normal radiological appearances, and an arthritis group, where patients had radiographic arthritis. The MTTA and the LTTA were measured. The overall mean \pm standard deviation MTTA was $88.7^\circ \pm 5.1^\circ$, and mean LTTA was $87.5^\circ \pm 5.2^\circ$ ($p < .01$). There was no statistically significant difference between the MTTA and LTTA in the normal group or on AP radiographs alone ($p = .09$). There was a statistically significant difference between the MTTA and LTTA in the arthritis group ($p < .01$) and when measured on mortise radiographs ($p = .02$). The MTTA had no difference when measured on the AP and mortise radiographs. There was a statistically significant difference in the LTTA between AP and mortise radiographs ($p = .04$). We have shown the MTTA to be a reliable and reproducible tool in all patients, on AP and mortise radiographs. The type of radiograph does not alter the measurement of deformity. In contrast, we have shown the LTTA to be unreliable and statistically different when measured on AP and mortise radiographs.

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The tibiotalar angle (TTA) is an important radiographic tool to determine alignment or malalignment of the ankle and hindfoot. Identifying differences can improve preoperative and intraoperative planning of reconstructive surgery of the hindfoot, total ankle replacement, or corrective osteotomies (1,2), and the TTA is also a measure frequently used in research studies.

The TTA is normally measured by the angle between 2 lines. The first line is along the anatomical axis of the tibia, and the second line is along the superior articular surface of the talus (2). It is mainly described as the angle on the medial side, so that angles of $>90^\circ$ are defined as a

valgus hindfoot and angles of $<90^\circ$ as a varus hindfoot (2–5). In this article, we refer to this method as the midline tibiotalar angle (MTTA).

Some studies have described a method of measuring the tibiotalar angle between a line along the lateral border of the tibia and a line along the superior articular surface of the talus (6–8). In this article, we have called this the lateral tibiotalar angle (LTTA).

Anteroposterior (AP) weightbearing radiographs show the tibia and fibula superimposed (Fig. 1A). Mortise weight bearing radiographs are performed with the tibia 15° to 20° internally rotated, to reveal an unobscured view of the talus and plafond (9) (Fig. 1B). The majority of studies have used the AP radiograph for assessment of the TTA (2,4,5,7,10), but others have used the mortise radiograph (8). Some studies have been inconsistent in their use of an AP (3) or a mortise (8) radiograph.

Knupp et al (2) calculated the TTA on full-length AP radiographs of the tibia using the tibial tuberosity as a reference point, as this was

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Fig. 1. (A) AP radiograph showing the tibia and fibula superimposed. (B) Mortise ankle radiograph revealing an unobscured view of the talus and plafond.

more likely to be used in the operating theatre. A multicenter randomized controlled trial comparing ankle replacement against ankle arthrodesis across 16 sites did not specify AP or mortise radiograph for recruitment (11), largely because some investigators routinely use mortise views only. Therefore, these data and methodology are not recorded.

This leads to the current study question: does it matter whether an AP or a mortise radiograph is used? The aims of this study therefore were to:

- 1) Compare TTA as measured on mortise and AP radiographs in a series of normal and pathological cases; and
- 2) Compare TTA as measured by 2 methods, MTTA and LTTA, to see if they are comparable and if both methods are reliable and reproducible.

Patients and Methods

A radiographic review was performed of sequential ankle radiographs taken between MM??/2016 and MM??/2017 across 4 specialist orthopedic centers in the UK. Our institutional review board classified this as a service evaluation using anonymized data, and no ethical approval was required. Each center used identical methods. The participating hospitals included the Robert Jones and Agnes Hunt Orthopaedic Hospital NHS Foundation Trust in Oswestry, the Royal National Orthopaedic Hospital NHS Trust in Stanmore, Barking Havering and Redbridge NHS Trust, and Northumbria Healthcare NHS Trust.

Patients with an obvious deformity of the tibia or fibula, ankle replacement, or any hindfoot fusion were excluded. Patients were categorized into 2 distinct groups.

In the normal group (NG), patients had no evidence of injury and normal radiological appearances. They were classified as 0 and 1 using the Kellgren-Lawrence grading system (12). In the arthritis group (AG), patients had radiographic changes as per the Kellgren-Lawrence scale 2 to 4. Measurements were calculated using a digital picture archiving and communication system with similar tools. The systems included Agfa Healthcare (Ghent, Belgium), Mckesson (Coventry, UK), Sectra (Stockholm, Sweden), and Synapse Fujifilm (Bedford, UK).

All radiographs were weightbearing and classified as either AP or mortise views based on the position of the talus and overlap of the tibia and fibula. The MTTA and LTTA were measured on each radiograph (Fig. 2). The center point of the medial and lateral margins of the diaphysis of the tibia were plotted at 2 points of the diaphysis. A line was drawn connecting these 2 points, and this was called the anatomical axis of the tibia. A separate line was drawn along the top of the articular surface of the talus. The medial angle was calculated to give the MTTA. The same points of the diaphysis were used to plot 2 points along the lateral border of the tibia. A line was drawn connecting these 2 points. A separate line was drawn along the top of the articular surface of the talus. The medial angle was calculated to give the LTTA.

Measurements at the Robert Jones and Agnes Hunt Orthopaedic Hospital NHS Foundation Trust were performed by author J.R., at the Royal National Orthopaedic Hospital

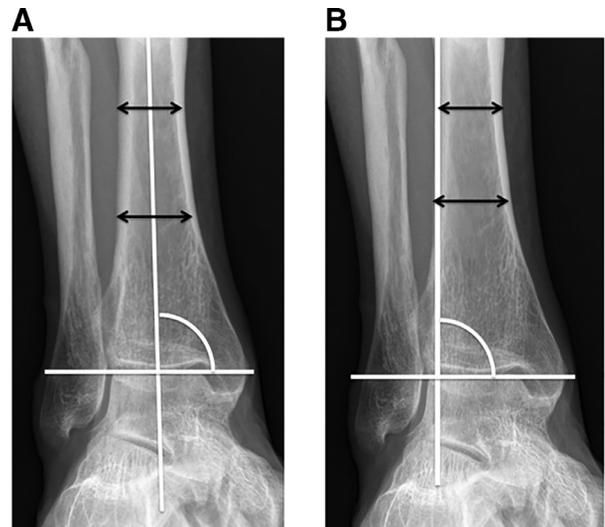


Fig. 2. (A) Ankle mortise radiograph with measurement of MTTA. The center points of the medial and lateral margins of the diaphysis of the tibia were plotted at 2 points of the diaphysis. A line was drawn connecting these 2 points, and this was called the anatomical axis of the tibia. A separate line was drawn along the top of the articular surface of the talus. The medial angle was calculated to give the MTTA. (B) Ankle mortise radiograph with measurement of LTTA. Two points of the diaphysis were plotted along the lateral border of the tibia. A line was drawn connecting these 2 points. A separate line was drawn along the top of the articular surface of the talus. The medial angle was calculated to give the LTTA.

NHS Trust by author B.B., at Barking Havering and Redbridge NHS Trust by author A.N., and at Northumbria Healthcare NHS Trust by author R.V. The radiographs were then assessed as to whether they were AP or mortise by A.N. and B.B. at 2 separate sittings, blinded to each other's assessments. Interobserver reliability was assessed using kappa coefficients. Differences between groups were evaluated using paired *t* tests and repeated-measures analysis of variance (SPSS, Chicago, IL). Differences in proportions between groups were evaluated with chi-squared tests with statistical significance set at *p* < .05. All results were expressed as the range in degrees ± standard deviation. The MTTA and LTTA measurements at the Royal National Orthopaedic Hospital NHS Trust were performed independently by 2 authors (A.N. and B.B.), blinded to each other's measurements. Intra- and interobserver reliability was assessed using kappa coefficients. All statistics were analyzed by author A.N.

Results

There were 425 radiographs reviewed in the study, of which 105 patients were excluded (leaving 320 radiographs for review). There were 148 females and 172 males in the study; 152 were normal radiographs, and 168 radiographs had evidence of arthritis. There were 117 AP and 203 mortise radiographs of the ankle.

There was no statistically significant difference with either MTTA (*p* = .4) or LTTA (*p* = .2) between males and females on all ankle radiographs. The overall mean MTTA was 88.7° ± 5.1° (range 77° to 104°), and the mean LTTA was 87.5° ± 5.2° (range 73° to 104°) (Table 1). There

Table 1

A Summary of the number of patients in the study and the overall mean MTTA and LTTA angles measured

	Number of Patients	MTTA (Mean Degrees ± SD)	LTTA (Mean Degrees ± SD)	<i>p</i> Value
All	320	88.8 ± 5.1	87.5 ± 5.2	<.01*
Normal	152	88.9 ± 3.0	88.6 ± 2.8	.09
Arthritis	168	88.6 ± 6.8	87.2 ± 7.2	<.01*

Abbreviation: SD, standard deviation.

* Statistically significant.

Table 2
A comparison of the mean values of MTTA and LTTA on the AP and Mortise Radiograph

	Angle	AP Radiograph (Mean Degrees ± SD)	Mortise Radiograph (Mean Degrees ± SD)	p Value
All	MTTA	88.1 ± 6.1	89.0 ± 4.6	.13
	LTTA	86.6 ± 6.1	87.9 ± 4.6	.048*
Normal	MTTA	88.5 ± 3.2	89.1 ± 3.0	.2
	LTTA	88.7 ± 2.6	88.5 ± 2.9	.7
Arthritis	MTTA	87.8 ± 7.5	88.9 ± 5.8	.2
	LTTA	85.1 ± 7.4	87.3 ± 5.8	.09

Abbreviations: AP, anteroposterior; LTTA, lateral tibiotalar angle; MTTA, midline tibiotalar angle; SD, standard deviation.

* Statistically significant.

was a statistically significant difference between the 2 groups ($p < .01$). There was no statistically significant difference between the MTTA and LTTA in the normal group; however, there was a statistically significant difference ($p < .01$) when comparing the MTTA and LTTA in the arthritis group. The normal and arthritis groups were compared directly; there was no statistically significant difference when measuring the MTTA or LTTA between the 2 groups.

A comparison of the MTTA and LTTA on AP and mortise radiographs is shown in Table 2. There was no statistically significant difference when the MTTA was measured between the AP and mortise radiographs. Broken down into the normal and arthritis groups, there remained no difference. There was a statistically significant difference in the LTTA between AP and mortise radiographs ($p = .04$). This difference did not reach statistical significance when the groups were broken down into normal or arthritis. There was no statistically significant difference between the MTTA or LTTA when measuring the angles on AP radiographs ($p = .09$). However, there was a statistically significant difference when measuring these angles in the mortise radiographs ($p = .02$).

The interobserver reliability of determining AP and mortise radiographs was excellent (kappa coefficient 0.9). Radiographic measurements of MTTA and LTTA were performed twice in separate sessions at least 1 week apart, indicating excellent intra- and interobserver reliability (kappa coefficient 0.86 and 0.89, respectively). Data were found to be parametric using Kolmogorov-Smirnov tests for normality.

Discussion

Understanding the TTA is key to planning for deformity correction. It is important that consistency of measurement methods is used for reporting.

In this article, we have shown the MTTA to be a reliable and reproducible tool for measuring the TTA in both normal and arthritic ankle radiographs. There was no difference when measuring the LTTA and MTTA in the normal and arthritis groups, which demonstrates that both angles can be used to assess deformity. More importantly, the type of radiograph taken (AP or mortise) will alter the measurements, and this is where the TTA becomes more difficult to interpret. There was no statistically significant difference when the MTTA was measured using an AP or a mortise radiograph, and therefore both radiographs can be used to measure the angle accurately. This is beneficial when reporting deformity on radiographs, as the true position of the ankle is not important. We have shown the LTTA to have statistically significant differences when measured using an AP and a mortise radiograph in all patients ($p = .04$) especially in those with arthritis ($p = .09$). This would lead to uncertainty during preoperative evaluation and research methodology.

The LTTA was a statistically significantly lower angle than the MTTA for both the AP and mortise radiographs. The LTTA may be an angle that is measured lower than the MTTA, but we were unable to find any data to demonstrate this in the literature. This may be more of a problem for the mortise radiographs. The higher MTTA is more in keeping with the results in other studies (2–4,13).

A key limitation of the study is sample size, and a type 2 error is possible that would have been picked up with a larger sample size. Another limitation is that measurements were taken using a variety of picture archiving and communication system systems by different authors, and it is possible that this introduced errors in measurement. However, these systems are validated against internal standards, are considered fit to use across the UK National Health System, and are also used in clinical recording of patients who might transfer their care between hospitals. Therefore, this limitation might also be considered a strength given the pragmatic nature of this study, and hence the generalizability of our findings.

A further limitation is that any proximal deformity in either the tibia or femur may also impact on measurement of overall TTA, but this issue pertains to both measurements (MTTA and LTTA) and hence is considered to be less of an issue for this study. It is, of course, of vital importance in the assessment of overall limb alignment in clinical practice.

In conclusion, herein we show the MTTA to be a reliable and reproducible tool for measuring the TTA, in both AP and mortise radiographs. The type of radiograph does not alter the measurement of deformity. This applies to patients with normal ankle radiographs and patients with ankle arthritis. In contrast, we have shown the LTTA to be unreliable and statistically different when measured on both AP and mortise radiographs.

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