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Radiographic diagnostics of an acute Achilles tendon rupture

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Abstract

Achilles tendon injury remains one of the most common injuries of the musculotendinous system [1]. The prevalence of injury among young and working-age individuals clearly highlights the need for early detection and accurate diagnosis [1, 2, 3].

The aim of this study was to evaluate the sensitivity and specificity of radiographic imaging for recent Achilles tendon rupture by comparing radiographs of patients who underwent surgery for Achilles tendon rupture with healthy patients without Achilles tendon injury.

The primary study method was a retrospective analysis of electronic patient records and radiographs of patients hospitalized with ICD-10 disease code S86.0. The authors analyzed the medical records and radiographs of patients who presented to the emergency department of the hospital as a control group and discharged for outpatient treatment in accordance with ICD-10 disease code S93.4.

Based on a retrospective analysis of the electronic medical records of 70 patients hospitalized between January 1, 2024, and January 1, 2025, with a presumed and subsequently confirmed diagnosis of complete rupture of the Achilles tendon S86.0, radiography of the affected ankle joint was performed in 47 cases. Signs of deformity of the Kaeger's triangle were observed in 44 cases. Toygar's angle was detected in 1 of 47 observations. Arne's sign was not detected in any of the radiographs. As a control group, radiographs of 40 patients who presented to the emergency department were analyzed for the presence of the above-mentioned signs between January 1, 2024, and January 1, 2025, and discharged for outpatient treatment in accordance with ICD-10 code S93.4. In none of the clinical cases were obvious changes in the Kaeger's triangle, Toygar's angle, or Arne sign verified.

As a result of the study, we determined the high sensitivity (89%) and specificity (100%) of ankle radiography in diagnosing Achilles tendon rupture. Changes in the Kaeger's triangle ($p < 0.001$) should be considered the most significant criterion for diagnostic verification. Based on the obtained by us data, we believe that it is useful for traumatologists to be aware of the adjunctive role of lateral ankle radiography when determining the presence of an Achilles tendon injury.

Introduction

Achilles tendon rupture is currently one of the most common injuries of the musculoskeletal system [1]. The epidemiological trend of a higher prevalence of injuries among young and working-age individuals clearly highlights the need for early diagnosis and diagnosis of tendon rupture [1, 2, 3]. However, to date, there is no "gold standard" for verifying the diagnosis in the hospital emergency department [2].

Relevance of the Study

When diagnosing Achilles tendon rupture, emergency room traumatologists increasingly rely on ultrasound imaging, which may significantly mismatch the clinical picture and physical examination

findings. It is important to note that the literature also describes cases of a lack of timely diagnosis of tendon injury even when using such a high-tech and expensive method as MRI [4]. However, the emergency department of every hospital, regardless of the level of medical care, is equipped with an X-ray machine, and the use of X-ray of the ankle joint in the lateral projection immediately upon admission to the hospital, according to numerous authors, can play a significant role in an accurate and timely diagnosis [3, 5, 6, 7]. The scientific literature repeatedly contains data on specific radiographic signs of Achilles tendon rupture. The main markers of injury include the Kaeger triangle - a radiolucent triangle representing a fatty pad, bordered anteriorly by the tendon of the long flexor of the big toe, posteriorly by the Achilles tendon, and inferiorly by the calcaneus. A change in its radiographic structure, such as obliteration or border distortion, is a reliable indicator of the presence of a hematoma and edema in the fat pad area, which, taking into account anamnestic and clinical data, allows for the verification of Achilles tendon injury [3, 8]. Numerous authors have attempted to determine the precise dimensions of the fat pad using various imaging methods, including ultrasound, MRI, and radiography. A number of studies have determined that a Kaeger triangle area of less than 5 centimeters reliably indicates fat pad atrophy, and the ratio of the fat pad area to the length of the Achilles tendon is 0.68, confirming the reliability of the morphological relationship between the aforementioned structures. A more than twofold increase in the triangle area indicates elongation of the Achilles tendon, which may be useful in diagnosing chronic Achilles tendon injuries. In addition, an equally important sign is the correlation between a decrease in the triangle's area and an increase in radiographic signal intensity and the severity of tendinopathy [9].

Toygar's angle is the angle of curvature of the skin projection of the posterior surface of the leg in relation to the tendon. An angle between 130 and 150 degrees indicates tendon injury [5].

Arne's sign is an S-shaped contour of the distal end of a ruptured Achilles tendon [5].

Therefore, interest in the role of routine radiography as an additional, and in some cases definitive, diagnostic method for Achilles tendon rupture continues, especially in institutions with limited technical equipment. Objective:

The objective of this study was to evaluate the sensitivity and specificity of radiographic imaging for acute Achilles tendon rupture by comparing radiographs of patients who underwent surgery for Achilles tendon rupture with healthy patients without Achilles tendon injury.

Materials and Methods

The authors conducted a retrospective analysis of the inpatient records of 70 patients admitted to the A.K. Yeramishantsev City Clinical Hospital of the Moscow Health Department from January 1, 2024, to January 1, 2025. All patients in the sample were hospitalized under ICD-10 disease code S86.0.

The charts and radiographs of 40 patients admitted to the emergency department of City Clinical Hospital No. 31 named after Academician G.M. served as a control group. Savelyeva, from January 1,

2024, to January 1, 2025. There were 17 male patients (43%) with a mean age of 37.6 years, and 23 female patients (57%) with a mean age of 37.7 years. All patients in the control group were discharged for outpatient treatment according to ICD-10 disease code S93.4.

A comparison of the sample and control group by gender and age is shown in Table 1.

Table 1
Comparison of the sample and control group according to gender and age.

Group (ICD)	N of patients	Men, n (%)	Average age of men, years	Women, n (%)	Average age of women, years	Note
S86.0	47	38 (81%)	41.5	9 (19%)	59.5	all presented within the first 3 days
S93.4 (control)	40	17 (43%)	37.6	23 (57%)	37.7	discharged as outpatients

Inpatient records were reviewed in the Unified Information and Analytical System (EMIAS) in accordance with consent to personal data processing. Radiographs were reviewed using RadiAnt DICOM viewer 2025.1 software, using the Measurements and tools tool.

The main radiographic signs of tendon rupture are obvious changes in the structure of the Kaeger triangle, the Toygar angle, and the Arne sign. According to the available scientific literature and publications, the following are accepted as indicators of the absence of a reliable radiographic picture of the disease: the ability to clearly verify the tendon of the deep flexor of the big toe, the Achilles tendon, the natural contrast of the fat pad in the lower third of the triangle, a triangular shape with the upper angle facing proximally and approaching the shape of an isosceles triangle; for the Toygar angle: a value greater than 150 degrees; uniformity of the contour of the posterior surface of the ankle in the area of the calcaneal tuberosity and the distal part of the tendon - a negative Arne sign [3, 4, 5, 6]. The statistical hypothesis for this study is the presence of one or more of the described features on lateral radiographs of injured ankle joints, with the subsequent acceptance or rejection of the null hypothesis of the absence of significantly significant radiographic signs of injury.

Statistical inferences were determined using the Pearson chi-square test in Microsoft Excel 2025.

Results

In a retrospective analysis of 70 patient charts from the sample hospitalized between January 1, 2024, and January 1, 2025, with a presumed and subsequently confirmed diagnosis of complete Achilles tendon rupture (S86.0), radiography of the affected ankle was performed in 47 cases (67%). The study group included 38 men (81%) with a mean age of 41.5 years, and 9 women (19%) with a mean age of 59.5 years.

All patients sought medical attention within the first three days after injury.

Forty-four cases (94%) showed signs of deformation of the Kaeger triangle. The observed changes included isolated narrowing of the triangle's area with irregular contours in 42 cases (89%) (Fig. 2) and irregular contours combined with decreased radiolucency of the fat pad in 39 cases (83%) (Fig. 3). Radiographs of two patients (4%) revealed complete obliteration of the triangle (Fig. 4).

Only one of the 47 cases (2%) showed a Toygar angle (Fig. 5). We attribute this low incidence of this sign to three main factors: swelling of the affected ankle, which blurs the contours of the skin on the posterior surface of the leg; the position of the plantar flexion of the foot on the patient's lateral radiographic position, which can produce a false-positive sign; and plantar flexion of the foot due to the presence of a plaster cast applied at the site of initial presentation.

For the reasons described above, we were unable to observe the Arne sign on any of the radiographs (Table 2).

Table 2
Presence of radiographic signs of Achilles tendon rupture in the control group.

Sign	**n of 47**	**%**	**Note**
Change in the contour of the Kaeger’s triangle	42	89	main sign - most common
Decreased radiolucency of the Kaeger’s fat pad	39	83	often combined with countour changes
Kaeger’s triangle obliteration	2	4	rare but pronounced sign
Toygar's angle	1	2	rare
Arne’s sign	0	0	not found

As a control group, radiographs of 40 patients who presented to the emergency department between January 1, 2024, and January 1, 2025, and were discharged for outpatient treatment in accordance with the ICD-10 diagnosis S93.4, were analyzed. The study group included 17 men (43%) with a mean age of 41.5 years, and 23 women (57%) with a mean age of 35 years.

In none of the clinical cases were we able to verify obvious changes in the Kaeger triangle, Toygar angle, or Arne's sign (Table 3).

Table 3
Absence of radiographic signs of Achilles tendon rupture in the control group.

Sign	n of 40	%	Note
Change in the contour of the Kaeger’s triangle	0	0	not found
Decreased radiolucency of the Kaeger’s fat pad	0	0	not found
Kaeger’s triangle obliteration	0	0	not found
Toygar's angle	0	0	not found
Arne’s sign	0	0	not found

Statistical analysis yielded a Pearson chi-square value of 23, which, with 2 degrees of freedom, corresponds to a p-value of less than 0.01. These differences were highly significant; therefore, the null hypothesis was rejected.

Lateral ankle radiography demonstrated high sensitivity (89%) and specificity (100%) in diagnosing Achilles tendon rupture. Discussion of Results:

Studies of radiographic manifestations of Achilles tendon injuries span approximately 50 studies and over half a century, beginning in the first half of the 20th century [9, 10]. Among the many signs, particular importance is attached to the Kaeger triangle, which is considered the most reliable indicator of both acute and chronic injuries [9]. Its significance is confirmed by the fact that structural changes in the fat pad forming this triangle are also detected by other diagnostic methods.

At the same time, Arne's signs and Toygar's angle are exclusively radiographic and are determined only in the lateral projection. Literary data indicate that a positive Arne's sign occurs in less than half of patients with Achilles tendon rupture, and clinically significant changes in the Toygar's angle are absent, which is consistent with the results of this study [9]. An important factor for the correct identification of these signs is the position of the foot during radiography. It has been found that in the same patients, Arne's signs and Toygar's angle may not be detected with the foot in a neutral position, but become positive with plantar flexion. In contrast, no significant changes in the Kaeger triangle dependent on foot position were detected, emphasizing its consistent diagnostic value.

We see a shortcoming of our study and an area for further research in the impossibility of conducting comparative radiography of the contralateral intact ankle in patients with Achilles tendon rupture, due to the retrospective nature of the study. In the future, it is recommended to consider performing an ultrasound examination of the peritendinous tissues of the affected side, based on the experience of international colleagues [9].

Conclusions

As a result of the study, we determined the high sensitivity (89%) and specificity (100%) of ankle radiography in diagnosing Achilles tendon rupture. Changes in the Kaeger triangle should be considered the most significant criterion for verifying the diagnosis ($p < 0.01$).

Based on these findings, we believe it would be helpful to educate traumatologists about the adjunctive role of lateral ankle radiographs when determining the presence of an Achilles tendon injury.

Further research into the radiographic diagnosis of muscle and tendon injuries could fundamentally change the diagnostic approach and be reflected in clinical guidelines.

Abbreviations

ICD-10 — the International Classification of Diseases - 10th Revision.

Declarations

Ethics approval and consent to participate:

This study was conducted in accordance with the Declaration of Helsinki. The first dataset used in the study was approved by the Department of Traumatology and Orthopedics at Peoples' Friendship University of Russia named after Patrice Lumumba. All participants provided written informed consent for use of their data prior to participation. For the second dataset used in the study, ethical approval was not required as confirmed by the Hospital named after Academician G.M. Savelieva ethics committee, since the radiography data were anonymized and collected during routine clinical care.

Consent for publication:

Not applicable.

Competing interests:

The authors declare no competing interests.

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Author Contribution

I.D.,D.A.,V.P. gave information about clinical casesE.M.,G.A., N.Z. prepared figures, found referencesA.A. wrote the main manuscript text

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Not applicable.

Data Availability

The radiography dataset analysed during the current study are available from the corresponding author on reasonable request.

References

1. Shamrock AG, Dreyer MA, Varacallo MA, Achilles Tendon R. 2023 Aug 17. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan–. PMID: 28613594.
2. Barrios-Cárdenas AL, Lazo-Vera JO. Características epidemiológicas, clínicas y terapéuticas de la ruptura de tendón de Aquiles [Epidemiological, clinical and therapeutic characteristics of Achilles tendon rupture]. Acta Ortop Mex 2021 May-Jun;35(3):252–6. Spanish. PMID: 34921533.
3. Kokulu K, Altunok İ, Sert ET, Özdemir S, Mutlu H, Akça HŞ. Diagnostic Value of Lateral Ankle Radiography in Achilles Tendon Rupture. Foot Ankle Spec. 2023;16(4):384–91. Epub 2022 Aug 29. PMID: 36036526.
4. Garras DN, Raikin SM, Bhat SB, Taweel N, Karanjia H. MRI is unnecessary for diagnosing acute Achilles tendon ruptures: clinical diagnostic criteria. Clin Orthop Relat Res. 2012;470(8):2268–73. 10.1007/s11999-012-2355-y. Epub 2012 Apr 27. PMID: 22538958; PMCID: PMC3392388.
5. Seouk KH, Keun RY. The roentgenographic findings of achilles tendon rupture. J korean radiological Soc. 1999;40(3):571–5.
6. The Influence of Ankle Position on Radiographic Diagnosis of Acute Achilles Tendon Rupture, Park Y, Hwan et al. J Foot Ankle Surg, 61, Issue 4, 845–9.
7. Szaro P, Polaczek M, Ciszek B. The Kager's fat pad radiological anatomy revised. Surg Radiol Anat. 2021;43(1):79–86. 10.1007/s00276-020-02552-1. Epub 2020 Aug 19. PMID: 32813031; PMCID: PMC7838075.
8. Yılmaz BK, Issı CT, Yesıl M, Kaya F, Ozcan O. The impact of Achilles tendon thickness and Kager's fat pad thickness on clinical and functional outcomes following open surgical repair of acute Achilles tendon rupture. Ulus Travma Acil Cerrahi Derg. 2025;31(6):587–95. PMID: 40511768; PMCID: PMC12183480.
9. Ogut E. Anatomical and clinical relevance of Kager’s triangle: diagnostic approaches and therapeutic implications for related pathologies. J Orthop Surg Res. 2025;20:682.
10. Kager H. Zur klinik und diagnostik des achillessehnenrisses. Chirurg. 1939;11(1):691–5.
11. Seouk KH, Keun RY. The roentgenographic findings of achilles tendon rupture. J korean radiological Soc. 1999;40(3):571–5.

Figures

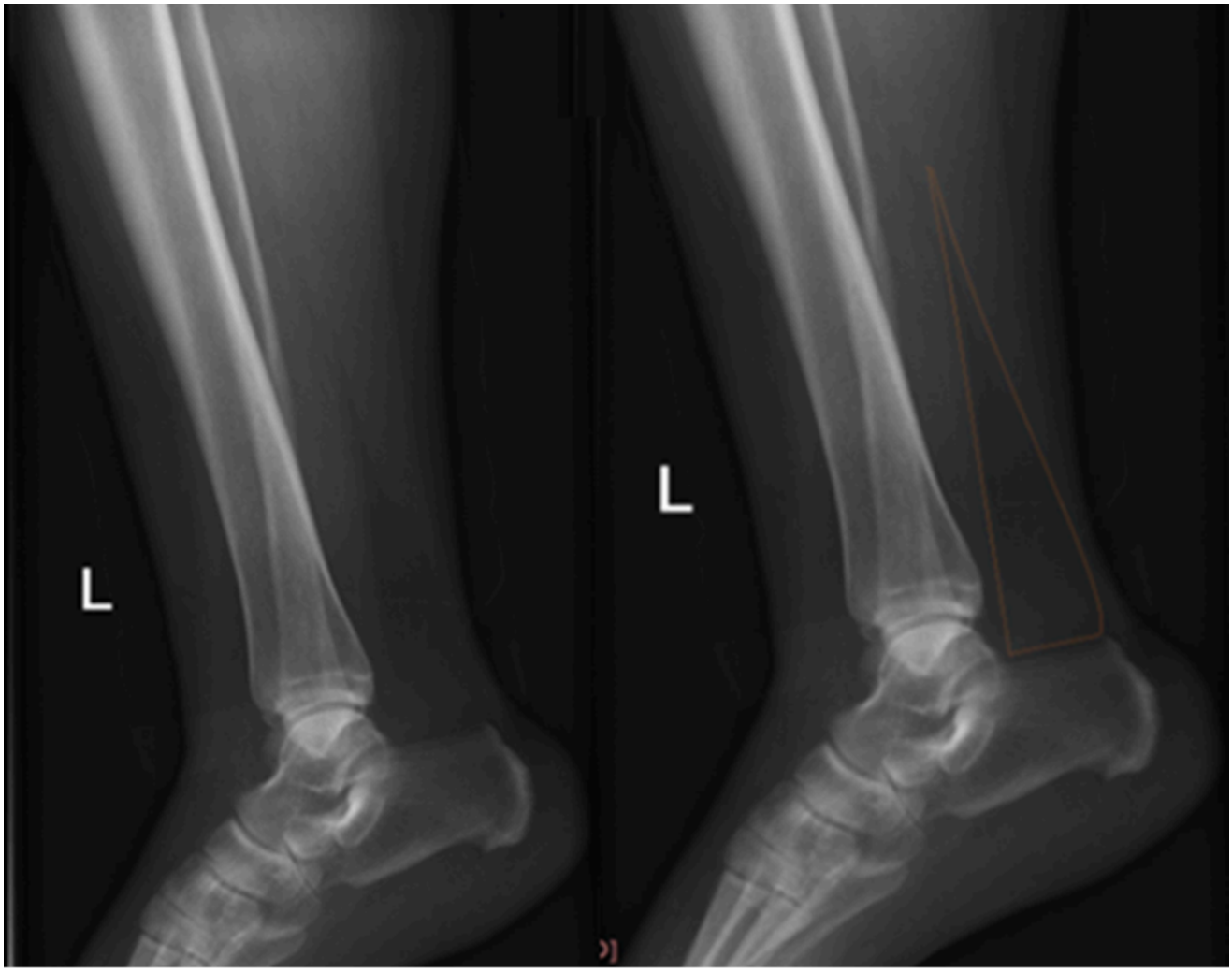


Figure 1

normal Kaeger’s triangle.



Figure 2

Contraction of the area of the Kaeger’s triangle



Figure 3

Decrease in transparency of the Kaeger’s fat pad.



Figure 4

Obliteration of the Kaeger's triangle

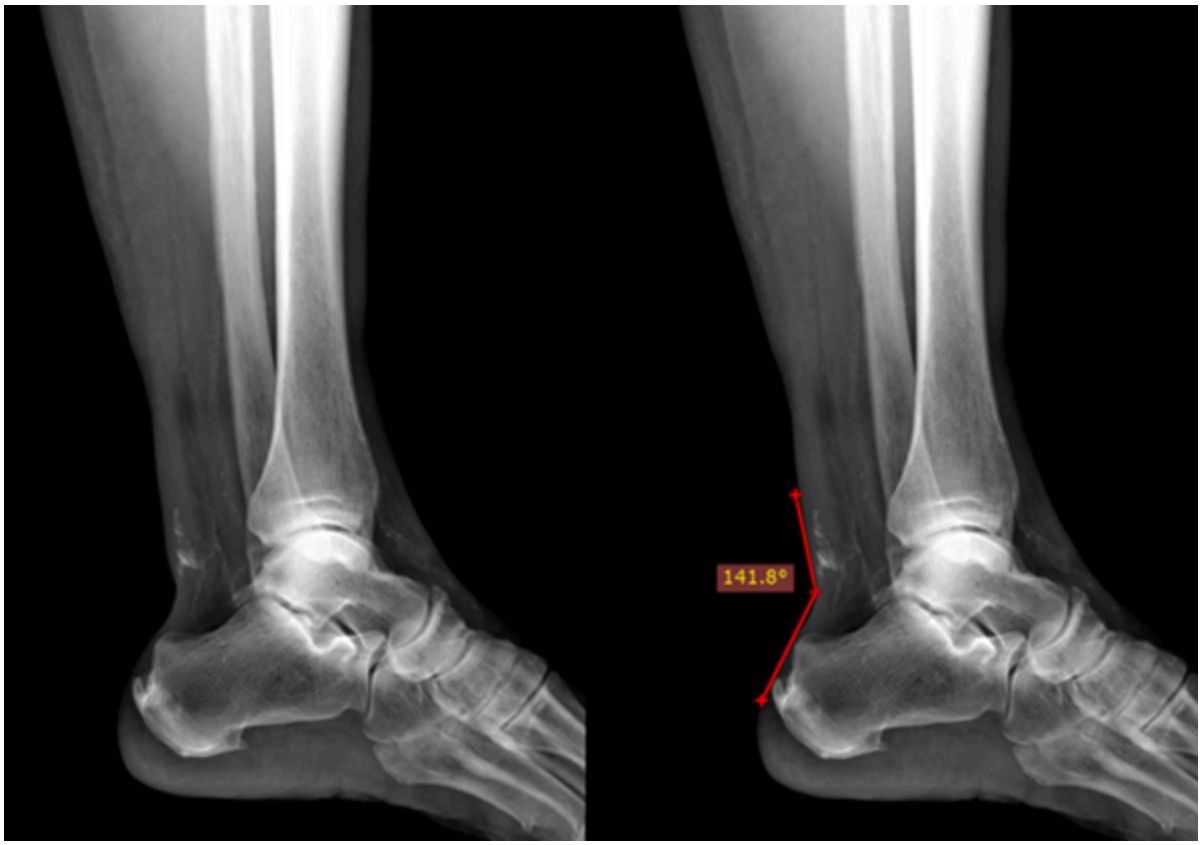


Figure 5

Toygar’s angle