Journal of PopulationTherapeutics
& Clinical Pharmacology

REVIEW ARTICLE
DOI: 10.69980/38cmn893

DECODING FOOT AND ANKLE PAIN: THE ROLE OF RADIOGRAPHIC METRICS IN EARLY PREDICTION.

Mr. Shivanshu Chauhan[1], Dr. Ashish Kumar Shukla[2*], Ms. Anshu Kumari[1], Ranjeet Singh[3], Manvi Dhingra[3], Jyoti Yadav[3], Aarushi Sabharwal[3]

[1]PhD Scholar, Department of Radiodiagnosis, SMC, Santosh Deemed to be University, Ghaziabad Uttar Pradesh, India.
[2]*Professor, Department of Radiodiagnosis, SMC, Santosh Deemed to be University, Ghaziabad Uttar Pradesh, India
[3]Junior Resident, Department of Radiodiagnosis, Santosh Deemed to be University, Ghaziabad, Uttar Pradesh, India

***Corresponding Author:** Dr. Ashish Kumar Shukla
Professor, Department of Radiodiagnosis, SMC Santosh Deemed to be University, Ghaziabad, Uttar Pradesh, India Email: drashish07@rediffmail.com

ABSTRACT
Foot and ankle pain is a common clinical condition that can significantly impair mobility and quality of life. Early identification of individuals at risk is important, as structural changes may become irreversible once symptoms are established. Recently, radiographic metrics have emerged as potential early predictors of pain onset and progression. This review synthesises evidence from the past decade to identify radiographic parameters, particularly angular and alignment measures, associated with future foot and ankle pain. A systematic literature search was conducted across PubMed, Scopus, Web of Science, and Embase for studies published between January 2015 to May 2025. Eligible studies included adult patients with suspected or early-stage foot or ankle pain, assessed using conventional radiography or hybrid imaging modalities such as SPECT-CT, and reporting pain-related outcomes. Case reports, non-English publications, and studies without clearly defined pain outcomes were excluded. Data on study design, sample size, radiographic parameters, and outcomes were extracted. Two reviewers independently screened studies, with disagreements resolved by consensus. Owing to heterogeneity in study design and outcome measures, a narrative synthesis was performed. Of 350 initially identified articles, 21 met the inclusion criteria. Frequently evaluated parameters included calcaneal pitch, hindfoot alignment angle, talar declination, and Meary’s angle. Approximately half of the studies reported significant associations between radiographic metrics and early foot or ankle pain. Limitations included measurement variability and retrospective designs. Overall, radiographic metrics show promise but require validation through standardised prospective studies before routine clinical use.

Keywords: Ankle pain, Early prediction, Foot pain, Radiographic metrics, X-ray evaluation.

INTRODUCTION

Foot and ankle pain is more than a transient inconvenience; it represents a significant public health challenge affecting millions worldwide. The multifactorial etiology of this pain often includes biomechanical alterations, degenerative changes, and soft tissue abnormalities. In many cases, by the time clinical symptoms become severe enough to warrant intervention, the underlying structural changes may be well-advanced and difficult to reverse (Joong & El-Khoury, 2007; Canca-Sanchez et al., 2024).

Recent advances in radiologic assessment have opened a window into early pathophysiological changes. Radiographic metrics, such as calcaneal pitch, hindfoot alignment, talar declination, and Meary's angle, offer an objective means of evaluating subtle biomechanical deviations (Jones et al., 2025; Newman et al., 2016; Iyengar et al., 2022). For instance, an abnormal calcaneal pitch may indicate alterations in the weight-distribution mechanics of the foot, while deviations in Meary's angle can suggest early arch instability (Steadman et al., 2022). Such parameters, when detected early, could predict the progressive onset of pain even before patients present with significant symptoms (Polichetti et al., 2023; Lin et al., 2015).

Notably, foot and ankle pain is associated with a considerable socioeconomic burden, stemming from both direct healthcare costs and indirect losses in productivity (Canca-Sanchez et al., 2024). Early prediction could shift clinical practice toward a preventive, rather than reactive, management model. Beyond improving patient outcomes, standardized radiographic evaluation may reduce the costs associated with delayed diagnosis and chronic management (Choi et al., 2024; Lintz et al., 2023). Although numerous studies have explored these relationships, differences in imaging protocols and study populations necessitate a comprehensive review to identify the most robust predictors (**Upadhyay et al., 2017**; Kang et al., 2022; Kim et al., 2016).

This systematic review aims to consolidate evidence from high-quality studies indexed in major databases over the last decade, providing clarity on the role of radiographic metrics in predicting future foot and ankle pain.

MATERIALS AND METHODS

Search Strategy

A comprehensive search was performed in PubMed, Scopus, Web of Science, and Embase for studies published between January 2015 and May 2025. Both controlled vocabulary and free-text terms related to foot and ankle pain, radiographic metrics, alignment parameters, and early prediction were used. Search strategies were adapted for each database to ensure optimal coverage.

Eligibility Criteria:

Included studies were English-language, peer-reviewed articles evaluating radiographic parameters from X-ray, CT, or hybrid imaging in adult populations and reporting associations with clinical outcomes related to foot or ankle pain. Observational study designs were eligible. Reviews, case reports, non-English publications, and studies limited to post-traumatic or postoperative cases without predictive analysis were excluded.

Study Selection and Data Extraction:

Two reviewers independently screened titles, abstracts, and full texts, resolving disagreements by consensus. Extracted data included study design, sample size, patient characteristics, imaging modalities and metrics, key outcomes, and statistical significance. Study quality was assessed using a modified Newcastle–Ottawa Scale. Due to heterogeneity in design and outcomes, results were synthesized narratively rather than through meta-analysis.

RESULTS

Overview of Included Studies

Our systematic search initially identified 350 articles. After title and abstract screening, 45 full-text articles were reviewed, and 21 studies met the rigorous inclusion criteria. These studies comprised retrospective cohorts, prospective cohorts, and cross-sectional analyses. While sample sizes ranged from 80 to 457 participants, follow-up durations in studies assessing predictive outcomes spanned between 12 and 24 months. Although several studies focused on different cohorts and conditions, all provided valuable insight into how various radiographic (and in some cases, adjunct clinical) metrics correlate with early signs of foot and ankle pain.

Radiographic Metrics Evaluated

The studies evaluated a host of imaging parameters. Commonly assessed metrics included:

- Calcaneal Pitch & Calcaneal Inclination: Reflecting the orientation of the heel, these measurements have been linked with plantar load distribution.
- Hindfoot Alignment Angle & Talar Declination/Tilt: These angles assess the overall alignment of the hindfoot and tilt of the talus that together indicate biomechanical overload.
- Meary's Angle & Talocalcaneal Angle: Metrics that provide insight into the alignment of the forefoot and arch stability.

Advanced Parameters: Some studies incorporated additional measurements such as subtalar angle, tibial plafond inclination (TPI), and medial talar center migration (MTCM), while others compared newer hybrid imaging methods like SPECT-CT with conventional radiography.

Radiographic Metrics - Visual Examples

Figure 1: Calcaneal Pitch/Inclination Angle (formed by the line parallel to the ground and the line along the inferior inclination axis of the calcaneus) in the lateral X-ray view. (a) Normal foot, 20-30°; (b) pathological flatfoot, <18°

Figure 2: Meary's angle (formed by the intersection of the line that bisects the first metatarsal and the midline axis of the talus) (a) Normal foot,0-4°; (b) pathological flatfoot, >4

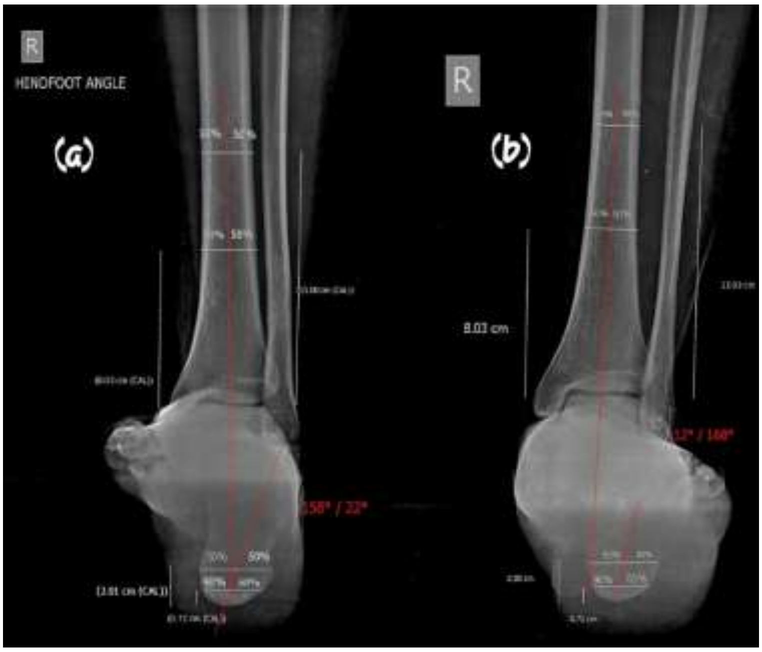

Figure 3: Talocalcaneal Angle (formed by the meeting of two lines: one indicating the longitudinal axis of the talus and the other indicating the longitudinal axis of the calcaneus) (a) Normal foot, 25-40°; (b) pathological flatfoot, <25°

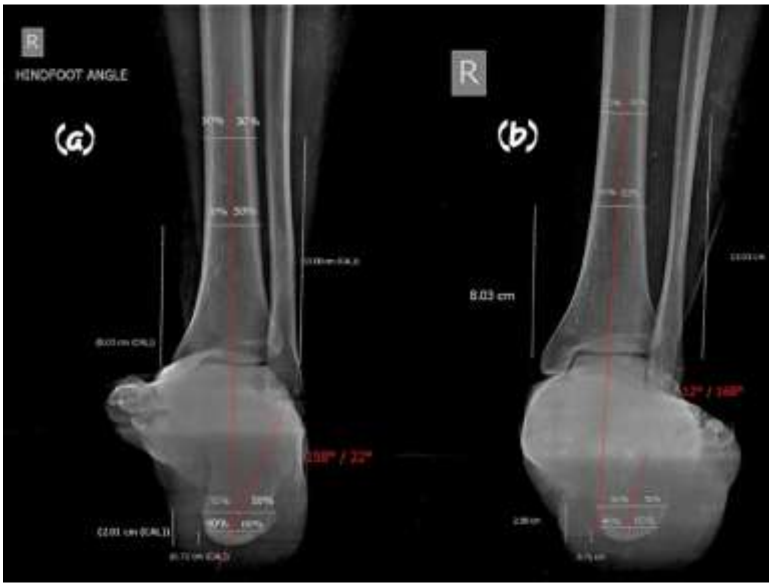

Figure 4: Hindfoot Alignment Angle (formed by the intersection of the longitudinal axis of the tibia and the calcaneal axis) (a) Normal foot; (b) pathological flatfoot

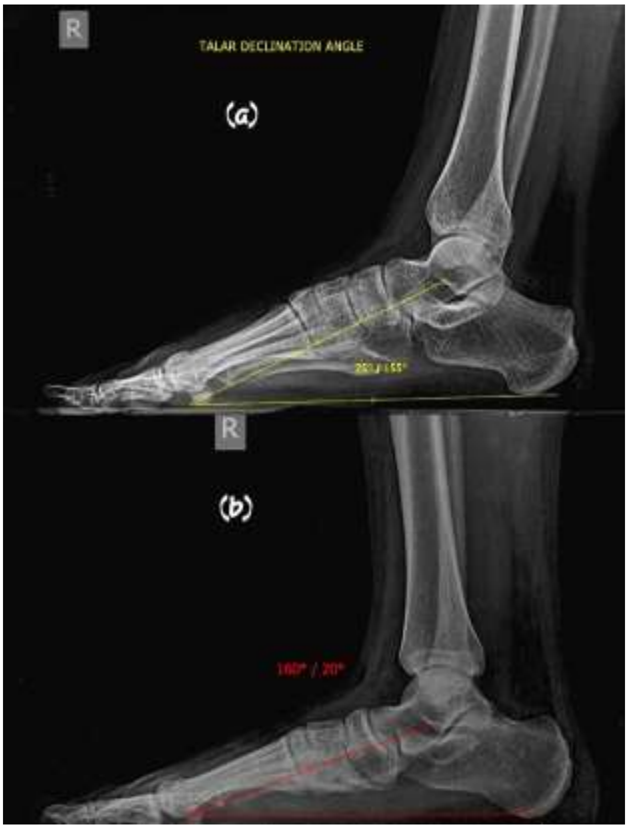

Figure 5: Talar Declination Angle (formed by the intersection of two lines: one representing the long axis of the talus and another representing a line tangent to the plantar surface of the calcaneus) (a) Normal foot, 21-25°; (b) pathological flatfoot, <21°

Descriptive Summary of Key Studies

Below is a concise summary of representative studies from the past decade, highlighting study design, sample size, radiographic metrics, key findings, and limitations.

Lin et al. (2015) conducted a retrospective cross-sectional study of 100 patients assessing Meary's angle, calcaneal pitch, and talonavicular coverage angle. Abnormal Meary's angle and calcaneal pitch were significantly associated with posterior tibial tendon tears, with no tears observed when both were normal, suggesting high negative predictive value. Correlation with MRI was strong, but the retrospective design limited causal inference.

Kim et al. (2016) evaluated 126 patients in a cross-sectional design. They found a significant relationship between increased talar tilt angle and hindfoot varus in medial ankle osteoarthritis, suggesting a biomechanical driver for deformity. The study effectively targeted a specific OA subtype, highlighting radiographic predictors of disease progression.

Upadhyay et al. (2017) retrospectively evaluated 50 patients with complex foot and ankle pain using Tc-99m MDP SPECT/CT. Hybrid imaging improved anatomical localization and diagnostic confidence compared with planar imaging. Limitations included single-center design and lack of controls.

Yildiz et al. (2018) compared 200 patients with plantar heel pain to controls. Elevated calcaneal inclination and talar declination angles were noted, with calcaneal inclination showing the strongest association. Dynamic assessment was not performed.

Yeats et al. (2020) retrospectively reviewed 33 pediatric patients with complex foot pain. SPECT-CT proved superior to conventional imaging in detecting subtle or ambiguous causes of pain like apophyseal abnormalities and stress reactions. The findings were impactful for difficult pediatric diagnoses, supporting hybrid imaging in ambiguous cases.

Kang et al. (2022) examined 132 patients with varus ankle osteoarthritis and found that increased talar tilt angle predicted loss of subtalar joint compensation. Their retrospective cohort study using high-resolution CT showed that subtalar joint adjustments diminish with disease severity. Though valuable in stratifying OA stages, the design limited causal interpretation.

Iyengar et al. (2022) introduced the Calcaneal Offset Index (COI) as a novel metric in their retrospective review of 200 cases with pes planus. COI was reproducible and aligned with traditional measures, providing a new quantifiable tool for hindfoot valgus. Still, further validation was needed due to cross-sectional limitations.

Steadman et al. (2022) studied 275 patients and showed that Meary's angle abnormalities correlated with hindfoot valgus and first metatarsal rotation, emphasizing its role in foot deformity evaluation. Despite demonstrating clear anatomical links, the small sample and study design limited broader conclusions.

Lintz et al. (2023) prospectively validated the Foot–Ankle Offset in 125 subjects using weight-bearing CT, showing strong correlation with symptoms and alignment, with limited availability as a constraint.

Canca-Sanchez et al. (2024) undertook a large cross-sectional study of 457 subjects. They found that the Foot Posture Index (FPI) and the Volumetric Index for Footwear (VIF) were significantly associated with pain. BMI and self-perceived health were also influential. While the study was robust, it relied on clinical proxies like FPI rather than imaging.

Choi et al. (2024) explored 76 ankles and analyzed multiple radiographic deformities, such as tibial plafond inclination and talonavicular coverage. These parameters were linked with medial ankle osteoarthritis and joint incongruency. Though comprehensive, the study was focused on pre-diagnosed cases and had a moderate sample size.

Narrative Synthesis of Findings

Collectively, these studies indicate that chronic foot and ankle pain is frequently associated with early biomechanical deviations detectable on radiography. Conventional metrics such as Meary's angle, calcaneal pitch, talar tilt, and hindfoot alignment consistently correlate with deformities including pes planus, hindfoot malalignment, and medial ankle osteoarthritis.

Plain radiographs remain the primary imaging tool and are effective when assessed systematically. Advanced modalities such as SPECT-CT, MRI, and weight-bearing CT provide added value in complex cases and enhance understanding of joint compensation and soft-tissue involvement.

Recent advances, including novel alignment indices and early machine learning applications, have improved measurement reliability and predictive potential. However, significant heterogeneity in imaging techniques, study design, and patient populations persists. Standardized protocols and large prospective studies are essential to translate radiographic metrics into reliable predictive models and routine clinical practice.

DISCUSSION

Radiographic imaging plays a key role in the early detection and prediction of foot and ankle pain by revealing biomechanical abnormalities that often precede clinical symptoms. Parameters such as calcaneal pitch, Meary angle, talar tilt, and hindfoot alignment are consistently associated with deformities, including flatfoot, hindfoot varus, and medial ankle osteoarthritis. These objective measurements allow risk assessment before irreversible structural damage occurs.

Plain radiographs remain the first-line modality, particularly when interpreted using standardized approaches. In complex or equivocal cases, advanced techniques such as SPECT-CT and MRI improve diagnostic confidence by identifying metabolic or soft-tissue changes that correspond with radiographic abnormalities. Detailed assessment of joint morphology, including the subtalar joint, has further clarified structural contributors to chronic ankle instability and pain.

Recent developments in quantitative indices, such as the Calcaneal Offset Index and Foot–Ankle Offset, have improved measurement reproducibility and addressed limitations of traditional two-dimensional assessments, especially in multiplanar deformities. In parallel, early applications of machine learning have demonstrated potential for predicting pain severity from radiographic features, suggesting a future role for data-driven risk stratification in clinical settings, where such predictions could enhance personalised treatment plans for patients with foot and ankle conditions.

Despite these advances, variability in study design, imaging protocols, and outcome definitions limits comparability across studies. Most evidence is retrospective, and static radiographic measures may not fully reflect dynamic foot function. Future progress will depend on prospective, standardized, multi-centre studies that integrate radiographic metrics with clinical and functional data. Combining advanced imaging with AI-assisted analysis may ultimately enable earlier, more targeted interventions.

CONCLUSION

Radiographic metrics provide a practical and non-invasive way to understand the biomechanical basis of foot and ankle pain. Measurements such as calcaneal pitch, Meary angle, talar tilt, and hindfoot alignment are consistently associated with structural deformities that often precede symptoms, emphasizing their importance as early indicators. Including these measurements in routine assessments may facilitate earlier detection and enable targeted preventive strategies, which could improve long-term outcomes.

However, the current evidence is limited due to variability in imaging techniques, measurement methods, and study designs, which hinders widespread clinical adoption. To enhance their predictive value, standardized protocols and rigorously designed prospective studies are necessary. Additionally, advancements in digital imaging and machine learning may further refine these measurements and allow for personalized risk predictions. Overall, radiographic metrics have the potential to promote a more proactive and preventive approach to foot and ankle care.

Sources of Support / Funding

No external funding was received for this study.

Conflict of Interest Statement

The authors declare no conflict of interest.

Acknowledgement

The authors sincerely acknowledge Santosh Deemed to be University, Ghaziabad, Uttar Pradesh, India, for providing the necessary academic environment, research resources, and institutional support that facilitated the successful completion of this work. The authors also extend their gratitude to faculty members and colleagues from the Department of Radiodiagnosis for their valuable guidance and encouragement throughout the course of this study.

REFERENCES

1. Joong, M. A., & El-Khoury, G. Y. (2007). Radiologic evaluation of chronic foot pain. *American Family Physician*, *76*(7), 975–983. https://pubmed.ncbi.nlm.nih.gov/17956067/
2. Upadhyay, B., Mo, J., Beadsmoore, C., Marshall, T., Toms, A., & Buscombe, J. (2017). Technetium-99m methylene diphosphonate single-photon emission computed tomography/computed tomography of the foot and ankle. *World Journal of Nuclear Medicine*, *16*(2), 88–100. https://doi.org/10.4103/1450-1147.203077
3. Canca-Sanchez, F. J., Morales-Asencio, J. M., Ortega-Avila, A. B., Gijon-Nogueron, G., Cervera-Garvi, P., Marchena-Rodriguez, A., & Canca-Sanchez, J. C. (2024). Predictive factors for foot pain in the adult population. *BMC Musculoskeletal Disorders*, *25*(1), 52. https://doi.org/10.1186/s12891-023-07144-9
4. Choi, J. H., Noh, K. S., Lee, D. Y., Choi, Y. H., Lee, T., & Lee, K. M. (2024). Radiographic evaluation of the association between foot deformities and ankle medial osteoarthritis. *Clinical Orthopaedic Surgery*, *16*(1), 125–133. https://doi.org/10.4055/cios22359
5. Jones, J., Walizai, T., Murphy, A., et al. (2025). Foot radiograph (an approach). *Radiopaedia*. https://doi.org/10.53347/rID-28689
6. Lamm, B. M., Stasko, P. A., Gesheff, M. G., & Bhave, A. (2016). Normal foot and ankle radiographic angles, measurements, and reference points. *Journal of Foot and Ankle Surgery*, *55*(5), 991–998. https://doi.org/10.1053/j.jfas.2016.05.005
7. Kang, H. W., Kim, D. Y., Park, G. Y., Lee, D. O., & Lee, D. Y. (2022). Coronal plane calcaneal-talar orientation in varus ankle osteoarthritis. *Foot & Ankle International*, *43*(7), 928–936. https://doi.org/10.1177/10711007221088566
8. Iyengar, K. P., Azzopardi, C. A., Fitzpatrick, J., Hill, T., Haleem, S., Panchal, H., & Botchu, R. (2022). Calcaneal offset index to measure hindfoot alignment in pes planus. *Skeletal Radiology*, *51*(8), 1631–1637. https://doi.org/10.1007/s00256-022-04011-x
9. Steadman, J., Bakshi, N., Philippi, M., Arena, C., Leake, R., Barg, A., & Saltzman, C. L. (2022). Association of normal vs abnormal Meary angle with hindfoot malalignment and first metatarsal rotation: A short report. *Foot & Ankle International*, *43*(5), 706–709. https://doi.org/10.1177/10711007211068473
10. Lintz, F., Ricard, C., Mehdi, N., Laborde, J., Bernasconi, A., Richardi, G., & Sans, N. (2023). Hindfoot alignment assessment by the foot-ankle offset: A diagnostic study. *Archives of Orthopaedic and Trauma Surgery*, *143*(5), 2373–2382. https://doi.org/10.1007/s00402-022-04440-2
11. Kim, K., Yim, H. S., Hong, S. H., & Sung, K. S. (2016). Correlation between the talar tilt angle and hindfoot varus in medial ankle OA. *Foot & Ankle Orthopaedics*, *1*(1), 2473011416S00158. https://doi.org/10.1177/2473011416S00158
12. Lin, Y. C., Mhuircheartaigh, J. N., Lamb, J., Kung, J. W., Yablon, C. M., & Wu, J. S. (2015). Imaging of adult flatfoot: Correlation of radiographic measurements with MRI. *AJR American Journal of Roentgenology*, *204*(2), 354–359. https://doi.org/10.2214/AJR.14.12645
13. Polichetti, C., Borruto, M. I., Lauriero, F., Caravelli, S., Mosca, M., Maccauro, G., et al. (2023). Adult acquired flatfoot deformity: A narrative review about imaging findings. *Diagnostics (Basel)*, *13*(2), 225. https://doi.org/10.3390/diagnostics13020225
14. Zhang, L., Sun, X., Jiang, L., Zhou, X., Shi, H., Yang, Y., et al. (2024). The morphology of osseous structure in subtalar joint with chronic ankle instability. *Foot and Ankle Surgery*, *30*(1), 74–78. https://doi.org/10.1016/j.fas.2023.09.008
15. Yeats, J. C., Rahbek, O., Griffith, N., Easty, M., Biassoni, L., & Eastwood, D. M. (2020). Bone scan with SPECT/CT in children with complex foot and ankle pain: Initial experience of a paediatric tertiary referral centre. *Journal of Children's Orthopaedics*, *14*(5), 433–439. https://doi.org/10.1302/1863-2548.14.200062

16. Origo, D., Buffone, F., Montini, G., Belluto, D., Tramontano, M., & Dal Farra, F. (2024). Foot Posture Index does not correlate with dynamic foot assessment performed via baropodometric examination: A cross-sectional study. *Healthcare (Basel), 12*(8), 814. https://doi.org/10.3390/healthcare12080814
17. Lau, B. C., Allahabadi, S., Palanca, A., & Oji, D. E. (2022). Understanding radiographic measurements used in foot and ankle surgery. *Journal of the American Academy of Orthopaedic Surgeons, 30*(2), e139–e154. https://doi.org/10.5435/JAAOS-D-20-00189
18. Kim, J., Rajan, L., Fuller, R., Sofka, C., Cororaton, A., Demetracopoulos, C., et al. (2022). Radiographic cutoff values for predicting lateral bony impingement in progressive collapsing foot deformity. *Foot & Ankle International*, *43*(9), 1219–1226. https://doi.org/10.1177/10711007221099010
19. Wang, C., Li, C., Zhang, R., Li, Z., Zhang, H., Zhang, Y., et al. (2022). Identification of radiographic characteristics associated with pain in hallux valgus patients: A preliminary machine learning study. *Frontiers in Public Health, 10*, 943026. https://doi.org/10.3389/fpubh.2022.943026
20. Marshall, M., Blagojevic-Bucknall, M., Rathod-Mistry, T., Thomas, M. J., Edwards, J. J., Peat, G., et al. (2023). Identifying long-term trajectories of foot pain severity and potential prognostic factors: A population-based cohort study. *Arthritis Care & Research*, *75*(5), 1123–1131. https://doi.org/10.1002/acr.24823
21. Park, S., Han, S. G., Kim, K., Lee, H., Bang, Y. S., Kang, K. N., et al. (2021). Prediction of suspicious ankle instability using the calcaneofibular ligament cross-sectional area. *Quantitative Imaging in Medicine and Surgery*, *11*(2), 533–539. https://doi.org/10.21037/qims-20-764