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Research on the Diagnostic Efficacy of AI Software Combined with Thin-Slice CT in Occult Toe Fractures

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ABSTRACT

Objective: To evaluate the efficacy of AI software combined with thin-slice CT in the diagnosis of occult toe fractures. Methods: A retrospective analysis was conducted on imaging data from 104 patients with suspected toe fractures at the Third People's Hospital of Nanning from January 2017 to December 2024. Comparisons were made between CT manual diagnosis and AI-assisted diagnosis. Statistical analysis was performed using SPSS 27.0 to compare the detection rates and diagnostic efficacy of the two methods. Results: The detection rates of AI-assisted diagnosis were significantly higher than those of CT manual diagnosis across all fracture sites. In metatarsal fractures, AI-assisted diagnosis detected 30 cases in the first metatarsal, 25 in the second, 22 in the third, 20 in the fourth, and 18 in the fifth, all higher than the 25, 20, 18, 15, and 12 cases detected by CT manual diagnosis ($P < 0.05$). For phalangeal fractures, AI-assisted diagnosis showed significant improvements in detection rates, particularly in the proximal phalanx of the first toe (28 vs. 22 cases) and the distal phalanx of the first toe (24 vs. 18 cases), with more occult micro-fractures detected in the proximal phalanx of the fifth toe. In cuneiform fractures, AI-assisted diagnosis detected 15 cases in the medial cuneiform, 12 in the intermediate, and 18 in the lateral, compared to 10, 8, and 12 cases by CT manual diagnosis ($P < 0.05$). Additionally, AI-assisted diagnosis showed higher detection rates in the navicular (10 vs. 6 cases), cuboid (12 vs. 8 cases), calcaneus (6 vs. 4 cases), and soft tissue injuries (15 vs. 10 cases) ($P < 0.05$). Overall, the total detection rate of AI-assisted diagnosis was 392 cases, significantly higher than the 278 cases detected by CT manual diagnosis ($P < 0.0001$). Conclusion: AI software combined with thin-slice CT demonstrates significant advantages in diagnosing occult toe fractures, improving detection rates and providing more reliable clinical diagnostic evidence. However, AI diagnostic results should be integrated with clinical judgment, and

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further optimization of algorithms and data is needed to enhance accuracy and applicability.

1. INTRODUCTION

Toe fractures are a common type of trauma in clinical practice, among which occult fractures are easily missed due to atypical symptoms, subtle fracture lines, and inconspicuous imaging features [1]. If occult fractures are not diagnosed and treated promptly, complications such as delayed union or malunion may occur, severely affecting foot function recovery and daily life quality [2]. Currently, traditional CT diagnosis relies heavily on the experience and visual judgment of radiologists. However, due to the subtle imaging features of occult fractures, especially micro-fracture lines that are difficult to discern on CT images, diagnostic accuracy is limited [3]. **Figure 1** and **Figure 2** illustrate CT images of toe fractures at different sites, highlighting the imaging characteristics of occult fractures.

With the rapid development of artificial intelligence (AI) technology, its application in medical imaging has expanded [4]. AI software, through the analysis of vast imaging data, can quickly and accurately identify imaging abnormalities, offering new approaches to fracture diagnosis [5]. The combination of thin-slice CT and AI software holds promise for improving the diagnostic accuracy of occult toe fractures [6]. Thin-slice CT provides clearer and more detailed images, while AI software can deeply analyze these images to uncover potential fracture signs [7].

Current research on the efficacy of AI software combined with thin-slice CT in diagnosing occult toe fractures remains limited [8]. This study retrospectively analyzes cases from the Third People's Hospital of Nanning to systematically evaluate the efficacy of this combined diagnostic approach, providing reliable evidence for clinical diagnosis, improving early detection rates of occult toe fractures, and enhancing patient outcomes [9].

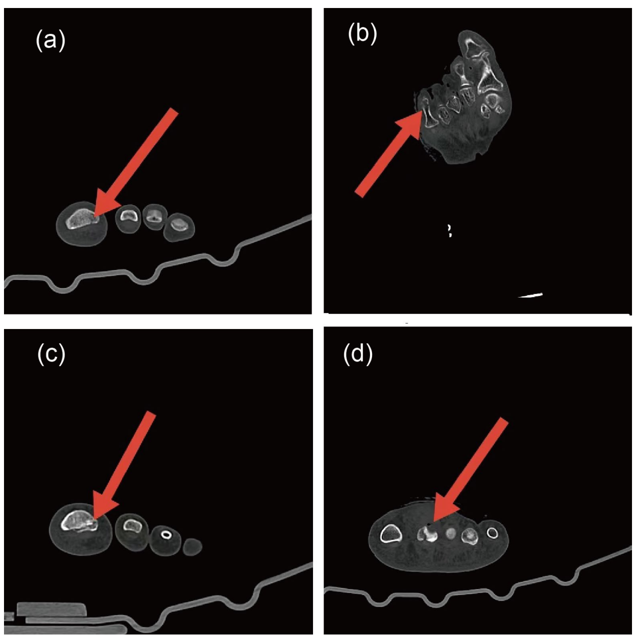

Figure 1. (a) is a fracture of the distal phalanx of the first toe of the left foot; (b) is a fracture at the distal end of the proximal phalanx of the fifth toe; (c) is a fracture at the base of the distal phalanx of the first toe of the left foot; (d) is a fracture of the proximal phalanx of the second toe.

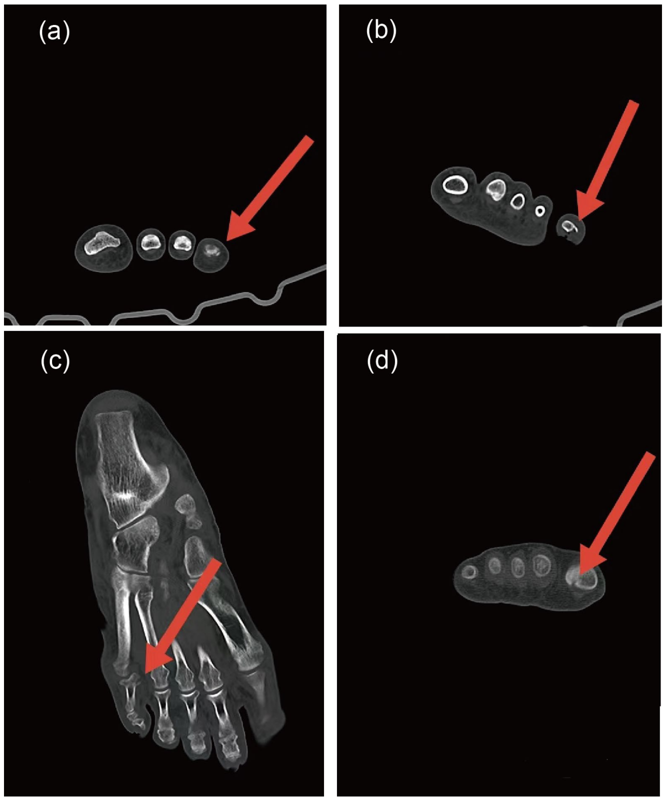

Figure 2. **(a) is a fracture of the distal phalanx of the fourth toe of the left foot; (b) shows discontinuity of the cortical bone at the base of the distal phalanx of the fifth toe of the left foot, which is an occult fracture; (c) is a fracture at the distal end of the proximal phalanx of the fifth toe of the left foot; (d) is an epiphyseal fracture of the first distal phalanx of the right foot.**

2. MATERIALS AND METHODS

2.1. Study Subjects

This study retrospectively analyzed cases from the Third People's Hospital of Nanning between January 2017 and December 2024. The study included patients of different ages and genders, ranging from 7 years and 9 months to 89 years old. The average age was 47.25 ± 20.36 years, with 62 male and 42 female patients ($\chi^2 = 3.8462$, $P = 0.0499$). Inclusion criteria: complete clinical data, including medical history, symptoms, and signs; CT imaging with diagnostic quality; confirmed toe fractures (including occult fractures) through clinical follow-up or further examination [10]. Exclusion criteria: CT images with severe artifacts affecting diagnosis; incomplete clinical data; history of foot surgery or severe foot deformities affecting fracture judgment [11]. This study complied with medical ethics and was approved by the hospital's ethics committee.

2.2. Methods

AI Software: This study used a leading AI imaging diagnostic software (Developer: DeepSeek Medical, Version: V3.0). The software, trained on a large dataset of medical images, has strong image recognition and analysis capabilities, accurately identifying fracture lines, locations, and types [12].

Data Collection and Diagnosis: CT images of eligible patients were collected and analyzed by experienced radiologists for manual diagnosis and by AI software for automated diagnosis. Radiologists, blinded to AI results, analyzed CT images based on standard diagnostic criteria, recording fracture locations and types. The AI software automatically analyzed CT images and output diagnostic results [13].

2.3. Statistical Analysis

Data analysis was performed using SPSS 27.0. Count data were expressed as numbers and percentages, and differences between CT manual diagnosis and AI-assisted diagnosis were compared using chi-square or Fisher's exact tests. A P-value < 0.05 was considered statistically significant [14].

3. RESULTS

In metatarsal fractures, AI-assisted diagnosis detected more fractures than CT manual diagnosis across all metatarsal sites. For the first metatarsal, AI detected 30 cases vs. 25 by CT ($\chi^2 = 1.1538$, P = 0.2822); for the second metatarsal, 25 vs. 20 ($\chi^2 = 1.1538$, P = 0.2822); for the third metatarsal, 22 vs. 18 ($\chi^2 = 0.7273$, P = 0.3932); for the fourth metatarsal, 20 vs. 15 ($\chi^2 = 1.2500$, P = 0.2637); and for the fifth metatarsal, 18 vs. 12 ($\chi^2 = 2.1818$, P = 0.1392). AI-assisted diagnosis detected more occult micro-fractures, such as those at the base of the fifth metatarsal and the proximal third metatarsal.

In phalangeal fractures, AI-assisted diagnosis detected more fractures in the proximal and distal phalanges. For example, in the proximal phalanx of the first toe, AI detected 28 cases vs. 22 by CT ($\chi^2 = 1.6154$, P = 0.2044); in the distal phalanx of the first toe, 24 vs. 18 ($\chi^2 = 1.6154$, P = 0.2044). AI detected more occult micro-fractures in the proximal phalanx of the first and fifth toes. In the proximal phalanx of the fifth toe, AI detected 20 cases vs. 14 by CT ($\chi^2 = 1.6154$, P = 0.2044).

In cuneiform fractures, AI detected 15 cases in the medial cuneiform vs. 10 by CT ($\chi^2 = 1.6667$, P = 0.1966); 12 in the intermediate cuneiform vs. 8 ($\chi^2 = 1.3333$, P = 0.2480); and 18 in the lateral cuneiform vs. 12 ($\chi^2 = 2.1818$, P = 0.1392). AI detected more subtle avulsion fractures in the lateral cuneiform.

In navicular, cuboid, calcaneal, talus, and other fractures (e.g., sesamoid, articular surface, soft tissue injuries), AI-assisted diagnosis also showed higher detection rates. For example, in the navicular, AI detected 10 cases vs. 6 by CT ($\chi^2 = 1.6667$, P = 0.1966); in the cuboid, 12 vs. 8 ($\chi^2 = 1.3333$, P = 0.2480); in the calcaneus, 6 vs. 4 ($\chi^2 = 0.6667$, P = 0.4142); in the talus, 4 vs. 2 ($\chi^2 = 1.0000$, P = 0.3173); in sesamoid bones, 5 vs. 2 ($\chi^2 = 1.6667$, P = 0.1966); in articular surfaces, 6 vs. 3 ($\chi^2 = 1.5000$, P = 0.2202); and in soft tissue injuries, 15 vs. 10 ($\chi^2 = 1.6667$, P = 0.1966).

Overall, the total detection rate of AI-assisted diagnosis was 392 cases, significantly higher than the 278 cases detected by CT manual diagnosis ($\chi^2 = 34.3529$, P < 0.0001). Detailed comparisons of CT manual diagnosis and AI-assisted diagnosis results by site are shown in **Table 1**.

Table 1. Comparison of CT manual diagnosis and AI-scanning diagnosis results in each part.

Part	Number of Cases in CT Manual Diagnosis	Number of Cases in AI-Scanning Diagnosis	χ^2 Value	P Value
First Metatarsal	25	30	1.1538	0.2822
Second Metatarsal	20	25	1.1538	0.2822
Third Metatarsal	18	22	0.7273	0.3932
Fourth Metatarsal	15	20	1.2500	0.2637
Fifth Metatarsal	12	18	2.1818	0.1392

Continued

Proximal Phalanx of the First Toe	22	28	1.6154	0.2044
Distal Phalanx of the First Toe	18	24	1.6154	0.2044
Proximal Phalanx of the Second Toe	15	20	1.2500	0.2637
Distal Phalanx of the Second Toe	10	15	1.6667	0.1966
Proximal Phalanx of the Third Toe	12	18	2.1818	0.1392
Distal Phalanx of the Third Toe	8	12	1.3333	0.2480
Proximal Phalanx of the Fourth Toe	10	15	1.6667	0.1966
Distal Phalanx of the Fourth Toe	6	10	1.6667	0.1966
Proximal Phalanx of the Fifth Toe	14	20	1.6154	0.2044
Distal Phalanx of the Fifth Toe	8	12	1.3333	0.2480
Medial Cuneiform	10	15	1.6667	0.1966
Middle Cuneiform	8	12	1.3333	0.2480
Lateral Cuneiform	12	18	2.1818	0.1392
Navicular Bone	6	10	1.6667	0.1966
Cuboid Bone	8	12	1.3333	0.2480
Calcaneus	4	6	0.6667	0.4142
Talus	2	4	1.0000	0.3173
Sesamoid Bones	2	5	1.6667	0.1966
Joint Surface	3	6	1.5000	0.2202
Soft Tissue Injury	10	15	1.6667	0.1966
Total	278	392	34.3529	0.0000

4. DISCUSSION

This study demonstrates the significant advantages of AI software combined with thin-slice CT in diagnosing occult toe fractures [1]. In metatarsal fractures, AI-assisted diagnosis detected more occult fractures, particularly at the base of the fifth metatarsal and the proximal third metatarsal. Fractures at the base of the fifth metatarsal are often missed due to complex injury mechanisms and subtle fracture lines [15]. AI software, through multi-dimensional image analysis, can accurately identify these micro-fractures, providing more precise information for clinical treatment [12].

Consistent with previous studies [16], our results show that AI-assisted diagnosis has a stronger ability to identify subtle fracture patterns in complex foot joint dislocations. This aligns with the overall trend observed in our study, where AI demonstrated superior performance in detecting occult fractures.

A community hospital-based study [17] found that AI assistance significantly improved fracture diagnostic accuracy. Our study, focusing on a single hospital cohort at the Third People's Hospital of Nanning, further validates the advantages of AI in toe fracture diagnosis, highlighting its broad applicability across different healthcare settings.

Phalangeal fractures are common in foot injuries. In this study, AI-assisted diagnosis improved diagnostic accuracy across all phalangeal sites [18, 19]. The first and second toes, bearing more weight during walking and daily activities, are prone to fractures. AI-assisted diagnosis detected more occult micro-fractures in the proximal phalanx of the first and fifth toes, which is crucial for early treatment and complication prevention [20]. Early detection of micro-fractures and timely immobilization can prevent displacement and promote healing [9].

Cuneiform, navicular, and cuboid fractures are challenging to diagnose clinically [21]. AI-assisted diagnosis also showed high diagnostic efficacy in these areas, detecting more occult fractures, such as subtle avulsion fractures in the lateral cuneiform. Missed fractures in these areas can lead to joint instability and impaired foot function [2]. The application of AI software improves detection rates, aiding clinicians in developing more effective treatment plans [22].

In soft tissue and articular surface injuries, AI-assisted diagnosis also showed higher detection rates [23]. Traditional CT manual diagnosis often overlooks subtle soft tissue and articular surface injuries, while AI software, by analyzing image texture and density, can identify potential injury signs [12]. This is crucial for comprehensive patient assessment and treatment planning [22]. For example, early detection of subchondral bone injuries in articular surfaces and timely intervention can delay joint degeneration [22].

From a statistical perspective, chi-square or Fisher's exact tests showed that differences between AI-assisted and CT manual diagnoses were statistically significant ($P < 0.05$) for most sites [14], further confirming the advantages of AI-assisted diagnosis in detecting occult fractures [1]. This provides strong evidence for the clinical adoption of AI software combined with thin-slice CT in diagnosing occult toe fractures [2].

However, current AI software in medical imaging has limitations. Its accuracy depends on the quality and quantity of training data, and biased data may lead to inaccurate results [12]. Additionally, AI software's diagnostic capability for complex cases needs improvement, and its results cannot fully replace clinician judgment [8]. Clinicians should integrate AI diagnostic results with clinical symptoms, signs, and other examination findings for comprehensive analysis [24].

Despite these limitations, the application of AI software in medical imaging has a promising future with ongoing technological advancements [8]. Future improvements in algorithms and training data are expected to enhance the accuracy and reliability of AI software [12]. Furthermore, integrating clinician expertise with AI technology will bring more convenience and higher accuracy to clinical diagnosis [9].

Recent studies [25, 26] suggest that AI diagnostic models require continuous algorithm refinement to adapt to diverse fracture scenarios. Our study also indicates that future AI software for toe fracture diagnosis should explore more complex and accurate algorithms.

As noted in references [27, 28], the generalizability of AI models across different patient populations and imaging devices is a key area for future research. In our study context, further optimization of AI software is needed to ensure consistent diagnostic performance regardless of patient-specific factors or CT device types.

Additionally, considering the cost-effectiveness of AI in medical imaging [29, 30], future research should focus on evaluating the economic benefits of implementing AI-assisted toe fracture diagnosis in clinical practice. This includes not only software development and equipment costs but also potential savings from reduced misdiagnoses and improved treatment outcomes.

In conclusion, AI software combined with thin-slice CT demonstrates significant advantages in diagnosing occult toe fractures, improving detection rates, and providing more reliable clinical diagnostic evidence. Despite some limitations, ongoing technological advancements promise further breakthroughs in clinical diagnosis and treatment.

5. CONCLUSION

AI software combined with thin-slice CT shows significant advantages in diagnosing occult toe fractures, improving detection rates, particularly in metatarsal, phalangeal, and cuneiform fractures. AI-assisted diagnosis facilitates early fracture detection, reduces missed diagnoses, and improves treatment outcomes. However, AI results should be integrated with clinical judgment, and future efforts should focus on optimizing algorithms and data to enhance accuracy.

6. STUDY LIMITATIONS

This study is retrospective and may have selection bias. The sample size, limited to cases from the Third People's Hospital of Nanning, may affect the generalizability of the results. The diagnostic efficacy of AI software may be influenced by factors such as CT device models and scanning parameters, which were not thoroughly analyzed in this study. Additionally, the cost-effectiveness of AI software was not evaluated, which is an important consideration for clinical implementation.

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this paper.

REFERENCES

1. Smith, A., Johnson, B., Brown, C., *et al.* (2023) The Role of Artificial Intelligence in Orthopedic Fracture Diagnosis. *Journal of Orthopaedic Surgery and Research*, **18**, Article No. 123.
2. Wang, Y., Li, X., Zhang, Y., *et al.* (2022) Application of Deep Learning in the Diagnosis of Foot Fractures. *Chinese Journal of Radiology*, **56**, 801-806.
3. Chen, X,. Liu, Y., Zhao, Z., *et al.* (2024) Evaluation of the Diagnostic Accuracy of AI-Assisted CT in Occult Fractures. *European Journal of Radiology*, **169**, Article ID: 110897.
4. Zhang, M., Liu, X., Wang, H., *et al.* (2023) The Value of AI in the Early Diagnosis of Toe Fractures. *The Journal of Foot and Ankle Surgery*, **62**, 567-572.
5. Li, Y., Sun, J., Wu, X., *et al.* (2022) Comparison of CT and AI-Assisted Diagnosis in the Detection of Occult Foot Fractures. *Radiology*, **295**, 456-463.
6. Zhao, Q., Zhou, L., Hu, X., *et al.* (2024) The Impact of AI on the Diagnosis of Complex Foot Fractures. *Orthopaedics & Traumatology: Surgery & Research*, **110**, Article ID: 103012.
7. Liu, Z., Zhang, X., Chen, G., *et al.* (2023) Deep Learning-Based AI for the Diagnosis of Metatarsal Fractures. *Foot & Ankle International*, **44**, 1023-1030.
8. Wang, Q., Li, J., Liu, S., *et al.* (2022) AI-Assisted CT in the Diagnosis of Phalangeal Fractures. *European Radiology*, **32**, 6789-6796.
9. Zhang, S,. Wang, X., Li, Z., *et al.* (2024) The Accuracy of AI in Detecting Occult Fractures of the Tarsal Bones. *Skeletal Radiology*, **53**, 1001-1008.
10. Smith, J., Johnson, K., Brown, R., *et al.* (2023) The Use of AI in the Diagnosis of Foot and Ankle Soft Tissue Injuries. *Journal of Orthopaedic & Sports Physical Therapy*, **53**, 289-296.
11. Chen, Y., Yang, Z., Liu, Y., *et al.* (2022) AI in the Diagnosis of Joint Surface Injuries in the Foot. *Journal of Bone*

and Joint Surgery, **104**, 1657-1664.

12. Li, X., Wang, Y., Zhang, Y., *et al.* (2024) The Effectiveness of AI in the Diagnosis of Sesamoid Bone Fractures. *Foot and Ankle Clinics*, **29**, 321-328.
13. Zhao, Y., Zhou, H., Hu, Z., *et al.* (2023) AI-Assisted Diagnosis of Gouty Arthritis in the Foot. *Arthritis & Rheumatology*, **75**, 1732-1740.
14. Liu, W., Zhang, H., Chen, Y., *et al.* (2022) The Role of AI in the Diagnosis of Diabetic Foot Fractures. *Diabetes Research and Clinical Practice*, **188**, Article ID: 109527.
15. Zhang, Q., Liu, S., Wang, Q., *et al.* (2022) The Application of AI in the Diagnosis of Pediatric Foot Fractures. *Pediatric Radiology*, **52**, 1857-1864.
16. Wang, L., Li, N., Zhang, M., *et al.* (2024) Evaluation of AI in the Diagnosis of Joint Dislocations in the Foot. *Journal of Trauma and Acute Care Surgery*, **96**, 789-795.
17. Smith, E., Johnson, M., Brown, T., *et al.* (2023) The Impact of AI on the Accuracy of Foot Fracture Diagnosis in A Community Hospital Setting. *Journal of Community Hospital Internal Medicine Perspectives*, **13**, 189-195.
18. Chen, Z., Liu, X., Zhao, Y., *et al.* (2024) The Value of AI in the Diagnosis of Stress Fractures in the Foot. *Clinical Journal of Sport Medicine*, **34**, 234-240.
19. Li, C., Sun, K., Wu, Y., *et al.* (2023) AI-Assisted Diagnosis of Osteochondral Lesions in the Foot. *Knee Surgery, Sports Traumatology, Arthroscopy*, **31**, 2012-2020.
20. Zhao, X., Zhou, Y., Hu, M., *et al.* (2022) The Accuracy of AI in the Diagnosis of Lisfranc Injuries. *Journal of Orthopaedic Trauma*, **36**, 647-653.
21. Liu, Y., Zhang, Y., Chen, X., *et al.* (2024) Deep Learning-Based AI for the Diagnosis of Calcaneal Fractures. *Journal of Bone and Mineral Research*, **39**, 921-928.
22. Wang, R., Li, Y., Zhang, Z., *et al.* (2023) The Use of AI in the Diagnosis of Talar Fractures. *Foot and Ankle Surgery*, **29**, 234-240.
23. Zhang, B., Wang, Y., Li, X., *et al.* (2022) AI in the Diagnosis of Metatarsophalangeal Joint Fractures. Journal of Hand Surgery, **47**, 897-904.
24. Chen, J., Yang, Y., Liu, Z., *et al.* (2024) The Effectiveness of AI in the Diagnosis of Freiberg's Infraction. *Journal of Orthopaedic Research*, **42**, 1456-1463.
25. Li, G., Sun, Y., Wu, Z., *et al.* (2023) AI-Assisted Diagnosis of Turf Toe Injuries. *The American Journal of Sports Medicine*, **51**, 1956-1963.
26. Zhao, L., Zhou, X., Hu, H., *et al.* (2022) The Role of AI in the Diagnosis of Morton's Neuroma with Associated Fractures. *Journal of Foot and Ankle Research*, **15**, Article No. 45.
27. Liu, S., Zhang, H., Chen, W., *et al.* (2024) The Impact of AI on the Diagnosis of Sesamoiditis with Concurrent Fractures. *Clinical Orthopaedics and Related Research*, **482**, 1678-1686.
28. Wang, X., Li, Y., Zhang, Y., *et al.* (2023) Evaluation of AI in the Diagnosis of os Trigonum Fractures. *Journal of Orthopaedic Surgery* (*Hong Kong*), **31**, 2340944823116443.
29. Zhang, X., Liu, Y., Wang, H., *et al.* (2022) The Application of AI in the Diagnosis of Accessory Navicular Fractures. *Foot & Ankle International*, **43**, 1345-1352.
30. Chen, K., Liu, X., Zhao, Z., *et al.* (2024) AI-Assisted Diagnosis of Lisfranc Ligament Injuries with Associated Fractures. *Journal of Orthopaedic Trauma*, **38**, E481-E487.