



The Role of Artificial Intelligence in Identifying Abuse-Related Fractures in Children: A Systematic Review

Nuri Koray Ülgen* and Nihat Yiğit

University of Health Sciences, Sincan Training and Research Hospital, Orthopaedics and Traumatology Clinic, Ankara, Turkey

ABSTRACT

Child abuse and neglect are globally prevalent issues with serious long-term consequences. Early identification of at-risk children is critical for effective intervention and rehabilitation. In recent years, artificial intelligence (AI)-assisted tools have begun to be explored for their potential in detecting child abuse and neglect. However, research on AI-supported fracture imaging in this context remains scarce. This study aimed to evaluate the limited number of existing studies and offer insights into future directions for research in this field.

A comprehensive literature search was conducted across PubMed, EMBASE, and Google Scholar databases for studies published up to March 2025. The review focused on AI-supported fracture imaging related to child abuse and neglect. Out of 165 studies initially identified, data from 5 relevant studies were included—specifically, two focused on clavicle fractures, two on rib fractures, and one on distal tibial metaphyseal fractures. Although the rib fracture studies included children under two years of age, most cases involved imaging from the neonatal period.

Orthopedics and traumatology play a pivotal role in the detection of child abuse and neglect through radiographic assessment. Specific radiological features have been identified to help differentiate fractures due to abuse from those resulting from accidental trauma. AI-driven algorithms capable of predicting the likelihood of abuse-related fractures on radiographs may significantly aid in identifying neglected cases. Nevertheless, current research in this area remains limited.

In conclusion, despite its widespread prevalence, child abuse and neglect continue to be underdetected. AI-based radiographic tools show promise in improving diagnostic accuracy, particularly within orthopedic and trauma settings. Expanding research in this field-across various fracture types and age groups-will be essential to enhance the clinical utility of AI in the early detection and management of child abuse and neglect.

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Introduction

Epidemiological studies show the prevalence of child abuse and neglect worldwide [1]. If child abuse and neglect cannot be prevented, there will be long-term negative effects for both individuals and society [2]. Child abuse and neglect can occur in the short term, but in most cases, long-term exposures occur. A careful approach is required to reveal and detect these exposures.

Researchers are developing methods to identify children who are subjected to child abuse and neglect or at risk. With the use of computer-aided artificial intelligence systems in different medical fields, studies have begun to be published on the detection of child abuse and neglect. However, the number of studies is still limited. A few studies have been described on the detection of child abuse and neglect from diagnosis codes and examination

notes using the Natural Language Processing (NLP) method [3-8]. Artificial intelligent (AI)-assisted applications for imaging bone fractures resulting from child abuse and neglect are still insufficient [9].

Orthopedics and traumatology play an important role in the detection and treatment of child abuse and neglect. Clues indicating child abuse and neglect in fracture imaging have been shown in studies [10-13]. With AI-supported imaging programs, child abuse and neglect can be detected more easily and quickly [9]. Studies in this area are still limited. In our article, we will evaluate the few studies conducted and make predictions about the future of this topic. We also wanted to indicate the points we see as deficiencies in this area for future research.

Contact Nuri Koray Ülgen, University of Health Sciences, Sincan Training and Research Hospital, Orthopaedics and Traumatology Clinic, Ankara, Turkey.

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We conducted a systematic review in the Pubmed, EMBASE and Google Scholar database and searched for articles on AI-supported detection of fractures resulting from child abuse and neglect. We also scanned studies on fracture areas that are open to investigation in this field and provide important clues in the detection of child abuse and neglect, and aimed to provide ideas for future research.

Results and Analysis

The authors conducted a comprehensive literature search in the PubMed, EMBASE, and Google Scholar databases for studies published up to March 2025. All studies that simultaneously addressed Artificial Intelligence (AI), Deep Learning (DL), and child abuse and neglect were reviewed. The primary focus was on fracture imaging studies related to child maltreatment. To inform future research directions, studies identifying diagnostic clues in specific fracture regions associated with child abuse and neglect were also included. For this purpose, additional searches were performed in the same databases using combinations of keywords related to child abuse, neglect, and fracture detection.

Following title and abstract screening, the full texts of eligible studies were reviewed. The inclusion criteria comprised studies that involved the application of AI and deep learning in the context of detecting child abuse and neglect.

A total of 165 studies addressing AI in relation to child abuse and neglect were identified. Of these, data from five studies that specifically employed AI to detect fractures associated with child maltreatment were extracted and analyzed. Table 1 summarizes the key features of these studies, including authorship, publication year, AI models utilized, and dataset sizes. These articles were published between 2022 and 2024.

Among the reviewed studies, two focused on clavicle fractures, two on rib fractures, and one on distal tibial metaphyseal fractures [14-18]. Although patients in the rib fracture studies were reported to be under two years of age, the imaging predominantly represented the neonatal period. Similarly, the clavicle fracture studies concentrated on the neonatal age group. The study on distal tibial metaphyseal fractures included imaging data from patients under one year of age. The two clavicle studies shared co-authors, as did the rib fracture studies, which also utilized a common dataset.

Table 1: Summary of Studies

No	First Author	Year	Input Data	Age	Output/ Prediction	Size of Dataset
1	Tsai A [14]	2022	Newborn chest X-ray	Newborn	Dating neonatal clavicle fractures using the DL model	2151 radiographs in the training, 100 radiographs for validation, and 1666 radiographs in testing datasets
2	Tsai A [15]	2023	Newborn chest X-ray	Newborn	Comparing the DL model and pediatric radiologists in dating neonatal clavicle fractures.	416 clavicle radiographs from 213 infants
3	Ghosh A [16]	2023	Newborn chest X-ray	Under 2 years old	Detecting rib fractures by developing a patch-based DL model	845 chest radiographs
4	Ghosh A [17]	2023	Newborn chest X-ray	Under 2 years old	Detecting rib fractures by Gradient-weighted class activation Maps DL model	1311 frontal chest radiographs
5	Tsai A [18]	2022	Distal tibia X-rays	Under 1 years old	Detection of child abuse in distal tibia fractures	117 normal distal tibia radiographs f And 73 child abuse images from distal tibia radiographs

Discussion

The application of artificial intelligence in medicine has significantly expanded over the past decade. AI-based tools are increasingly utilized in diagnosis, treatment planning, and disease management across various medical specialties [19]. However, while some fields have seen extensive AI integration, others remain relatively unexplored. One such underrepresented area is child abuse and neglect—a global issue with well-known challenges in timely and accurate detection.

AI has the potential to address these challenges and improve the early identification of child maltreatment, ultimately contributing to better outcomes and societal reintegration for affected individuals. Nonetheless, current research in this domain remains limited, especially when compared to the broader scope of AI in medicine [3-8]. Existing AI studies in child abuse and neglect predominantly focus on Natural Language Processing (NLP) for extracting information from diagnosis and treatment notes. In contrast, fewer studies investigate AI-based imaging analysis.

Orthopedics and traumatology are critical disciplines in the identification of child abuse and neglect, as specific radiographic features can distinguish abuse-related fractures from those caused by accidental trauma [10-13]. AI-based algorithms capable of identifying such patterns on radiographs may significantly enhance detection accuracy. Unfortunately, research on AI-assisted fracture detection in this context remains scarce.

All studies identified in our review focused on neonates or children under two years of age. There is a pressing need for studies encompassing older pediatric age groups [14-18]. The five included studies were conducted by two research teams, with overlapping datasets and collaborative authorship, limiting the diversity of available data.

Tsai et al. developed a deep learning (DL) model to estimate the age of neonatal clavicle fractures [14]. Since clavicle fractures at birth provide a reliable temporal reference, the model was trained to retrospectively determine the fracture date. Their model achieved a mean absolute error of 4.2 days, an intraclass correlation coefficient of 0.919, and an 83.7% accuracy in estimating fracture age within ± 7 days of the ground truth. This study demonstrated the potential of DL models in estimating trauma chronology.

In a subsequent study, Tsai et al. compared their DL model with assessments from three experienced pediatric radiologists [15]. The DL model outperformed the radiologists in estimating the actual fracture dates. Both the model's and radiologists' prediction accuracies declined as the fracture aged, but the DL model maintained higher precision. These findings suggest that future DL models trained on larger datasets may play a key role in trauma dating in child abuse investigations.

Ghosh et al. developed two DL models for rib fracture detection using shared datasets [16,17]. Rib fractures are a common yet often overlooked indicator of child abuse, especially in the absence of external trauma. The first model, which utilized patch-based CNN architecture, demonstrated limited sensitivity and specificity [16]. The second model, employing Gradient-weighted Class Activation Mapping (Grad-CAM), yielded improved performance metrics [17]. As with other studies, larger and more diverse datasets are needed to enhance model reliability.

Tsai et al. also explored AI-based detection of distal tibial metaphyseal fractures in infants under one year old [18]. Their model achieved an overall sensitivity of 88% and specificity of 96%. Similar to previous studies, increased sample sizes could enhance the generalizability and robustness of their model.

Fractures of the femur and humerus are also commonly associated with child abuse [20,21]. AI-based studies targeting these fracture types could significantly contribute to improved detection. Additionally, AI algorithms designed to identify the radiographic characteristics of metaphyseal fractures—regardless of location—may offer substantial diagnostic value [10].

Conclusion

Child abuse and neglect remain pervasive global issues, and their detection continues to pose significant challenges. Orthopedics and traumatology play a critical role in identifying abuse through radiographic evaluation. Deep Learning (DL)-based programs have shown promise in detecting fractures resulting from abuse and neglect. However, current studies are limited in scope, both in terms of fracture types and patient age groups, with most research focusing on a narrow set of anatomical regions and exclusively on neonates or infants under two years of age. Expanding DL-based fracture detection research across a broader range of fracture sites—including the humerus and femur—could significantly enhance diagnostic accuracy and support clinicians in identifying abuse. Moreover, the ability of DL models to estimate the timing of fractures can be particularly valuable for forensic investigations. Future studies involving older pediatric populations and diverse fracture patterns will be essential to developing comprehensive AI tools that aid in the timely and accurate detection of child abuse and neglect.

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