This review will first discuss AI in fracture detection, followed by osteoporosis, bone tumors, and finally, bone age assessment, with each section detailing advancements in various diagnostic tasks over the specified period {2017-2025}

AI has been a matter of hot interest in fracture detection because publication was easy*(as a matter of fact). Since the task was mostly about classification,detection,segmentation,age assessment,prognostication etc.

Olzack et al. 2017 initialized the question if deep learning can be as good as human in fracture detection type task,then selected 5 openly available deep learning networks that were adapted for these images. The most accurate network was benchmarked against a gold standard for fractures.

Antonio et al. 2018 came up with a system for Vertebra Fracture Classification from 3D CT Lumbar Spine Segmentation Masks Using a CNN.The network achieved 93.29% testing accuracy.

Lindsay et al. ,2018 The model was tested on two different datasets: on Test Set 1, the model achieved an AUC of 0.967; on Test Set 2, the model achieved an AUC of 0.975. With the same set of images used for clinicians' evaluations, the model operated at 93.9% sensitivity and 94.5% specificity

Kim et al. 2018 Transfer learning, from neural networks pre-trained on non-medical images, makes machine learning widely accessible. This strategy results in a test with high area under the curve accuracy (0.954).

Tomita et al. 2018 Osteoporotic vertebral fracture detection using deep learning. trained and evaluated our system on 1432 CT scans, consisting of 10,546 two-dimensional (2D) images in sagittal view. Our system achieved an accuracy of 89.2% and an F1 score of 90.8% based on our evaluation on a held-out test set of 129 CT scans,

Ebsim et al. 2019 a system that uses Convolutional Neural Networks (CNNs) to detect wrist fractures (distal radius fractures) in posterior anterior (PA) and lateral (LAT) radiographs using Random Forest Regression Voting Constrained Local Model (RFCLM) to automatically segment the radius,AUC performance 96% on 1010 patients dataset. RF-CLM was employed as a reliable and efficient preprocessing step to improve accuracy, robustness, and clinical applicability of their deep learning-based wrist fracture detection system

Markus et al. 2019 shows in his research that CNN is good for fracture detection ,but multimodal can be a better result achiever. Also followed a lot of methodologies that CNN does not follow mostly (**AUC = 0.78**).

Rayan et al. 2019 A multiview approach was used for the model by combining both a convolutional neural network and recurrent neural network to interpret an entire series of three radiographs together. Sensitivity, specificity, positive predictive value, negative predictive value, area under the receiver operating characteristic curve (AUC), and their 95% confidence intervals were calculated.Large dataset.

Cheng. et al,2019 showed the feasibility of using DCNN for hip fractures detection and localization by plain frontal pelvic radiographs (PXR).The algorithm achieved an accuracy of 91%, a sensitivity of 98%, a false-negative rate of 2%, and an AUC of 0.98 for identifying hip fractures. The visualization algorithm showed an accuracy of 95.9% for lesion identification.

Nicolaes et al. (2019) present a detection method to opportunistically screen spine-containing CT images for the presence of these vertebral fractures using CNN for 3D images (first in their knowledge). Their 3D method produces an Area Under the Curve (AUC) of 95% for patient-level fracture detection and an AUC of 93% for vertebra-level fracture detection in a five-fold cross-validation experiment. Used 90 CT scan images.(There was less work in this field)
Pranata et al. 2019 deep learning and surf for classification and detection of calcaneus fractures in CT images.Two types of Convolutional Neural Network (CNN) architectures with different network depths, a Residual network (ResNet) and a Visual geometry group (VGG), were evaluated and compared for the classification performance of CT scans into fracture and non-fracture categories.

ResNet outperformed VGG in bone fracture classification.High accuracy and reduced runtimes achieved in automatic fracture detection using SURF algorithm.

Guan et al. 2019 Thigh fracture (first time) detection using deep learning method based on new dilated convolutional feature pyramid network .FPN was used to enable the model to detect thigh fractures of varying sizes by combining low-level spatial details with high-level semantic features across multiple scales.

Zhang et al. 2020 demonstrated that a DCNN analyzing lumbar spine X-rays can reasonably screen for osteopenia and osteoporosis, achieving AUCs in the **0.72–0.81** range and sensitivities around **70–85%**, supporting its potential role in opportunistic screening pathways alongside DXA

Evaluate the feasibility and accuracy of a two-channel deep convolutional neural network (DCNN) to classify postmenopausal women

Yadav et al. 2020 his study successfully demonstrates that a **CNN with data augmentation and Adam optimizer** can classify healthy and fractured bones from X-ray images with high accuracy (92–95%).

Tanzi et al. 2020 Introduction of a multistage approach which surpassed the classic approach for proximal femur feature.We obtained an averaged accuracy of 0.86 (CI 0.84—0.88) for three classes classification and 0.81 (CI 0.79—0.82) for five classes classification. The average accuracy improvement of specialists was 14 % with and without the CAD (Computer Assisted Diagnosis) system.

Yasaka et al. Prediction of bone mineral density from computed tomography: application of deep learning with a convolutional neural network. DXA is expensive and there are not much work this sect other than bone fracture classification, using X ray for BMD .

Hong et al. 2020 two EfficientNet-based deep-learning models, VERTE-X pVF and osteo, reliably detect vertebral fractures and osteoporosis from lateral spine X-rays. They outperform clinical models (AUROCs 0.92–0.93 vs. ~0.78–0.79) and meaningfully improve referral decisions (NRI ~0.10–0.14). Applying spine-radiography-driven DCNN models in clinical practice might improve the opportunistic detection of individuals at high risk of fractures.

Mutasta et al, 2020 GANs and DRRs can be used to improve the accuracy of a tool to diagnose and classify femoral neck fractures.
introduced a robust two-stage pipeline enhanced by **GAN+DRR augmentation**, achieving **92.3% accuracy (AUC 0.92)** in fracture detection and **86% accuracy (AUC 0.96)** in Garden stage classification. While newer models with larger datasets now exhibit superior performance, this work was foundational in showing how synthetic image augmentation elevates radiological AI for femoral neck assessments.

Beyaz et al. 2020 n this experimental study utilized CNNs in the detection of bone fractures in radiography. The trained model yielded an overall Acc of 77.7% when 50¥50 image sizes were used.
A different CNN network by 5 layers
Performance (5-fold CV, 50×50 crops):
Sensitivity: 83% Specificity: 73% Accuracy: ~83% Cohen's κ: 0.55
Strengths: First femoral-neck fracture DL study; compact input size; genetic-hyperparameter tuning. Limitations: Small/imbalanced dataset; moderate agreement score.

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Using Resnet Algorithm in differential diagnosis of benign
and malignant vertebral fracture on CT.
Used active learning style from a 20 year experienced senior radiologist
*When the imaging features were subtle, deep learning was more likely to make wrong predictions, and in these cases, even experienced radiologists could misdiagnose them.

[Can deep convolutional neural networks (DCNNs) detect occult scaphoid fractures not visible to human observers?]

The result shows they can.

[Yao et al 2021] Rib fracture detection system based on deep learning .This study developed a Rib Fracture Detection System that achieved high performance in rib fracture detection on chest CT images based on the deep learning algorithm. By radiologist-model collaboration, radiologists can significantly reduce their workload, and minimize misdiagnosis. This Rib Fracture Detection System is readily available in the clinical setting.

Title: *Transfer Learning Models for Osteoporosis Classification*
Focus: Comparing the performance of three state-of-the-art (SOTA) models—GoogLeNet, VGG-16, and ResNet50—for osteoporosis classification.
Key Focus: Comparing runtimes, model architectures, accuracy, and effectiveness of transfer learning techniques.

Title: *Bone Fracture Detection using SFNet with Canny Edge Algorithm*
Focus: Proposes a model using SFNet, combining CNN with an improved Canny edge algorithm for bone fracture detection in X-ray images.
Key Focus: Optimized computational performance with SOTA outcomes, and gap analysis regarding model feature extraction and performance.
Gap: Feature extraction requires expertise, with suboptimal current models.

Enhanced Vision Transformer with Attention Mechanisms for Fracture Detection
SOTA fracture detection using Vision Transformer (ViT) with scale-aware and spatial-aware attention mechanisms for improved accuracy.Accuracy improvements using physicians' reviewed data and model enhancements via ATSS and PVT backbone integration.

[Frederik Russe et al] 2024 The study developed two convolutional deep neural network models, VERTE-X pVF (for vertebral fractures) and VERTE-X osteo (for osteoporosis), which were tested against clinical models and traditional diagnostic methods like DXA (Dual-energy X-ray Absorptiometry).The models outperformed traditional clinical methods and could be a valuable tool in opportunistic screening, potentially improving patient care.

Yaseen et al 2024 Cervical Spine Fracture Detection and Classification Using Two-Stage Deep Learning Methodology,,In the first stage, a convolutional neural network (CNN) is used to identify the presence or absence of a fracture in cervical spine CT scans, with Grad-CAM employed for enhanced visualization. In the second stage, the study focuses on specific vertebrae using YOLOv5 and YOLOv8 models trained on 9170 images, with evaluation metrics showing high performance (precision: 0.900, recall: 0.890, mAP50: 0.935, mAP50-90: 0.872).

Zhou et al 2024 •
New classification for whole body bone fractures into four patterns.Enhance YOLOv7 with attention mechanism for precise fracture detection.Introduce EIoU loss for accurate bounding box predictions.The customized YOLOv7-ATT leads in performance with a mAP of 80.2% and excels in FracAtlas dataset.

Kong et al 2024 A cT scan based fracture prediction model.The model using the images of the vertebral bone and paravertebral muscle showed better performance than that using the images of the bone-only or clinical variables. Opportunistic CT screening may contribute to identifying patients with a high fracture risk in the future.
The image models were developed using an attention convolutional neural network–recurrent neural network model from images of the vertebral bone and paravertebral muscles.

Yisak Kim et al 2024 To develop and validate a deep learning prediction model for subsequent fracture risk using digitally reconstructed radiographs from hip CT in patients with recent hip fractures.The model demonstrated promising performance, with an area under the receiver operating characteristic curve (AUC) of 0.74, indicating its potential utility in clinical settings for personalized fracture prevention strategies

Parvin et al 2024, utilised a a customized dataset named "Human Bone Fractures Multi-modal Image Dataset" which includes 641 images representing ten different classes of bone fractures.system attained 95% precision, 93% recall, and 92% of mean average precision. The outcomes demonstrated that the method achieves cutting-edge performance.

Network	P(%)	R(%)	mAP(%)	GFLOPs	Model Size (MB)
Faster R-CNN	86.8	77.6	80.8	207.07	134.5
YOLOv5	90.4	85.9	88.9	49	41.1
YOLOX	91.5	87.4	90.2	26.8	70.21
YOLOv7	92.8	88.3	90.7	104.7	72.1
YOLOv8	**95.3**	**92.8**	**91.6**	**78.7**	**49.7**

Liu 2025 Experimental results [39] show that combining a Residual Network (ResNet) [40] with the Global Attention Mechanism (GAM) extensively enhances the model performance.There is a need for models that can detect fractures across various images and positions.

The paper addresses limitations in wrist fracture detection models, such as partial detection and inconsistent performance due to image resolution. It enhances feature extraction by integrating ResNet_GAM and attention mechanisms with YOLO11. The introduction of SE_BLOCK refines feature collection, improving focus on fracture-prone areas and overall detection accuracy.

Elsheikh et al. 2025 This study proposes a Deep Learning-Driven Computer Vision Model for Multi-Region Bone Fracture Detection and Classification (DLCVMMBFDC) techniquepre-processing to improve the image quality by mitigating noise and preserving crucial details, getting the proper representation of images,improves performance in diverse ways,The novel integration of WF, DenseNet201, SAE, and WGOA hyperparameter optimization presents a unified bone fracture detection and classification framework

Tang et. al 2025 The value of a deep learning image reconstruction algorithm for assessing vertebral compression fractures using dual-energy computed tomography.In conclusion, DLIR can reduce noise in 70 keV VMIs and VNHAP images, enhancing overall image quality and intervertebral contrast for acute VCFs, thereby improving the diagnostic efficiency for acute VCFs with MRI serving as reference.

Paradava et al. 2025 Real-Time Bone Fracture Detection Using MobileNetV2 and Explainable AI for Clinical Integration.The purpose of the study is to create a real-time, clinically practical system to detect a fracture combining lightweight deep learning, interpretability, and system-level integration. This model had an accuracy of 89.26 percent, a precision of 91.52 percent, F1 score of 89.04 percent and a minimum false negative of 14 cases out of 1018 cases. CNN based approach

To improve the generalization power of the model with the use of advanced data augmentation techniques

Wang et al AI4Skeletons: bringing in a new era of the digital intelligent skeleton with artificial intelligence.tiagent technology, and digital twins, digital skeletons are bringing new development opportunities in orthopedics. Data-driven deep learning (DL) network models can effectively learn medical feature representations from multimodal and cross-scale datasets to accurately identify orthopedic diseases, making the most of the vast amount of medical imaging data and records collected over the years.