Supplementary File 1. Q-Angle glossary.

1) Coordinate Regression
In machine learning, coordinate regression refers to the task of predicting the (x, y) coordinates of specific key points within an image. In medical applications, instead of classifying or detecting objects, the model learns to output precise locations of anatomical landmarks directly from the image data.
2) YOLO (You Only Look Once)
YOLO is a family of state-of-the-art deep learning models designed for real-time object detection and key point prediction. The "You Only Look Once" philosophy means the model processes the entire image in a single forward pass, making it highly efficient. YOLOv8, the version used in this study, is optimized for tasks like object detection, segmentation, and pose estimation without relying on intermediate representations like heatmaps. It predicts bounding boxes and key point coordinates directly, which makes it suitable for applications requiring fast and accurate localization, such as automated Q-angle measurement from radiographic images.
3) Contrast Limited Adaptive Histogram Equalization (CLAHE)
An image preprocessing technique that enhances local contrast in images, especially useful in medical imaging. CLAHE adjusts the histogram of pixel intensities to improve the visibility of anatomical structures without amplifying noise.
4) Non-Local Means Denoising
An advanced noise reduction algorithm that preserves fine details while removing noise from images. It works by averaging pixels with similar intensity patterns, regardless of their location, making it effective for medical images where detail preservation is essential.
5) Edge Detection
An image processing method used to identify and highlight the boundaries or edges within an image. Enhancing edges makes it easier for models to recognize anatomical structures and key points.
6) Data Augmentation
Techniques used to artificially expand a training dataset by applying random transformations to the images, such as flipping, rotation, scaling, and color adjustments. This helps improve model robustness by simulating variations the model might encounter in real-world data.
7) Random Flipping
A data augmentation method where images are flipped horizontally (left-right) or vertically (up-down) with a certain probability. This helps the model learn invariance to orientation changes.
8) Mosaic Augmentation
A data augmentation technique that combines four different images into one mosaic image. This exposes the model to a variety of contexts and scales within a single training example, improving its ability to generalize.
9) Mean Squared Error (MSE)

A loss function used to measure the average squared difference between predicted and actual values. In the context of coordinate regression, it quantifies how accurately the model predicts key point coordinates compared to the ground truth.
10) Early Stopping
A training strategy where model training is halted when the performance on a validation set stops improving. The "patience" parameter defines how many epochs the model waits for improvement before stopping, helping to prevent overfitting.
11) Fine-Tuning
The process of taking a pre-trained model and further training it on a new, often smaller, dataset specific to a particular task. This adapts the model to new data without starting training from scratch, leveraging learned features.
12) Bounding Box
A rectangular box that fully encloses an object or region of interest within an image. In object detection tasks, bounding boxes are used to localize and identify objects.
13) Pose Estimation
A computer vision task that involves predicting the positions of key points defining the pose of a person or object within an image. It is essential for understanding spatial configurations in images.
14) Annotations
Labels or markings added to data to indicate important features or attributes. In this study, annotations refer to the manual marking of anatomical key points on radiographic images, serving as ground truth for model training.
15) Ground Truth
The accurate, real-world data used as a benchmark for training and evaluating models. It represents the correct output that models aim to predict, allowing for the assessment of model performance.
16) Key Points
Specific, predefined points of interest in an image, such as anatomical landmarks like the ASIS, patella center, or tibial tuberosity. Accurate detection of key points is crucial for measurements like the Q-angle.
17) Heatmaps
In the context of key point detection, heatmaps are spatial probability distributions that indicate the likelihood of a key point's presence at each location in an image. They are often used in pose estimation but were not utilized in this study's YOLOv8 approach.
18) Object Key-point Similarity (OKS) Metric
A performance metric used to evaluate key point detection models by comparing predicted key points to ground truth while considering object scale and key point visibility. It aligns the training objective with the evaluation criteria.