Combining Fractal- and Entropy-based Bone Texture Analysis for the Prediction of Osteoarthritis: Data from the Multicenter Osteoarthritis Study (MOST)

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Introduction
Osteoarthritis (OA) is one of the leading causes of long-term pain and disabilities associated with musculoskeletal disorders. Effective treatment and disease-progression slowdown depend on early detection and quantification of risk. However, current disease parameters, like joint space width (JSW), have proven to be insufficient for the prediction of OA.

Hypothesis
The purpose of the present study was to investigate if combining fractal- and entropy-based bone texture analyses with joint space width (JSW) and joint space area (JSA) may improve prediction of OA.

Methods
Conventional posterior-anterior (PA) knee radiographs of men and women were obtained from the Multicenter Osteoarthritis Study (MOST) database, which provides valuable information to identify and define modifiable biomechanical, bone and structural, nutritional, and other risk factors for new disease and progression of existing disease (1) Oriented fractal- and entropy based texture algorithms were developed, using state-of-the-art computer hardware and software as well as specific machine-learning algorithms. The selected subchondral area used for textural analyses included 4 regions of interest (ROI) in the proximal tibia and one on each condyle of the distal femur (Figure 1). Furthermore, JSW and JSA were assessed using newly developed and fully automated software.

Figure 1
Results
1092 conventional knee radiographs obtained from one study center were screened for eligibility. Of these, a total of 574 radiographs (230 women, 344 men) met the inclusion criteria, i.e. a Kellgren & Lawrence (KL) score of 0 at baseline. At month 84, 41 female and 79 male patients had developed KL≥1, and 189 female and 265 male patients remained at KL0. Area-Under-the-Curve (AUC) for incident OA using JSW/JSA and clinical features was 0.67±0.08 for women, and 0.61±0.1 for men. In contrast, combining fractal/entropy-based texture, JSW/A and clinical features resulted in significantly improved AUC for women and men (0.80±0.07 for women and 0.69±0.1 for men, respectively). To test whether these differences in predicting incident-OA were significant, we performed classifier comparison: t = 3.84; p < 10-3 for women, and t = 3.38; p < 10-3 for men.

Conclusion
This study provides strong evidence, that a combination of fractal- and entropy-based textural analyses of plain subchondral bone radiographs together with JSW/A and clinical features is superior to JSW/A and clinical features alone in predicting incident OA in men and women.

Keywords
osteoarthritis, fractal analysis, early prediction, imaging, radiology, orthopedics, machine learning