

Early Detection of Osteoarthritis Using Computer-aided Radiography

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Introduction: The availability of plain radiographs makes them the most commonly used tools in the evaluation of OA joints, despite known limitations in detecting early disease and subtle changes over time. However, while the human reader is limited by what the human eye can see, computer-aided image analysis methods have the advantages of detecting subtle differences in textures and intensity variations within an image. Such methods have been used to analyze changes in the radiographic texture of the bone, and were found effective for the detection of present knee and hip OA (Boniatos et al., 2007; Podsiadlo et al., 2008; Shamir et al., 2009). The purpose of this study is to determine whether computer-based analysis can detect features predictive of osteoarthritis (OA) development in radiographically normal knees.

Methods: The dataset included longitudinal conventional film-screen radiographs of the knees, AP, standing, with resolution of approximately 8-10 line pairs/mm. The X-rays were acquired for the Baltimore Longitudinal Study of Aging (BLSA) project, which is a longitudinal normative aging study. Participants had baseline X-rays that were classified as normal (Kellgren-Lawrence grade 0), and on follow-up ~20 years later either developed knee OA (defined as KL grade >2) or remained normal.

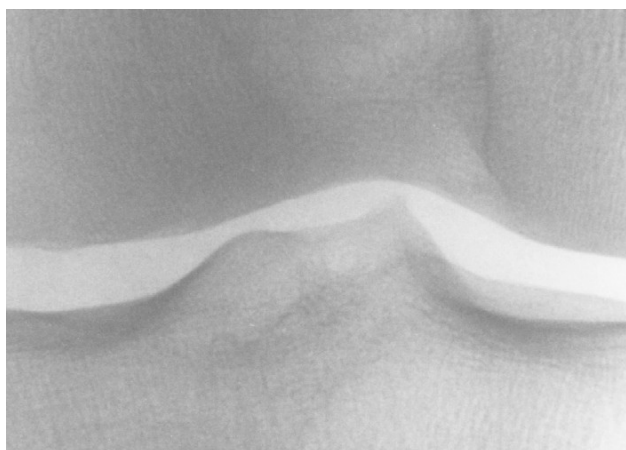


Figure 1. A sample joint center image used for the image analysis of the knee X-rays

The film X-rays were digitized using a UMAX Power-Look 1100 scanner, and an automatic joint detection mechanism was applied to detect the center of the knees, producing a dataset of images of the center of the joint with dimensionality of 700x500 pixels, as demonstrated by Figure 1.

A systematic computer-aided image analysis method (*wnd-charm*) was then used to analyze pairs of weight-bearing knee X-rays and automatically classify between normal joints that ~20 years later developed radiographic OA, and joints that remained normal (KL grade 0).

Results: The computer-aided method predicted whether a knee would change from KL grade 0 to grade 3 with 72% accuracy ($P < 0.00001$), and to grade 2 with 62% accuracy ($P < 0.01$). Although a large part of the predictive signal comes from the image tiles that contained the joint, the region adjacent to the tibial spines provided the strongest predictive signal.

Conclusion: Radiographic features detectable using a computer-aided image analysis method can predict the future development of radiographic knee OA, ~20 years before it can be detected using standard clinically utilized classification schemes. The results of this study suggest that the regions of knee image that contain the joint and the tibia just beneath the trochlear groove provide the most predictive information.

References:

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- Shamir L., et al., *IEEE Trans. BioMed. Eng.*, 2009, In Press.