論文の要旨

*Automatic System for Diagnosing Osteoporosis based on Dental Panoramic Radiographs using Statistical Classification Techniques*

（歯科パノラマX線写真を用いた統計的分類技術適用による骨粗鬆症診断システム）

Name: Muthu Subash Kavitha

Osteoporosis is a degenerative bone disease that mainly affects the post-menopausal women as a consequence of a reduction in estrogen levels. However, osteoporosis for postmenopausal women can be identified through dental radiographs which can be considered as prevention. The objectives of the study are to develop an automatic computer-aided diagnostic (CAD) system which can continuously measure the mandibular cortical width (MCW) to achieve a higher ability in the identification of the low bone mineral density (BMD) or osteoporosis than the previously developed one-point measurement system. In addition, various statistical techniques are employed to identify postmenopausal women with low BMD for higher diagnostic accuracy.

Dental panoramic radiographs of 100 postmenopausal women taken between 1996 and 2001 (Hiroshima University Hospital, Japan) with BMD assessments of the lumbar spine and the femoral neck have been used to identify the low BMD in this study. The mandibular cortical width below the mental foramen on the dental radiographs was measured using various image processing methods and mathematical morphological techniques such as distance transform and dynamic programming. Clustering thresholding algorithm was applied to separate the cortical bones that construct histogram segmentation which maximizes interclass variance and minimizes intraclass variance. High-pass filtering was used for the image enhancement and various steps were followed to obtain a smooth image. The resultant images were masked, disks were inserted to develop a clear bone boundary images. Finally to determine the direction of the mandibular cortical width measurements, the least squares method was used. The results of the continuous measurement were summarized by trimmed mean method. The performance of the developed CAD system in screening osteoporosis was confirmed.
through various statistical measures and receiver operating characteristic (ROC) curve evaluation to screen the people for low BMD or osteoporosis (called as sensitivity) and healthy (called as specificity).

The sensitivity and specificity of the developed CAD system were 93.3% (95% Confidence Interval [CI], 85.9-100.0) and 82.9% (95% CI, 71.4-92.7) at the lumbar spine and 92.3% (95% CI, 84.5-99.5) and 75.7% (95% CI, 63.0-87.0) at the femoral neck, respectively. The area under the curve (AUC) of this system was almost ≥ 0.8, indicating that the diagnostic efficacy of the system in identifying postmenopausal women with low skeletal BMD is high. To obtain better diagnostic accuracy, various statistical estimates were utilized in the measurements of the cortical width values.

In the proposed system of continuous measurement of cortical bone results sometimes affected by noises. Due to noises, a thicker cortical bone region will cause a bone image to appear thinner than the original image. This kind of variations in thickness of the cortical bone can influence the measurement results. To resolve this measurement error, a novel clustering algorithm based on histograms was proposed. The sensitivity for both the right and left cortical width of the lumbar spine and the femoral neck was 92% (95% CI, 81.0–100.0). The specificity for the right and left cortical width of the lumbar spine was 67% (95% CI, 56.0–77.0) and 64% (95% CI, 56.2-74.3) and with femoral neck these were 55% (95% CI, 48.3–63.9) and 75% (95% CI, 65.9–87.1), respectively. The improved specificity proved that measuring cortical width using the clustering algorithm could ensure better noise removal by preserving the most significant part of the cortical bone.

Further, this study proposed the application of kernel based - support vector machine (SVM) method in diagnosing and classifying of women with low BMD to achieve higher diagnostic accuracy. This is the first CAD system that analyzed the classification of women with low BMD from the MCW using SVM for screening osteoporosis. The results showed that the sensitivity and specificity for identifying women with low BMD were 90.9% (95% CI, 85.3–96.5) and 83.8% (95% CI, 76.6–91.0), respectively at the lumbar spine and 90% (95% CI, 84.1–95.9) and 69.1% (95% CI, 60.1–78.6), respectively at the femoral neck. The application of SVM in this
study provided a high degree of consistency and reproducibility in the results with the highest accuracy of 88%.

The advantage of the developed CAD system is the continuous measurement of MCW, which enables the application of statistical analyses resulting the highest diagnostic accuracy of detecting low Bone Mineral Density (BMD) or osteoporosis. The proposed system could able to overcome the problem of the conventional CAD system that is the one-point measurement of the MCW could be easily influenced by the measurement error. It also proved the superiority in terms of efficacy for diagnosing low BMD or osteoporosis over the conventional methods. This study concludes the performance comparison and simplicity of this proposed system support strongly that the dental clinics could offer a new triage platform to identify individuals at risk of osteoporosis and can reduce the incidence of osteoporotic fractures.