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Opportunistic Screening for Osteoporosis Using Hand Radiographs: A Preliminary Study

Farid Ghareh MOHAMMADI[a,b] and Ronnie SEBRO[a,b,1]
[a] *Department of Radiology, Mayo Clinic, Jacksonville, Fl, 32224, USA*
[b] *Center for Augmented Intelligence, Mayo Clinic, Jacksonville, Fl, 32224, USA*

Abstract. Patients with low bone mineral density (BMD) are at risk for fractures however are often undiagnosed. Therefore, there is a need to opportunistically screen for low BMD in patients who present for other studies. This is a retrospective study of 812 patients aged 50 years or older who had dual-energy X-ray absorptiometry (DXA) and radiographs of the hands within 12 months of each other. This dataset was randomly split into training/validation (n=533) and test (n=136) datasets. A deep learning (DL) framework was used to predict osteoporosis/osteopenia. Correlations between the textural analysis of the bones and DXA measurements were obtained. We found that the DL model had an accuracy of 82.00%, sensitivity of 87.03%, specificity of 61.00% and an area under the curve (AUC) of 74.00% to detect osteoporosis/osteopenia. Our findings show that radiographs of the hand can be used to screen for osteoporosis/osteopenia and identify patients who should get formal DXA evaluation.

Keywords. Deep Learning, Radiograph, DXA, Bone Mineral Density, Hand

1. Introduction

Bone mineral density (BMD) loss begins in the fourth decade of life and increases significantly after menopause for women [1] [2]. Low BMD increases the risk of fractures [1] [2]. Dual-energy X-ray absorptiometry (DXA) is the gold standard test for the evaluation of BMD [3]. Most patients who are at risk for low BMD are often not screened using DXA, so there is a need for opportunistic screening for low BMD [1] [2]. A recent study showed that radiographs of the hip and lumbar spine could be used to predict BMD [4]. We hypothesized that hand radiographs could also be used to predict BMD, so the goal of the study was to use hand radiographs for opportunistic screening for low BMD to identify patients who should have a formal evaluation with DXA.

2. Methods

We conducted a retrospective cohort study of patients at Mayo Clinic aged >=50 years with DXA and hand radiographs taken within 12 months of each other between 01/01/2010 and 12/31/2021.

[1] Corresponding Author: Ronnie Sebro, E-mail: Sebro.ronnie@mayo.edu.

2.1. Image acquisition and image pre-processing

Radiographs were obtained using Siemens YSIO (Siemens Healthineers, Erlangen, Germany) radiographic machines. Posterior-anterior, oblique, and lateral radiographs were obtained. The patients were randomly split into training/validation (80%) and test (20%) datasets. Images were converted into Joint Photographic Experts Group (JPEGs /JPGs) format, resized to 256 x 256, followed by image intensity normalization.

2.2. CNN architecture

We used Python 3.9.15 to create a deep learning model (four convolutional neural network (CNN) layers along with three layers of fully connected neural network (FCNN)) using 2388 hand radiographs from 533 patients to predict whether a patient had osteopenia/osteoporosis. The cross-entropy loss function was minimized. The model was run over 50 epochs using Adam optimization. Five-fold cross-validation was used to tune the model and the optimal tuned model was evaluated in the test dataset. Sensitivity, specificity, accuracy, area under the curve (AUC), positive predictive value (PPV), and negative predictive value (NPV) were calculated.

3. Results

The study comprised of 669 patients (84% women) with mean age of 65.48 (50-91) and stand deviation of 8.90. 17.60% of patients were osteoporotic; 59.00% were osteopenic; and 23.40% had normal BMD. When predicting osteopenia/osteoporosis, the optimal model had sensitivity of 93.45%, specificity of 97.05%, accuracy of 94.37%, AUC of 95.25%, PPV of 98.91%, and NPV of 83.54% in the training dataset and sensitivity of 87.03%, specificity of 61.00%, accuracy of 82.00%, AUC of 74.00%, PPV of 89.52%, and NPV of 55.00% in the test dataset.

4. Conclusion

Opportunistic screening for low BMD can be done using deep learning models evaluating hand radiographs. Hand radiographs can be used to identify patients who should go on to get screening DXA studies. Further research is needed to assess whether deep learning models could also predict future fracture risk from radiographs.

5. References

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