Tooth caries classification with quantitative light-induced fluorescence (QLF) images using convolutional neural network for permanent teeth in vivo

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Background

Owing to the remarkable advancements of artificial intelligence (AI) applications, AI-based detection of dental caries is continuously improving. We evaluated the efficacy of the detection of dental caries with quantitative light-induced fluorescence (QLF) images using a convolutional neural network (CNN) model.

Methods

Overall, 2814 QLF intraoral images were obtained from 606 participants at a dental clinic using Qraypen C® (QC, AIOBIO, Seoul, Republic of Korea) from October 2020 to October 2022. These images included all the types of permanent teeth of which surfaces were smooth or occlusal. Dataset were randomly assigned to the training (56.0%), validation (14.0%), and test (30.0%) subsets of the dataset for caries classification. Moreover, masked images for teeth area were manually prepared to evaluate the segmentation efficacy. To compare diagnostic performance for caries classification according to the types of teeth, the dataset was further classified into the premolar (1,143 images) and molar (1,441 images) groups. As the CNN model, Xception was applied.

Results:

Using the original QLF images, the performance of the classification algorithm was relatively good showing 83.2% of accuracy, 85.6% of precision, and 86.9% of sensitivity. After applying the segmentation process for the tooth area, all the performance indices including 85.6% of accuracy, 88.9% of precision, and 86.9% of sensitivity were improved. However, the performance indices of each type of teeth (both premolar and molar) were similar to those for all teeth

Table1. Evaluation metrics for caries classification according to the types of teeth (molar and premolar)

Evaluation metrics	Q-ray images	
	Molar	Premolar
True-positive case, n (%)	262 (60.5)	141 (41.1)
False-positive case, n (%)	38 (8.8)	29 (8.5)
True-negative case, n (%)	96 (22.2)	145 (42.3)
False-negative case, n (%)	37 (8.5)	28 (8.2)
Sensitivity	0.876	0.834
Specificity	0.716	0.829
Negative predictive value	0.722	0.834
f1-scores	0.875	0.832
Precision	0.873	0.829
Accuracy	0.827	0.834
AUC	0.881	0.905

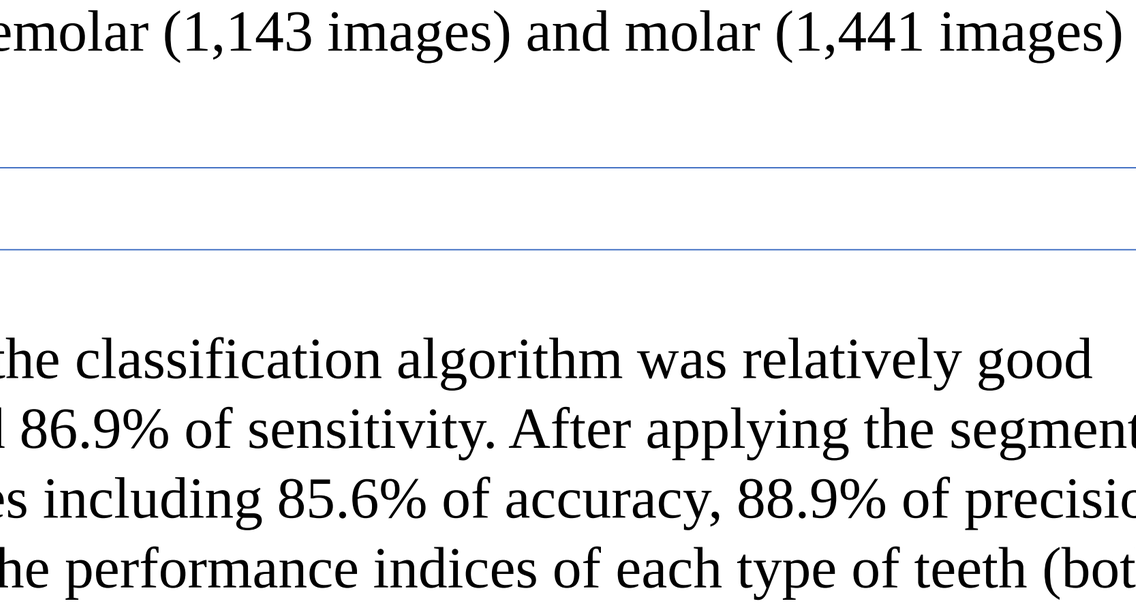

Fig.1 Receiver operating characteristic (ROC) curve according to tooth area segmentation and type of tooth (premolar and molar). The Blue, orange, and green line are ROC curves of artificial intelligence (AI) models trained using total teeth, molar, premolar images without masking background, respectively. The red line is a ROC curve of AI model trained using total teeth images with masking background through tooth area segmentation

Conclusions

The application of AI to QLF images for caries classification demonstrated a good performance regardless of teeth type among posterior teeth. Additionally, tooth area segmentation through background elimination from QLF images exhibited a better performance. Accordingly, this study may contribute to a comprehensive evaluation of oral health risk factors, including dental caries and plaques, using the QLF system. Thus, further studies on the development of AI model for evaluating oral health and hygiene using QLF images are warranted.