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Multi-Institutional Collaborative Research Using Ophthalmic Medical Image Data Standardized by Radiology Common Data Model (R-CDM)

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Abstract. Observational Medical Outcome Partners - Common Data Model (OMOP-CDM) is an international standard model for standardizing electronic medical record data. However, unstructured data such as medical image data which is beyond the scope of standardization by the current OMOP-CDM is difficult to be used in multi-institutional collaborative research. Therefore, we developed the Radiology-CDM (R-CDM) which standardizes medical imaging data. As a proof of concept, 737,500 Optical Coherence Tomography (OCT) data from two tertiary hospitals in South Korea is standardized in the form of R-CDM. The relationship between chronic disease and retinal thickness was analyzed by using the R-CDM. Central macular thickness and retinal nerve fiber layer (RNFL) thickness were significantly thinner in the patients with hypertension compared to the control cohort. It is meaningful in that multi-institutional collaborative research using medical image data and clinical data simultaneously can be conducted very efficiently.

Keywords. Medical imaging data, data standardization, ophthalmology

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1. Introduction

Observational Medical Outcome Partners - Common Data Model (OMOP-CDM) is an international standard model for standardizing electronic medical record data. The ultimate goal of OMOP-CDM is to standardize the medical data held by various medical institutions so that large-scale, multi-institutional collaborative research can be conducted efficiently. However, due to the nature of OMOP-CDM, which standardizes structured clinical data such as drug prescription data and disease diagnosis data, unstructured data such as medical imaging data is difficult to be used for multi-center collaborative research. Radiology-CDM (R-CDM) was developed for standardization of medical imaging data, in order to lay the foundation for efficient multi-institutional collaborative research that utilizes standardized clinical and image data at the same time [1].

By scanning the internal structure of the eyeball, optical coherence tomography (OCT) calculates various features about retinal thickness. Studies have been conducted to analyze the significant relationship between age, hypertension, type 2 diabetes, vitamin D deficiency, and retinal thickness using OCT data [2-4]. However, since these studies require various types of clinical data and medical imaging data at the same time, all of these studies have a limitation in that they analyzed a small number of patients in a single medical institution. By standardizing multi-center OCT data into the R-CDM format, multi-center collaborative research that requires OCT data and multiple clinical data at the same time could be efficiently conducted.

2. Methods

2.1. Securing OCT data for research purposes, standardizing it into R-CDM format

OCT medical imaging data for R-CDM standardization were collected from Ajou University Hospital and Seoul National University Bundang Hospital, tertiary hospitals in Korea. The OCT data obtained from Ajou University Hospital are taken with ZEISS medical device from 2013 to April 2022, and the data from Seoul National University Bundang Hospital are taken with HEIDELBERG medical device from July 2006 to August 2019. The OCT data collected from both hospitals were standardized in the form of R-CDM as shown in the right side of figure 1. R-CDM organizes data such as the pseudonymized ID of the patient, the date of the image, the type of image, the imaging equipment, and the path to the image file.

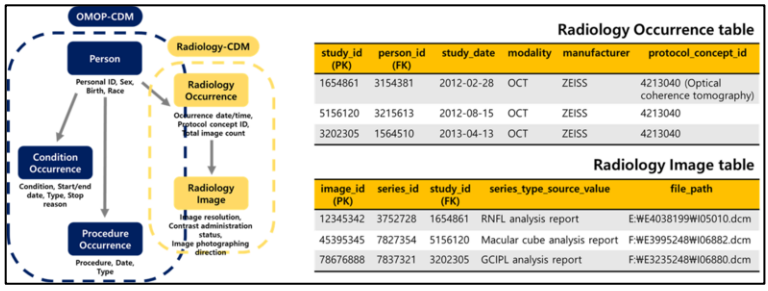

Figure 1. Schematic diagram of the R-CDM (left) and part of the R-CDM database (right).

2.2. Design study to analyze changes in retinal thickness due to hypertension and diabetes

We analyzed the difference in retinal thickness between the control cohort and the patient cohort who received drug treatment for more than 10 years after being diagnosed with hypertension or diabetes. If the patient cohort did not take the drug for more than 180 days, it was considered as discontinuation of drug treatment and follow-up was stopped. The control group included patients with no history of hypertension and diabetes, and excluded patients whose blood pressure had deviated from normal at least once. Furthermore, patients with macular disorders such as retinal vein occlusion and macular degeneration, patients with a history of intravitreal injection of drugs such as bevacizumab or aflibercept, and patients with a central macular thickness over 350μm were all excluded from the analysis. Age and gender were matched with 1:2 propensity score matching (PSM) method, and the last OCT data of the left eye taken during the follow-up period was used for analysis.

2.3. OCT data extraction through interworking of R-CDM and OMOP-CDM

By linking OMOP-CDM and R-CDM, an environment has been established to extract specific medical imaging data taken by a specific patient cohort. The previously set hypertensive, diabetic, and control cohorts were constructed through OMOP-CDM, and then the OCT data they took were extracted through R-CDM.

2.4. Extracting retinal thickness from OCT data using optical character recognition (OCR) technique

Since the R-CDM database contains information that can be used to describe and categorize an image but does not contain feature or pixel data for each image, it was necessary to apply additional OCR techniques to extract the retinal thickness written in the OCT data extracted through R-CDM. From the OCT data of Ajou University Hospital taken with the ZEISS medical device, data was extracted using the easyOCR package of python. From the OCT data of Seoul National University Bundang Hospital taken through the HEIDELBERG medical device, data was extracted using the OCR machine learning model developed in-house [5]. The retinal nerve fiber layer (RNFL) thickness and central macular thickness data was successfully extracted from the OCT result sheets. The extracted retinal thickness values were analyzed within each institution, and the analysis of the entire data was also performed by standardizing the data for each institution into Z-Scores.

3. Results

3.1. Composition of R-CDM standardized OCT data

The OCT data of Ajou University Hospital and Seoul National University Bundang Hospital standardized in R-CDM format are 261,874 and 475,626, respectively, and composition of the data is shown in figure 2. OCT data which contains features of central macular thickness, and RNFL thickness are colored in red, and green, respectively.

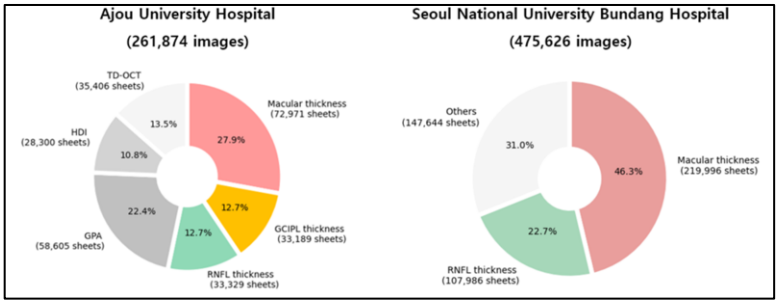

Figure 2. Composition of OCT data standardized in the form of a R-CDM.

3.2. Analysis of retinal thickness in hypertensive and diabetic patients

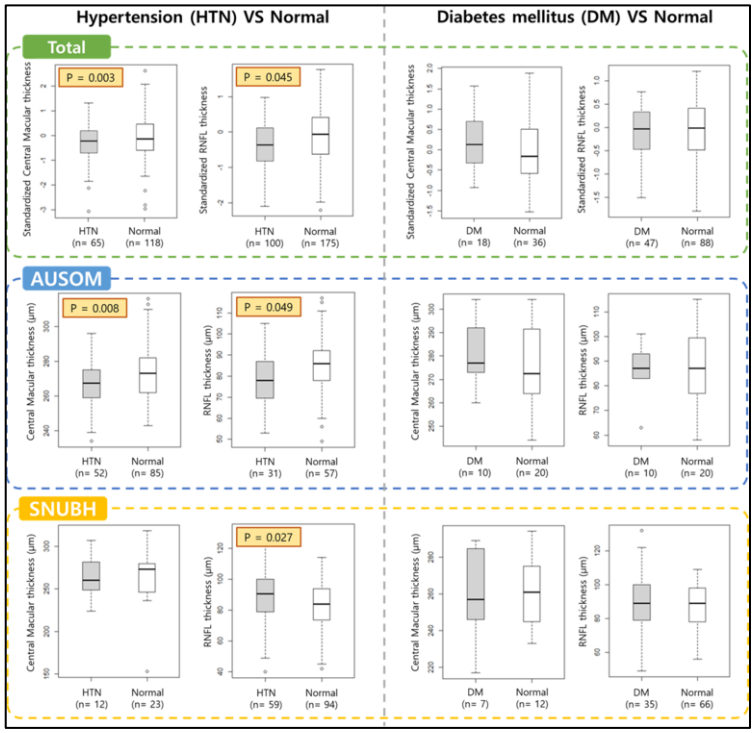

Figure 3. Retinal thickness analysis results.

Figure 3 shows the results of analysis using standardized overall data and the analysis by institution. The retinal thickness was significantly thinner in the hypertensive cohort compared to the control cohort. For comparison of central macular thickness, data of 65 patients from hypertensive cohort and 118 patients from control cohort were compared, and for comparison of RNFL thickness, data of 100 and 175 patients were compared. The same result was found in the analysis using Ajou University Hospital data, and a significant difference was observed only in RNFL thickness at Seoul National University Bundang Hospital. The difference in retinal thickness between the diabetes mellitus cohort and control cohort was not significant.

4. Conclusions

OCT data from the two tertiary hospitals from South Korea was standardized into the R-CDM format. The relationship between chronic disease and retinal thickness was analyzed in order to validate the concept. Central macular thickness and RNFL thickness were significantly thinner in the patients with hypertension compared to the control cohort. It is meaningful in that multi-institutional collaborative research which combines clinical and image data in various ways can be conducted very efficiently. It is easy to correlate clinical data with various features extracted from not only OCT data but also other imaging data, and it is efficient to develop multi-modal deep learning models that simultaneously learn multi-institutional imaging data and clinical data.

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