Multi-institutional collaborative research using ophthalmic medical image data standardized by Radiology Common Data Model (R-CDM)

Chul Hyoung Park[1], Sang Jun Park[2], Da Yun Lee[2], Seng Chan You[3], Su Ji Yeo[4], Ki Hwang Lee[4], Rae Woong Park[1,5]

1. Dept. of Biomedical Informatics, Ajou University School of Medicine, Yeongtong-gu, Suwon 16499

2. Department of Ophthalmology, Seoul National University College of Medicine, Seoul National University Bundang Hospital, Seongnam, Korea

3. Department of Preventive Medicine and Public Health, Yonsei University College of Medicine, Seoul, South Korea

4. Department of Ophthalmology, Ajou University School of Medicine, Yeongtong-gu, Suwon

5. Dept. of Biomedical Sciences, Ajou University Graduate School of Medicine, Yeongtong-gu, Suwon 16499

Background

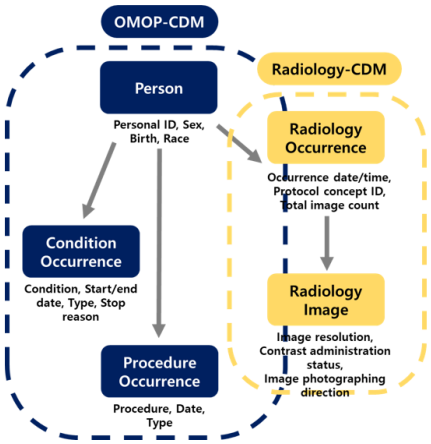
Observational Medical Outcomes Partnership Common Data Model (OMOP-CDM), which standardizes electronic medical record data such as prescription, diagnosis, and procedure, assists multi-institutional cooperative research to proceed in a very efficient way. However, data beyond the range standardized by OMOP-CDM is difficult to be used for multi-institutional collaborative research, and OMOP-CDM-based extended models are being developed to overcome this. The Radiology CDM (R-CDM) standardizes medical imaging data in order to support the search and extraction of required imaging data [1]. Its necessity has been recognized by being adopted as a data collection standard in the European cancer data collection chameleon project, and by winning the best oral presentation award at the Korean Society of Medical Informatics (KOSMI) for standardizing multi-center fundus image data.

By scanning 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. R-CDM lays the foundation for efficient large-scale research that requires linkage of clinical and medical imaging data.

Methods

1. Securing ophthalmic medical imaging 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.



Radiology Occurrence table

study_id	person_id	study_date	modality	manufacturer	protocol_concept_id
1654861	3154381	2012-02-28	OCT	ZEISS	4213040 (Optical coherence tomography)
5156120	3215613	2012-08-15	OCT	ZEISS	4213040
3202305	1564510	2013-04-13	OCT	ZEISS	4213040

Radiology Image table

image_id	series_id	study_id	series_type_source_value	file_path
12345342	3752728	1654861	RNFL analysis report	E:₩E4038199₩I05010.dcm
45395345	7827354	5156120	Macular cube analysis report	F:₩E3995248₩I06882.dcm
78676888	7837321	3202305	GCIPL analysis report	F:₩E3235248₩I06880.dcm

Figure 1. Schematic diagram of the R-CDM linked with OMOP-CDM (left) and R-CDM standardized OCT imaging data (right)

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 cohort included only patients who had no history of diagnosis of hypertension or diabetes, no drug use, and whose blood pressure normal. In order to exclude patients with retinal problems from the analysis, patients with a diagnosis 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 350 μm were all excuded from the analysis. Age and gender was 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.

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 image 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. The RNFL thickness and central macular thickness data of Ajou University Hospital and RNFL thickness data of Seoul National University Bundang Hospital were successfully extracted and used for analysis.

4. Extracting retinal thickness from OCT result sheet using optical character recognition (OCR) technique

Thickness of the retina contained in the extracted OCT scan result sheet was extracted by OCR technique. From the OCT result sheet of Ajou University Hospital taken with the ZEISS medical device, data was extracted using the easyOCR package of python. From the OCT result sheet 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].

Results

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. Significant OCT scan reports that includes features of retinal thickness are macula, GCIPL, and RNFL thickness reports, and are colored in red, yellow, and green, respectively.

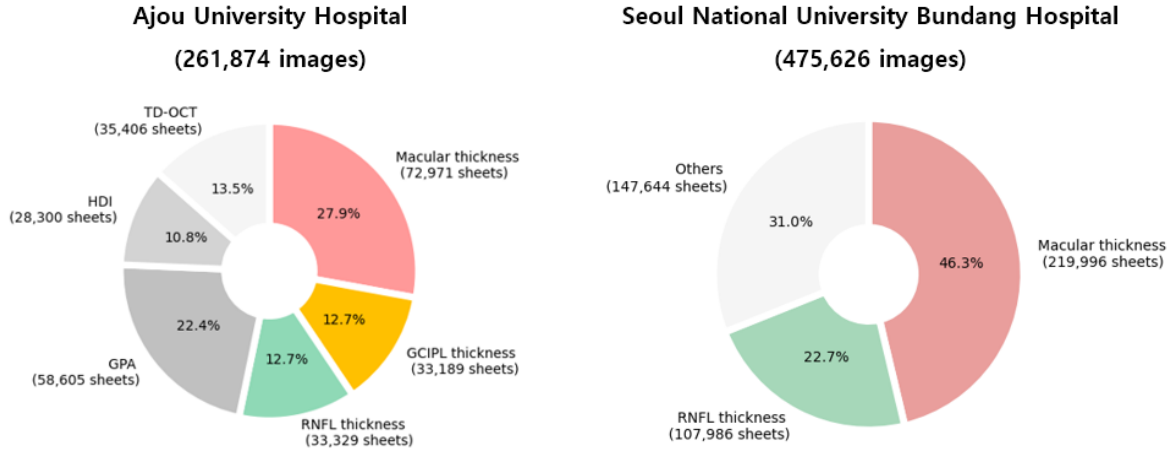


Figure 2. Composition of OCT imaging data standardized in the form of a R-CDM

2. Analysis of retinal thickness in hypertensive and diabetic patients

For comparison of RNFL thickness, 101 and 176 patients in the hypertension cohort and the control cohort were matched, respectively. The hypertension cohort and control cohort each had an average thickness of 80.70μm, 86.80μm. RNFL thickness from hypertension cohort was significantly lower than that of the normal control cohort. For comparison of central macular thickness, 52 and 85 patients in the hypertension cohort and control cohort were matched, respectively. The hypertension cohort and control cohort each had an average thickness of 265.73μm, 273.05μm. Central macular thickness from hypertension cohort was significantly lower than that of the normal control cohort. There was no significant difference in RNFL thickness and central macular thickness between the diabetes cohort and the control cohort.

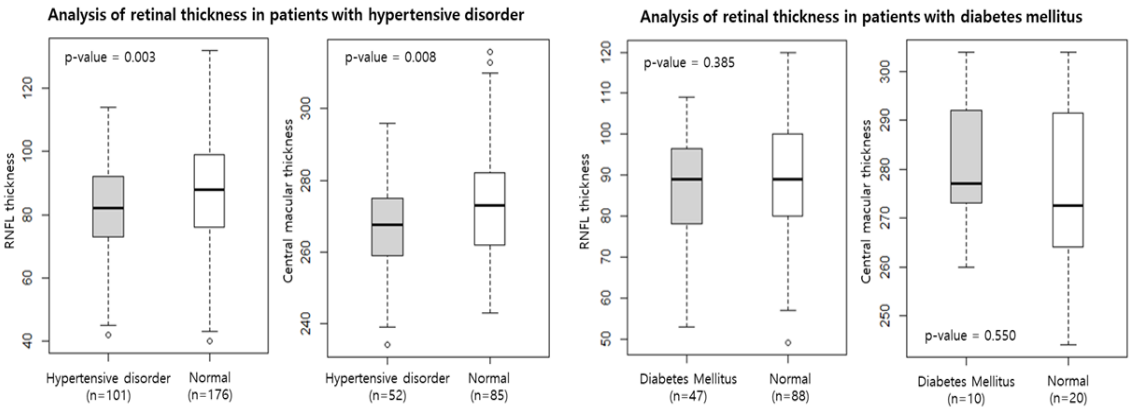


Figure 3. The difference in retinal thickness between the hypertensive group and the normal group (left), and the diabetic group and the normal group (right)

Conclusion

By converting OCT data from Ajou University Hospital and Seoul National University Bundang Hospital to R-CDM, the foundation for multi-institutional cooperative research was laid. The relationship between chronic disease and retinal thickness was analyzed as a PoC of study linking image data and clinical data. It was confirmed that the 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.

Acknowledgement

This research was supported by a grant of the project for Infections Disease Medical Safety, funded by the Ministry of Health, Republic of Korea (grant number: HG22C0024). This research was also

funded by the Bio Industrial Strategic Technology Development Program (20003883, 20005021) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea) and a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HR16C0001).

References

1. Park C, You SC, Jeon H, Jeong CW, Choi JW, Park RW. Development and Validation of the Radiology Common Data Model (R-CDM) for the International Standardization of Medical Imaging Data. Yonsei Med J. 2022;63(Suppl):S74-S83.

2. Nieves-Moreno M, Martínez-de-la-Casa JM, Morales-Fernández L, Sánchez-Jean R, Sáenz-Francés F, García-Feijoó J (2018) Impacts of age and sex on retinal layer thicknesses measured by spectral domain optical coherence tomography with Spectralis. PLoS ONE 13(3): e0194169

3. Lee, Soo Hyun MD; Lee, Woo Hyuk MD; Lim, Hyung Bin MD; Jo, Young Joon MD, PhD; Kim, Jung Yeul MD, PhD. THICKNESSES OF CENTRAL MACULAR, RETINAL NERVE FIBER, AND GANGLION CELL INNER PLEXIFORM LAYERS IN PATIENTS WITH HYPERTENSION, Retina: September 2019 - Volume 39 - Issue 9 - p 1810-1818

4. Jing Jiang, Yan Liu, Yingchao Chen, Bo Ma, Yiwen Qian, Zhenzhen Zhang, Dongqing Zhu, Zhiliang Wang, Xiaofang Xu, "Analysis of Changes in Retinal Thickness in Type 2 Diabetes without Diabetic Retinopathy", Journal of Diabetes Research, vol. 2018, Article ID 3082893, 7 pages, 2018.

5. Mun, Y., Kim, J., Noh, K.J. et al. An innovative strategy for standardized, structured, and interoperable results in ophthalmic examinations. BMC Med Inform Decis Mak 21, 9 (2021)