

Machine-Learning MRI-Based Model for Papilledema Detection

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Background

Optic nerve sheath diameter (ONSD) on Magnetic Resonance Imaging (MRI) has been described as a sensitive marker of raised intracranial pressure (ICP). In this study, we evaluated relationships between ONSD, Evans’ index, Artificial Intelligence (AI)-based ventricular volume and intracranial cerebrospinal fluid volume fraction (ICV%) on 3D-MRI brain using machine learning (ML) model for predicting clinically-determined Grade of papilledema (Frisen Grade).

Methods and materials

Eighty subjects (mean age 47.10 ± 20.08 years) who underwent MRI brain and fundoscopy were retrospectively analyzed. The mean of right & left ONSD was used for evaluation. Ventricular size was quantified by Evans index and ventricular volume, latter determined by AI-based tool. The intracranial CSF fraction was then recorded as ICV%. Frisen grade for both eyes were recorded; a binary outcome (Frisen bin) was defined as grade ≥2 in either eye. Group comparisons used t-test or Mann–Whitney U tests as appropriate. Inter-eye agreement was quantified with Cohen’s kappa. Associations between continuous measures were assessed using Spearman or Pearson correlation. Multivariable regression models were constructed, and supervised ML classifiers (logistic regression, random forest, support vector machine) were trained to predict Frisen bin using imaging and demographic features. Classification performance was evaluated with cross-validation and ROC analysis.

Results

Mean ONSD in the study was 5.17±0.47mm. ONSD correlated positively with Evans index ($r \sim 0.27, p = 0.016$), ventricular volume ($r \sim 0.29, p = 0.010$), and ICV% ($r \sim 0.29, p = 0.008$). Evans index and ventricular volume were strongly correlated ($r \sim 0.58, p < 0.000001$). Inter-eye agreement for Frisen grade was excellent ($\kappa = 0.98$). Bland-Altman analysis revealed minimal mean bias between right and left ONSD. Logistic regression showed ONSD and Evans index as independent predictors of papilledema; combined model yielded good discrimination (AUC = 0.88). Among ML classifiers, random forest achieved the highest accuracy (88%) and AUC (0.90), outperforming traditional regression.

Conclusion

MRI-derived ONSD and ventricular indices are significantly associated with papilledema and enable accurate non-invasive prediction of raised ICP. Machine learning-based classification further enhances diagnostic performance, supporting integration of quantitative MRI biomarkers with AI for neuro-ophthalmological assessment. However, prospective multi-center validation of the study is needed.



Image 1 (Control): 3DT2W Axial MR Image at the level of optic nerve shows ONSD of 4.6mm on right & 4.5mm on left side. The AIABV was 15.02 ml and Frisen Grade was 0 on both sides.

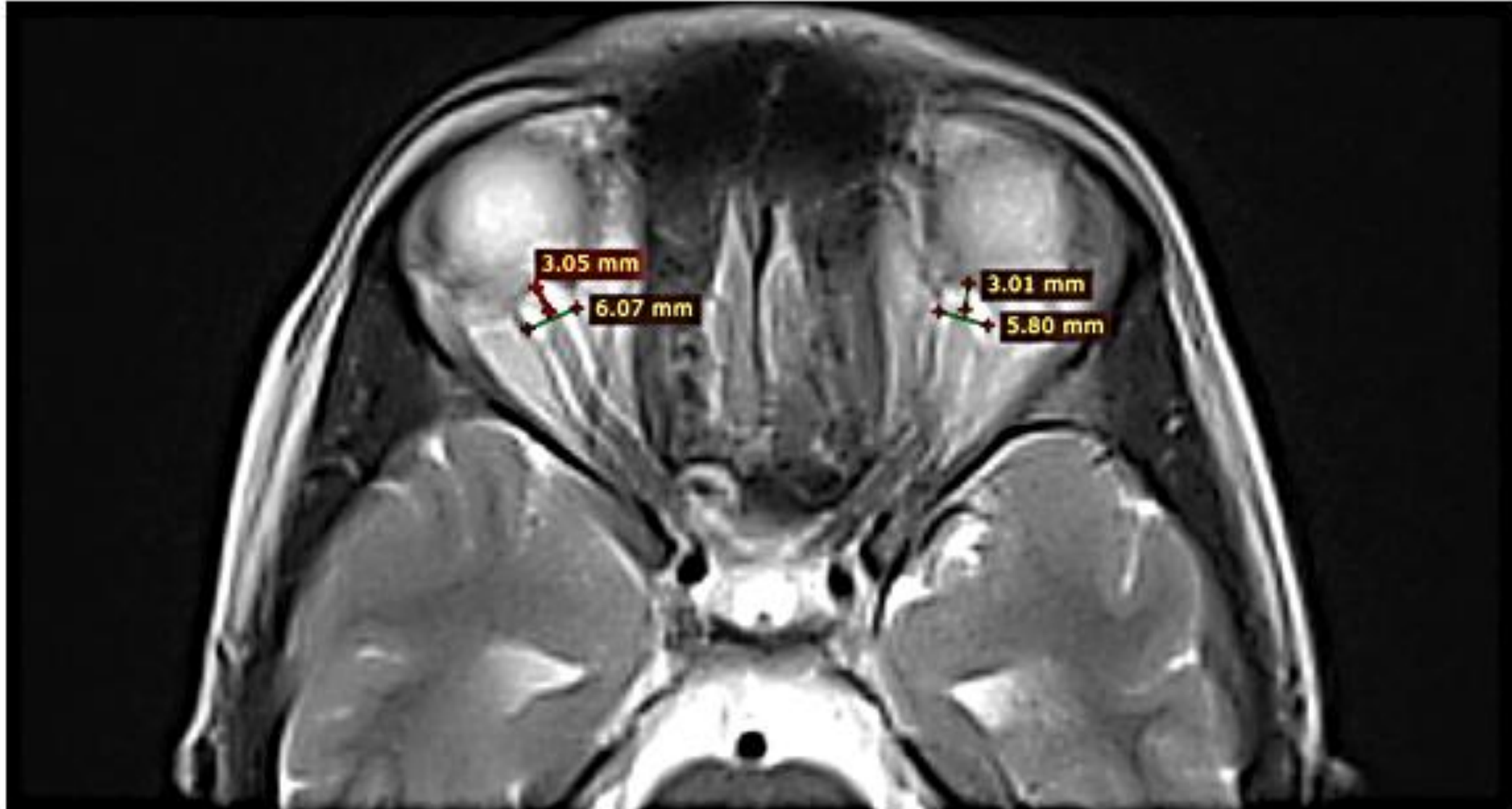
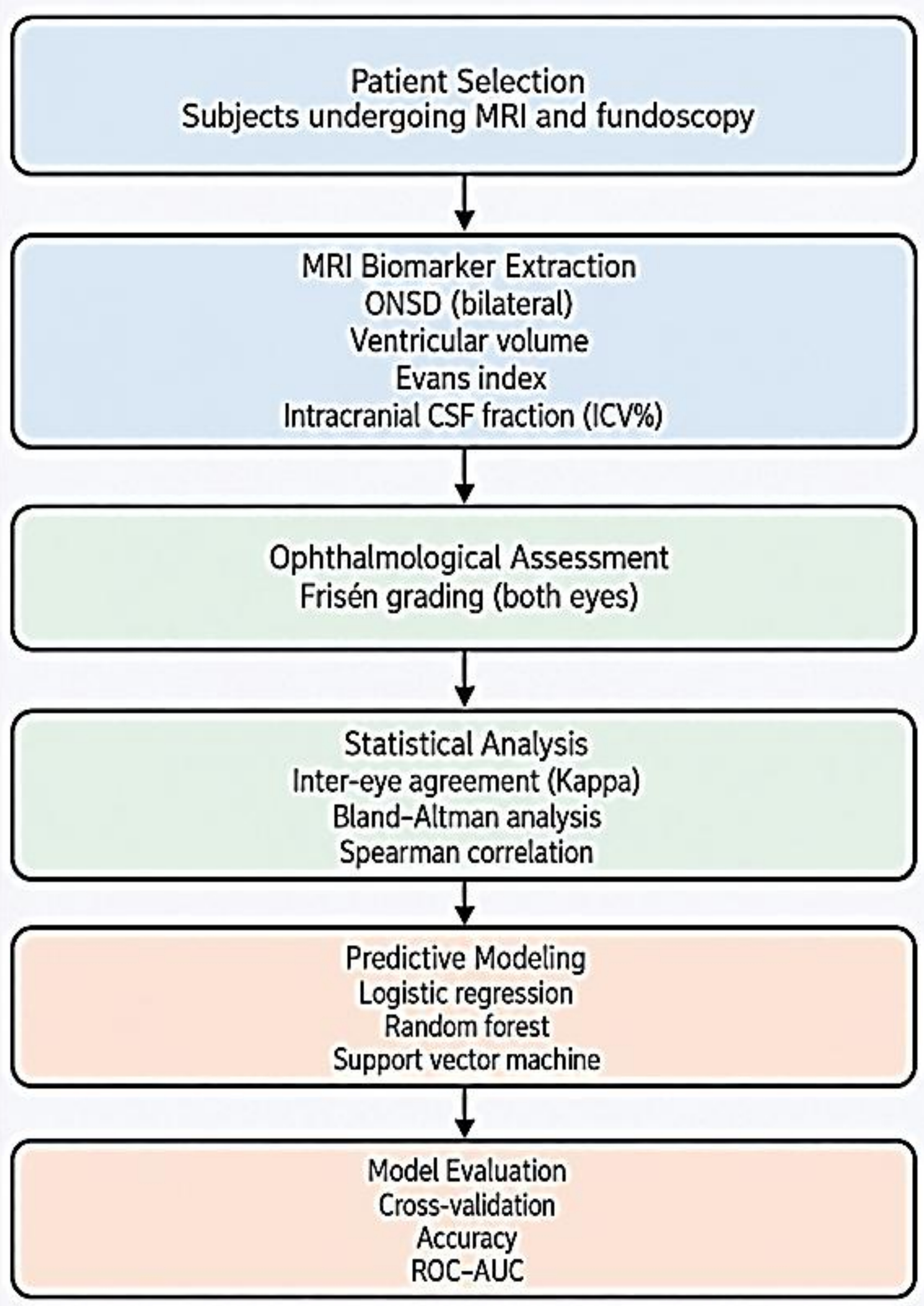


Image 2: 3DT2W Axial MR Image at the level of optic nerve shows increased ONSD of 6.07mm on right & 5.8 mm on left side. The AIABV was found 141.25 ml and Frisen Grade was 3 on both sides



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