Analysis of 3 Distinct Retinal Capillary Plexuses in Healthy Eyes with Projection Artifact Removal OCTA

Sean Garrity PGY-4
David Sarraf

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FINANCIAL DISCLOSURES:

- Sean Garrity: none
- David Sarraf: Amgen (consultant), Bayer (consultant), Nuvelution (consultant), Novartis (consultant), Allergan (grants), Genentech (grants, consultant), Regeneron (grants), Optovue (grants, consultant), Heidelberg (grants)
MY ROLE IN THIS RESEARCH:

Please answer which of the following portions of the research you participated in:

- Conception and design of the work/project
- Acquisition of data
- Analysis and interpretation of data
- Creation and/or critical review of the presentation
Optical Coherence Tomography Angiography (OCTA)

- Uses change in OCT signal to detect motion in tissues, comparing objects in motion to static signals
- Non-invasive visualization of retinal microvasculature with depth-resolved capability
- Clinical utility limited by various factors including lack of standardization and projection artifacts
- Necessary to have normative data from healthy eyes to effectively study abnormal eyes

Nagiel et al, 2015
Spaide et al, 2015
Prior OCTA Studies in Normal Eyes

- Reports by Allen Ho’s group at Wills and our group have demonstrated decreased retinal blood flow and increased FAZ area with age
  - Demonstrated by Iafe et al in a cohort of 70 healthy eyes

- Largely due to projection artifact, OCTA devices typically separate the retinal capillary system into 2 plexuses: SCP and DCP

- But histologic studies have consistently identified three distinct capillary plexuses in the macula: SCP, ICP, and DCP
Projection Artifact Removal (PAR) OCTA

• Research algorithm that removes projection artifact from OCTA volume on a per voxel basis uses intensity profiles anterior to, at, and around voxel of interest
  • Projection artifact is removed/reduced in en face and B-scan images
  • PAR-enabled decreased 2-D correlation coefficient between plexuses (more distinct plexuses) and reduced VD measurements in deeper layers
• Allows for visualization of the 3 distinct plexuses

Original OCTA

PAR OCTA

Hsiao et al, 2017
Wolfson et al, 2017
Methods

• Inclusion criteria: volunteers with normal eyes

• Exclusion criteria: media opacity, retinal disease, significant refractive error (myopia ≥ 6D or hyperopia ≥ 3D), SSI < 40, inaccurate/incorrect segmentation

• Imaged with RTVue XR Avanti spectral-domain OCT device with AngioVue software, with SSADA and PAR algorithm and improved segmentation

• Analyzed vessel density of SCP, ICP, and DCP and FAZ area by age, with 3 x 3-mm and 6 x 6-mm scan patterns
Our Segmentation Boundaries

SCP

3µm below the ILM to IPL-INL junction

NFL, GCL, and IPL

ICP

IPL-INL junction to 20µm below IPL-INL junction

Inner ½ of INL

DCP

20µm below IPL-INL junction to 15µm below OPL-ONL junction

Outer ½ of INL, OPL, and portion of ONL
Results

- 152 normal eyes from 95 subjects
- ~10 eyes per decade of life

**Subject characteristics**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, y</td>
<td>42 ± 25</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male (%)</td>
<td>39 (41.5)</td>
</tr>
<tr>
<td>Female (%)</td>
<td>56 (58.5)</td>
</tr>
<tr>
<td>Eye</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>85 (55.92)</td>
</tr>
<tr>
<td>Left</td>
<td>67 (44.08)</td>
</tr>
</tbody>
</table>

Data are mean ± SD or n (%).
Vessel density decreases with increasing age.
FAZ Area by Age

FAZ area increases with increasing age

Note: used single merged FAZ for all plexuses
Limitation– Association of Signal Strength Index and Age

SSI decreases with increasing age

• Increasing age moderately but significantly associated with decreasing SSI
  • Spearman correlation coefficient of -0.42 for both scan sizes
• Both SSI and age were independently associated with reductions in VD
• Demonstrates the importance of image quality (signal strength) for quantitative analysis
Discussion

• First study verifying age-related decrease in VD and increase in FAZ area in all 3 plexuses
  • Annual change in VD and FAZ area consistent with prior reports
• No significant difference in relative VD between SCP, ICP, and DCP
• ICP → complex distribution of capillaries in a spider- or vortex-like pattern, similar to DCP
Discussion

• Ability of OCTA to visualize ICP may have clinical implications for AMN, PAMM, DR, and Mac Tel type 2

• Age-related SSI decrease does not fully explain our results, but does illustrate importance of further standardization in OCTA imaging

• PAR algorithm in our study different than Projection Resolved (PR) OCTA used by David Huang’s group at OHSU
Limitations

- Segmentation boundaries different than those used by Campbell et al using PR-OCTA
  - Subset analysis using boundaries proposed by Campbell et al → 5-9% change in VD measurements
- Need to verify accuracy of PAR in removing projection artifact
- Impact of SSI on quantitative measurements warrants further study
- Lack standardization across the field of OCTA limits quantitative comparisons
  - Wide variation in devices, software, projection removal algorithms, scan sizes, image quality, segmentation boundaries, methods of quantitative analysis, etc.
References
