Posterior Scleral Bowing With Choroidal Nevus on Enhanced-Depth Imaging Optical Coherence Tomography

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IMPORTANCE Recognition of posterior scleral bowing with choroidal nevus is essential to avoid an underestimation of tumor thickness.

OBJECTIVE To describe a particular observation of posterior scleral bowing associated with choroidal nevus on enhanced-depth imaging (EDI) optical coherence tomography (OCT).

DESIGN, SETTING, AND PARTICIPANTS Retrospective observational case series at a referral center involving 17 eyes of 17 patients. Patients were seen from June 2013 to July 2014, with all data collected and analyzed from June 2014 to July 2014.

INTERVENTIONS Retrospective medical record review and multimodal imaging including fundus photography, autofluorescence, infrared reflectance, ultrasonography, and EDI-OCT.

MAIN OUTCOMES AND MEASURES Clinical and imaging characteristics.

RESULTS Analysis of 318 consecutive patients with choroidal nevus imaged over a 1-year period revealed that 17 cases (5%) demonstrated the EDI-OCT feature of posterior scleral bowing. Of these 17 cases, the mean patient age was 58 years (median, 58 years; range, 36-75 years) and there were 6 men (35%) and 11 women (65%). The nevus was classified as pigmented (n = 3; 18%), nonpigmented (n = 2; 12%), and mixed pigmentation (n = 12; 71%), and with no surrounding halo (n = 7; 41%). Associated features included overlying drusen (n = 9; 53%), retinal pigment epithelial alterations (n = 9; 53%), subretinal fluid (n = 5; 29%), and orange pigment (n = 3; 18%). The nevus was clinically estimated to be of 4.91-mm basal dimension and measured ultrasonographically at 1.59-mm thickness. By EDI-OCT, the nevus mean thickness was 628 μm (0.63 mm). All cases demonstrated posterior scleral bowing with mean scleral excavation of 398 μm (median, 377 μm; range, 134-739 μm). Underlying the nevus, the scleral thickness was not measurable; however, at the nevus margin, the choroid and sclera appeared normal. Clinical features correlated with posterior scleral bowing included reduced distance to the optic disc (difference, 1.3 mm; 95% CI, −2.95 mm to 5.51 mm; \( P = .01 \)) and the foveola (difference, 2.14 mm; 95% CI, 0.80 mm to 3.48 mm; \( P < .001 \)), as well as the presence of surrounding halo (difference, 36%; 95% CI, 16.86% to 59.27%; \( P < .001 \)).

CONCLUSIONS AND RELEVANCE Choroidal nevus can show focal posterior scleral bowing on EDI-OCT in 5% of cases. This finding was related to more posterior location of nevus, less/mixed pigmentation, and surrounding halo. This finding could lead to underestimation of tumor thickness as the tumor bows backward rather than forward.
Choroidal nevus is a relatively common ocular fundus tumor. This lesion generally presents as a flat pigmented mass within the choroid, often associated with overlying drusen, retinal pigment epithelium (RPE) alterations, or occasionally subretinal fluid. Autofluorescence can be useful in the evaluation overlying lipofuscin that tends to manifest with small melanoma rather than nevus.\(^2\) Choroidal nevus is seen as hyperreflectant on infrared reflectance.\(^2\)

Previous advances in retinal and choroidal imaging, in particular the advent of enhanced-depth imaging (EDI) optical coherence tomography (OCT), have provided important information on various retinal and choroidal diseases.\(^3\) In the field of ocular oncology, EDI-OCT allows an exact anatomic localization of tumor, helping to establish the diagnosis in challenging cases.\(^4\) In addition, a more accurate analysis of the lesion and the accompanying features could assist in earlier diagnosis and treatment of possible sight-threatening and life-threatening conditions.\(^4\)

Our first large-scale analysis of choroidal nevi using EDI-OCT revealed tomographic hallmarks including a gentle domed surface contour, choriocapillaris compression overlying the nevus, and partial or complete posterior choroidal shadowing.\(^5\) Frequent accompanying findings, such as drusen, disruption of the outer retinal layers and the RPE, and subretinal fluid or cleft, were documented.\(^3\) A major benefit of EDI-OCT was the improved accuracy in precise tumor thickness measurement, a feature previously overestimated on ultrasonography.\(^3\)

Using EDI-OCT, we observed a particular feature with choroidal nevus, that is, posterior scleral bowing, where the nevus is bowed backward into the sclera, rather than forward into the RPE. This feature is seen as a focal excavation of the scleral tissue underlying the choroidal nevus and without extra-scleral extension.

Herein, we analyzed the frequency and features of posterior scleral bowing associated with choroidal nevus on EDI-OCT. To our knowledge, there are no previous OCT reports on this topic.

### Methods

A retrospective analysis was performed on the clinical and multimodal imaging data from patients diagnosed as having choroidal nevus associated with posterior scleral bowing at the Ocular Oncology Service, Wills Eye Hospital, Philadelphia, Pennsylvania. We identified the presence of posterior scleral bowing as an excavation of the sclera underlying choroidal nevus \((\text{Figure 1}).\) The study was conducted in accordance with the principles of Helsinki and in compliance with the Wills Eye Hospital institutional review board. Written informed consent was obtained from all patients.

Demographic data from all patients were collected including age, sex, race/ethnicity (white, African American, Asian, and others), affected eye (right or left), history of ophthalmic disease, and presence of symptoms (blurred vision, floaters, photopsia, metamorphopsia, and others). A comprehensive ophthalmic examination was performed recording best-corrected visual acuity and dilated fundus examination with multimodal imaging analysis including color photography (OIS Winstation; Merge Healthcare), autofluorescence (OIS Winstation; Merge Healthcare), infrared confocal scanning laser ophthalmoscopy (Heidelberg Spectralis HRA-OCT; Heidelberg Engineering GmbH), ocular ultrasonography (Eye Cubed; Ellex Medical Lasers Ltd), and EDI-OCT imaging (Heidelberg Spectralis HRA-OCT; Heidelberg Engineering GmbH).

On fundus examination, we analyzed the choroidal nevus for location (peripapillary, macular, and midperiphery periphery of the retina), pigmentation (pigmented, nonpigmented, or mixed pigmentation), largest basal diameter (in millimeters), and distance to the optic disc (in millimeters) and to the foveola (in millimeters). We assessed the presence of risk factors for transformation of choroidal nevus into melanoma including thickness greater than 2 mm, presence of subretinal fluid, symptoms, orange pigment, margin of the tumor within 3 mm of the disc, hollowness in the ultrasound image, and absence of halo or drusen.\(^4\) The RPE was assessed for features overlying the nevus including atrophy, hyperplasia, fibrous metaplasia, and trough.

Diagnostic testing was reviewed for each case with ultrasonography of the nevus analyzed for tumor thickness (in millimeters), configuration (plateau, dome, hollowness, or flat), and presence of subretinal fluid. The autofluorescence images were reviewed to assess RPE status (hyperautofluorescent, hypoautofluorescent, or isoautofluorescent) and infrared reflectance image for lesion status (hyperreflectant, hyporeflectant, or isoreflectant).

Spectral-domain EDI-OCT imaging was performed through a dilated pupil with automated EDI and real-time tracking using the 5.7.5.0 software version (Heidelberg Engineering GmbH) for acquisition and analysis. The acquisition protocol included 1 horizontal and 1 vertical raster line over the lesion, measuring 9 mm in diameter with automatic real-time averaging image set at 100 images. We manually measured the maximum basal diameter of the lesion in both the horizontal axis and vertical axis (in micrometers), the maximum thickness of the lesion (as the distance between the sclerochoroidal boundary and the apex of the lesion; in micrometers), the overlying choroidal thickness (distance between the apex of the lesion and the outer RPE contour or the Bruch membrane; in micrometers), the RPE elevation (perpendicular distance between the highest point of the RPE at the apex of the lesion and the lowest level of the RPE at the boundaries of the lesion; in micrometers), and the maximum posterior scleral

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### At a Glance

- We analyzed the characteristics of posterior scleral bowing in choroidal nevus by enhanced-depth imaging (EDI) optical coherence tomography (OCT).
- Choroidal nevus can show focal posterior scleral bowing on EDI-OCT in 5% of cases.
- Posterior scleral bowing may be misdiagnosed by conventional ultrasonography.
- Amelanotic nevus and nevus showing mixed pigmentation or peripapillary location were found to be associated frequently with posterior scleral bowing.
bowing (perpendicular distance from the outermost point of the sclerochoroidal boundary to the innermost sclerochoroidal boundary surrounding the lesion; in micrometers). We also assessed the retinal layers for anatomical alterations.

Patients were seen between June 2013 and July 2014 and all data were collected and analyzed between June 2014 and July 2014. A comparison of the clinical features of choroidal nevus with bowing (n = 17 cases in this cohort) vs choroidal nevus in general (n = 3422 consecutive cases; published data4) was performed using the univariate Mann-Whitney U nonparametric test. Changes in correlation between continuous variables were calculated using the Spearman correlation. Multivariate analysis was applied to define the association between the presence of posterior scleral bowing and those clinical and tomographic parameters found to be significant on univariate analysis. All analyses were conducted using SPSS (SPSS Inc).

Results

A total of 318 choroidal nevi in 302 patients were analyzed by EDI-OCT over a 1-year period on the Ocular Oncology Service at Wills Eye Hospital. Of these, 17 (5%) showed posterior scleral bowing on EDI-OCT.

Demographic data are listed in Table 1. The mean age was 58 years (median, 58 years; range, 36-75 years). There were 6 male and 11 female patients.

The clinical characteristics and imaging results are presented in eTable 1 in the Supplement. The nevus location was peripapillary in 5 patients (29%), macular in 4 (24%), midperipheral in 6 (35%), and peripheral in 2 (12%). The tumor was a mean distance to the optic nerve of 3.03 mm and a mean distance to the foveola of 1.69 mm. The mean basal nevus diameter by clinical estimation was 4.91 mm (median, 4.50 mm; range, 1.50-8 mm). The tumor was pigmented in 3 (18%), nonpigmented in 2 (12%), and mixed pigmentation in 12 (71%). Other features included drusen in 9 cases (53%), RPE alterations in 9 (53%), subretinal fluid in 5 (29%), and orange pigment in 3 (18%). In 7 cases (41%), there was surrounding yellow halo or inverted halo. The fundus autofluorescence revealed overlying RPE hyperautofluorescence in 4 cases.

Table 1. Posterior Scleral Bowing of Choroidal Nevus on Enhanced-Depth Imaging Optical Coherence Tomography in 17 Eyes of 17 Cases

<table>
<thead>
<tr>
<th>Feature</th>
<th>No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (median) [range], y</td>
<td>58 (58) [36-75]</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>6 (35)</td>
</tr>
<tr>
<td>Female</td>
<td>11 (65)</td>
</tr>
<tr>
<td>Race/ethnicity</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>17 (100)</td>
</tr>
<tr>
<td>African American</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Asian</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Affected eye</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>9 (53)</td>
</tr>
<tr>
<td>Left</td>
<td>8 (47)</td>
</tr>
<tr>
<td>Symptoms</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>11 (65)</td>
</tr>
<tr>
<td>Blurred vision</td>
<td>3 (18)</td>
</tr>
<tr>
<td>Floaters</td>
<td>1 (6)</td>
</tr>
<tr>
<td>Photopsia</td>
<td>1 (6)</td>
</tr>
</tbody>
</table>
(24%), hypoautofluorescence in 7 (41%), and isoautofluorescence in 6 (35%). The choroidal nevus appeared hypoautofluorescent in 10 cases (59%) and isoautofluorescent in 7 (41%). The infrared imaging was accessible in 14 cases, and the choroidal nevus was hyperreflective in 4 cases (29%), hyporeflective in 5 (36%), and isoreflective in 5 (36%).

The EDI-OCT features are listed in eTable 2 in the Supplement. Enhanced-depth imaging OCT images showed posterior scleral bowing in all cases, with a mean scleral excavation of 398 μm (median, 377 μm; range, 134-739 μm). The mean thickness of the choroidal nevus was 628 μm (median, 608 μm; range, 269-963 μm) by EDI-OCT. Subretinal fluid was present in 5 cases (29%), drusen in 7 (41%), and RPE disruption in 9 (53%). The sclerochoroidal boundary was completely seen in 13 cases (77%) and the entire choroidal mass with some degree of shadowing was evident in all cases. Underlying the tumor, the inner portion of the bowed sclera was visible in all cases; however, the outer limit of the sclera was poorly seen owing to nevus-induced shadowing and EDI-OCT limitations. At the nevus margin, the choroid and sclera appeared normal in all cases. Conventional B-scan ultrasonography showed a mean nevus thickness of 1590 μm (median, 1600 μm; range, 1100-2100 μm), with a dome configuration in 1 case (6%) and a flat shape in 16 (94%) (Figure 2). Posterior scleral bowing on ultrasonographic evaluation was not evident in any case.

A comparison of the clinical characteristics of nevus with scleral bowing (n = 17) vs nevus in general from a published comprehensive cohort of 3422 cases6 is summarized in Table 2. Choroidal nevus with posterior bowing demonstrated differences with the general population of choroidal nevi in those located in the midperiphery (difference, 35%; 95% CI, 11.65% to 53.15%; \( P = .002 \)), distance to the optic nerve (difference, 1.3 mm; 95% CI, −2.95 mm to 5.51 mm; \( P = .01 \)), and distance to the foveola (difference, 2.14 mm; 95% CI, 0.80 mm to 3.48 mm; \( P < .001 \)). Those lesions also appeared more likely to have predominantly mixed pigmentation compared with our historical control population (difference, 58%; 95% CI, 34.07% to 73.99%; \( P < .001 \)) (eFigure in the Supplement).

We used multivariate analysis to explore other correlations between the presence of posterior scleral bowing and clinical and tomographic findings including age, sex, basal diameter, thickness of the lesion, and the presence of drusen, RPE alterations, subretinal fluid, halo, or orange pigment. The presence of subretinal fluid was more frequent in cases showing posterior scleral bowing (29% vs 10% for a difference of 19% [95% CI, 2.90% to 42.81%]; \( P = .01 \)). Retinal pigment epithe-
visualization of the nevus was limited.1-8 With spectral-tailson the overlying retina and RPE have been established and ing tissue is gained using OCT. With time-domain OCT, de-
tional information regarding the nevus’ effect on surround-
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tional information regarding the nevus’ effect on surround-
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tional information regarding the nevus’ effect on surround-

### Discussion

Choroidal nevus has characteristic clinical features.5,7 Additional information regarding the nevus' effect on surrounding tissue is gained using OCT. With time-domain OCT, details on the overlying retina and RPE have been established and visualization of the nevus was limited.1,8 With spectral-domain EDI-OCT, further information on the surrounding tissues and the deeper levels of the choroid and sclera are now visualized.3,5 Furthermore, high-resolution EDI-OCT offers accurate assessment of true nevus thickness, precluding over-
estimation of thickness by comparatively low-resolution ultrasonography technique.5,9

In this report, we described an observation of choroidal ne-
vus using EDI-OCT, that is, the presence of posterior scleral bowing at the site of the nevus, found in 5% of patients with nevus. This feature is characterized by abrupt posterior exca-
vation in the scleral tissue, most commonly found with cho-oroidal nevus located nearer to the optic disc and foveola com-
pared with a previous large cohort of patients.6 In addition, posterior scleral bowing was more often found with tumors demonstrating mixed pigmentation (pigmented/nonpig-
mented) and those with surrounding halo.

In our cohort, the finding of posterior scleral bowing was only evident on EDI-OCT and not on ultrasonography or clinical examination. However, this finding has been noted previ-
ously with choroidal melanoma, particularly in young patients.10,11 We previously published a report describing a 14-
year-old patient with ultrasonographic and histopathologic posterior scleral bowing at the site of a 4.9-mm thick choroi-
d melanoma.9 Cham and Pavlin11 provided an analysis of 24 young patients (<30 years old) with choroidal melanoma and found posterior scleral bowing on ultrasonography in 14 (58%). They noted tumor thickness in the group with scleral bowing was less (mean, 4.4 mm) compared with those without this finding (mean, 5.7 mm). Of those with scleral bowing, 9 came to enucleation; all were low-grade mixed predominantly spindle cell or pure spindle cell melanoma and there was no extrascleral extension.11 In our series of patients with chori-

### Table 2. Comparison of Clinical Features of Choroidal Nevus With Posterior Scleral Bowing to Choroidal Nevus in General Based on a Comprehensive Published Report

<table>
<thead>
<tr>
<th>Feature</th>
<th>No. (%)</th>
<th>Choroidal Nevus With Scleral Bowing (n = 17 patients)</th>
<th>Choroidal Nevus in Our Previously Reported Cohort of Nevi* (n = 3422 patients)</th>
<th>Difference Between the Two Samples, %</th>
<th>95% CI of the Difference Between Samples</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient age, mean (median) [range], y</td>
<td>58 (58)</td>
<td>60 (62) [4-97]</td>
<td>2</td>
<td>−41.76 to 45.76</td>
<td>.28</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juxtapapillary</td>
<td>5 (29)</td>
<td>7</td>
<td>2</td>
<td>−11.32 to 26.49</td>
<td>.76</td>
<td></td>
</tr>
<tr>
<td>Macular</td>
<td>4 (24)</td>
<td>7</td>
<td>2</td>
<td>−11.32 to 26.49</td>
<td>.76</td>
<td></td>
</tr>
<tr>
<td>Midperiphery</td>
<td>6 (35)</td>
<td>7</td>
<td>2</td>
<td>−11.32 to 26.49</td>
<td>.76</td>
<td></td>
</tr>
<tr>
<td>Periphery</td>
<td>2 (12)</td>
<td>3</td>
<td>2</td>
<td>−11.32 to 26.49</td>
<td>.76</td>
<td></td>
</tr>
<tr>
<td>Distance to the optic disc, mean (median) [range], mm</td>
<td>3.03 (3.05) [0-7]</td>
<td>4.33 (5.00) [0-21]</td>
<td>1.30</td>
<td>−2.95 to 5.51</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Distance to the foveola, mean (median) [range], mm</td>
<td>1.69 (1.00) [0-5]</td>
<td>3.83 (4.00) [0-21]</td>
<td>2.14</td>
<td>0.80 to 3.48</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Basal tumor diameter, mean (median) [range], mm</td>
<td>4.91 (4.50) [1.5-8]</td>
<td>4.33 (5.00) [0.4-24]</td>
<td>0.58</td>
<td>−1.17 to 2.33</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>Tumor thickness by ultrasonography, mean (median) [range], mm</td>
<td>1.59 (1.60) [1.1-2.1]</td>
<td>1.33 (1.50) [0.6-4.5]</td>
<td>0.26</td>
<td>0.22 to 0.30</td>
<td>.89</td>
<td></td>
</tr>
<tr>
<td>Tumor color</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brown</td>
<td>3 (18)</td>
<td>2628 (77)</td>
<td>59</td>
<td>35.72 to 70.69</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>2 (12)</td>
<td>356 (10)</td>
<td>2</td>
<td>−7.18 to 23.93</td>
<td>.78</td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>12 (71)</td>
<td>437 (13)</td>
<td>58</td>
<td>34.07 to 73.99</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Halo present</td>
<td>7 (41)</td>
<td>162 (5)</td>
<td>36</td>
<td>16.86 to 59.27</td>
<td>&lt;.001</td>
<td></td>
</tr>
</tbody>
</table>

### Associated features

<table>
<thead>
<tr>
<th>Feature</th>
<th>No. (%)</th>
<th>Choroidal Nevus With Scleral Bowing (n = 17 patients)</th>
<th>Choroidal Nevus in Our Previously Reported Cohort of Nevi* (n = 3422 patients)</th>
<th>Difference Between the Two Samples, %</th>
<th>95% CI of the Difference Between Samples</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drusen</td>
<td>9 (53)</td>
<td>1819 (53)</td>
<td>0</td>
<td>−20.75 to 22.26</td>
<td>&gt;.99</td>
<td></td>
</tr>
<tr>
<td>Subretinal fluid</td>
<td>5 (29)</td>
<td>354 (10)</td>
<td>19</td>
<td>2.90 to 42.81</td>
<td>.01†</td>
<td></td>
</tr>
<tr>
<td>Orange pigment</td>
<td>3 (18)</td>
<td>238 (7)</td>
<td>11</td>
<td>1.00 to 34.09</td>
<td>.08</td>
<td></td>
</tr>
<tr>
<td>RPE alterations</td>
<td>9 (53)</td>
<td>939 (27)</td>
<td>26</td>
<td>3.47 to 46.45</td>
<td>.02</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: RPE, retinal pigment epithelium.

**Based on the article by Shields et al.6**

**P value calculated using Mann-Whitney U test.**

**Subretinal fluid was judged by enhanced-depth imaging optical coherence tomography in the scleral bowing group (n = 17) and by clinical examination in the comprehensive cohort (n = 3422) so the latter could be an underestimation.
scleral shape. 

With true choroidal excavation, there is no modification of the pears more acoustically hollow than the surrounding choroid. True seen with choroidal melanoma in which the tumor ap-

tion. The latter is a term describing an ultrasonographic fea-

ture to differentiate scleral bowing from true choroidal excava-

tion. The latter is a term describing an ultrasonographic fea-

ures between individual in the rigidity of the scleral tissue,

leading to progressive distortion. The relationship between the presence of scleral bowing and the likelihood for growth of cho-

roidal nevus was not assessed in the present report.

Conclusions

In summary, we report a particular EDI-OCT observation of pos-

terior scleral bowing with choroidal nevus in 5% of cases. This feature represents a focal ectasia of the choroid at the site of nevus and could lead to underestimation of nevus thickness as the tumor protrudes posteriorly rather than anteriorly. Further studies are warranted to better assess the prevalence of this scleral configuration with choroidal nevus and its implications.

ARTICLE INFORMATION

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Author Contributions: Dr C. L. Shields had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Dolz-Marco. Acquisition, analysis, or interpretation of data: All authors. Drafting of the manuscript: Dolz-Marco, Hasanisoglu.

Critical revision of the manuscript for important intellectual content: Dolz-Marco, J. A. Shields, C. L. Shields. Statistical analysis: Dolz-Marco, C. L. Shields. Obtained funding: J. A. Shields. Administrative, technical, or material support: Hasanisoglu, C. L. Shields. Study supervision: Hasanisoglu, J. A. Shields, C. L. Shields.

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REFERENCES


