Subfoveal Choroidal Thickness and Cataract: The Beijing Eye Study 2011

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PURPOSE. This study examined subfoveal choroidal thickness (SFCT) in eyes with cataracts.

METHODS. The population-based Beijing Eye Study 2011 included 3468 individuals with a mean age of 64.6 ± 9.8 years (range, 50–93 years of age). Enhanced depth imaging spectral domain optical coherence tomography was applied for measurement of SFCT. Using lens photographs, we graded cataracts by the Age-Related Eye Disease Study system.

RESULTS. Assessments of SFCT and cataract were available for 2548 subjects. After adjusting for age, axial length, sex, anterior chamber depth, and lens thickness, we found that SFCT was not significantly associated with presence of nuclear cataract (P = 0.41). Conversely, the degree of nuclear cataract (P = 0.73) was not significantly associated with SFCT after adjusting for age and sex. In contrast, thicker SFCT was significantly associated with lower degree of posterior subcapsular cataract (P = 0.027; standardized regression coefficient β: −0.04; regression coefficient B: −127; 95% confidence interval [CI]: –240 to −15) or with lower degree of cortical cataract (P = 0.028; β: −0.06; B: −51.5; 95% CI: −97.3 to −5.59) after adjusting for younger age, shorter axial length, and deeper anterior chamber. Conversely, the degree of posterior subcapsular cataract (P = 0.027; β: −0.06) or the degree of cortical cataract (P = 0.01; β: −2.55) was associated with thinner SFCT in multivariate analysis. Correspondingly in binary regression analysis, presence of subcapsular cataract was associated with older age (P < 0.001; odds ratio [OR]: 1.11; 95% CI: 1.09–1.14) and thinner SFCT (P = 0.006; OR: 0.997; 95% CI: 0.995–0.999).

CONCLUSIONS. Although nuclear cataract was not significantly associated with an abnormal SFCT, the association between thin SFCT and subcapsular cataract or cortical cataract may have clinical importance, because thin SFCT is associated with low vision.

Keywords: Beijing Eye Study, cataract, choroidal thickness, cortical cataract, enhanced depth imaging optical coherence tomography, nuclear cataract, optical coherence tomography, posterior subcapsular cataract

Age-related cataract is a major cause of visual impairment and blindness worldwide.1 Previous studies revealed that age and female sex are among the most important factors associated with cataract.2 It has remained unclear so far whether cataract is associated with changes in the choroid, namely with an abnormal thickness of the choroid. The choroid, which receives approximately 95% of all the blood of the ophthalmic artery, is highly important for the physiology and pathophysiology of the eye in general and may indirectly influence the development of cataract, in particular, because the cause of cataract has not yet been fully elucidated. A potentially reduced choroidal thickness may be the surrogate for a reduced choroidal blood flow which directly or indirectly through the posterior long ciliary arteries may have an effect on the lens. Since the landmark study by Spaide et al.,3 who described the technical possibility of visualizing the choroid and measuring its thickness by using enhanced depth imaging mode of spectral domain optical coherence tomography (OCT), it has become possible to measure the subfoveal choroidal thickness (SFCT) in normal subjects and patients with choroidal or retinal diseases.4–7 We therefore conducted this study to assess SFCT in individuals with cataract and to compare the measurements with those obtained in persons without cataract. In order to avoid the potentially confounding effect of a referral bias adherent to any hospital-based investigation, we applied the design of a population-based investigation, measured SFCT in a relatively large study population, and addressed the question of whether cataract in general and whether three different types of cataract (nuclear cataract, cortical cataract, and subcapsular posterior cataract) were associated with an abnormal thickness of the subfoveal choroid.

METHODS

The Beijing Eye Study 2011 was a population-based cross-sectional study which was performed in five communities in the urban district of Haidian in the north of Central Beijing and in three communities in the village area of Yufa of the Daxing District south of Beijing.2,7 The Medical Ethics Committee of
the Beijing Tongren Hospital approved the study protocol, and all participants gave informed consent. The only eligibility criterion for inclusion in the study was an age of ≥50 years. Of a total population of 4,403 eligible individuals ≥50 years of age, 3,468 individuals (956 women [55.6%]) participated in the eye examination, corresponding to a response rate of 78.8%. The study was divided into a rural part (1,653 subjects [47.1%]; 943 women [57.7%]) and an urban part (1,855 subjects [52.9%]; 1,020 women [55.6%]). The mean age was 64.6 ± 9.8 years (median, 64 years of age; range, 50–93 years of age).

The examinations included an interview with standardized questions of family status, level of education, income, quality of life, psychological depression, physical activity, known major systemic diseases, quality of vision, biochemical blood examinations for the determination of concentration of serum lipids, glucose and glycosylated hemoglobin (Hb) A1c, blood pressure measurement, assessments of body height and weight and circumference of the waist and hip, and an ophthalmic examination. The last examination consisted of measurement of presenting, uncorrected and best corrected visual acuity, tonometry, slit lamp examination of the anterior segment, biometry (of the right eyes) using optical low-coherence reflectometry (Lenstar 900 Optical Biometer; Haag-Streit, Koeniz, Switzerland), photography of the macula and optic disc (CR6-45NM fundus camera; Canon, Inc., Tokyo, Japan) and slit lamp-based digital photography of the lens (BG-4 unit; Topcon Medical Systems, Inc., Tokyo, Japan). For the lens photographs, the slit lamp beam had a width of 0.3 mm and a height of 9.0 mm. The angle between the slit lamp beam and the sagittal axis was set at 45°. The slit lamp beam bisected the central lens from its superior pole to its inferior pole and was focused on the center of the lens nucleus. The degree of nuclear opacities of the lens was assessed in six grades, using the Age-Related Eye Disease Study grading system. Grade 1 was no nuclear opacity in the lens, and grade 6 was very dense nuclear lens opacity. In addition, photographs of the retro-illuminated lenses were obtained (CTR camera; Neitz Instruments Co., Tokyo, Japan). On these photographs, the cortical and posterior subcapsular opacities appeared as darkly shaded areas on a white background. The percentage of the areas with lens opacities was measured using a grid. The standard for diagnosing a nuclear cataract was a nuclear cataract grade of 4 or more; the standard for diagnosing a posterior subcapsular cataract was an amount of posterior subcapsular opacity of 0.01 or more; and the standard for diagnosing a cortical cataract was an amount of cortical opacity of 0.05 or more. Lens grading was performed by an experienced and trained ophthalmologist (JSZ). In case of doubt, photographs were reassessed by a panel including several ophthalmologists (YXW, QSY, and WWB).

RESULTS

After excluding aphakic or pseudophakic eyes and those who refused pupil dilation for lens examination, measurements of the SFCT and assessments for cataract were available for 2,548 subjects (75.5%; 1,450 women [56.9%]). The mean age was 64.1 ± 9.3 years (median: 63 years of age; range, 50–91 years of age), mean refractive error (spherical equivalent) was −0.15 ± 1.99 D (D; median: 0.25 D; range, −20.0 to +7.00 D), and mean axial length was 23.22 ± 0.15 mm (median: 23.12 mm; range, 18.96–30.69 mm). The group of subjects without measurements of the SFCT or without assessment of cataract compared with the group of subjects with both examinations was significantly (P < 0.001) older (65.9 ± 10.9 vs. 64.1 ± 9.3 years of age) and was more myopic (−0.38 ± 2.67 D vs. −0.15 ± 1.99 D, respectively; P = 0.05) and did not vary significantly in sex (P = 0.55). Neither SFCT nor the degree of cortical cataract, nuclear cataract, and subcapsular cataract were normally distributed (P < 0.001).

Cataracts (grades 4–7) were detected in 1,110 subjects (43.6%); cortical cataract was found in 446 subjects (17.5%); and posterior subcapsular cataracts were diagnosed in 144 subjects (5.7%). Altogether, 1,336 individuals (52.4 ± 1.9% [95% CI: 50.5–54.3%] of the study population) fulfilled the diagnosis of cataract. Nuclear cataract and cortical cataract combined were present in 221 individuals (8.7% of the whole study population); nuclear cataract and subcapsular posterior cataracts combined were present in 102 individuals (4.0%); cortical cataract combined and subcapsular posterior cataract combined were present in 67 individuals (2.6%); and all three types of cataract were present in 42 persons (1.6%). In 730 individuals, only nuclear cataract without any other type was present; in 165 individuals, only cortical cataract without any other type was present; and in 15 individuals, only subcapsular posterior cataract without any other type was present. The mean age in the overall cataract group was 68.8 ± 8.57 years of age; the refractive error was −0.15 ± 2.22 D, and the mean coefficient of 1.00; and a mean coefficient of variation of 0.85% ± 1.48%).

Statistical analysis was performed using a commercially available statistical software package (SPSS for Windows [Microsoft, Redmond, WA], version 22.0; IBM-SPSS, Chicago, IL). In the first step, we examined the mean values (presented as means ± SDs) of SFCT. The distribution of the outcome parameters was examined using the Kolmogorov-Smirnov test. In the second step, using the nonparametric Mann-Whitney test for unpaired samples, we compared SFCT between the study groups. In the third step, we performed a multivariate linear regression analysis, with SFCT as dependent parameter and those parameters as independent parameters which had previously been shown to be associated with SFCT. Standardized regression coefficients β, regression coefficients B, odds ratios (OR), and 95% confidence intervals (CI) were presented. All P values were two-sided and were considered statistically significant when the values were less than 0.05.

If a lens had more than one type of cataract, each type was assessed separately in the first part of the analysis. To cite one example, persons with cortical cataract and nuclear cataract were included in the analysis for cortical cataract and in the analysis for nuclear cataract. In this first part of the analysis, individuals with more than one type of cataract were, thus, not categorized in mutually exclusive groups, but they contributed more than once to the analysis, because it could not be decided which type of cataract was the predominant one. In the second part of the analysis, only individuals with a single type of cataract were included.
### TABLE

Demographic Parameters, Ocular Parameters, and Subfoveal Choroidal Thickness (Mean ± SD) in Groups of Patients With Different Types of Cataract and the Remaining Control Group in the Beijing Eye Study 2011

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Total Cataract Group</th>
<th>Nuclear Cataract Group</th>
<th>Cortical Cataract Group</th>
<th>Posterior Subcapsular Cataract Group</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>N</strong></td>
<td>1336</td>
<td>660</td>
<td>446</td>
<td>114</td>
<td>56</td>
</tr>
<tr>
<td><strong>Age, y</strong></td>
<td>68.8 ± 8.65</td>
<td>68.8 ± 8.57</td>
<td>71.2 ± 7.95</td>
<td>71.2 ± 7.95</td>
<td>68.8 ± 8.57</td>
</tr>
<tr>
<td><strong>Visual acuity, logMAR</strong></td>
<td>0.08 ± 0.14</td>
<td>0.09 ± 0.14</td>
<td>0.10 ± 0.14</td>
<td>0.10 ± 0.14</td>
<td>0.08 ± 0.14</td>
</tr>
<tr>
<td><strong>Cortical thickness, mm</strong></td>
<td>2.55 ± 0.39</td>
<td>2.55 ± 0.39</td>
<td>2.53 ± 0.39</td>
<td>2.53 ± 0.39</td>
<td>2.55 ± 0.39</td>
</tr>
<tr>
<td><strong>Axial length, mm</strong></td>
<td>23.1 ± 1.11</td>
<td>23.1 ± 1.11</td>
<td>23.1 ± 1.11</td>
<td>23.1 ± 1.11</td>
<td>23.1 ± 1.11</td>
</tr>
<tr>
<td><strong>Subfoveal choroidal thickness, μm</strong></td>
<td>37.7 ± 9.57</td>
<td>37.7 ± 9.57</td>
<td>37.7 ± 9.57</td>
<td>37.7 ± 9.57</td>
<td>37.7 ± 9.57</td>
</tr>
</tbody>
</table>

- **N** represents the number of individuals with each type of cataract and the control group.
- **Age** is measured in years.
- **Visual acuity** is measured in logMAR units.
- **Cortical thickness** is measured in millimeters.
- **Axial length** is measured in millimeters.
- **Subfoveal choroidal thickness** is measured in micrometers.

**P Value (1)**: statistical significance of the difference between the total cataract group and the control group.

**P Value (2)**: statistical significance of the difference between the posterior subcapsular cataract group and the cataract group.

**P Value (3)**: statistical significance of the difference between cortical cataract group and the control group.

**P Value (4)**: statistical significance of the difference between posterior subcapsular cataract group and the cataract group.

**P Value (5)**: statistical significance of the difference between posterior subcapsular cataract group and the control group.

Mean central corneal thickness was significantly thicker in the group of patients with cataract than in the control group, whereas mean central corneal thickness did not differ significantly between individuals without cataract and those with cortical cataract (221 μm [mean] ± 684 μm; range, 8–684 μm). The cataract group as a whole and even differentiated into nuclear, cortical, and posterior subcapsular groups was significantly (P < 0.001) different from the control group (Table). Axial length in the posterior subcapsular cataract group was significantly longer (P < 0.001) than in the control group, whereas axial length in the nuclear cataract group (P = 0.17) did not differ significantly (P = 0.16) from that in the control group (Table).

In univariate analysis, and compared with the control group, mean SFTC was significantly (all P < 0.001) lower in the nuclear cataract group (235 ± 104 μm [median: 226 μm; range, 9 μm to 684 μm]), the cortical cataract group (221 ± 107 μm [median: 205 μm; range, 8–561 μm]), and the posterior subcapsular cataract group (190 ± 114 μm [median: 165 μm; range, 34–602 μm]) (Table, Fig.). Similarly, if only individuals with a single type of cataract were included in the analysis, mean SFTC was significantly lower in the nuclear cataract group (245 ± 102 μm [median: 242 μm; range, 22–684 μm]; P < 0.001), the cortical cataract group (227 ± 105 μm [median: 212 μm; range, 8–529 μm]; P < 0.001), and the posterior subcapsular cataract group (208 ± 131 μm [median: 183 μm; range, 49–504 μm]; P = 0.006) than in the group of individuals without any type of cataract (281 ± 101 μm [median: 285 μm; range, 8–814 μm]).

Because SFTC has been shown to be associated with younger age, axial length, male sex, deeper anterior chamber, and thicker lens in the study population of the Beijing Eye Study, we performed a multivariate analysis with SFTC as the dependent variable and age, axial length, sex, anterior chamber depth, lens thickness, and presence of cataract as independent variables. Analysis revealed that thicker SFTC was significantly associated with younger age (P < 0.001; standardized coefficient B: −0.41; regression coefficient B: −4.60; 95% CI: −5.02 to −4.17), shorter axial length (P < 0.001; B: −0.38; 95% CI: −0.77 to −0.39), male sex (P < 0.001; B: −0.14; 95% CI: −0.29 to −0.04; B: −2.7; 95% CI: −11.0 to 5.6) was not significantly associated. If lens thickness was dropped from the list of independent parameters of the multivariate analysis, similar results were obtained.

<table>
<thead>
<tr>
<th>Parameter</th>
<th><strong>P Value (1)</strong></th>
<th><strong>P Value (2)</strong></th>
<th><strong>P Value (3)</strong></th>
<th><strong>P Value (4)</strong></th>
<th><strong>P Value (5)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>Visual acuity, logMAR</strong></td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>Cortical thickness, mm</strong></td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>Axial length, mm</strong></td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>Subfoveal choroidal thickness, μm</strong></td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Mean visual acuity was significantly worse in any of the cataract groups than in the control group (Table).
prevalence of cataract ($P = 0.42$) was not significantly associated. If a binary regression analysis was performed with the presence of cataract as dependent variable and with age and sex (factors which in a previous study were significantly associated with the prevalence of cataract) and SFCT as independent variables, presence of cataract was significantly associated with older age ($P < 0.001$; OR: 1.15; 95% CI: 1.14–1.17) and female sex ($P = 0.02$; OR: 1.25; 95% CI: 1.04–1.51), whereas SFCT ($P = 0.86$; OR: 1.00; 95% CI: 1.00–1.00) was not significantly associated with cataract.\(^2\)

If only the group of patients with nuclear cataract (single or combined with other types of cataract) was considered, thicker SFCT was significantly associated with younger age ($P < 0.001$), shorter axial length ($P < 0.001$), deeper anterior chamber ($P < 0.001$), and larger lens thickness ($P < 0.001$), whereas the degree of nuclear cataract ($P = 0.96$; $\beta$: 0.01; B: 0.10; 95% CI: $-5.65$ to $3.84$) was not significantly associated. If a regression analysis was performed with the degree of nuclear cataract as dependent variable and age, sex, and SFCT as independent variables, degree of nuclear cataract was significantly associated with older age ($P < 0.001$; $\beta$: 0.49; B: 0.06; 95% CI: 0.05–0.06), whereas sex ($P = 0.87$) and SFCT ($P = 0.73$) were not significantly associated with the presence of nuclear cataract.

If only the group of patients with single nuclear cataract without any other type of cataract ($n = 750$) and individuals without any type of cataract ($n = 1212$) were considered, thicker SFCT was significantly associated with younger age ($P < 0.001$), shorter axial length ($P < 0.001$), male sex ($P < 0.001$), deeper anterior chamber ($P < 0.001$), and larger lens thickness ($P < 0.001$), whereas the degree of nuclear cataract ($P = 0.73$; $\beta$: -0.01; B: -0.77; 95% CI: $-5.07$ to $3.53$) was not significantly associated. If in the same analysis, the degree of nuclear cataract was replaced by the presence of nuclear cataract, thicker SFCT was significantly associated with younger age ($P < 0.001$), shorter axial length ($P < 0.001$), male sex ($P < 0.001$), deeper anterior chamber ($P < 0.001$), and thicker lenses ($P < 0.001$), whereas the presence of nuclear cataract ($P = 0.41$; $\beta$: -0.02; B: -3.88; 95% CI: $-13.1$ to 5.31) was not significantly associated. If a regression analysis was performed with the degree of nuclear cataract as dependent variable and age, sex, and SFCT as independent variables, degree of nuclear cataract was significantly associated with older age ($P < 0.001$; $\beta$: 0.46; B: 0.06; 95% CI: 0.05–0.06), whereas sex ($P = 0.84$) and SFCT ($P = 0.71$) were not significantly associated with the presence of nuclear cataract.

If only the group of patients with cortical cataract was considered, thicker SFCT was significantly associated with younger age ($P < 0.001$), shorter axial length ($P < 0.001$), male sex ($P < 0.001$), deeper anterior chamber ($P < 0.001$), and thicker lens thickness ($P < 0.001$), whereas the degree of cortical cataract ($P = 0.39$; $\beta$: -0.02; B: -12.6; 95% CI: $-41.2$ to 15.9) was not significantly associated. If a regression analysis was performed with the degree of cortical cataract as dependent variable and age, sex, and SFCT as independent variables, degree of cortical cataract was significantly associated with older age ($P < 0.001$; $\beta$: 0.31; B: 0.005; 95% CI: 0.004–0.006), and female sex ($P < 0.001$; $\beta$: 0.14; B: 0.04; 95% CI: 0.03–0.05), whereas SFCT ($P = 0.17$) was not significantly associated with degree of cortical cataract.

If only the group of patients with single cortical cataract without any other type of cataract ($n = 165$) and individuals without any type of cataract ($n = 1212$) were considered, thicker SFCT was significantly associated with younger age ($P < 0.001$), shorter axial length ($P < 0.001$), male sex ($P < 0.001$), deeper anterior chamber ($P = 0.002$), and thicker lenses ($P = 0.02$) and with a lower degree of cortical cataract ($P = 0.028$; $\beta$: -0.06; B: -51.5; 95% CI: $-97.3$ to $-5.59$). If a regression analysis was performed with the degree of cortical cataract as dependent variable, and age, sex and SFCT as independent variables, higher degree of cortical cataract was significantly associated with older age ($P < 0.001$), female sex ($P < 0.001$), and with thinner SFCT ($P = 0.01$; $\beta$: -2.55; B: 0.000; 95% CI: 0.000–0.000).

If only the group of patients with posterior subcapsular cataract was considered, thicker SFCT was significantly associated with younger age ($P < 0.001$), shorter axial length ($P < 0.001$), deeper anterior chamber ($P < 0.001$), and thicker lens thickness ($P < 0.001$), and marginally significantly with lower degree (percentage) of posterior subcapsular cataract ($P = 0.047$; $\beta$: -0.04; B: -115; 95% CI: $-228$ to $-1.6$). If due to colinearity (variance inflation factor: 2.0) lens thickness was dropped from the list of independent variables, the association between thicker SFCT and lower degree of posterior subcapsular cataract was statistically significant ($P = 0.027$; $\beta$: -0.04; B: -126; 95% CI: $-240$ to 15). If presence of diabetes mellitus was added to the list of independent variables, thicker SFCT was associated with higher prevalence of diabetes mellitus ($P = 0.008$; $\beta$: 0.05; B: 3.77; 95% CI: 3.55–24.1) in addition to a lower degree of subcapsular cataract ($P = 0.029$; $\beta$: -0.04; B: -126; 95% CI: $-249$ to $-13$). If a regression analysis was performed with degree of posterior subcapsular cataract as dependent variable and age, sex, axial length, sex, anterior chamber depth, and SFCT as independent variables, degree of posterior subcapsular cataract was significantly associated with older age ($P < 0.001$; $\beta$: 0.10; B: 0.000; 95% CI: 0.000–0.001), axial length ($P = 0.003$; $\beta$: -0.08; B: -0.002; 95% CI: -0.004 to -0.001), deeper anterior chamber ($P = 0.004$; $\beta$: 0.08; B: 0.007; 95% CI: 0.002–0.012), and thinner SFCT ($P = 0.027$; $\beta$: -0.06; B: -0.001; 95% CI: 0.000–0.000), whereas sex was not significantly associated ($P = 0.52$). In binary regression analysis with the presence of subcapsular cataract as dependent variable and age, sex, and SFCT as independent variables, presence of subcapsular cataract was significantly associated with older age ($P < 0.001$; OR: 1.11; 95% CI: 1.09–1.14), and thinner SFCT ($P = 0.006$; OR: 0.997; 95% CI: 0.995–0.999), whereas it was not significantly associated with sex ($P = 0.21$).

The group of individuals with only subcapsular cataract without any other type of cataract was too small ($n = 15$) for a multivariate analysis.

**DISCUSSION**

In our population-based study, individuals with subcapsular cataract had SFCT that was thinner than those in individuals without cataract after adjusting for systemic and ocular factors such as age and axial length. As a corollary, a higher degree of subcapsular cataract was significantly associated with a thinner SFCT in a multivariate model. In a parallel manner, individuals with a higher degree of purely cortical cataract had a significantly thinner SFCT in the multivariate model. As a corollary, thinner SFCT was associated with a higher degree of cortical cataract in multivariate analysis. In contrast, presence and degree of nuclear cataract were not significantly associated with SFCT in the multivariate model.

The findings of our study cannot be compared with results obtained in previous investigations because SFCT in eyes with cataract has not yet been systematically examined. Previous studies addressed associations between SFCT and cataract surgery.\(^10\)\(^11\) Ohnuki et al.\(^10\) examined 100 eyes with cataract and found that postoperative choroidal thickness in the foveal region and infratemporal region increased significantly during the follow-up after surgery. The increase in choroidal thickness was negatively correlated with axial length. In the study by
Falcao et al., SFCT and retinal thickness were measured in 14 patients undergoing cataract surgery with phacoemulsification. The increase in retinal macular thickness was not associated with changes in SFCT. It was concluded that the morphologic response of the posterior segment to cataract surgery was observed mainly at the retinal level and that these retinal changes might not be accompanied by changes in SFCT. None of these studies compared SFCT in eyes with cataract to that in eyes without cataract.

With respect to the association between subcapsular posterior cataract and a thinner SFCT, one may note that in some eyes, a systemic inflammatory disorder might have affected the choroid, leading after an acute phase with choroidal thickening ultimately to a thinning of the SFCT and might simultaneously have led to subcapsular posterior cataract. The group of eyes with subcapsular posterior cataract, however, did not show remarkable fundus changes indicating previous choroiditis. The cause of the association between a thinned foveal choroid and prevalence and severity of subcapsular posterior cataract has thus remained elusive so far.

Similarly, cortical cataract, if not occurring together with nuclear cataract, was associated with a thinner SFCT in the multivariate analysis. Clinically, the finding of our study concerning the associations among subcapsular posterior cataract and thinner SFCT and the finding of an association between a thinner SFCT and cortical cataract may be of interest because a thin SFCT has been reported to be associated with decreased best corrected visual acuity after adjusting for confounding factors such as age, refractive error, and ocular diseases. Future studies may address whether a thin SFCT in some eyes with subcapsular cataract or with cortical cataract compared to eyes with nuclear cataract is associated with a lower best corrected visual acuity after cataract surgery.

Spaide et al. were the first to report on the development of enhanced depth imaging by OCT to visualize the choroid as the landmark study. Following the study by Spaide et al.,3 investigations have shown the importance of measuring SFCT in various diseases. These investigations revealed that, under normal conditions, SFCT depends on age, axial length, sex, anterior chamber depth, and lens thickness. The studies also showed that some diseases, such as central serous chorioretinopathy, polyoidal choroidal vasculopathy, and idiopathic choroidal neovascularization are associated with an abnormally thick SFCT, whereas myopic maculopathy and nonarteritic anterior ischemic optic neuropathy are associated with abnormally thin SFCT. Eyes with open-angle glaucoma showed a normal SFCT. According to our study, the list of diseases associated with an abnormal SFCT may be extended now including also subcapsular posterior cataract as a disorder associated with an abnormally thin SFCT.

Potential limitations of our study should be mentioned. First, a major concern in any prevalence study is nonparticipation. The Beijing Eye Study 2011 had a reasonable response rate of 78.8%; however, differences between participants and nonparticipants could have led to a selection artifact. Because the group of subjects without OCT measurements and assessments of cataract were older and more myopic than the group of subjects with these measurements, one may argue that the nonparticipation of a part of the elderly eligible study population may have influenced the results of the investigation. Second, previous studies by Chakraborty et al. and others showed a circadian rhythm change of approximately 20 to 30 μm in choroidal thickness measurements by OCT. The participants of our study underwent OCT examinations at various times of the day. Because these examinations were performed in a randomized manner with respect to the presence or absence of cataract, it was unlikely that the dependence of SFCT on the time of the day introduced a bias in our study. Third, choroidal thickness was examined only in the right eye of each study participant, so that inter-eye differences and their associations with inter-eye differences of other parameters could not be assessed. Fourth, previous studies, each with less than 50 patients, have suggested that removal of cataract was associated with thicker measurements of macular thickness, most evident in patients with posterior cataracts. It remains unclear whether the mild increase in foveal thickness
was due to subclinical retinal changes and/or to an influence of changes in optic media of the eyes. In another study, Esmaeelpour et al. examined 34 individuals with cataract and found that eyes with cataract showed a reduced OCT signal strength in 65% of the examinations if a 870-nm OCT was applied compared to 10% of the examinations if a 1060-nm laser beam was used. It may indicate that future studies applying a longer-wavelength laser beam for the OCT examination may more precisely measure the choroidal thickness. Fifth, the subgroup of subjects with posterior subcapsular cataracts was the smallest subgroup with their data-set having only 144 eyes compared to 1110 subjects with nuclear cataract and 446 subjects with cortical cataract. It may make any statistical association less convincing and more prone to errors caused by other contributing factors. Sixth, it could have been useful to differentiate reasons for posterior subcapsular cataract in association with observed thinning of the subfoveal choroid. Due to the character as a population-based study, however, it was not possible that, based on the answers in the questionnaire or based on the ophthalmological examination, causes for subcapsular posterior cataract were detected in a substantial number of individuals.

In conclusion, a higher prevalence for and degree of posterior subcapsular cataract and a higher prevalence for and degree of cortical cataract were associated with a thinner subfoveal choroidal thickness, whereas occurrence and degree of nuclear cataract were not significantly associated with an abnormal SFCT after adjusting for ocular and systemic parameters. Because a thin SFCT is associated with low vision, the finding of the association between subcapsular cataract or cortical cataract with a thin SFCT may have clinical and pathogenetic importance.

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