Corneal Thickness and Intraocular Pressure in a Nonglaucomatous Burmese Population

The Meiktila Eye Study

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Objective: To determine correlates of central corneal thickness (CCT) and its relationship to intraocular pressure (IOP) in a Burmese population.

Methods: We performed a population-based survey of inhabitants 40 years or older in Myanmar; of 2076 participants, data from 1909 nonglaucomatous subjects who underwent ultrasound pachymetry and Goldmann applanation tonometry were analyzed. Linear mixed effects models adjusting for nonindependence of right and left eye data were constructed.

Results: Mean (SD) CCT was 521.9 (33.3) µm, and the mean (SD) IOP was 14.5 (3.4) mm Hg. Intraocular pressure and spherical equivalent were significant predictors of CCT (P = .001 and P = .01, respectively). Age, sex, body mass index, and corneal curvature were not significant predictors. Central corneal thickness was the only significant predictor of IOP (i.e., an increase of 100 µm in CCT predicted an increase of 1.3 mm Hg in IOP). The Spearman correlation between CCT and IOP for the right and left eyes was highly significant (P < .001), but the Spearman rank correlation values (R² = 0.016 and R² = 0.017, respectively) were weak.

Conclusions: The CCT in this Burmese population was significantly associated with IOP and spherical equivalent. The weak association between CCT and IOP is consistent with that of other population-based studies. Other corneal factors are likely to influence Goldmann applanation tonometry.

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The theoretical influence of central corneal thickness (CCT) on intraocular pressure (IOP) measurement by Goldmann applanation tonometry (GAT) has been demonstrated in several studies,

Although most studies have reported a significant positive correlation between CCT and IOP, the relationship is often weak. In the Barbados Eye Studies, no significant correlation between CCT and IOP was found.

Although glaucoma, particularly angle-closure glaucoma, is a major ophthalmic problem in East Asia,

There is evidence that CCT varies within Asian subgroups (Chinese, Filipino, and Japanese).

METHODS

Foster et al reported a significant association between CCT and IOP in a Mongolian population and, more recently, Suzuki et al reported a significant but weak correlation in a Japanese population.

Herein, we report data concerning factors associated with CCT and IOP and explore the relationship between these 2 variables in a nonglaucomatous Burmese population.

The Meiktila Eye Survey was a population-based, cross-sectional ophthalmic survey of the residents of rural villages in the Meiktila district of central Myanmar. The district is arbitrarily divided into 6 zones served by a centrally located eye hospital in Meiktila. Participants were selected using a randomized, stratified, cluster sampling process. A sampling frame consisting of a list of all villages in the Meiktila district and their populations was obtained from the Ministry of Health. For
logistical reasons, sampling was restricted to villages within a 3-hour drive from Meiktila (an area encompassing approximately 80% of the district).

STUDY POPULATION

All persons 40 years or older within each selected village were eligible for inclusion. Health care workers from Meiktila Township enumerated the selected villages (and advertised and promoted the survey) before commencement of the survey. All eligible subjects belonged to the Burman ethnic group (the majority ethnic group in Myanmar).

DATA COLLECTION

A single survey team conducted the entire study in November 2005. Each team member was assigned specific tasks and was well trained in the appropriate area before the commencement of the study. All equipment and personnel were transported to each village, and the data collection occurred on site. A tonometrist obtained 2 IOP readings using GAT (calibrated at each site) and recorded the average. Another observer then measured CCT (calibrated at each site) with the use of an ultrasonic pachymeter (Pocket II Precision pachymeter; Quantel Medical Inc, Bozeman, Montana) and recorded the average of 5 readings (standard practice for this instrument). As quality assurance, the IOP and CCT measurements were regularly verified by one of the attending ophthalmologists (R.J.C.). The mean (SD) intraobserver variability for the GAT was 1.13 (0.74) mm Hg (n=40). The intraclass correlation coefficient for the GAT was 0.94 (n=50) and for the pachymetry, 0.96 (n=50). Subjects meeting the diagnostic criteria for glaucoma defined by the International Society of Geographic and Epidemiologic Ophthalmology (ISGEO)\(^2\) in 1 or both eyes were excluded on the grounds that the IOP in most of these subjects was elevated as a component of the disease, a factor that would mask any underlying relationship between CCT and GAT-measured IOP in this population. For consistency, subjects with glaucoma and normal IOP were also excluded. Similarly, subjects meeting the ISGEO definition of primary angle closure with an IOP of greater than 22 mm Hg were excluded. The methods used to diagnose glaucoma, which included stereoscopic examination of the optic discs and comparison with standard disc photographs, have been previously reported.\(^2\) The possible association of thinner CCTs with glaucoma was not a hypothesis in this report. Subjects with central corneal scarring were also excluded. Those with ocular hypertension (no glaucoma but an IOP of >22 mm Hg) were not excluded.

ETHICS

The Meiktila Eye Survey was approved by the Ministry of Health in Myanmar and had ethical approval from the Royal Adelaide Hospital Ethics Committee. Consent for participation was obtained from the head of each village before commencement of the survey; written, informed consent in the participants’ own language was obtained after verbal instruction from all participants. The study was conducted in accordance with the Declaration of Helsinki.

STATISTICAL METHODS

To estimate mean CCT and IOP and to identify predictor variables associated with these outcomes, linear mixed effects models were fitted to the data. This type of analysis does not assume independence of data; the correlation between observations of the right and left eyes can be accounted for by fitting the participant as a random effect in the model. Demographic and biometric predictor variables for each model were chosen a priori on the basis of biological plausibility and prior knowledge. For CCT as the outcome, the predictor variables included age, IOP, sex, spherical equivalent, corneal curvature, and body mass index. For IOP as the outcome, they included age, CCT, and sex.

Linear mixed effects models suffer the disadvantage that, unlike a multivariate coefficient of determination value in a general linear model, there is no overall measure of the proportion of variance explained by the model. Hence, the strength of association between significant predictors and the outcome variable in the models were calculated using univocal data. Initial exploration of the data indicated that parametric assumptions for correlation analyses between CCT and IOP may not be met; hence, a Spearman rank correlation was calculated.

We considered P < .05 to be statistically significant. Unless otherwise indicated, data are expressed as mean (SD).

RESULTS

A total of 2481 subjects were eligible, and 2076 were examined (836 men and 1240 women [participation rate, 83.7%]). The mean age was 56.2 (11.5) years. We excluded 101 subjects with glaucoma. An IOP measurement and a corresponding pachymetry recording from at least 1 eye were available in 1909 subjects (76.9%), of whom 756 (39.6%) were men and 1153 (60.4%) were women.

Allowing for clustering of data, the overall mean IOP was 14.5 (3.4) mm Hg, and the mean CCT was 521.9 (33.3) (range, 409-640) µm. The mean IOP in men (14.6 [3.6] mm Hg) was not significantly different from that in women (14.5 [3.8] mm Hg) (P=.68). The mean CCT in men (532.0 [32.8] µm) was not significantly different from the mean CCT in women (521.9 [33.2] µm) (P=.86). One hundred twenty-one nonglaucomatous eyes had an IOP of greater than 22 mm Hg (the 97.5th percentile), with a range of 23 to 40 mm Hg. This group of ocular hypertensive eyes had a significantly higher mean CCT of 536 (41.8) µm compared with eyes that had IOPs within the reference range (P < .001).
The mean CCT in this Burmese population was thinner than that generally found in white populations. This is consistent with the preponderance of evidence that indicates that there is considerable racial variation in CCT; however, the use of different measuring devices in various epidemiological studies makes comparisons difficult. Cho and Lam reported a mean CCT of 575 (32) μm in Hong Kong Chinese, but Foster et al, using optical pachymetry, reported considerably thinner CCTs in a Mongolian population. In a refractive surgery clinic–based population, Shimmyo et al reported that the mean CCT in Asian eyes was 550 (32) μm.

Reports of a sex-specific difference in CCT have been inconsistent. Several studies of nonwhite populations have found a small but statistically significant sex difference, with men tending to have slightly thicker CCTs than females. In the present study, the difference was not statistically significant. Similarly, reports of an age-dependent effect on CCT are inconsistent, but most of the data from Asian populations and from the Barbados Eye Studies indicate a tendency for the CCT to decrease with age. However, in the present study, CCT was not significantly associated with age.

The relationship between CCT and IOP measured by GAT is complex. Imbert and Fick (publishing independently and shortly after Malakoff) are jointly credited with the Imbert-Fick Law, developed specifically for
the Ocular Hypertension Treatment Study reported that the relationship between IOP and CCT becomes more apparent. Although CCT is weak, when the IOP is categorized, a relation-

increase of 1.3 mm Hg was predicted. With the finding from the present study, where an increase of 1.3 mm Hg was predicted.

In 1975, using in vivo manometry, Ehlers et al4 found a statistically significant linear relationship between CCT (measured optically) and the error in the IOP measured by GAT (Foster) and Schmidt1 in applanation tonometry. They highlighted the fact that there were ocular factors that under- mine the assumptions inherent in this "law." Goldmann and Schmidt maintained that, when a corneal diameter of 3.0 to 3.5 mm was applanated in normal human corneas, the elastic and surface tension forces canceled each other and the resultant measurement was virtually the original undisturbed IOP. They recognized that, theoretically, CCT affected applanation tonometry, but it appears they believed it would be insignificant under physiologic conditions. The CCT in their calibration experiments was assumed to be 500 µm.

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ing the relationship between IOP and CCT relate to this population only.

Unfortunately, we have no information about the characteristics of the nonparticipants. Owing to the limited time and resources, our enumeration recorded only the total number of people who were 40 years or older in each of the selected villages. There are no reliable census data to determine the identity and characteristics of the nonparticipants; however, given that the participation rate was greater than 80% (as was expected), the lack of data about nonparticipants is unlikely to alter the conclusions of the study.

In conclusion, the CCT in this Burmese population was thinner than that found in white populations. The CCT had a weak but significant correlation with IOP. This relationship was more apparent when the IOP was divided into subgroups and obvious when the CCT in ocular hypertensive subjects was compared with that of normotensive subjects. It seems likely that the relationship between IOP and CCT is influenced by a number of unknown variables.

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REFERENCES