Internal Astigmatism and its Correlation to Corneal and Refractive Astigmatism

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Abstract

Objective : To evaluate the internal astigmatism and its relationship to corneal and refractive astigmatism in a refractive surgery patient population.

Method : Patients who underwent pre-operative evaluation for Laser in situ Keratomileusis (LASIK) at Excimer Laser Clinic, Siriraj Hospital, Mahidol University were included. Pre-operative data including age, manifest refraction and corneal topography obtained by Orbscan Corneal Topography were performed. Regression Analysis was done to find the correlation between refractive and corneal astigmatism.

Results : 110 patients (220 eyes : 110 right eyes and 110 left eyes) were included. The mean age was 31.14 $\pm$ 7.00 year (range 19 to 48 years). The mean astigmatism measured by manifest refraction (refractive astigmatism) was 0.76 $\pm$ 0.72 diopters (range 0 to 3.50 diopters). The mean astigmatism measured by Orbscan Corneal Topographer (corneal astigmatism) was 1.38 $\pm$ 0.72 diopters (range 0.20 to 5.30 diopters). The mean difference in magnitude of refractive and corneal astigmatism (internal astigmatism) was 0.62 $\pm$ 0.67 diopters (range 0 to 3.00 diopters) and 74 per cent were within $\pm$ 1.00 diopters difference. The mean difference in axis of astigmatism was 0.95 $\pm$ 23 degree (range 0 to 85 degree) and 79.6 per cent were within $\pm$ 15 degree difference. There was low correlation between corneal and internal astigmatism ($R^2 = 0.12$, $p < 0.05$), also low correlation between refractive and internal astigmatism ($R^2 = 0.27$, $p < 0.05$). There was a statistically significant difference between magnitude of corneal and refractive astigmatism ($p < 0.05$) but no difference in the axis of astigmatism ($p = 0.55$).

Conclusion : This study demonstrated non-mutual agreement between refractive and corneal astigmatism (presence of internal astigmatism). High value (> 1.00 diopter) of internal astigmatism was demonstrated in 1/3 of the cases. Kerato-refractive surgery that attempts to correct refractive astigmatism at corneal plane may effect long-term evaluation of the astigmatism.

Key word : Astigmatism, Cornea, Refraction

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Astigmatism is one of the myths among refractive surgeons. Many investigators have demonstrated several components of astigmatism[1-3]. Those included corneal astigmatism, lenticular astigmatism, retinal astigmatism and even that brain perception can sometimes cause a small degree of astigmatic perception[4]. All components except corneal astigmatism are known as internal astigmatism. Most of the time, a refractive surgeon relies on the astigmatism measured by manifest refraction. This is an effective method to correct astigmatism due to manifest refraction representing total astigmatism of the eye. But astigmatic surgery has usually been performed at the corneal plane. By ignoring the corneal astigmatism and internal astigmatism, this procedure might effect the total astigmatic evaluation after the surgery especially when cataract extraction is required in the future. This study was performed to find the correlation between refractive, corneal and internal astigmatism.

MATERIAL AND METHOD

All patients who visited the Excimer Laser Clinic at Siriraj Hospital, Mahidol University, Bangkok, Thailand from June 2001 to March 2002 were included in this study. Complete ocular evaluation for Laser in situ Keratomileusis (LASIK) was done. Patients with any eye diseases such as keratoconus, dry eyes, pterygium, post ocular surgery (including penetrating keratoplasty, cataract extraction, and filtering procedure) were excluded. Pre-operative data including age, sex, manifest refraction (both sphere and cylinder) and corneal topography obtained by Orbscan Corneal Topography (Bausch & Lomb, Salt Lake City) were recorded. Astigmatism was extracted from cylinder manifest refraction (refractive astigmatism) and corneal topography (corneal astigmatism). The axis of corneal astigmatism was standardized periodically (180 degrees) with respect to the refractive cylinder axis. Correlation between refractive and corneal astigmatism was evaluated by using regression analysis.

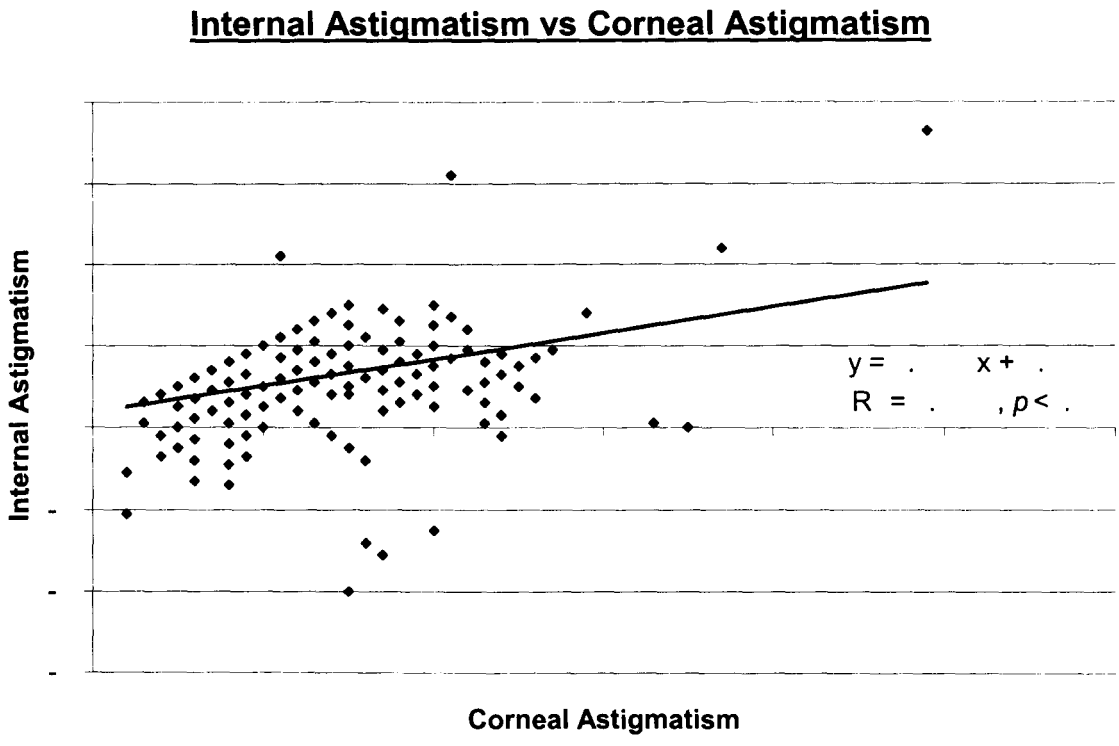

Fig. 1. Demonstrates the relationship between internal astigmatism and corneal astigmatism. No correlation was found.

RESULTS

There were 110 patients (220 eyes : 110 right and 110 left eyes) included in the study. 75 per cent were female and 25 per cent were male. The mean age was 31.14 ± 7.00 year (range 19 to 48 years). The mean manifest refraction (spherical equivalent) was -4.91 ± 2.28 diopters (range -0.50 to -11.50 diopters). The refraction can be broken down to spherical component and astigmatism component. The mean spherical component was -4.55 ± 2.23 diopters (range 0.50 to -11.00 diopters) and the mean astigmatism component (refractive astigmatism) was 0.76 ± 0.72 diopters (range 0 to 3.50 diopters). The mean astigmatism measured by Orbscan Corneal Topography (corneal astigmatism) was 1.38 ± 0.72 diopters (range 0.20 to 5.30 diopters). The mean difference between magnitude of refractive and corneal astigmatism (internal astigmatism) was 0.62 ± 0.67 diopters (range 0 to 3.00 diopters) and 74 per cent were within ± 1.00 diopters difference. The mean difference between axis of refractive and corneal astigmatism was 0.95 ± 23 degree (range 0 to 85 degree) and 79.6 per cent were within ± 15 degree difference.

Regression analysis was performed to find the correlation between internal, refractive and corneal astigmatism. There was low correlation between corneal and internal astigmatism ($R^2 = 0.12$, $p < 0.05$) (Fig. 1), also low correlation between refractive and internal astigmatism ($R^2 = 0.27$, $p < 0.05$) (Fig. 2). There was statistically significant difference between magnitude of corneal and refractive astigmatism ($p < 0.05$) but no difference in the axis of astigmatism ($p = 0.55$). There was also a high correlation between the axis of corneal and refractive astigmatism ($R^2 = 0.95$, $p < 0.05$) (Fig. 3).

DISCUSSION

Several articles have described astigmatism in different ways[5-8]. Mostly known by ophthalmologists, refractive astigmatism represents the astigmatism of the entire optical system and has been measured by manifest refraction for almost a century. This

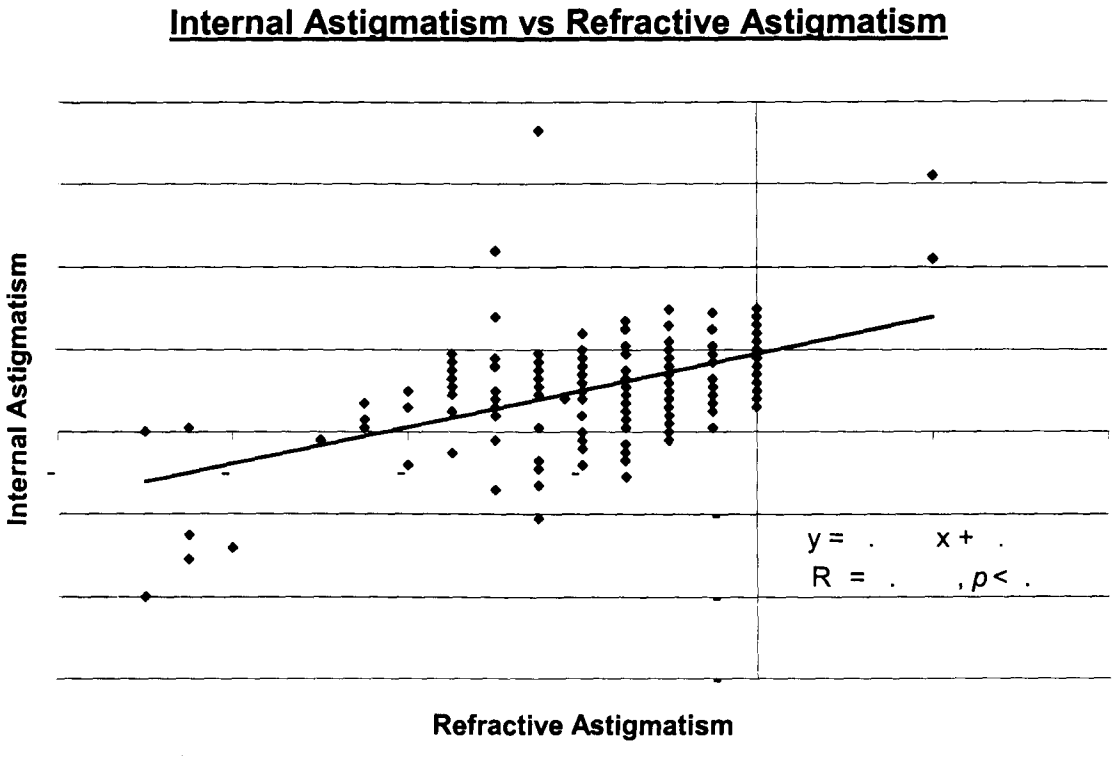

Fig. 2. Demonstrates the relationship between internal astigmatism and refractive astigmatism. No correlation was found.

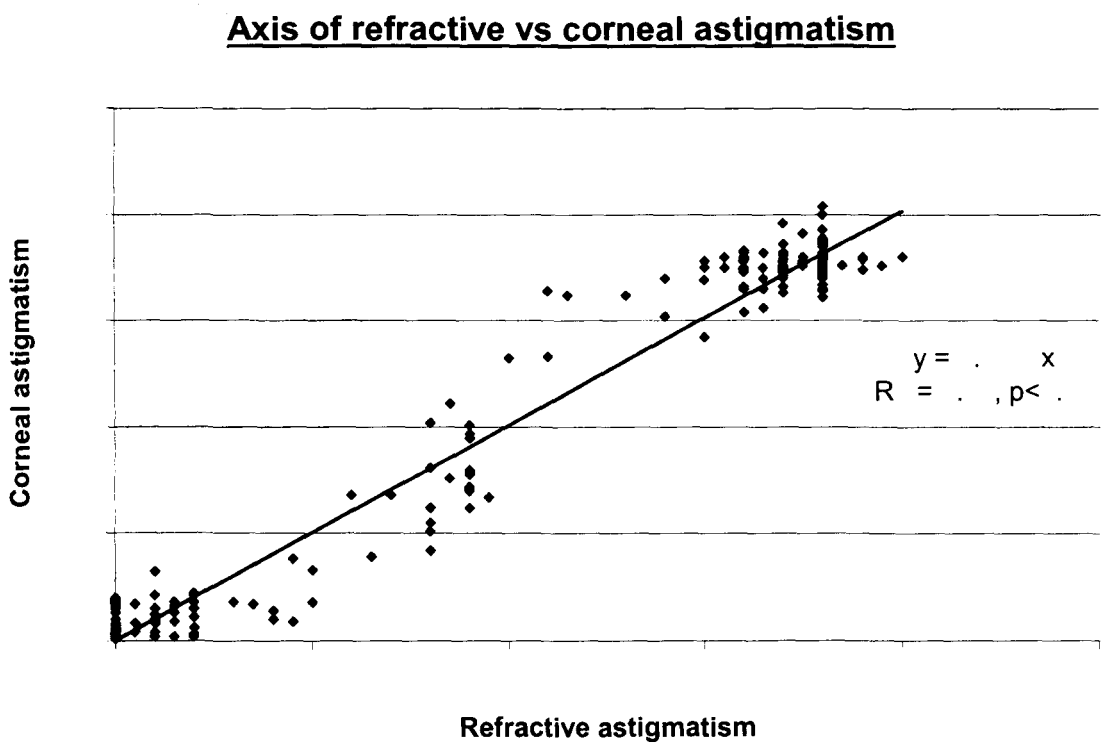

Fig. 3. Demonstrates the relationship between the axis of corneal and refractive astigmatism. Note that the strong correlation indicated the relation of the axis of internal astigmatis.

astigmatism is comprised of several components[9]. The anterior surface of the cornea (corneal astigmatism) contributes most part of the refractive astigmatism because of the major difference in refractive index between air and cornea interface. A slightly change in the curvature of the anterior cornea can produce a significant change in astigmatism. The posterior surface of the cornea and the rest of the optical system also contribute some degree of astigmatism. This astigmatism is known as internal astigmatism which can sometimes play a major role in refractive astigmatism[10]. In the presence of internal astigmatism, it can be detected by measuring the difference between corneal and refractive astigmatism [11]. The present study demonstrates the statistically significant difference in the amount of corneal and refractive astigmatism; therefore, the internal astigmatism is statistically present but can't be predicted because no correlation can be found. The correlation of the axis of corneal and refractive astigmatism demonstrates that the internal astigmatism is mostly aligning in the same relation with the axis of corneal astigmatism and 79.6 per cent were within ± 15 degree difference (almost the same axis).

Traditionally, the relationship between corneal and refractive astigmatism has been summarized by Javal's rule, which predicts refractive astigmatism from keratometry based on the assumption that the eye's internal astigmatism has a value of 0.50 diopter [12,13]. The present study supports part of Javal's rule in the amount of internal astigmatism (0.69 diopter in average). Interestingly, the percentage of patients who had internal astigmatism more than ± 1.00 diopter was one third of the study population. This finding is very critical because of the rapid growth in keratorefractive surgery. The surgery attempts to correct refractive astigmatism at the corneal plane. By changing the curvature of the anterior surface of the cornea in respect to the entire optical astigmatism, can sometimes produce asymmetrical cornea. This asymmetry is intentionally produced to compensate internal astigmatism. This condition might effect the evalua-

tion of astigmatism in the future. For example, if intraocular surgery that involved removing some component of the eye (such as cataract extraction) is required, the amount of internal astigmatism will change. The asymmetrical cornea will show up and produce an unexpected change in refractive astigmatism in the same amount as the change of internal astigmatism. Identifying internal astigmatism prior to keratorefractive surgery is very useful to clarify this unexpected situation.

The present study was performed to demonstrate the importance of internal astigmatism in refractive surgery population. With today's technology, the only component of internal astigmatism that can be detected is the posterior surface of the cornea[14]. Details of lenticular astigmatism and the rest of the optical system still can't be measured. Awareness of the presence of internal astigmatism is required prior to keratorefractive surgery.

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การวิเคราะห์ค่าสายตาเอียงชนิด Internal Astigmatism และ ความสัมพันธ์กับค่าสายตาเอียง ที่วัดได้จากการวัดสายตา (Refractive Astigmatism) และ ค่าสายตาเอียงที่วัดได้จากความเอียงของกระจกตา (Corneal Astigmatism)

*สบง ศรีวรรณบูรณ์, พบ**

วัตถุประสงค์ : เพื่อหาความสัมพันธ์ระหว่างค่าสายตาเอียงชนิด Internal Astigmatism กับค่าสายตาเอียงที่วัดได้จากการวัดสายตาและค่าสายตาเอียงที่วัดได้จากความเอียงของกระจกตาในกลุ่มประชากรที่ได้รับการทำผ่าตัดแก้ไขสายตาผิดปรกติ

วิธีการ : การศึกษานี้ทำในผู้ที่มารับการตรวจเพื่อทำผ่าตัดแก้ไขสายตาผิดปรกติจำนวน 220 ตาที่ภาควิชาจักษุ-วิทยา คณะแพทย์ศิริราชพยาบาล โดยทำการตรวจและบันทึกข้อมูลเกี่ยวกับ อายุ เพศ ค่าวัดสายตาผิดปรกติทั้งสั้นและเอียง ค่าความเอียงของกระจกตาที่ตรวจวัดด้วยเครื่อง Orbscan Corneal Topography (Bausch & Lomb, Salt Lake City) แล้วนำค่าสายตาเอียงที่วัดได้จากการวัดสายตาและค่าสายตาเอียงที่วัดได้จากความเอียงของกระจกตามาคำนวณหาค่าสายตาเอียงชนิด Internal Astigmatism และความสัมพันธ์ระหว่างกลุ่มโดยวิธี Regression Analysis

ผลการวิจัย : ผู้ที่มารับการตรวจ 110 ราย (220 ตา) เป็นชาย 40 ราย หญิง 70 ราย มีอายุเฉลี่ย 31.14 $\pm$ 7.00 ปี (19 ถึง 48 ปี) มีค่าสายตาเอียงที่เฉลี่ยวัดได้จากการวัดสายตา 0.76 $\pm$ 0.72 diopters (0 ถึง 3.5 diopters) มีค่าความเอียงเฉลี่ยของกระจกตา 1.38 $\pm$ 0.72 diopters (0.2 ถึง 5.3 diopters) ค่าสายตาเอียงชนิด Internal Astigmatism ที่คำนวณได้เฉลี่ยเท่ากับ 0.62 $\pm$ 0.67 dipoters (0.00 ถึง 3.00 diopters) และพบ 74% ที่มีค่าอยู่ระหว่าง $\pm$ 1.00 diopter ไม่พบว่ามีความสัมพันธ์ระหว่างค่าสายตาเอียงชนิด Internal Astigmatism กับ ค่าสายตาเอียงที่เฉลี่ยวัดได้จากการวัดสายตา (R^2 = 0.27, $p < 0.05$) และ ค่าความเอียงของกระจกตา (R^2 = 0.12, $p < 0.05$)

สรุป : การศึกษานี้พบว่าค่าสายตาเอียงชนิด Internal Astigmatism ในปริมาณมาก (> 1.00 diopter) พบได้ประมาณ 1 ใน 3 ของกลุ่มประชากรที่ได้รับการทำผ่าตัดแก้ไขสายตาผิดปรกติ ซึ่งอาจมีผลต่อการประเมินสภาวะสายตาเอียงในอนาคตได้

คำสำคัญ : ค่าสายตาเอียง, กระจกตา, การวัดสายตา

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