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ORIGINAL PAPER

Comparison of the keratometric corneal astigmatism and refractive astigmatism after phacoemulsification and foldable intraocular lens implantation

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Abstract Here we aimed to define keratometric and refractive astigmatism in a series of patients who underwent phacoemulsification, using small corneal incision and implantation of foldable intraocular lenses. Furthermore, we compared keratometric astigmatism and refractive astigmatism of the patients both before and after surgery. We performed a follow-up study of patients with newly diagnosed cataract before and after phacoemulsification surgery. Eighty eyes from 78 patients with a mean age of 62.9 ± 12.03 (32–86) years were studied. Thirty-nine (48.8 %) were male and 41(51.2 %) were female. All subjects underwent 3.5 mm corneal incision with the temporal (75 patients; 94 %) or superior (5 patients; 6 %) approach. The patients were followed for a mean of 74.21 ± 71.25 (30–400) days. Patients had higher values of keratometric measurements after surgery compared to those before surgery [45.81 ± 0.11 (45.06–45.94) vs. 45.2 ± 0.20 (44.6–45.41)] ($p < 0.001$). There was no significant difference in the keratometric astigmatism, refractive astigmatism and keratometry axis pre- and postoperatively. The mean keratometric astigmatism was 0.9 ± 0.54 (0.00–4.00) diopters (D) preoperatively and 0.93 ± 0.45 (0.00–4.00) D postoperatively ($p = 0.444$). The keratometric axis was 97.7 ± 9.4 preoperatively and 115 ± 15.8 postoperatively ($p = 0.185$). Refractive astigmatism was 1.15 ± 0.77 (5–180) with the refractive axis of 89.7 ± 5.89 (5–180) degrees in the follow-up ($p = 0.752$). Ninety percent of the patients had <1.00 D difference in the keratometric and refractive astigmatism, postoperatively. In conclusion while there is no significant difference in postoperative keratometric and refractive astigmatism in most of the eyes, about 10 % show >1 D difference in these measurements.

Keywords Phacoemulsification · Keratometric astigmatism · Refractive astigmatism

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Introduction

Cataract surgery is one of the most common outpatient procedures performed in the elderly. Phacoemulsification through clear corneal incision is the principal method for cataract surgery [1, 2]. Corneal astigmatism after phacoemulsification has always been a concern to most surgeons [3]. Astigmatism may cause blurred vision, glare sensation, monocular diplopia and asthenopia. Procedures such as clear corneal incision [4], foldable intraocular lenses (IOLs) [5, 6]

and incisions placed on the steep axis of the cornea [7, 8] have been adopted to reduce surgical-induced astigmatism and also to correct pre-existing astigmatism [9]. Clinical examination, refraction, keratometry, and topography are the standard tools used to define the status of astigmatism after surgery. Here we aimed to compare keratometric and refractive astigmatism following phacoemulsification. We determined the efficacy of this method when using small corneal incision and foldable IOLs. The refractive and keratometric astigmatism were compared postoperatively.

Methods

We performed a follow-up study of patients with newly diagnosed cataract before and after phacoemulsification. Patients were recruited from the ophthalmology clinic of Shafa Hospital, affiliated to Kerman University of Medical Sciences, with a diagnosis of cataract grade II–IV [lens opacities classification system (LOCS) III)] [10]. Patients were excluded if they had previous history of ophthalmic surgery , glaucoma, corneal disease of any type, irregular astigmatism, with tilted or decentered IOL or eventful phacoemulsification surgery. All patients underwent preoperative and postoperative examinations. Preoperative assessment consisted of a full standard comprehensive ophthalmic examination including uncorrected and best-spectacle corrected distance visual acuities, slit-lamp examination, intraocular pressure measurement (IOP) by Goldmann applanation tonometry, cataract grading (LOCS III System), indirect binocular ophthalmoscopy and keratometry of the eye. Refractive astigmatism was obtained using an autorefractometer (Topcorn KR-8000; Paramus, NJ, USA) and keratometric astigmatism was measured with a keratometer (Model Javel; HAAG STREIT) both before and at least one month after surgery. We did not measure surgical-induced astigmatism by the standard methods [11]. The patients underwent phacoemulsification surgery (Storz Protégé) and implantation of foldable nontoric IOLs (Bausch & Lomb, Salt Lake City, UT, USA). All the procedures were performed by one surgeon using sutureless phacoemulsification techniques [12] at the University Hospital of Shafa from January 2008 to March 2009. Phacoemulsification was performed using topical application of tetracaine eye drops and peribulbar injection of lidocaine 2 %, through a 3.5 mm clear corneal incision temporal or superior, with intraocular foldable nontoric IOL implantation. Routine postoperative medication included betamethasone 0.5 % eye drops and chloramphenicol eye drops after a pressure patch for 1 day.

Statistical analysis

The statistical package SPSS 17 for windows (Chicago, IL, USA), was used for analysis. Variables distributed normally are presented as mean and standard deviation (SD). Kolmogorov–Smirnov test was employed to test the normality of variables. The Wilcoxon matched pairs test was used for paired comparisons of refractive and keratometric astigmatism both before and after treatment.

Results

Eighty eyes from 78 patients with a mean age of 62.9 ± 12.03 (32–86) years were included in the study. Thirty-nine (48.8 %) of them were male and 41(51.2 %) were female. All patients underwent corneal incision—75 (94 %) of them temporal and five (6 %) superior incisions (incision in the steep axis of cornea). The patients were followed for a mean of 74.21 ± 71.25 (30–400) days. Anterior to posterior length was 23.26 ± 1.87 mm. The IOL power was 19.19 ± 5.27 diopters (D).

Keratometric measurements were significantly higher after surgery compared to those before surgery (45.81 ± 0.11 (45.06–45.94) vs. 45.2 ± 0.20 (44.6–45.41), $p < 0.001$). There were no significant differences in the keratometric astigmatism and keratometric axis pre- and postoperatively. The mean keratometric astigmatism was 0.9 ± 0.54 (0.00–4.00) D preoperatively and 0.93 ± 0.45 (0.00–4.00) D postoperatively ($p = 0.444$). The keratometric axis was 97.7 ± 9.4 preoperatively and 115 ± 15.8 postoperatively ($p = 0.185$).

Refractive astigmatism was 1.15 ± 0.77 (5–180) with a refractive axis of 89.7 ± 5.89 (5–180) degrees in the follow-up ($p = 0.752$). We did not measure refractive astigmatism before surgery. There were no significant differences in the astigmatism values measured by refractive and keratometric methods. Difference of refractive and keratometric astigmatism was 0.58 ± 0.09 (0–2) D. We stratified the difference of measurement of astigmatism into four categories of <0.5, 0.5–1, 1–2 and >2 D (Table 1).

Table 1 Number of patients according to the difference in keratometric and refractive astigmatism

Number (%)	Difference in keratometric and refractive astigmatism
29 (36.3 %)	<0.5 D
43 (53.7 %)	0.5–1D
8 (10 %)	1–2 D
0 (0 %)	>2 D

Discussion

We implanted a foldable nontoric single-piece IOL in 80 eyes. Visual outcome in the early postoperative period and at last follow-up was evaluated. Our data demonstrated that there was no significant difference in keratometric and refractive astigmatism of the patients undergoing phacoemulsification surgery. Ninety percent of our studied population had <1.00 D difference in keratometric and refractive astigmatism after surgery. Furthermore, despite stable keratometric astigmatism postoperatively, keratometric measurements of the patients significantly increased after the procedure. We also did not observe any significant difference in the axis of kertometric astigmatism.

Astigmatism is a refractive condition where power variations exist in different meridians of the cornea. The major source of astigmatism is the anterior surface of the cornea; however, it could also be produced by the posterior cornea, lenticular surface, or lenticular zonular. The total amount of astigmatism for any one patient is the sum of all of the astigmatism produced by the refractive system secondary to normal variations in the surfaces of different ocular media, therefore, the combination of corneal (keratometry) and lenticular astigmatism. In a phakic eye, the corneal astigmatism is modified, either compensated or enhanced, by the internal lenticular astigmatism resulting in a difference between keratometry and refractive astigmatism [3]. However, in a pseudophakic eye, a well-positioned monofocal IOL hardly induces any internal astigmatism unless it is tilted to or decentered from the visual axis [13]. Therefore, keratometric astigmatism is likely to manifest as a total refractive astigmatism postoperatively. We showed that the postoperative difference in keratometric and refractive astigmatism was <1 D in 90 % of the patients [14–19].

We also showed an increased keratometric measurement postoperatively, while keratometric astigmatism was stable. We did not observe a significant difference in the axis of kertometric astigmatism. Surgical-induced astigmatism has always been a concern to most surgeons [20]. Consistent with our findings, it has been shown that the parameters for visual performance are not affected by the presence of surgically induced astigmatism [21]. Why the increase in keratometric measurements did not change the keratometric astigmatism is not clear for us; it may have been induced by the surgical procedure but it was not severe enough to change keratometric astigmatism.

The principal limitation of the current study was its short-term follow-up duration. One would consider patient recruitment as a limitation of the study as it was very strict and we only used temporal and superior incisions. The incision in the phacoemulsification cataract extraction has developed from sclera incision to the clear corneal incision. At the present time, cataract surgery by phacoemulsification through clear corneal incision has become the principal surgical method because of its bloodless and fast approach [22, 23]. Amesbury and Miller showed that in phacoemulsification, the incision placed on the steep axis of cornea can correct small amounts of astigmatism, depending on the location of the axis [19]. Moreover, the aim of present study was to compare mean keratometric or refractive astigmatism before and after surgery. If we used different methods, we could not fulfill our aim. The surgical procedures influence the corneal astigmatism and that would be a confounding factor. On the other hand, we took advantage of a relatively large sample size and close similarity between participants in most of the confounding variables.

In conclusion we showed that the measurements of keratometric and refractive astigmatism are close (<1 D difference); however, in 10 % of eyes we found >1 D difference that can be clinically important for prescription of glasses. This finding is related to factors other than anterior corneal surface, such as zonular weakness in a part of lens periphery, irregularities in capsular bag, posterior corneal surface and other unknown factors. Moreover, the axes of keratometric and refractive astigmatism were close to each other. Small increases in keratometry can be a source of postoperative myopic shift, which interferes with precise calculation of IOL power.

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