ORIGINAL ARTICLE

THE DIFFERENCE OF PREDICTED AND FINAL REFRACTION USING BU-II AND SRK/T FORMULA IN HIGH MYOPIA PATIENT AT DR. KARIADI HOSPITAL

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ABSTRACT

Introduction: *Studies showed 38% refractive errors after intraocular lens (IOL) implantation are caused by deviations in calculation of IOL power. The difference between the formula's refractive prediction and patient's final outcome highly increases in cases of high myopia, but needs to be more research on this topic. This study aims to show difference between predicted and final refractive outcomes using Barrett II Universal (BU-II) and SRK/T in patients with high myopia who underwent phacoemulsification and IOL implantation.*

Method: *This analytical observational study with cross-sectional design was conducted on high myopia patients (axial length ≥ 26.0 mm) who underwent phacoemulsification and intraocular lens implantation between January 2021 and January 2022 at Dr. Kariadi General Hospital Semarang. Data used in this study consisted of biometric measurements and difference between predicted refractive outcomes using BU-II and SRK/T formulas and final refractive outcomes of patients one month after surgery. Data were analyzed using one-sample T-test, and significance level of $p < 0.05$ was considered statistically significant.*

Results: *Thirty-five eyes participated in this study, the mean axial length was (29.33 ± 2.01). BU-II formula has mean difference in refraction prediction with patient's final refraction result closer to zero (1.19 ± 1.31) than SRK/T formula ($1.25 \pm 1,12$). The difference between two formulas was statistically significant ($p < 0.05$).*

Conclusion: *The BU-II formula has lower difference between predicted and final refractive outcomes of high myopia patients after phacoemulsification and IOL implantation than SRK/T formula.*

Keywords: *High myopia, refractive prediction error, Barrett Universal II formula, SRK/T formula, IOL strength calculation formula*

INTRODUCTION

High myopia is one of the eye disease with the highest prevalence worldwide.[1] High myopia refers to myopia with a lens refractive power of ≥ -6 diopters (D) or an axial length (AL) of ≥ 26 mm. It is estimated that high myopia affected 4% of the global population (300 million) in 2010, and this number is projected to increase to 10% (925 million) by 2050.[2]

Numerous studies have confirmed that the accuracy of preoperative eyeball biometric measurements, selection of surgical procedures, and calculation results of intraocular lens (IOL) power are key factors determining the refractive outcome after lens extraction surgery in

patients with high myopia.[3] The development of phacoemulsification techniques with small incisions and the availability of eyeball biometry measurements have reduced the incidence of postoperative hyperopia. Therefore, IOL power calculation is crucial to achieve optimal visual outcomes in high myopia patients undergoing lens extraction and IOL implantation surgery. High myopia patients have a longer axial length, and the presence of posterior staphyloma can reduce the accuracy of calculating the strength of the IOL to be implanted, leading to postoperative hyperopia, which decreases patient satisfaction with the final surgical outcome.[4,5]

When the axial length is extreme, the variation in prediction's results increases significantly, which highlights the importance of selecting the most appropriate formula in determining the strength of the IOL to be implanted. The first-generation formula, namely SRK I, the second-generation formula, namely SRK II, and the Hoffer formula have paved the way for designing a more modern third-generation formula, namely the Holladay 1 formula, the Hoffer Q formula, and the Sanders-Retzlaff-Kraff theoretic (SRK/T) formula, as well as the fourth generation formula, namely the Formula Haigis and Barrett Universal II (BU-II) formulas.[4,5] The SRK/T formula has been shown to provide lower difference between the prediction and patient's final outcome with AL of 27.0 mm.[6] Recently, the BU-II formula, introduced as the modified version of the original Barrett formula in 2010, has been considered capable of offering even lower difference between predicted refractive outcomes and final refractive outcomes of patients than the SRK/T formula, especially in eyes with long AL. The BU-II formula calculates several eye ball biometric measurement datas such as axial length (AL), keratometry, white-to-white distance (WTW), preoperative anterior segment depth (ACD), lens thickness (LT), and lens factor in determining the IOL power to be implanted in patients post-surgery.[7]

However, until now, there has yet to be any research on how's the difference between the predicted refractive outcome and the final patient's refractive outcomes using these two formulas at Dr. Kariadi Hospital. This study aims to show the difference between the predicted refractive outcome and the final refractive outcomes of patients using the BU-II formula and the SRK/T formula in high myopia patients who have undergone phacoemulsification and intraocular lens implantation at Dr. Kariadi Hospital.

METHODS

Study Population

This analytical observational study was conducted at Dr. Kariadi General Hospital, Semarang, from January 2021 to January 2022. The study was conducted retrospectively using

medical records from 23 high myopia patients undergoing lens extraction and intraocular lens implantation surgery. The study protocol was approved by the Kariadi General Hospital's Department of Education and Research. Patients who underwent phacoemulsification had valid eye ball biometric measurement data using the IOL Master Advanced Technology V.7.5, patients who had a record of the implanted IOL power, and patients who followed-up 1 month postoperative were included in this study. Patients who experienced intraoperative and postoperative complications that affected refractive outcomes, patients who had central corneal abnormalities, patients who had history of previous corneal or intraocular surgery, patients who had the history of glaucoma, and patients with IOL implanted outside the bag were excluded from this study.

Data collection

The data collected in this study include demographic data such as age and gender, also eye ball biometric measurements, including preoperative axial length (AL), anterior segment depth (ACD), flat keratometry (K1), and steep keratometry (K2); implanted IOL power from the medical record, patient's refractive prediction calculations using BU-II formula and SRK/T formula, and the patient's actual spherical equivalent (SE) one month after the surgery.

Variable Definitions

High myopia is a refractive error of ≥ -6 diopters or an axial length of ≥ 26 mm. The axial length is measured from the corneal apex to the retina using the IOL Master 500 biometry. The implanted IOL power in patients is calculated using the BU-II and SRK/T formulas. Refractive outcomes are examined one month after the surgery with the best corrected visual acuity, and the SE value is calculated by summing the patient's spherical value and half of the cylindrical value. This study compares the difference between refractive prediction of the BU-II fromula and SRK/T formulas with the patient's SE 1 month postoperative with zero.

Statistic analysis

All statistical analyses were performed using IBM SPSS Statistics 25 software. Numeric variables are reported as mean and standard deviations (SD), while categorical variables are reported as numbers and percentages. Data normality is assessed using the Shapiro-Wilk test. One-sample T-test is used to determine whether the difference between the refractive prediction and the final refractive outcome of patients using the BU-II formula and SRK/T formula significantly differs from zero.

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RESULTS

This study included 35 eyes from 23 patients with high myopia who underwent lens extraction and intraocular lens implantation. Most patients were female (56.52%), and the right eye was predominantly affected (54.30%). The average age of the patients was 33.60 ± 10.28 years, with the mean axial length (AL) of 29.33 ± 2.01 mm, flat keratometry (K1) of 43.03 ± 1.55 D, steep keratometry (K2) of 44.78 ± 1.73 D, and anterior segment depth (ACD) of 3.64 ± 0.43 mm. Patient's spherical equivalent (SE) value 1 month post operative of -0.09 ± 1.20 D, intraocular lens power (IOL) strength implanted of 4.85 ± 5.59 D, refractive prediction calculations using the BU-II formula of 0.04 ± 1.38, and the SRK/T formula of -0.76 ± 1.13. The basic characteristics and biometric measurements of the patients are presented in Table 1.

The comparison between the difference in refractive prediction between the BU-II formula and SRK/T formula and the final refractive outcome of the patients with zero was analyzed using one-sample T-test. The BU-II formula had the mean difference in refractive prediction closer to zero (1.19 ± 1.31 D) than SRK/T formula (1.25 ± 1.12 D). The study's results also showed a significant mean difference between the difference in refractive prediction of the BU-II formula ($p = 0.000$) and SRK/T formula ($p = 0.000$) with zero. The comparison between the difference in refractive prediction of the BU-II formula and SRK/T formula and the final refractive outcome of the patients with zero is presented in Table 2.

Figure 1 presents the percentage of differences in refractive prediction values of the BU-II formula and SRK/T formula compared to the patient's final refractive outcome 1 month post operative, classified into 5 categories: < 0.25 D, 0.25-0.50 D, > 0.50-1.00 D, > 1.00-2.00 D, and > 2.00 D. The highest percentage of refractive prediction differences in the BU-II formula (25.7%) and the SRK/T formula (25.6%) was observed in the category of > 0.50-1.00 D.

Table 1. Basic Patient Characteristics and Biometric Measurements

No	Variable	N	%	Median	Means ± SD	Reach (min-max)	P value
1	Age (years)			35	33.60 ± 10.28	15 – 55	0.840
2	Gender (N = 23)						
	Male	10	43,47				
	Female	13	56,52				
3	Eyes Used (N = 35)						
	Right eye	19	54,30				
	Left eye	16	45,70				
4	AL(mm)			28,91	29.33 ± 2.01	26.54 – 33.87	0.099
5	K1 (D)			43,21	43.03 ± 1.55	39.43 – 45.98	0.739
6	K2 (D)			44,82	44.78 ± 1.73	41.21 – 48.56	0.328
7	ADC(mm)			3.59	3.64 ± 0.43	2.96 – 5.19	0.000
8	SE (D)			-0.30	-0.09 ± 1.20	-3.50 – 3	0.072
9	IOL Power (D)			6	4.85 ± 5.59	-9 – 13	0.076
10	BU Formula II			-0.09	0.04 ± 1.38	-3.42 – 3.12	0.107
11	Formula SRK/T			-0.64	-0.76 ± 1.13	-3.88 – 2.02	0.007

SD: Standard deviation, min: minimum, max: maximum, AL: axial length, K1: flat keratometry, K2: steep keratometry, ACD: anterior segment depth, SE: refractive value, IOL power: intraocular lens power.
[a]Shapiro-Wilk normality test.

Table 2. Comparison between difference in refractive prediction of BU-II and SRK/T formula and final refractive outcome with zero

No	Variable	Means SD	P value	95% CI
1	BU-II formula	1.19 ± 1.31	0.000*	0.74 – 1.64
2	Formula SRK/T	1.25 ± 1.12	0.000*	0.87 – 1.64

SD: standard deviation, BU-II formula: Barrett II formula, SRK/T formula: Sanders-Retzlaff-Kraff theoretic formula
[a]*One-sample T-test*

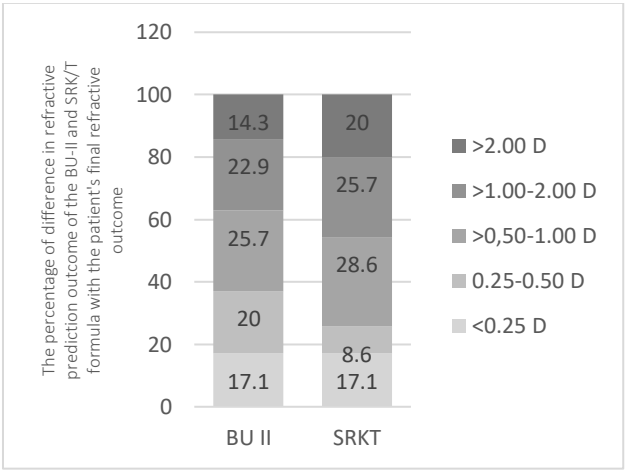

Figure 1.The percentage of difference in refractive prediction outcome of the BU-II and SRK/T formula with the patient's final refractive outcome

DISCUSSION

This study compare the difference in refractive prediction outcome of the BU-II formula and SRK/T formula with the patient's final refractive outcome one month after undergoing the

lens extraction and IOL implantation for high myopia. IOL implantation aims to achieve optimal postoperative refractive outcomes, which can be achieved through the accurate biometric measurements, small incision phacoemulsification techniques, and an appropriate IOL power selection. Postoperative hyperopia can occur due to the miscalculations in IOL power calculations, especially in cases of high myopia. The difference between predicted refractive outcomes and patient's actual refractive outcomes 1 month postoperative tends to increase with longer axial length (AL).[8] Patient's refractive outcome examination in this study was performed 1 month after the surgery. This is in accordance with the study of Wang et al. which stated that the patient's refraction outcome would be stable by 3 weeks or more after the phacoemulsification surgery with IOL implantation.[9] In this study, the mean age of the patients was 33.60 ± 10.28 years, and female were the highest proportion of patients (56.52%). These findings are consistent with a study performed by Zhou et al., which evaluated the accuracy of refractive prediction by multiple formulas for IOL power calculation in high myopia and found that most patients with high myopia were female (62.2%). The range of AL in this study is similar to the study conducted by Chen et al., with an AL range of 26.01-35.93 mm and an average of 29.03 ± 2.05 mm. The mean of the K value in this study is consistent with a study by Zhang et al., with a mean of 43.85 ± 1.62 D. The mean ACD in this study is also in accordance with the study by Zhang et al., with a mean of 3.51 ± 0.39 mm.[10,11]

The Barrett II formula uses the lens thickness (LT) and white to white (WTW) values determined by the paraxial ray tracing method on its prediction's calculation, and the formula also calculates the lens factor which also provides a precise estimation of the effective position of the lens.[12] These findings support the Barrett II formula as the formula which provides lower difference between the formula's refractive prediction and the patient's final refractive outcome in eyes with long, medium, and short AL. [4] In another study conducted by Abulafia et al. which included 106 eyes with an AL of more than 26.00 mm, the Barrett II formula showed the lowest predictive difference of 0.28 ± 0.19 D (0.26 D).[13] These findings are consistent with the results of this study, in eyes with an AL of more than 26.00 mm, the difference in prediction of refraction of the BU-II formula with the final refractive outcome of the patients one month post operative was smaller compared to the SRK/T formula. This study shows that the BU-II formula has an average difference in the prediction of refractive outcome with the final patient's refractive outcome closer to zero (1.19 ± 1.31 D) compared to the SRK/T formula (1.25 ± 1.12). Furthermore, the results show that the average difference between the prediction of refraction outcome and the final refraction outcome significantly differs between the BU-II formula ($p = 0.000$) and SRK/T formula ($p = 0.000$) with zero. This finding was also supported by Chong et

al. in their previous study, which explained that Barrett Universal II formula and SRK/T formula were equally accurate in high myopia patients and IOL strength > 6.00 D.[14]

Some of the limitations of this study include the limited number of samples. It is hoped that further studies could use a larger sample study size. Second, this study was conducted retrospectively; therefore, prospective cohort studies in other populations are still needed to confirm the authenticity of our study's results. Furthermore, this study did not separate different IOL materials implanted in patients, which could contribute to more variation in patient's final refractive outcome. Further study with the same IOL material should be conducted to minimize this confounding factor.

CONCLUSION

In conclusion, the Barrett Universal II (BU-II) formula has a lower difference between predicted refractive outcomes and final refractive outcomes of high myopia patients after phacoemulsification and IOL implantation than the Sanders-Retzlaff-Kraff theoretic (SRK/T) formula.

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