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THE MAGNITUDE AND TYPE OF POSTOPERATIVE ASTIGMATISM AFTER SMALL INCISION CATARACT SURGERY AT A TERTIARY CARE CENTRE: A PROSPECTIVE OBSERVATIONAL STUDY.

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ABSTRACT.

Background:
Cataract is the leading cause of blindness accounting for 51% of blindness worldwide. Manual small incision cataract surgery (MSICS) is the most popular surgical management option for cataracts in developing countries. The location, size, and shape of incisions used in MSICS influence postoperative surgically induced astigmatism (SIA).
Objective: The aim was to study the magnitude and type of postoperative astigmatism after cataract surgery (MSICS with posterior chamber intraocular lens i.e., PCIOL) by using different sites and shapes for incisions.

Methods:
This prospective observational study included 104 patients presenting to the Department of Ophthalmology M.K.C.G Medical College, Berhampur who had undergone cataract surgery (MSICS) over one year from September 2020 to August 2021.

Results:
Mean surgically induced astigmatism was 1D±0.4840 at the postoperative 3rd month. Superior incisions induced more postoperative astigmatism as compared to Supertemporal and temporal incisions. Straight incision induced more postoperative astigmatism as compared to frown and inverted V or Chevron incision.

Conclusions:
The site, size, and shape of incisions used in MSICS influence postoperative astigmatism. Incision at the steeper meridian is a simple, safe, and effective procedure to correct mild to moderate preoperative astigmatism at the time of cataract surgery.

Recommendation:
Some surgeons recommend the use of a temporal incision to minimize SIA, as the temporal limbus is further forming the visual axis than the superior limbus.

Keywords: Astigmatism, Cataract, Keratometry, Intraocular pressure
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INTRODUCTION.

Cataract poses both a significant socioeconomic burden and a public health concern as it is the leading cause of blindness worldwide. The major causes of visual impairment are uncorrected refractive errors (43%) followed by cataracts (33%); the first cause of blindness is cataracts (51%) [1]. The current treatment for cataracts is surgery and while phacoemulsification remains the more advanced and technically superior method of cataract surgery, manual small incision cataract surgery (MSICS) is the most popular surgical management option for cataracts in developing countries [2,3]. This is mainly because of the low cost, short surgical time, reduced dependence on technology, and equivalent visual outcome to phacoemulsification [4].

The location, size, and shape of incisions used in MSICS influence postoperative surgically induced astigmatism (SIA). The temporal approach has been reported to result in a smaller SIA than the superior approach [5]. Small incisions (6 mm) induced the smallest SIA when compared with medium (6.5 mm) and large (7 mm) incisions [6]. The chevron-shaped incision has also been reported to give minimal SIA when compared with straight and frown incisions [7]. Corneal or keratometric SIA is the vector difference between the preoperative corneal or keratometric astigmatism and the postoperative astigmatism [8].

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Concerning the location of the incision, placing the incision on the steeper corneal meridian based on the preoperative keratometry (K) reading has been recommended [9]. The idea is that because of the one-to-one coupling from corneal incisions, there is a flattening of the corneal curvature in the meridian on which the incision is placed, with a corresponding steepening to the same degree as the orthogonal meridian [10].

With increasing age, the horizontal corneal meridian becomes more curved than the vertical meridian leading to or increasing existing against-the-rule (ATR) astigmatism [11]. Thus, there is an ATR shift in astigmatism with age. Placing an incision on the vertical meridian (superior approach) for a cataract patient with preoperative ATR astigmatism may cause further flattening of the already flatter vertical meridian and a corresponding steepening to the same degree of the already steeper horizontal meridian leading to high postoperative corneal astigmatism.

With senile cataracts being the most common type of cataract in developing countries and since there is an ATR shift in astigmatism with age, most cataract patients in developing countries may have preoperative ATR astigmatism. Hence, the choice of the location of incision for these groups of patients is important [11,12].

Over the years a better understanding of various preoperative and intraoperative determinants of surgically induced astigmatism has made it possible to plan out the surgical intervention and their modification according to the preoperative state of astigmatism of the patient to achieve the minimum possible post-operative astigmatism. The purpose of modern cataract surgery is not only cataract extraction followed by IOL implantation but also to reduce or correct existing astigmatism [13].

Estimates of the incidence of significant naturally occurring astigmatism vary widely from 7.5% to 75%. Pre-existing astigmatism is present in over 60% of all patients scheduled for cataract surgery [14]. The aim was to study the magnitude and type of postoperative astigmatism after cataract surgery (MSICS with posterior chamber intraocular lens i.e., PCIOL) by using different sites and shapes for incisions.

METHODS.

Study Design, Duration, and Location.

This prospective observational study was carried out in the Department of Ophthalmology, M.K.C.G Medical College and Hospital, Berhampur, Odisha, India from September 2020 to August 2021 after Ethical was obtained from the institute's ethics committee clearance letter number 914 of the year 2020.

Study population.

Patients presenting to the Department of Ophthalmology M.K.C.G Medical College, Berhampur, Odisha, India both outpatient and inpatient departments who had undergone cataract surgery (manual SICS) from the period of September 2020 to August 2021.

Inclusion Criteria.

Patients with uneventful cataract surgery (Manual SICS with PCIOL) and completing all the follow-up for 3 months.

Exclusion criteria.

Patients with coexisting glaucoma, uveitis, subluxated lens., complicated cataract, irregular or oblique astigmatism, grade 4 nuclear sclerosis, presenile cataract, posterior segment pathology, keratoconus, corneal pathology, or patients did not consent for study or lost to follow-up.

Materials required.

Snellen's Chart for visual acuity, Goldmann applanation tonometer for IOP measurement, Lacrimal syringing Cannula, Auto refractometer, Trial frame and trial box, Slit lamp, Direct & Indirect ophthalmoscope, Bausch and Lomb keratometer.

Preoperative evaluation.

All patients assigned to undergo cataract surgery (MSICS with PCIOL) were admitted one day before surgery. A detailed history was recorded. Thorough anterior segment evaluation was done using a slit lamp. Visual acuity (VA), both unaided as well as aided using spectacles or pinhole was checked with Snellen's acuity chart. After pupillary dilatation, the cataract was assessed and graded. Posterior segment evaluation was done and retinoscopy was performed.

Intraocular pressure (IOP) was measured using the Goldmann Applanation Tonometer. The patency of lacrimal passages was checked using lacrimal sac syringing. Keratometry was done using a manual Bausch and Lomb keratometer axial length was measured with a zoomed-A scan unit (ophthalmic ultrasound) and IOL power was calculated using the Sanders-Retzlaff-Kraff (SRK)-2 formula.

Investigations including HIV1 and2, HBsAg, RBS or FBS, urine routine and microscopic and a general physical examination done for all patients. All patients received 1 hourly topical antibiotic eye drop one day before surgery. Tropicamide (0.8%) and phenylephrine (5%) eye drop was instilled for mydriasis every 15 minutes starting 1 hour before surgery. Then surgery (MSICS with PCIOL) on the patients was done. On postoperative 1st week, 1st month, and 3rd month,

Student's Journal of Health Research Africa
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Original article

Keratometry and VA were checked on follow-ups. Refraction readings were noted from 1st week onwards. Final subjective refraction was done after 2 months and spectacles were prescribed.

Cases with a steep axis at 900±300were considered with-the-rule (WTR) and those with a steeper axis at 0/1800±300 were considered ATR. Patients with steeper axes in between these were considered oblique astigmatism.

Statistical analysis.

Data was entered into a Microsoft Excel spreadsheet and then analyzed by SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and GraphPad Prism version 5. Unpaired proportions were compared by Chi-square test or Fischer's exact test, as appropriate. The Mann–Whitney U test is a nonparametric test of the null hypothesis that it is equally likely that a randomly selected value from one sample is less than or greater than a randomly selected value from a second sample. Z-test (Standard Normal Deviate) was used to test the significant difference in proportions. The correlation was calculated by Pearson correlation analysis. Multivariate analysis was performed by logistic regression method for the calculation of risk factors.

The Kaplan–Meier estimator (Kaplan-Meier survival analysis) was a non-parametric statistic used to estimate the survival function from time data. Once a t value is determined, a p-value can be found using a table of values from Student's t-distribution. If the calculated p-value is below the threshold chosen for statistical significance (usually the 0.10, 0.05, or 0.01 level), then the null hypothesis is rejected in favor of the alternative hypothesis. $p\text{-value} \leq 0.05$ was considered statistically significant.

RESULTS.

Table 1: Distribution of age.

Age group (years)	n (%)
51-60	36 (34.6)
61-70	34(32.7)
71-80	16(15.4)
81-90	18(17.3)
Total	104(100)

n: number of subjects

The mean age (Yrs.) (mean±s.d.) of patients was 66.6827± 10.1247.

Table 2: Distribution of Incision Site and Shape.

Incision Site	n (%)
Gr-1 (ST)	20(19.2)
Gr-2 (SU)	61(58.7)
Gr-3 (T)	23(22.1)
Total	104(100)
Incision shape	
Gr-1 (Fr)	46(44.2)
Gr 2 (St)	55(52.9)
Gr 3 (inverted V)	3(2.9)
Total	104(100)

ST (Supertemporal), SU (superior), T (temporal) incision site.
Frown (Fr) shaped, straight (St) incision

Table 3: Distribution of SIA (ATR/WTR/OBL) in Post-operative 1st week.

Parameters	Post-operative 1st week: n (%)	Post-operative 1st month: n (%)	Post-operative 3rd month: n (%)
ATR	74(73.3)	74(73.3)	62(73.3)
OBL (Oblique)	6(5.9)	7(5.9)	7(6.9)
WTR	21(20.8)	20(20)	30(19.8)
Total	101(100)	101(100)	99(100)

D- diopter

Student's Journal of Health Research Africa
Vol. 4 No. 12 (2023): December 2023 Issue
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Original article

Table 4: Comprising of Astigmatism.

Astigmatism power (D)	Pre operative astigmatism: n (%)	Astigmatism postoperative1st week: n (%)	Astigmatism postoperative 1st month: n (%)	Astigmatism postoperative 3rd month: n (%)
<1 (Gr-1)	50 (48.1%)	54 (51.9%)	57 (54.8%)	57 (54.8%)
1-2 (Gr-2)	38 (36.5%)	31 (29.8%)	28 (26.9%)	28 (26.9%)
2-3 (Gr-3)	11 (10.6%)	15 (14.4%)	15 (14.4%)	15 (14.4%)
≥3 (Gr-4)	5 (4.8%)	4 (3.8%)	4 (3.8%)	4 (3.8%)
Total	104	104	104	104

Pre-Operative Astigmatism.

Preoperatively, 50 (48.1%) patients had <1D astigmatism,38 (36.5%) patients had 1-2 D astigmatism,11 (10.6%) patients had 2-3 D astigmatism, and 5 (4.8%) patients had ≥3D astigmatism. Astigmatism Power post-operative 1st week: In this study,54 (51.9%) patients had <1D astigmatism,31 (29.8%) patients had 1-2 D astigmatism,15 (14.4%) patients had 2-3 D astigmatism and 4 (3.8%) patients had ≥3 D astigmatism. Astigmatism Power post-operative 1st month and 3rd month was <1 D in 57 (54.8%) patients, 1-2 D in 28 (26.9%) patients, 2-3D in 15 (14.4%) patients and ≥3 D in 4 (3.8%) patients.

Table 5: Astigmatism Power (D) All Parameters.

	Number	Mean	SD	Minimum	Maximum	Median
Pre-Operative Astigmatism	104	.8702	.8295	0.0000	3.0000	1.0000
Astigmatism Power Post-Op. 1st week	104	1.0673	.9497	0.0000	4.5000	0.7500
Astigmatism Power Post-Op. 1st Month	104	1.0481	.9897	0.0000	4.5000	0.7500
Astigmatism Power Post-Op.3rdMonth	104	1.0601	.9782	0.0000	4.5000	0.7500

Table-6: SIA (D)all parameters.

	Number	Mean	SD	Minimum	Maximum	Median
SIA postoperative1stweek	104	.9459	.4530	0.0000	1.5000	1.0000
SIA postoperative 1st month	104	1.0144	.4723	0.0000	1.7500	1.0000
SIA postoperative 3rd month	104	1.0000	.4840	0.0000	1.7500	1.0000

Table 7: Comprising of SIA.

SIA power (D)	SIA postoperative1st week	SIA postoperative 1st month	SIA postoperative3rd month
<1 (Gr-1)	35 (33.7%)	34 (32.7%)	34 (32.7%)
1-2 (Gr-2)	69 (66.3%)	70 (67.3%)	70 (67.3%)
Total	104	104	104

Table 8: Comprising of SIA.

SIA	SIA postoperative1st week	SIA postoperative1st month	SIA postoperative 3rd month
ATR	74 (73.3%)	74 (73.3%)	74 (73.3%)
OBL	6 (5.9%)	7 (6.9%)	7 (6.9%)
WTR	21 (20.8%)	20 (19.8%)	20 (19.8%)
Total	101 (100.0%)	101 (100.0%)	101 (100.0%)

Student's Journal of Health Research Africa
Vol. 4 No. 12 (2023): December 2023 Issue
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Original article

Table 9: Sites of incision and mean astigmatism power.

Different Incisions Site	Astigmatism power (D) 3rd Month						
	Number	Mean	SD	Minimum	Maximum	Median	p-value
ST	20	1.1500	1.4987	0.0000	4.5000	0.8750	0.0347
SU	61	1.1885	.9021	0.2500	4.5000	1.0000	
T	23	.6413	.2902	0.2500	1.0000	0.7500	

Table 10: Mean SIA at postoperative 3rdmonth among.

Different Incisions Site	SIA Power 3rd Month						
	Number	Mean	SD	Minimum	Maximum	Median	p-value
ST	20	.9125	.3561	0.2500	1.5000	1.0000	<0.0001
SU	61	1.2828	.3044	0.5000	1.7500	1.2500	
T	23	.3261	.1757	0.0000	0.5000	0.2500	

Table 11: Mean astigmatism power (D) at postoperative 3rd month.

Different Incision Shape	Astigmatism power (D) postoperative 3 month						
	Number	Mean	SD	Minimum	Maximum	Median	p-value
Fr	46	1.0598	1.0880	0.0000	4.5000	0.7500	0.0452
St	55	1.0773	.9127	0.0000	4.5000	0.7500	
Inverted V	3	.7500	.0000	0.7500	0.7500	0.7500	

Table 12: Mean SIA POWER at postoperative 3rd month.

Different Incisions Shape	SIA (D) 3rd month						
	Number	Mean	SD	Minimum	Maximum	Median	p-value
Fr	46	.7880	.4563	0.0000	1.5000	1.0000	<0.0001
St	55	1.2182	.3940	0.2500	1.7500	1.5000	
Inverted V/chevron	3	.2500	.0000	0.2500	0.2500	0.2500	

Table 13: Correlation between pre- and post-operative astigmatism at 3rd month.

Pre-Operative Astigmatism Power (D)	Astigmatism Power (D) 3rd month	Remarks
Pearson Correlation Coefficient (r)	.363**	Positive correlation
p-value	<0.0001	Significant
Number	104	

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DISCUSSION.

This prospective observational study included 104 eyes of 104 patients undergoing cataract surgery (Manual SICS with PCIOL) with the same incision size of 5.5-6mm and follow-up for 3 months and patients were selected irrespective of age & and sex.
The mean age group of patients in this study was 66.6827±10. 1247. All patients had MSICS+PCIOL surgery out of which 20 (19.2%) patients had ST incision site, 61 (58.7%) patients had SU incision site, and 23 (22.1%) patients had T incision site. 46 (44.2%) patients had Frown (Fr) shape incision, 55 (52.9%) patients had straight (St)shape incision, and 3 (2.9%) patients had inverted V shape incision. At postoperative 1week-At postoperative 1week, 51 (49.5%) patients had ATR astigmatism, 11 (10.7%) patients had OBL astigmatism, and 41 (39.8%) patients had WTR astigmatism. 35 (33.7%) patients had <1D (Gr-1) SIA and 69 (66.3%) patients had >1D (Gr-2) SIA. 74 (73.3%) patients had ATR SIA at the postoperative 1st week, 6 (5.9%) patients had OBL SIA and 21 (20.8%) patients had WTR SIA.
At postoperative 1 month - 74 (73.3%) patients had ATR SIA at postoperative 1st month, 7 (6.9%) patients had OBL SIA, and 20 (19.8%) patients had WTR SIA.
At the postoperative 3rd month- 62 (62.6%) patients had ATR astigmatism, 7 (7.1%) patients had OBL astigmatism, and 30 (30.3%) patients had WTR astigmatism at the 3rd month. 34 (32.7%) patients had <1D (Gr-1) SIA,70 (67.3%) patients had >1D (Gr-2) SIA .74 (73.3%) patients had ATR SIA at 3rd month, 7 (6.9%) patients had OBL SIA at 3rd month and 20 (19.8%) patients had WTR SIA.

The most common type of astigmatism seen in the postoperative 3rd month was ATR type (62.6%) and the most common incision given was superior incision (58.7%). Superior incision causes more ATR shift as the incision on the superior meridian causes flattening of the vertical meridian and steepening of the horizontal meridian leading to more ATR shift postoperatively. This finding matches with the Hazra et al study [15]. A comparison of preoperative and postoperative astigmatism in the study by Gokhale et al is depicted [16].

Table 14: A comparison of preoperative and postoperative astigmatism in the study.

Name of study	Preoperative astigmatism (D)	Postoperative astigmatism (D) (45th postop day)
by Nikhil S. Gokhale et al	1.5	1.28

In our study SIA in the post-operative 1st month was 1.01 and in the post-operative 3rd month was 1.00. In the ST (superotemporal) incision site, the mean astigmatism postoperative 3rd month (mean± s.d.) of patients was 1.1500± 1.4987. In the SU (superior) incision site, the mean astigmatism postoperative 3rd month (mean± s.d.) of patients was 1.1885± .9021. In the T (temporal) incision site, the mean astigmatism at the postoperative 3rd month (mean± s.d.) of patients was .6413± .2902. The distribution of mean astigmatism power at the postoperative 3rd month with different incision sites was statistically significant(p=0.0347). In this study mean astigmatism at the postoperative 3rd month was found to be higher in the SU (superior)incision as compared to the ST (superotemporal) incision site and least in the T (temporal) incision site which was found to be statistically significant. (p value=0.0347). In the ST incision site, the mean SIA at postoperative 3rd month (mean± s.d.) of patients was .9125± .3561. In the SU incision site, the mean SIA at postoperative 3rd month (mean± s.d.) of patients was 1.2828± .3044. In the T incision site, the mean SIA postoperative 3rd month (mean± s.d.) of patients was .3261±. 1757.In this study the mean SIA was found to be higher in superior (SU) incisions as compared to superotemporal (ST) incisions and least in temporal incisions. The distribution of mean SIA at the postoperative 3rd month with the incision site was statistically significant (p<0.0001). Gokhale and Sawhney studied SIA in MSICS using a 6mm frown incision,1.50mm from limbus at different locations [16]. They reported an SIA of 1.36±1.03D in superior incisions,0.51±0.49D in superotemporal incisions, and 0.40±0.40D in temporal incisions by vector method [17]. Kimura. H et al 53 (1999) studied 6-8.5mm incisions in MSICS using superior or superotemporal sites. They found SIA of 1.41±0.72D in the superior incision group and 1.02±0.66D in the superotemporal group which shows slightly higher results than this study [18]. This is probably because the incision length was between 5.5-6mm in this study. In Fr (frown) shape incision, the mean astigmatism at postoperative 3rd month (mean± s.d.) of patients was 1.0598± 1.0880. In St (straight) incision, the mean astigmatism at postoperative 3rd month (mean± s.d.) of patients was 1.0773± .9127. In inverted V incision, the mean astigmatism at postoperative 3rd month (mean± s.d.) of patients was .7500± .0000 (the number of inverted V incision were very less i, e 3). The distribution of mean astigmatism at the postoperative 3rd month with different incision shapes was statistically significant (p=0.0452). In Fr incision, the mean SIA at postoperative 3rd month (mean± s.d.) of patients was .7880± .4563. In St incision, the mean SIA at postoperative 3rd month (mean± s.d.) of patients was 1.2182± .3940. In inverted V incision, the mean SIA at postoperative 3rd month (mean± s.d.) of patients was .2500±. 0000. In this study mean SIA was found to be higher in straight (St) incisions as compared to frown (Fr) shaped incisions and least in inverted V-shaped incisions (number of inverted V-shape incisions taken in this study were very less i, e 3). Distribution of mean SIA at the postoperative 3rd month according to different incision shapes was statistically significant

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(p<0.0001) in this study. Henning (2001) studied SICS using a 6-8mm chord length sutureless frown incision and reported an SIA of 0.66±0.41D/ [19]. The chevron-shaped incision has also been reported to give minimal SIA when compared with straight and frown incisions [20]. The value of the Pearson Correlation Coefficient (r) was .363**. A positive correlation was found between astigmatism power in 3rd postoperative month vs pre-operative astigmatism power (d). The P-value was <0.0001. The result was statistically significant.

SUMMARY.

All 104 patients underwent manual SICS with PCIOL with the same incision size of 5.5-6mm. The mean age of patients was 66.6827 years. Postoperative astigmatism in cataract patients who underwent MSICS with PCIOL was in the moderate range (1-2D) and the type of astigmatism depended upon the size and shape of the incision. Low postoperative astigmatism may be due to the small incision size i.e., 5.5-6mm in all 104 patients. ATR type of postoperative astigmatism was in 62.6% of patients at 3rd postoperative month. Mean postoperative astigmatism was higher as compared to mean preoperative astigmatism. Mean surgically induced astigmatism was 1D±0.4840 at the postoperative 3rd month. Superior incision caused most commonly ATR type of astigmatism postoperatively. Superior incisions induced more postoperative astigmatism as well as surgically induced astigmatism as compared to supratemporal and temporal incisions. Superotemporal and temporal incision consistently induced less astigmatism as compared to superior incision in MSICS. Straight incision induced more postoperative astigmatism as well as more surgically induced astigmatism as compared to frown and inverted V / Chevron incision. Frown-shaped incisions and inverted v/chevron incisions consistently induced less postoperative astigmatism as compared to straight incisions.

CONCLUSIONS.

Cataract is the major cause of worldwide blindness with the majority of cases in developing countries. The site, size, and shape of incisions used in MSICS influence postoperative surgically induced astigmatism. The control of postoperative astigmatism and surgically induced astigmatism has added a unique dimension to cataract surgery with an emphasis more on the refractive aspect of surgery in the present era. Since lenticular astigmatism is eliminated with extraction of the cataract only the corneal astigmatism is considered when planning cataract surgery. So, an Incision at a steeper meridian is a simple, safe, effective procedure to correct mild to moderate preoperative astigmatism at the time of cataract surgery. Due to changes in the surgical orientation, temporal and supratemporal approaches may require little practice, if one considers preoperative astigmatism when selecting the location of incision in MSICS, one can minimize postoperative keratometry surgically induced astigmatism. A simple modification in incision placement produces comparable results to other sophisticated procedures & hence offers a way to attain better surgical outcomes with limited resources available in most of the setups.

LIMITATIONS.

The sample size was small due to the ongoing COVID-19 pandemic and lockdown. The study has been done in a single-center tertiary care hospital, so hospital bias cannot be ruled out. A multicentric study with a greater number of cases can improve the external validity of the study.

RECOMMENDATION.

Some surgeons recommend the use of a temporal incision to minimize SIA, as the temporal limbus is further forming the visual axis than the superior limbus.

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LIST OF ABBREVIATIONS.

MSICS- Manual small incision cataract surgery
SIA- surgically induced astigmatism
PCIOL- posterior chamber intraocular lens
K- keratometry
ATR- against-the-rule
VA- Visual acuity
IOP- Intraocular pressure
SRK- Sanders-Retzlaff-Kraff
HIV- Human Immunodeficiency Virus
HBsAg- Hepatitis B surface antigen
RBS- Random blood sugar
FBS- Fasting blood sugar
WTR- with-the-rule
SPSS- Statistical Package for Social Sciences

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CONFLICT OF INTEREST.

The authors report no conflicts of interest in this work.

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