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Comparison of Surgically Induced Astigmatism Following Manual SICS: Superior and Temporal Approach

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Abstract:

Aim: The operable cataract cases in the developing world is high compared to the cataract surgical rate, and economical and effective methods are required to deal with this curable blindness, in order to provide the highest achievable uncorrected distance visual acuity. This study aimed to compare the surgically induced corneal astigmatism in patients undergoing manual small incision cataract surgery by superior (s-MSICS) and temporal (t-MSICS) scleral tunnel incisions.

Methods: Prospective, interventional cases series of 60 eyes of 60 patients. Uncorrected distance visual acuity (UDVA), mean keratometry (K_{Mean}) and surgically induced astigmatism (SIA) were the main outcome measures which were compared between the two groups, s-MSICS and t-MSICS.

Results: The mean patient age was 58.60 ± 7.11 years and 59.63 ± 8.39 years in the s-MSICS and t-MSICS groups respectively. Uncorrected distance visual acuity (UDVA) on day 90 was 0.27 ± 0.14 logMAR in the s-MSICS group and 0.18 ± 0.16 logMAR in the t-MSICS group (p=0.05). At the final assessment s-MSICS had 1.43 ± 0.99D of SIA and t-MSICS had 0.76 ± 0.66D of SIA (p=0.02). Four patients in the s-MSICS group and 25 patients in the t-MSICS group had WTR astigmatism (p<0.001). Likewise, there were 26 cases of ATR and one case of ATR in the s-MSICS and t-MSICS respectively (p<0.001).

Conclusion: In this prospective study, t-MSICS had significantly lesser surgically induced astigmatism than s-MSICS. The temporal incision decreased against the rule astigmatism, as well, which is the astigmatism prevalent in the adult population.

Keywords: Surgically induced astigmatism, manual small incision cataract surgery, cataract surgery, astigmatism, keratometry.

Introduction

The number of operable cataract eyes with visual acuity less than 6/60 is increasing by 4–5 million/year. The cataract surgical rate (CSR) in the world is approximately 10 million/year, rates varying from 100 to 6000 operations/million population/year. The CSR has to be at least as great as the incidence of operable

cataract. Several developing countries, like India have developed good quality cataract surgery at a reasonable cost close to where people live.[1] In India cataract is responsible for 50-80% of the bilaterally blind in the country.[2] Phacoemulsification is the favoured procedure in developed countries. For developing countries, manual small incision cataract surgery (MSICS) is affordable with encouraging results.[3]

Against the rule (ATR) astigmatism increases with age whereas with the rule (WTR) astigmatism decreases with age.[4] Astigmatism induces distortion of images. There is 0.3% image distortion per diopter of astigmatism.[5] Uncorrected astigmatism causes blurred image, glare and/or monocular diplopia. Even with appropriate spectacle correction the meridional magnification may create distortion. Any of these effects may create not only dissatisfaction with visual outcome, but also discomfort with an otherwise uneventful surgery.

The site, length, shape and depth of the cataract incision are a few important parameters that influences postoperative astigmatism. These factors allow the surgeon to tailor the wound parameters to suit individual cases to achieve the goal of emmetropia. An incision of the cornea or sclera creates tissue gape. As shown by Merriam et al, this gape causes corneal flattening along the meridian of the incision and steepening in the meridian 90˚ away, with several factors determining the magnitude of this effect.[6]

There have been a few studies conducted in Indian population, comparing the astigmatism induced by superior and temporal MSICS and phacoemulsification,[7-9] but none of them have taken all subjects who have preoperative nil astigmatism.

METHODS

Study design

A prospective comparative randomized study was done in a tertiary eye care center in North India for a period of 1 year. Thirty patients were randomized by simple randomization into the group s-MSICS (patients undergoing MSICS through superior approach) and 30 patients into t-MSICS group (patients undergoing the procedure through temporal approach). The study was approved by the Institute Ethics Committee. Written, informed consent was obtained from all patients and the procedure followed in the study was in accordance with the Declaration of Helsinki.

Inclusion criteria

Inclusion criteria included patients of the age group of 40–70 years with uncomplicated immature senile cataract with cortical cataracts and grade three or less nuclear sclerosis. They should have completed all post-operative visits with the necessary investigations during the three months follow up period and have pre-operative keratometric astigmatism of 1.0D or less.

Exclusion criteria included patients with complicated cataract, congenital cataract, glaucoma, corneal scarring or degeneration, uveitis, immature cataract associated with other ocular diseases, previous history of ocular trauma and those who had undergone previous intra-ocular surgeries. Patients with intra-operative and post-operative complications and with pre-op oblique/irregular astigmatism were excluded as well.

Data collection

Study examinations were undertaken at baseline before the surgery, and postoperatively at day 1, day 7, day 45 and day 90. The baseline examination consisted of noting down the patients Unique Health Identification (UHID) number, age, sex; visual acuity using logarithm of the minimum angle of resolution (logMAR) chart; intraocular pressure (IOP) was recorded; slit lamp biomicroscopy was used for anterior

segment examination and fundus examination was done with 90D or 78D. At each visit, corneal astigmatism was measured by keratometer (Bausch & Lomb): K_H(Horizontal), K_V(Vertical) and axis. All cases had at least 3 consistent keratometry measurements. As there was no dearth of patients undergoing cataract surgery, we found a large number of patients with nil astigmatism. We, therefore, included only eyes with preoperative nil astigmatism and used simple randomization to randomize them into either group.

Surgical technique

All surgeries were conducted under aseptic and antiseptic conditions, by a single experienced surgeon (SK) and under peribulbar anesthesia. The incision architecture was similar in both groups. A 6mm, tri-planar scleral incision, 1.5mm from the limbus was made with a 15 number Bard Parker blade. It was given in straight line at the sclera, 1.5 mm behind the superior most part of the cornea at 90˚ (12 o' clock) position, for vertical incision and at 0˚(3 o' clock) position for left eye or 180˚(9 o' clock) position for right eye for the temporal incisions. Funnel shaped sclerocorneal pocket incision was created with crescent knife. Side port was made 90º to the right side of the scleral tunnel. Capsulorrhexis was performed with cystitome. Anterior chamber was entered with 3.2mm angled keratome 1.5mm into the clear cornea to create a self-sealing corneal valve. Hydro-dissection and hydro-delineation were performed with Balanced salt solution (BSS). Nucleus was delivered using irrigating wire vectis. Cortical matter was aspirated with Simcoe two-way irrigation and aspiration cannula. A single piece polymethyl methacrylate (PMMA) intraocular lens of 6 mm optic size and 12.5 mm total size was implanted into the capsular bag. Antibiotic-steroid eye drops were administered in post-operative period. Surgically Induced astigmatism was calculated using Surgically induced Astigmatism (SIA) Calculator version 1.0, a free software program. Preoperative and postoperative (day 90) uncorrected distance visual acuity (UDVA), keratometric readings (K_{Mean}) and SIA were used for final analysis. Amplitude of preoperative and postoperative astigmatism was calculated from the difference in the keratometric value in the steeper and flatter meridians, using the plus cylinder notation and the vector directed towards the steeper meridian. For example, keratometry values of 44 x 90º and 44.5 x 180º would mean an astigmatism of 0.5D 180º.

Statistical Analysis

Statistical analysis was performed using Stata software (Stata 12.3, Stata Corp LLC, Texas, USA). Descriptive statistics – mean, standard deviation and range were determined. Chi square test, unpaired t test and Mann Whitney U test were used as the tests for statistical significance. For all analysis, a P-value of <0.05 was considered to be statistically significant.

RESULTS

A total of 60 patients were operated, 30 in each group. The mean age of the patients in the s-MSICS group was 58.60 ± 7.11years, range 43 to 70years and in the t-MSICS group it was 59.63 ± 8.39 years, range 40 to 70 years. [Table 1] The number of females in the study was 32 (53.33%) and the number of males was 28 (46.67%). [Figure 1] [Table 2].

UDVA on day 90 was 0.27 ± 0.14 logMAR in the s-MSICS group and 0.18 ± 0.16 logMAR in the t-MSICS group (p=0.05). UDVA on days 1, 7 and 45 in the two groups also showed statistical difference. [Table 3]

On day 1, there were 12 patients in s-MSICS group and 20 patients in the t-MSICS group who had WTR astigmatism (p=0.03). Whereas, 17 patients in the first group and ten patients in the second group had ATR astigmatism (p=0.06). [Table 4]

By the final assessment, day 90, four patients in the s-MSICS group and 25 patients in the t-MSICS group had WTR astigmatism ($p<0.001$). Likewise, there were 26 cases of ATR in the first group and one case of ATR in the second group ($p<0.001$). There was one case in the first group and three cases in the second group with nil astigmatism. [Table 5]

On day 90, the amount of WTR astigmatism in s-MSICS was 1.19 ± 0.69D and ATR astigmatism was 1.53 ± 1.01D. In t-MSICS WTR astigmatism was 0.90 ± 0.63D and ATR astigmatism was 0.25D.[Figure 2] [Table 5]

The mean SIA on day 1 was 1.34 ± 0.84D in the s-MSICS group and 0.92 ± 0.55D in the t-MSICS group ($p=0.04$). At final assessment s-MSICS had 1.43 ± 0.99D of SIA and t-MSICS had 0.76 ± 0.66D of SIA ($p=0.02$). [Table 6] Line charts show the relationship of the two groups with respect to amount of SIA and type of astigmatism from day 1 to day 90. [Figure 3] [Figure 4]

K_{Mean} at final assessment was 44.91 ± 1.16D in s-MSICS and 44.80 ± 1.44D in t-MSICS for patients having WTR astigmatism ($p=0.75$). While for patients having ATR astigmatism, it was 44.71 ± 1.96D in s-MSICS and 45.56 ± 0.97D in t-MSICS ($p=0.55$).

Six patients had minimal corneal oedema, 2 patients had minimal hyphaema and 1 patient had conjunctival retraction on the first post-operative day. One patient had zonular dialysis of approximately 4 clock hours and it was managed by endocapsular ring followed by IOL implantation in the bag.

DISCUSSION

Modern day cataract surgery aims not only at the 'Restoration of sight' and 'Reduction of economic blindness' but on an 'Early restoration of optimum visual acuity' and therefore reduction in SIA.

Our study correlates with the observation made by Reddy et al.[7] where they studied comparison of astigmatism induced by superior and temporal section in MSICS and compared the astigmatism in phacoemulsification. Conclusions were that temporal MSICS group had WTR shift in astigmatism and superior MSICS and phacoemulsification groups had ATR shift in astigmatism. Another study by Merriam et al,[6] assessed changes in horizontal and vertical meridians of cornea after cataract surgery using five different incision types. They found the 6 mm superior sclero-corneal tunnel induced ATR astigmatism and temporal sclero-corneal tunnel induced WTR astigmatism.

Our findings correlate well with the observation made by Kohnen T et al. who studied the corneal topographic changes that are induced by superior and temporal 5mm scleral pocket incisions and found there was mild flattening along with the meridian of the incision in both groups and the changes were greater with superior incisions. However, the differences between the groups were not statistically significant.[10] In the present study, the SIA in s-MSICS group was 1.43 ± 0.99D and in t-MSICS group it was 0.76 ± 0.66 ($p=0.028$). A study conducted by Malik et al, showed similar results with superior group having SIA of 1.45 ± 0.738D and temporal group having SIA of 0.75 ± 0.406D.[8]

Gokhale et al assessed SIA in MSICS using a 6mm frown incision at different locations. SIA reported was 1.36 ± 1.03D in superior incisions, 0.51 ± 0.49D in supero-temporal incisions and 0.40 ± 0.40D in temporal incisions. These values correlate with results of the present study.[9] Another study by Kimura et al, assessed 6–8.5mm incisions in MSICS using superior or supero-temporal sites. They found SIA of 1.41 ± 0.72D in superior incision group and 1.02 ± 0.66D in supero-temporal group which shows slightly higher results than the present study, probably because incision length was between 6-7mm in this study.[11] This is shown by Burgansky et al., that an increase in astigmatism occurs with increase in incision size. In their

study by vector analysis, the mean induced astigmatism was 0.6 ± 0.3D for 6mm incision, 0.75 ±0.67D for a 6.5mm incision and 1.36 ± 0.77D for a 7mm incision.[12]

There is immediate steepening of the vertical meridian and flattening of the horizontal meridian in case of incisions on the superior meridian. This is followed by a gradual flattening of the vertical meridian and steepening of the horizontal meridian.[4,13-20] However, in the case of temporal incisions, this does not lead to measurable changes in the horizontal and vertical meridians.[9] These findings also corroborate findings of our study. There was statistical difference in UDVA between the two groups in the study on all days of observation. Gokhale et al,[9] concluded that a shift in the incision site to the supero-temporal or temporal sclera is recommended except in patients with a pre-existing 'with the rule' astigmatism of about 1D.

A corneal scar which forms in a superior incision is closer to the visual axis. Eyelid blink and the effect of gravity create a drag on the incision.[21] These factors impart significant corneal shape changes resulting in high SIA. In case of temporally placed incision, these forces are neutralized better. Being free from the effect of gravity and eyelid blink and the fact that it is away from the visual axis, leads to less SIA. Most elderly cataract patients have preoperative ATR astigmatism, therefore, WTR astigmatism induced by temporal incision is advantageous.[8] Also, it is easier in deep-set eyes, it avoids the brow and allows the option of glaucoma filtering surgery in the superior limbal area, if required later.

Although our study was prospective in design, it had a number of potential limitations including the period of follow up, which was too short, corneal topographic changes were not analyzed and the sample size was small.

In conclusion, our results suggest that the temporal approach in MSICS has significantly lesser surgically induced astigmatism than the superior approach. The temporal incision decreased ATR astigmatism as well, which is prevalent in the adult population.

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Table 1: Patient demographics, baseline visual and keratometry parameters.

	s-MSICS	t-MSICS	*P*-value
Eyes (n)	30	30	
Age (years)	58.60 ± 7.11 (43 – 70)	59.63 ± 8.39 (40 – 70)	0.61*
UDVA (logMAR) ***Preoperative***	1.05 ± 0.34 (0.6 – 1.8)	1.11 ± 0.43 (0.6 – 1.8)	0.97†
K_{Mean} (D) ***Preoperative***	44.07 ± 1.91	44.72 ± 1.91	0.81*

*Unpaired *t* test, †Mann-Whitney *U* test, s-MSICS: superior manual small incision cataract surgery, t-MSICS: temporal manual small incision cataract surgery, n: number, UDVA: uncorrected distance visual acuity, logMAR: logarithm of the minimum angle of resolution, K_{Mean}: average keratometry, D: dioptre.

Table 2: Age and sex distribution in the s-MSICS and t-MSICS groups.

Age (Years)	s-MSICS				t-MSICS			
	Male	**Female**	**Total**	**%age**	**Male**	**Female**	**Total**	**%age**
40 – 50	1	3	4	13.33	1	2	3	10
51 – 60	6	8	14	46.67	4	7	11	36.67
61 – 70	9	3	12	40	7	9	16	53.33
Total	16	14	30		12	18	30	

s-MSICS: superior manual small incision cataract surgery, t-MSICS: temporal manual small incision cataract surgery, %age: percentage.

Table 3: Mean change in visual acuity over 90 days in the s-MSICS and t-MSICS groups.

	s-MSICS	t-MSICS	*P*-value*
UDVA (logMAR) ***Preoperative***	1.05 ± 0.34 (0.6 – 1.8)	1.11 ± 0.43 (0.6 – 1.8)	0.970
UDVA (logMAR) ***Day 1***	0.56 ±0.19 (0.2 – 1)	0.39 ± 0.18 (0 – 0.8)	**0.002**
UDVA (logMAR) ***Day 7***	0.38 ± 0.14 (0.2 – 0.6)	0.31 ± 0.14 (0 – 0.5)	**0.002**
UDVA (logMAR) ***Day 45***	0.30 ± 0.15 (0 – 0.7)	0.24 ± 0.12 (0 – 0.5)	**0.05**
UDVA (logMAR) ***Day 90***	0.27 ± 0.14 (0 – 0.5)	0.18 ± 0.16 (0 – 0.5)	**0.05**

*Mann-Whitney *U* test, s-MSICS: superior manual small incision cataract surgery, t-MSICS: temporal manual small incision cataract surgery, UDVA: uncorrected distance visual acuity, logMAR: logarithm of minimum angle of resolution.
Note: Significant *P*-values are given in bold.

Table 4: Type of astigmatism and the amount of surgically induced astigmatism (SIA) on Day 1 and Day 7 in the s-MSICS and t-MSICS groups.

Day 1	WTR astig (n)	SIA	ATR astig (n)	SIA	Nil astig (n)
s-MSICS	12	0.98 ± 0.71	17	1.68 ± 0.78	1
t-MSICS	20	1.15 ± 0.53	10	0.48 ± 0.21	0

***P*-value**	**0.03***	0.201†	0.06*	**<0.001†**	
Day 7					
s-MSICS	10	0.88 ± 0.70	19	1.79 ± 0.79	1
t-MSICS	22	1.33 ± 0.67	7	0.5 ± 0.35	1
***P*-value**	**0.004***	**0.05†**	**0.004***	**<0.001‡**	1

*Chi square test, †Mann-Whitney *U* test, ‡Unpaired *t* test, WTR: with the rule, astig: astigmatism, n: number, SIA: surgically induced astigmatism, ATR: against the rule, s-MSICS, superior manual small incision cataract surgery; t-MSICS, temporal manual small incision cataract surgery. Note: Significant *P*-values are given in bold.

Table 5: Type of astigmatism and the amount of surgically induced astigmatism (SIA) on Day 45 and Day 90 in the s-MSICS and t-MSICS groups.

Day 45	WTR astig (n)	SIA	ATR astig (n)	SIA	Nil astig (n)
s-MSICS	4	1.25 ± 0.91	22	1.52 ± 1.01	4
t-MSICS	21	1.06 ± 0.45	5	0.75 ± 0.40	4
***P*-value**	**<0.001***	0.791†	**<0.001***	0.108†	1
Day 90					
s-MSICS	4	1.19 ± 0.69	26	1.53 ± 1.01	1
t-MSICS	25	0.9 ± 0.63	1	0.25	3
***P*-value**	**<0.001***	0.409†	**<0.001***	0.158†	0.60

*Chi square test, †Mann-Whitney *U* test, WTR: with the rule, astig: astigmatism, n: number, ATR: against the rule, SIA: surgically induced astigmatism, s-MSICS: superior manual small incision cataract surgery, t-MSICS: temporal manual small incision cataract surgery. Note: Significant *P*-values are given in bold.

Table 6: Mean surgically induced astigmatism (SIA) on day 1, day 7, day 45 and day 90 in the s-MSICS and t-MSICS groups.

	s-MSICS	t-MSICS	*P*-value*
SIA *day 1*	1.34 ± 0.84 (0.75 – 1.75)	0.92 ± 0.55 (0.5 - 1.25)	**0.04**
SIA *day 7*	1.42 ± 0.89 (0.75 - 2.0)	1.09 ± 0.72 (0.5 -1.5)	0.16
SIA *day 45*	1.28 ± 1.04 (0.25 – 2.25)	0.87 ± 0.54 (0.5 – 1.25)	0.19
SIA *day 90*	1.43 ± 0.99 (0.75 – 2)	0.76 ± 0.66 (0.25 – 1)	**0.02**

*Mann-Whitney *U* test, s-MSICS: superior manual small incision cataract surgery, t-MSICS: temporal manual small incision cataract surgery, SIA: surgically induced astigmatism. Note: Significant *P*-values are given in bold.

Legends for figures

FIGURE 1 – Age and sex distribution in the s-MSICS and t-MSICS groups. Yrs – years.

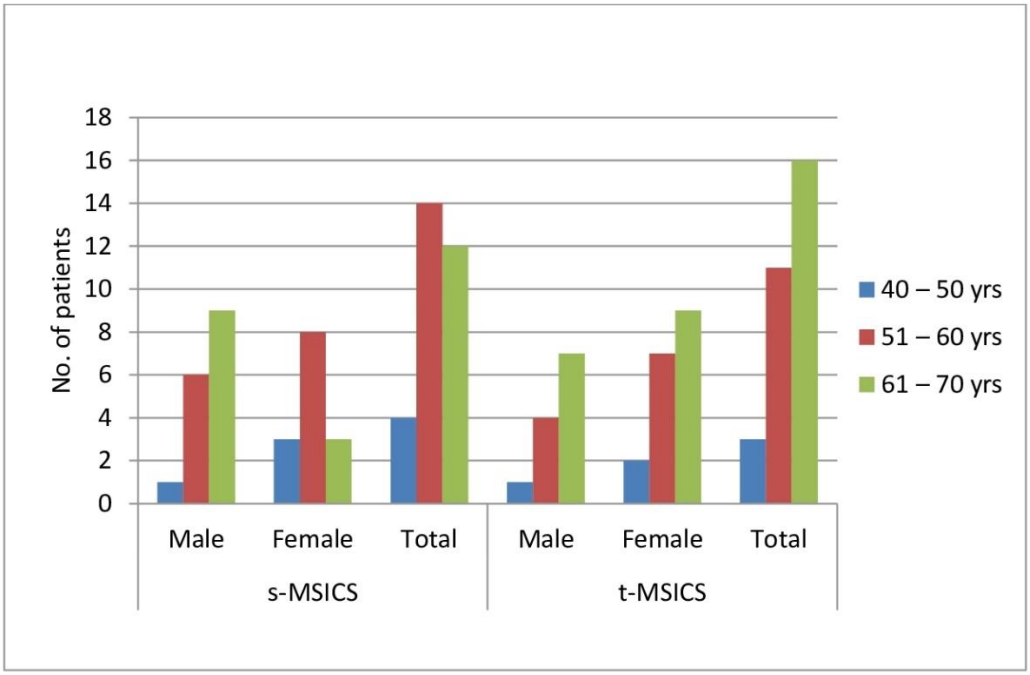

FIGURE 2 – Amount and type of surgically induced astigmatism (SIA) on day 90 in the s-MSICS and t-MSICS groups. WTR – with the rule; ATR – against the rule.

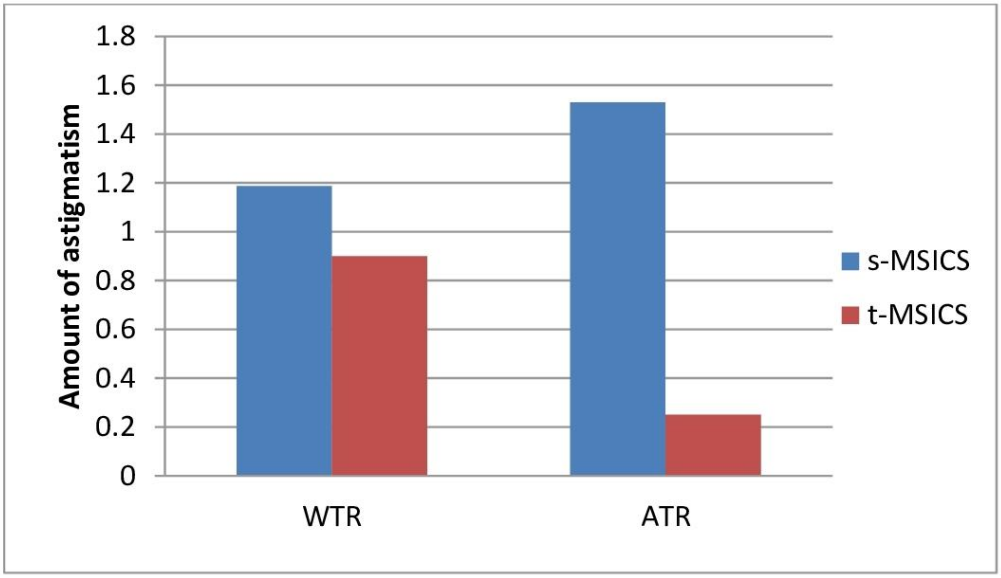

FIGURE 3 – Line chart showing the change in amount and type of surgically induced astigmatism (SIA) from day 1 to day 90 in the s-MSICS group. WTR – with the rule; ATR – against the rule.

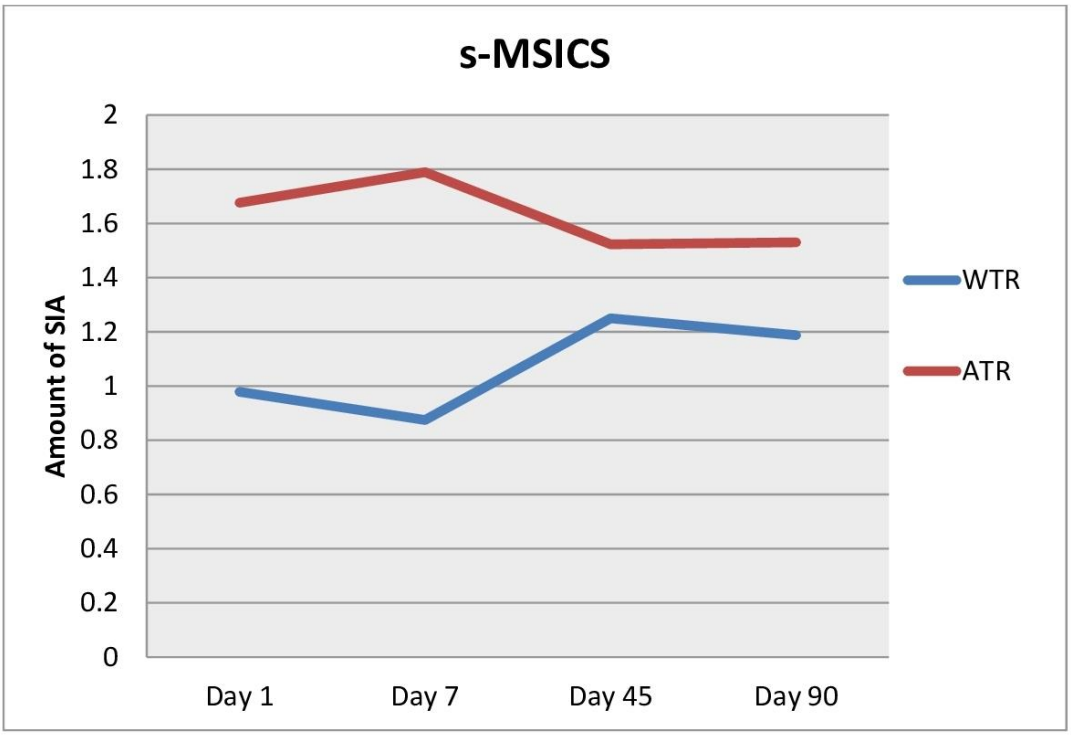

FIGURE 4 – Line chart showing the change in amount and type of surgically induced astigmatism (SIA) from day 1 to day 90 in the t-MSICS group. WTR – with the rule; ATR – against the rule.