SICS Tunnel Construction with Oblique Limbal Stab Incision and its Effectiveness in Self-Sealing, Nucleus Delivery and Astigmatism - Minimal Duration Cataract Surgery

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Abstract: Manual small incision cataract surgery SICS is very versatile surgery as it is easily modifiable, needs minimal instruments, no equipment dependence, can be performed quickly and at very low cost. The technique can be further simplified by constructing a limbo-corneal tunnel with controlled stab incision obliquely at the posterior limbus without superior rectus stitch, conjunctival flap or cautery. It reduces the overall surgical time to 9-12 minutes by eliminating many avoidable surgical steps and related complications. The technique has the advantages of both the approaches (scleral tunnel for SICS and corneal pocket for phaco) with comparable induced astigmatism than superior incision and better AC manipulations. Limbal incisions heal faster and resist more deformation pressure than cornea. The technique is comfortable to perform and visual outcome is equally good.

Keywords: Small incision cataract surgery, scleral tunnel, surgically induced astigmatism.

INTRODUCTION

The small incision cataract surgery (SICS) is as effective as phacoemulsification for visual rehabilitation of cataract patients [1]. Although phaco surgery is the best option in standard situation but its limitation of high cost and longer learning curve due to machines, foldable IOL, training and laser incision makes the surgery unrealistic for poor patients. It is more important when a cheaper and effective alternative of SICS is available. The concept of cataract surgery has changed from visual restoration to vision enhancement now. So the modern day surgery not only removes cataract along with IOL implantation but also corrects any pre-existing astigmatism by positioning the incision or giving a relaxing incision at the appropriate site. The entry in SICS is done through self sealing tunnel, which has the flexibility of location, size, and can be extended in complicated situation without changing the technique, as is required in complicated phaco.

The site of incision in cataract surgery varies from purely scleral in standard SICS to clear corneal incision in MICS. The clear corneal incision has the advantage of better AC approach during surgery but its limitation becomes apparent when it needs enlargement; either for implantation of rigid IOL or in complicated surgery, where suturing will be required and astigmatism will be significant. Similarly scleral incision has the advantage of lesser induced astigmatism, infections; despite large incision. But it makes surgery difficult particularly in hard cataracts, smaller pupil and deep set eyes.

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The sclero-corneal tunnel gives the advantages of both the approaches with lesser surgical induced astigmatism (SIA) and better AC manipulations. Limbal incisions heal faster and resist more deformation pressure than cornea [2]. In small incision cataract surgery, superior and temporal approaches are comparable in terms of visual rehabilitation and induction of regular and irregular astigmatism [3]. SICS is significantly faster, less expensive, and less technology dependent than phacoemulsification [4]. So this technique of tunnel construction in manual SICS with oblique limbal stab incision was studied and its effectiveness in self-sealing, nucleus delivery and astigmatism assessed. The results were compared with phaco surgery in terms of visual outcome, SIA, surgical duration and complications.

PATIENTS AND METHODS

Technique

The technique was carried out in all types and grades of cataract even where phacoemulsification could be difficult such as pseudoexfoliation, miotic pupil and hard cataracts. 100 patients undergoing oblique posterior limbal incision (6-7mm) cataract surgery were compared with another age and sex matched 100 patients undergoing posterior limbal incision (3.2mm) phacoemulsification surgery.

Direct Stab Incision

After application of wire speculum, the incision is given directly with keratome (3.2mm) through the limbal conjunctiva, where it is firmly adhered with the episclera, like a clear corneal incision in phaco. The tip

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of keratome is inserted just posterior to the limbus and slowly pushed through the limbal tissue (Figure **1**). Once the tip reaches in the cornea, the forward force is reduced and knife is slightly elevated initially to move along the corneal curvature and later dipped down into the anterior chamber to make a sharp and straight entry. The optimal incision depth is usually one-half of the thickness of the limbus or about 0.3-0.4 mm.

The shape of external entry incision is straight or slightly curved and that of internal entry is straight (Figure **2**). The position of stab incision is oblique in supero-temporal quadrant in right eye and supero-nasal in left eye taking 10:30 clock hour of limbus as centre point. Since more space is available on the sides rather than at 12 o'clock limbus, that is supero-temporally in right or supero-nasally in left, so surgical manipulation is easier on sides in the absence of superior rectus suture.

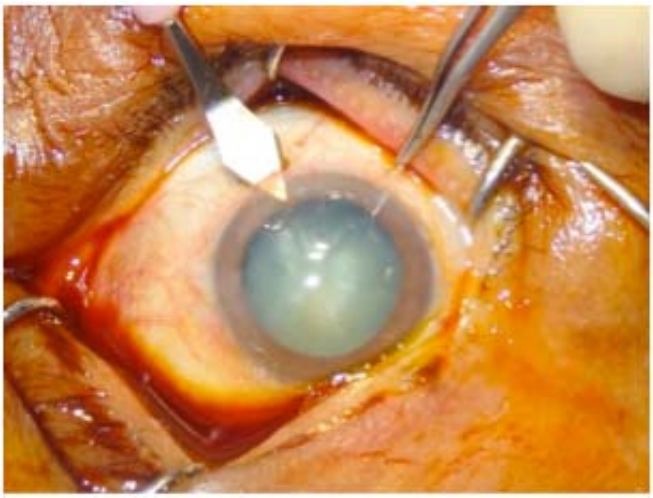

Figure 1: Direction and location of knife for oblique limbal stab incision.

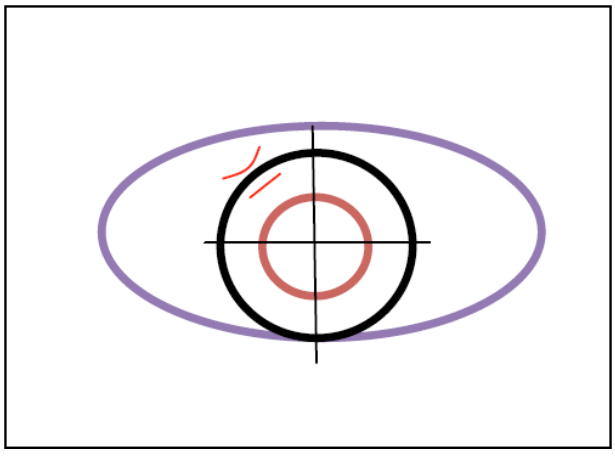

Figure 2: Position of stab between two standard corneal meridians.

The anterior limit of the tunnel is 1-2 mm in the clear cornea making a total width of tunnel from 2.5-3.5 mm depending upon the desired length of tunnel keeping the length to breadth ratio of 2:1. The direct stab incision passes through different tissue strengths of limbus and cornea which makes it self-sealing. It has better apposition due to the smoother opposing tunnel surfaces due to single initial stab. The tougher limbal tissue provides the external pressure to the outer incision at the same time aqueous pressure provides the internal sealing force to the inner incision.

Capsular Opening

The capsule can be opened with any type of capsulotomy or by capsulorrhexis, the best capsular opening is a continuous curvilinear capsulorrhexis (CCC); it guarantees the long-term, in the bag IOL. But CCC is more difficult to learn and can cause zonular dehiscence during rotation in big nuclei and weaker zonules. So rhexis should be either large in size for SICS or can be enlarged by giving relaxing cuts (2-3) on its margin with capsulotomy needle. It can be in the form of U shaped cuts (non-extending) or V cut deeper at zonular insertion (extends as radial tear) with tip of the needle and side of the needle tip respectively (Figures **3** and **4**).

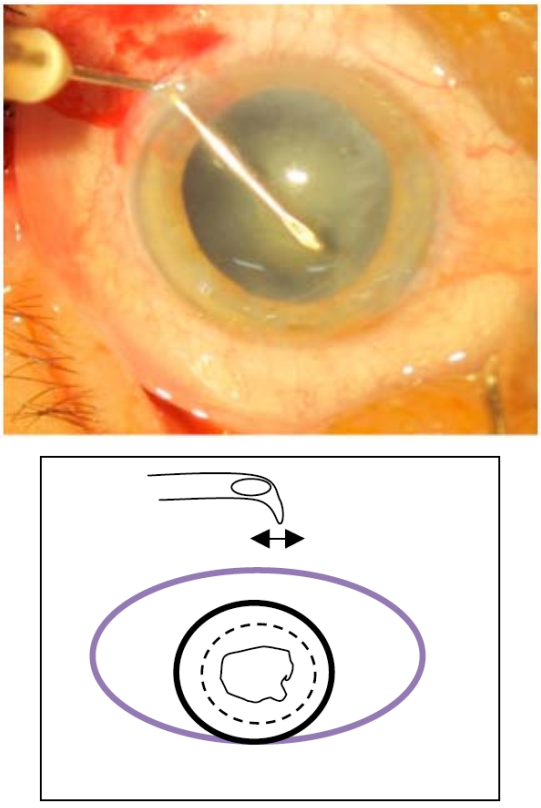

Figure 3: U-shaped extension cuts of rhexis (non extending cuts).

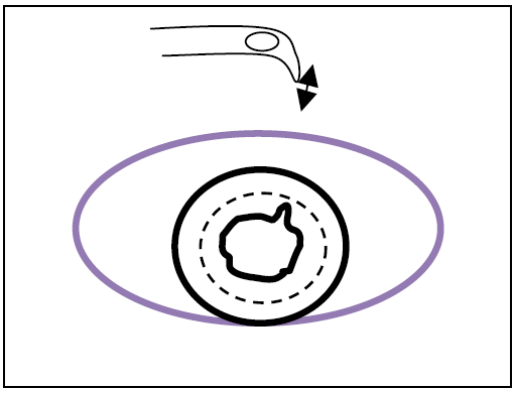

Figure 4: Deeper V-shaped extension cuts at rhexis edge (extending cuts).

The anterior radial tear prevents the stress on the zonules and facilitates delivery of nucleus during rotation in cases where cortico-nuclear mass is formed during hydro-procedures or in hard nuclei. But this radial tear does not affect the surgery rather helps in delivery of nucleus, pushing the upper haptic of rigid IOL in the bag and facilitates sub-incision cortex removal. So an anterior radial tear can be a curse during phaco surgery but can turn up blessing in SICS.

Self Sealing Tunnel

The tunnel is extended for SICS with 5.5 mm blade to the desired length based on the nucleus size (Figures **5** and **6**) and phaco is performed without extension. Care is taken while extending the tunnel, the extension blade is positioned straight in the stab and globe should be stabilized, so that external incision doesn't tear away. The length of the self sealing incision varies from 6-6.5 mm for cortical cataract, and can be extended safely from 7 to 8 mm for brown and hard grade IV cataract (Figure **8**). Tunnel can be extended prior to hydro-procedures, so that softer nucleus is delivered in a single step as dissection, delineation and hydro-delivery.

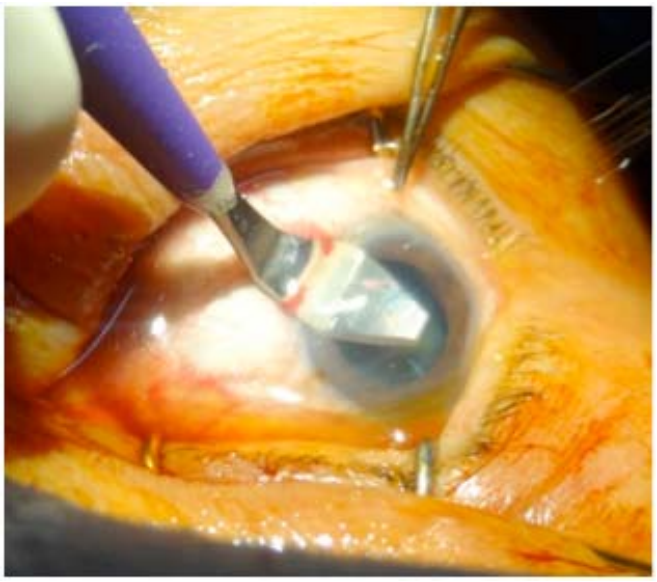

Figure 5: Tunnel extension prior to hydro-procedures for SICS.

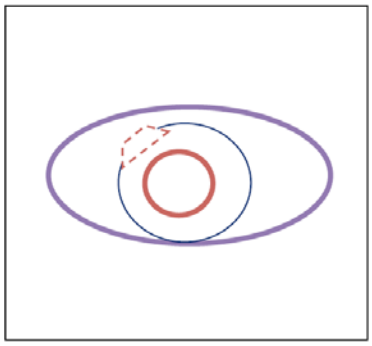

Figure 6: Extent of limbocorneal tunnel after extension at 9-12 at clock hour position.

OBSERVATIONS

The study was carried out on 200 patients undergoing uncomplicated cataract surgeries, which were divided into two equal groups, A -SICS and B - phaco. These groups were further subdivided into two subgroups - For right eye, oblique temporal posterior limbal incision (A_1, B_1) and for left eye, oblique nasal posterior limbal incision (A_2, B_2). The surgeries were carried out by single surgeon and standard preoperative, postoperative care and medications were given to both the groups. The procedure was studied in terms of astigmatism, visual outcome, surgical duration and complications.

The patients were subjected to standard preoperative evaluation such as visual acuity, slit lamp

Table 1: Pre Operative Keratometery Cylinder in Dioptre (D)

Keratometery	SICS (% age)	Phaco (%age)			
Cylinder Dioptre	A1(right eye)	A2 (left eye)	B1(right eye)	B2 (left eye)	Total
<0.25	7	2	5	7	21 (11.5%)
0.25-1	4	4	1	7	16 (8%)
1-1.5	32	42	37	28	139 (69.5%)
>1.5	7	2	7	8	24 (12%)
Total	50	50	50	50	200 (100%)

Table 2: Post Operative Keratometery Cylinder in Dioptre

Keratometery	SICS (% age)	Phaco (%age)			
Cylinder in Dioptre	A1	A2	B1	B2	Total
<0.25	0	0	0	2	2 (1%)
0.25-1	23	13	20	16	72 (36.0%)
1-1.5	27	34	25	30	116 (58%)
>1.5	0	3	5	2	10 (5%)
Total	50	50	50	50	200 (100 %)

examination, IOP recording, fundus, keratometery and biometry. Periodic follow up was done till 12 weeks postoperatively. Patients having some known associated disorder affecting surgical outcome were excluded from the study.

Keratometery was done to know the astigmatism and cylindrical axis as most of the eyes had hazy media due to cataract. The preoperative and post operative keratometery is shown in Tables **1** and **2**.

Mean surgically induced astigmatism was measured by auto refractometer at 6 weeks, which was less than 1 D in 86 % cases in both the groups (+ 0.62D ± 0.34 in Group A in 83% and + 0.46 D ± 0.39 in Group B in 89%) as shown in Table **3**. However, the induced astigmatism was further less in phaco group because of smaller incision and this difference was statistically significant with p - value - 0.0015.

Table 3: Surgically Induced Astigmatism

SIA in Dioptre	SICS	Phaco	Total	p- value
Nil	12	23	35 (17.5%)	0.0015
<0.25	0	3	3 (1.5%)	
0.25 -1	71	63	134 (67%)	
1-2	17	11	28 (14.0%)	
Total	100	100	200	

The mean surgical duration was 690 seconds in SICS and 926 seconds in phacoemulsification. The difference between the 2 groups was statistically significant (p value <0.0032) (Table **4**).

Table 4: Mean Surgical Duration

Duration	SICS	Phaco			
Time in seconds	Mean	SD	Mean	SD	p value
	690.09	104.60	1246.13	86.13	0.0014

The post-operative visual acuity after 12-weeks was 6/18 or better in 96% cases in SICS group and 98% cases in phaco group. It was between 6/24-6/60 in 4% cases in SICS group and 2% cases in phaco group (Table **5**). This difference in visually acuity at 12 weeks postoperatively was not statistically significant between the 2 groups (p-value 0.67).

Table 5: The Post Operative Visual Acuity after 12 Weeks

Visual acuity	6/6	6/9	6/12	6/18	6/24-6/60	Chi square	p-value
Group A	26	57	7	6	4	10.7	0.06
Group B	68	15	12	3	2		
Total	94	72	19	9	6	200	

Posterior capsular rent was seen in 1% of the cases in SICS group and 7% in phaco group. Subconjunctival haemorrhage was the commonest postoperative finding in SICS group in 16 % of the cases and 5% in

phaco. Striate keratopathy was common complication in 21% in phaco group and it was 13% in SICS group. The mild hyphema was seen in 2% cases in SICS, which was self resolving. PCO was seen in 12 % of the cases in SICS and 5% in phaco. All complications were managed appropriately. None of the patient had leaking AC or required suturing (Table **6**).

Table 6: Complications in Oblique Limbal Stab Incision

Complications	SICS	Phaco	Total	p-value
Hyphema	2	1	3	0.73
Post capsular rent	1	7	8	
Subconjunctival haemorrhage	16	5	21	
Striate Keratopathy	13	21	34	
Residual Cortex	2	7	9	
Tunnel leakage/infections	0	0	0	
Posterior-capsular opacification	12	5	17	
Total	45	39	84	

ADVANTAGES

Minimal Duration Surgery

This technique reduces overall surgical time to 9-12 minutes by eliminating many surgical steps such as superior rectus stitch, conjunctival flap and cautery (Table **4**). Average time required for standard MDCS (Minimal duration cataract surgery) was 6-9 minutes [5] but one should always concentrate on good surgery rather than duration.

Easier Nucleus Delivery

The nucleus can be delivered in any of the three ways. It can be done either by hydro or visco or vectis delivery. In small soft nucleus and fully opened eye lids, it can be done in a single step where hydro-dissection, delineation and delivery (D3) are done simultaneously. The nucleus is hydro-delineated and lifted up simultaneously out of the capsular bag and engaged in the tunnel, which is opened with the back of hydro-cannula, and fluid is pushed towards 6 o'clock position and nucleus comes out easily with least damage to the endothelium (Figure **7**).

Options during Difficult Situations

The hydro-delivery is not possible in deep set eye, rigid pupil, exfoliation syndrome and in narrow palpebral fissure. In such situations visco delivery or vectis delivery is done, while holding down the eye at 5-6 clock hour limbus with one hand and delivery done with other. One can deliver nucleus by any of the methods such as sandwich [6] or nucleus bisection [7,8]. Nucleus delivery is more difficult in left eye.

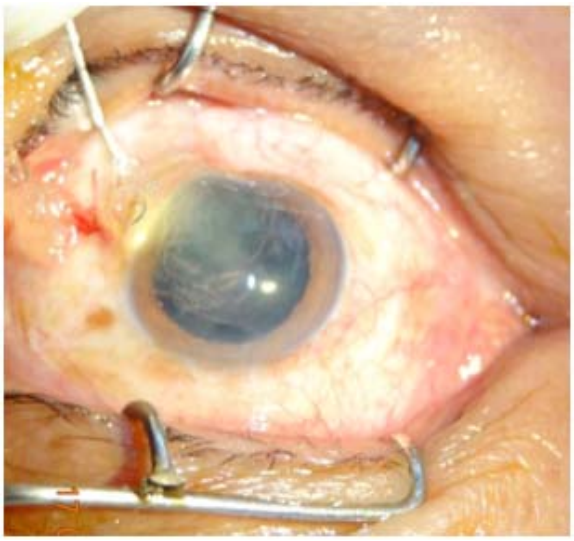

Figure 7: Nucleus delivery combined with Hydro-dissection and delineation.

Rigid IOL Implantation without Suture

Rigid IOL can be implanted without application of suture if the incision is on the posterior limbus instead of clear cornea (Figure **8**). A larger corneal incision requires suturing which adds cost and additional procedure to remove and also increases astigmatism. One can perform phaco surgery through the limbal tunnel if rigid IOL is planned with phaco. This will neither require suturing nor will have post operative astigmatism as happens in large corneal incision.

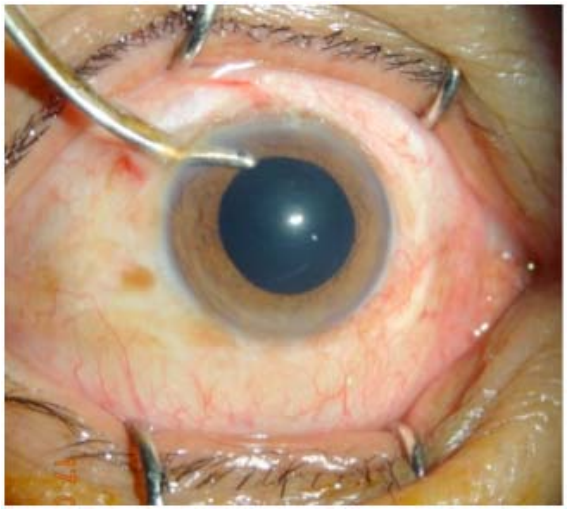

Figure 8: IOL implanted.

Minimal instruments are required for the technique and the steps of surgery are also less. During a standard procedure only 5 instruments are required i.e. wire speculum, two forceps (Hoskin's, Mc-pherson's) Sinsky's hook, cannula 2-way and two blades, 26 G needle.

Lesser Astigmatism

Surgically induced astigmatism is lesser or equal in temporal incision as compared to superior incision of SICS [3, 9]. In this study it was <1 D in 83 % cases in SICS because part of the tunnel is scleral and lack of cautery and smooth incision reduces the fibroblastic reaction and scarring. The position of the oblique incision is away from the two primary meridians (90^o and 180^o) of cornea. Very big, brown nuclei require longer tunnel, so flexible incision makes that possible at any stage of surgery. However, larger tunnels are also self-sealing and don't need suturing, provided they are prepared correctly. If there is doubt about the self-sealing effect, the surgeon may apply one or two sutures at the end of surgery. The studies have shown that surgically induced astigmatism is less with an oblique incision than with a superior incision due to arrangement of fibres in the sclera that makes this a tight and least astigmatic tunnel [10].

PRECAUTIONS

- The instruments used for direct oblique tunnel construction such as keratome and 5.5 mm blade has to be sharp to avoid Descemet's detachment during entry and ragged cutting during tunnel extension.

- Visibility of keratome through the tissue during insertion is the rough guide to access the appropriate depth of the tunnel. Partial visibility of keratome during its passage through the sclero-limbal tissue will indicate the proper depth. If it is seen clearly then it is too superficial and might perforate outside; if it is invisible it is too deep to make premature entry into the anterior chamber.

- The position of tunnel has to be at least 1-1.5 mm in opaque limbal area and 1-2 mm in clear cornea; so that limbus makes part of the tunnel and attaining a total width of 2.5-3.5 mm.

- Extra care is taken while extending the tunnel as whole length of the tissue needs to be incised on both sides of the tunnel, contrary to the pre-formed cleavage in SICS tunnel. In order to ensure the symmetrical outer (smiling) and inner (straight) incision, 5.5mm blade is gently pushed with its tip in AC and sides are extended by stabilizing the globe well.

- Bleeding from the limbal vessels is minimal and it does not interfere in surgery as blood does not enter through the self sealing tunnel. Rarely hyphema can occur from perforating vessels in tunnel, if it is positioned posteriorly or vessel comes on the way while extending the tunnel. In order to reduce the risk of postoperative hyphema ensure that there is no leakage of blood in AC at the end of surgery or one can inject an air bubble. Mild postoperative hyphema disappears in 1-2 days.

- Best way to deliver the nucleus is either by hydro-delivery or visco-delivery, if this is not possible vectis delivery is always possible by holding the eyeball in down gaze position. To avoid corneal endothelium damage during nucleus delivery, its rubbing with the cornea must be avoided by injecting viscoelastic in front of it and tunnel should be larger in big hard nuclei.

- Subconjunctival injection is given above the incision site that not only provides high concentration of drugs near the incision but ballooning conjunctiva also seals the entry (Figure **9**).

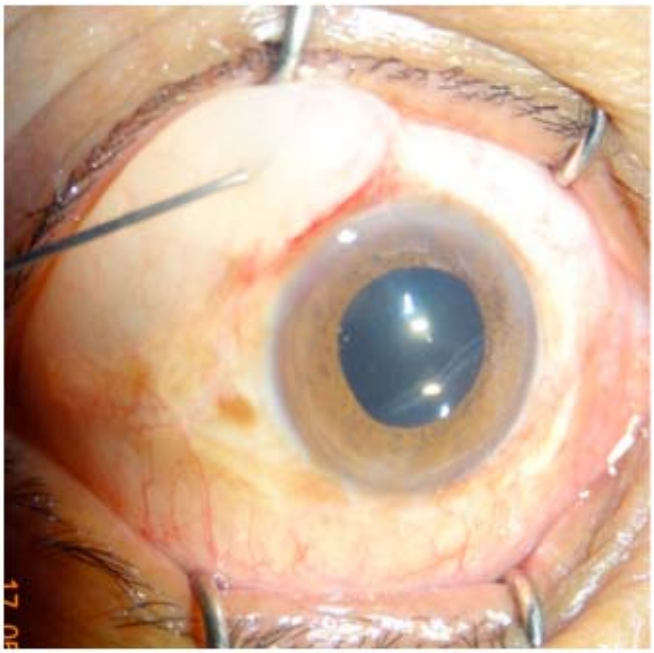

Figure 9: Subconjunctival injection at the end further help in sealing tunnel.

Figure 10: Minimal visible scar at four weeks post-operatively.

DISCUSSION

Cataract is not only the leading cause of blindness in the world but it is also an important cause of low vision in both developed and developing countries. The trend in cataract surgery is now towards correction of low vision and any existing refractive error. Even where surgical services are available, low vision associated with cataracts may still be prevalent, as a result of long waiting for operations, cost, and lack of information and transportation problems.

The techniques of cataract surgery have been continuously evolving since its first description by Indian surgeon, Sushruta (6th century BCE) [11]. Cataract surgery, using a temporal approach phaco-emulsification probe (in right hand) and chopper (in left hand) is being done across the world today. There could be some place for extra-capsular cataract extraction (ECCE) and intra-capsular cataract extraction (ICCE) but it is rarely performed that to in complicated situation. SICS is the simple, effective, cheap alternative procedure for management of cataract in the developing world.

SICS is a technique that allows lots of flexibility depending upon the patient need and surgeon's comfort. It needs minimal instruments, no equipment dependence and is easy to learn, can be performed quickly and at very low cost. It has good post operative visual results with least complications in trained hands. The post-operative visual acuity at 12 weeks was 6/18 or better in 96% cases in SICS group and 98% cases in phaco group (Table **5**). The surgery can be performed without application of superior rectus suture (truly stitch less) or construction of conjunctival flap or cautery [5].

To perform a successful SICS, pupil should be fully dilated and for rigid pupil iris hooks are applied or sphincterotomy should be done; capsule can be opened by any technique but rhexis has to be either large or extended by relaxing incisions. These could be either V or U shaped cuts and placed on the supero-temporal and superonasal part of the capsulorrhexis to facilitate nucleus delivery into the anterior chamber and also for the subsequent sub-incisional cortex aspiration [1,5]. These extensions also help in implantation of rigid IOL in the bag and they facilitate the delivery of corticonuclear mass out of the rhexis by getting extended as anterior radial tear without causing zonular dehiscence.

Although surgeon should be able to position his incision on the steep meridian of cornea around the patient's head; to convert the effect of induced astigmatism into the advantage by correcting any preoperative astigmatism. But in cases where no such positioning is required; the standard position for a right handed surgeon will be on the right side of both the eyes. This was the reason to position the incision on right side i.e. temporal in right eye and nasal in left eye.

The temporal location of incision in cataract surgery is farthest from the visual axis, and any flattening due to wound is less likely to affect the corneal curvature at the visual axis [8]. When incision is located superiorly, both gravity and eyelid blink tend to create a drag on the incision. These forces are better neutralized with temporal incision because it is parallel to the vector of the forces [12]. The study has shown that cataract surgery using supero-temporal incision in phacoemulsi-fication induced significantly less SIA in the early postoperative period [13, 14].

The site supero-temporal (right eye) or supero-nasal (left eye) incision provides more space on the sides than superiorly in the absence of superior rectus suture. Planes of incision and intraocular manipulations are more accurate as eye is straight with better fundal glow rather than in down gaze position, as occur in superior rectus suture. The tunnel is created as one step incision and 2nd step during extension; so the opposing surfaces are smoother for better sealing and healing. The closure placement of the tunnel to the limbus also facilitates delivery of nucleus.

The technique of direct limbal stab incision reduces the overall surgical time to 9-12 minutes by eliminating five surgical steps and related complications - superior rectus stitch, conjunctival flap, cautery, incision and tunnel making. The technique is comfortable to perform and visual outcome is good. A supero-temporal stab is given initially with 2.8 or 3.2mm keratome in right eye and supero-nasally in left eye. Phaco is performed through the stab tunnel and it is extended for SICS, rigid IOL or in complicated phaco with 5.5 mm blade to the desired length without any suturing.

The surgically induced astigmatism with oblique temporal incision is less than similar size superior SICS [9] but is more as compared to smaller size incision of phaco. Mean SIA at 6 weeks was less than 1 D in 83% of cases in SICS and 89% in phaco groups (+ 0.62D ± 0.34 in Group A and + 0.46 D ± 0.39 in Group B), the SIA was further less in phaco group because of smaller incision and this difference was statistically significant with p-value <0.0015. The technique can be performed in any stage or grade of cataract with comfort.

One could find this technique difficult in beginning and in deep set eyes, narrow palpebral fissure, non dilating pupil, pseudoexfoliation, hypotony, bleeding tendencies as is true for other techniques. The surgery is best performed under peribulbar block but is possible under topical anaesthesia as there is least tissue manipulation in absence of superior rectus stitch, conjunctival flap and cautery. So this technique can be performed by any surgeons with ease, who are either doing SICS to refine their technique or by phaco surgeons in difficult cases.

Subconjunctival haemorrhage was the commonest (16%) post-operative finding in SICS group and 5% in phaco group. The subconjunctival bleeding was due to the posteriorly located incision, where conjunctival vessels are present and cautery was not used. The striate keratopathy (SK) was the commonest (21%) complication in phaco group and it was seen in 7% of SICS group. Posterior capsular rent was seen in 1% of cases in SICS group and 7% in phaco group. SK and posterior capsular rent was higher in phaco group due to higher use of energy and manipulation in harder cataract (advanced ISC or MSC). As most patients in our setup opt for late surgery once they have significant visual loss (<6/60). All complicated phaco were converted to SICS with IOL implantation without suture an advantage of this technique. Mild hyphema was seen in 2% cases in SICS but did not require surgical intervention. None of the patient in the two groups with oblique limbal stab incision had leaking anterior chamber or endophthalmitis.

Although the clear corneal incision provide the benefits of shorter tunnel length, eliminate the need of cautery and shorter operative time but has limitation of more astigmatism, higher chances of infections [15] and will need suture if length of incision is larger than 3.2 mm and hence not suitable for SICS. So a direct posterior limbal incision has the advantages of both and the surgery is faster, AC approach is easy (even for phaco), lesser astigmatism and rigid IOL can be implanted without suture. The lesser duration of surgery is very important because it reduces the tissue manipulation and is useful in high volume surgery. The mean surgical duration was 690 seconds in SICS and 926 seconds in phacoemulsification. The difference between the 2 groups was statistically significant (P value <0.0032).

What was known?

Standard manual SICS is done by constructing a self sealing tunnel by using 4 different knives (incision blade, crescent knife, keratome and extension blade) after bridle stitch, conjunctival flap and cauterisation, which consume more time, requires multiple steps.

What this paper adds?

One can eliminate the steps of bridle stitch, conjunctival flap and cauterisation and self sealing tunnel can be made in single step by keratome 2.8 mm as done for phaco but at the posterior limbus and extended in second step. The technique is as effective, easy, less time consuming and eliminate the complications of these additional steps.

SOURCE(S) OF SUPPORT

Nil.

PRESENTATION AT A MEETING

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CONFLICTING INTEREST

Authors do not have any financial or conflicting interest to disclose.

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None.

DISCLOSURE

I/we certify that I/we have participated sufficiently in the intellectual content, conception and design of this work or the analysis and interpretation of the data (when applicable), as well as the writing of the manuscript, to take public responsibility for it and have agreed to have my/our name listed as a contributor. I/we believe the manuscript represents valid work.

KEY MESSAGES

The article describes an easier technique of SICS with equally good results as with other technique. The surgery is done without superior rectus stitch, conjunctival flap or cautery and hence the technique might open the way for SICS under topical anaesthesia.

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