Manual Small Incision Cataract Surgery: A Review

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Abstract: We aim at reviewing published peer-reviewed studies that evaluate the safety and efficacy of manual small incision cataract surgery (MSICS). Literature searches of the PubMed and the Cochrane Library databases were conducted with no date restrictions; the searches were limited to articles published in English only. All publications with at least level II and III evidence were studied and surgical techniques were analyzed. MSICS was also compared with phacoemulsification and large incision extracapsular cataract surgery (ECCE) with respect to visual outcome, surgery time, cost, intra and postoperative complications and suitability for high volume surgical practices in the developing world.

The overall safety profile of MSICS was found to be excellent with intra and postoperative complication rates comparable to phacoemulsification and ECCE. Multiple studies reported the safety and efficacy of MSICS for complicated cases, such as brunescent and white cataract and cataracts associated with phacolytic and phacomorphic glaucoma. Compared to phacoemulsification MSICS was associated with lower and shorter operative times. Visual outcomes were excellent and comparable to phacoemulsification with up to 6 months follow up.

The literature provides outcome analysis of a variety of different MSICS techniques. As a whole, MSICS provides excellent outcomes with a low rate of surgical and postoperative complications. Particularly in the developing world, MSICS appears to provide outcomes that are of comparable quality to phacoemulsification at a much lower cost.

Key Words: cataract, MSICS, developing world, high volume, small incision

Cataract is the leading cause of avoidable blindness worldwide, accounting for nearly half (47.8%) of all cases of blindness.[1] According to the World Health Organization, an estimated 20 million people worldwide are blind from bilateral cataracts, and this growing backlog poses one of the greatest public health challenges for the 21st century.[2] Tabin et al,[3] in their review on cataract surgery in the developing world, concluded that cataract accounts for almost 75% of cases of avoidable blindness. It is estimated that more than 90% of the world's visually impaired live in developing countries.[4] In these communities in particular, blindness is associated with considerable disability and excess mortality.[4] For these reasons, cataract blindness has a profound societal and economic impact through the loss of productivity of both the blind and those who care for them. Because of the significant reduction in life expectancy and quality of life for the blind, sight-restoring cataract surgery is undoubtedly one of society's most cost-effective medical interventions. The increase in economic productivity during the first postoperative year alone is estimated to exceed the cost of the surgery by a factor of 15.[5]

The cataract surgical rate (CSR) is an important public health metric, which represents the number of cataract operations annually performed per 1 million of population. There are significant variations in the CSR among different countries. As expected, the highest rates are seen in countries with the highest gross domestic product. The CSR in the most economically prosperous countries is usually between 4000 and 6000 cataract operations. India has dramatically increased its CSR in the last 20 years from less than 1500 to approximately 4000 currently. In the middle-income nations of Latin America and parts of Asia, the CSR ranges between 500 and 2000 per million per year. In most of Africa, China, and the poorer countries of Asia, the CSR is closer to 500 or less.[6] It is certainly surprising that China, which has experienced a 10-fold rise in its gross domestic product since 1978, has such a low CSR. This places China on a par with some of the poorest African nations.[5] Naturally, the rate of cataract blindness is increasing most rapidly in those countries with the lowest CSR. There is clearly a pressing need in the developing world to reduce the backlog of cataract blindness by increasing the CSR over current low rates.

To prevent a country's backlog of cataract blindness from increasing, the CSR must at least equal the annual rate of new cases of advanced cataract. There are many reasons for low CSRs in developing countries. Besides major factors such as lack of affordable care or access to cataract surgeons, less obvious barriers to delivering needed care include fear of surgery, cultural factors, and poor visual outcomes associated with poor surgeons and practices.[6] Because of this, having governments and nongovernmental organizations subsidizing the costs of cataract surgery alone is not enough.

Phacoemulsification (phaco) is the accepted standard for cataract surgery in the developed world. Although phaco is often available in the developing world, particularly to those cataract patients who can privately afford it, there are numerous disadvantages to this method for the poorest societies. Compared with manual extracapsular cataract extraction (ECCE), phaco requires a significant capital purchase and higher supply costs per case. Annual phaco machine maintenance is an issue not only of cost, but also of readily available qualified technical support. In addition, there is a longer learning curve for new cataract surgeons to master phaco, which is particularly challenging given the poorer educational infrastructure available to ophthalmologists in the developing world. Finally, the advanced mature cataracts and brunescent hard cataracts that are so prevalent among poor populations are more challenging to extract with phaco, and the complication rate is higher in most hands except in most skilled and experienced phaco surgeons.

Because of these problems associated with phaco in the developing world, alternative cataract surgical techniques such as sutureless manual small incision cataract surgery (MSICS) are gaining popularity. Manual small incision cataract surgery is able to achieve excellent outcomes with lower cost and average

surgical time than phaco. This review covers the history, surgical variations, clinical outcomes, and cost-effectiveness of MSICS and its suitability for high-volume cataract surgery settings.

HISTORY OF MANUAL SMALL INCISION CATARACT SURGERY

Classic Blumenthal Technique of Manual Small Incision Cataract Surgery

As phaco became more popular in the 1980s, ECCE techniques utilizing smaller incisions were also developed. In 1987, Blumenthal and Moisseiev[7] first described the use of an anterior chamber maintainer (ACM) in ECCE along with a reduction in incision size. The classic "Mininuc" MSICS procedure as described by Blumenthal uses the ACM to allow virtually all steps to be performed under positive irrigation pressure. After self-retaining placement of the ACM cannula, a side port is made, and a capsulotomy is performed. The scleral tunnel incision is made, and the hydro steps are carried out. The nucleus is guided out of the eye by a glide, and this maneuver is facilitated by the positive pressure generated by the ACM. Aspiration of the cortex is carried out through a side port aspirating cannula, whereas continuous irrigation is supplied by the ACM. The ACM is removed only after the intraocular lens (IOL) is inserted, and the incision is confirmed to be watertight.

Modifications to Manual Small Incision Cataract Surgery Technique

Another major modification in the technique of MSICS was later introduced by Ruit et al.[8] A 6.5- to 7-mm temporal scleral tunnel was created with a straight incision, starting 2 mm posterior to the limbus. A side-port incision was created to facilitate further intraocular manipulation. A V-shaped capsulotomy and hydrodissection were performed. Viscoelastic was injected above and behind the nucleus, which was then prolapsed into the anterior chamber. An irrigating Simcoe cannula with a serrated surface was inserted below the nucleus, before extracting it through the scleral tunnel. The remaining cortex was manually removed with the same Simcoe irrigation-aspiration cannula. After implanting a poly methyl methacrylate (PMMA) lens into the capsular bag, the unsutured scleral pocket incision was confirmed to be watertight.

Other significant modifications to the MSICS technique described in the literature relate either to the incision or method of nucleus delivery.

Variations in Incision

Kratz was the first surgeon to move the cataract incision posteriorly from the limbus to the sclera to enhance wound healing and reduce astigmatism. It was Girard et al,[9] who coined the term "scleral tunnel" incision. Singer[10] described the "frown incision," which was a modified scleral pocket incision, curved opposite to the natural limbal contour. The purpose of the frown configuration was to reduce wound-induced astigmatism. Lam et al[11] developed the sutureless large-incision manual cataract extraction technique as a modified manual ECCE technique specifically designed to allow less experienced surgeons in developing countries to reliably extract the nucleus through a self-sealing temporal scleral pocket incision. The salient features of this modified technique include (1) a medium to large scleral pocket incision (8-mm linear length) to permit safe and easy nucleus expression, (2) a long sclerocorneal tunnel (4 mm) to achieve a self-sealing sutureless wound, (3) a posterior incision location (2 mm posterior to the limbus) and a frown-shaped

wound configuration for astigmatic neutrality, and (4) the use of an ACM to facilitate nucleus delivery. Gokhale and Sawhney[12] compared the induced astigmatism with various scleral incision locations (superior, superotemporal, and temporal incision) for MSICS and found that surgically induced astigmatism was lower with the temporal and superotemporal incisions compared with incisions located superiorly.

Variations in Nucleus Delivery

Hydroexpression and Viscoexpression

Corydon and Thim[13] introduced the concept of hydroexpression or viscoexpression of the nucleus with the help of a specially designed bent cannula to deliver the nucleus through a continuous curvilinear capsulotomy. Several studies have confirmed the efficacy of this procedure.[14,15]

Sandwich Technique

Bayramlar et al[16] performed MSICS in 37 eyes using their sandwich technique. After capsulorrhexis, hydrodissection, and hydrodelineation, the nucleus was prolapsed into the anterior chamber and extracted by sandwiching it between the irrigating vectis and iris spatula.

Modified Fish Hook Technique

Hennig et al[17] reported data from 500 eyes in which MSICS was performed using the fish-hook technique for nucleus delivery. This technique utilizes a sclerocorneal tunnel, capsulotomy, hydrodissection, and nucleus extraction with a needle tip bent until it forms a sharply curved hook. The best corrected visual acuity was 6/18 or better in 96.2% of eyes at 6 weeks and in 95.9% at 1 year. The mean duration of surgery was 4 minutes. Intraoperative complications included 47 eyes (9.4%) with hyphema and 1 eye (0.2%) with posterior capsular tear and vitreous prolapse in the anterior chamber. Six weeks postoperatively, 85.5% of eyes had against-the-rule astigmatism, with a mean induced cylinder of 1.41 (SD, 0.8) diopter (D).

Use of Anterior Chamber Maintainer

Blumenthal and Moisseiev[7] described the use of an ACM during surgery. Its use was found to increase intraoperative safety, which was later confirmed in other studies as well.[18,19]

Irrigating Cannula

Nishi[20] described the use of an irrigating cannula for nucleus delivery. It consists of a 20-gauge needle attached with a flat insertion plate at 90 degrees to its axis with a flow outlet. The apex of the plate, with the flow outlet, is inserted beneath the nucleus during continuous irrigation, and the nucleus is expelled by the irrigating solution.

Manual Phaco Fracture

Bartov et al[21] described a technique for planned manual ECCE incorporating a modification of Mininuc ECCE, in which the scleral tunnel is made wide enough to allow a nucleus of any size to become lodged within the tunnel. A 5.0-mm, inverted-V "Chevron" frown incision is made in which the exposed part of the nucleus lodged in the scleral pocket can be manually sliced and fragmented until it is small enough to be removed through the incision. Vector analysis of preoperative and 3-month postoperative keratometric astigmatism in 30 patients showed that the surgically induced vector was 0.54 (SD, 0.58) D.

Nucleus Trisection

Kansas and Sax[22] described a technique in which the nucleus is manually split into 3 pieces using Kansas trisector and vectis, so that the resulting smaller fragments can be viscoexpressed through a small incision. Hepşen et al[23] performed MSICS by manual phaco trisection technique in 59 eyes of 54 patients. After capsulorrhexis and hydrodissection were performed, the endonucleus was prolapsed into the anterior chamber and trisected using an anteriorly positioned triangular trisector and posteriorly placed solid vectis. Postoperatively, best spectacle-corrected visual acuity of 20/40 or greater was achieved in 48 eyes (83%) and of 20/25 or greater in 28 eyes (47%). The most frequent intraoperative complication was posterior capsular rupture seen in 5 eyes (8.4%), and the most frequent postoperative complication was transient corneal edema, which developed in 32 eyes (54%); however, there were no cases of corneal decompensation.

Nuclear Management by Snare Technique

Keener[24] in 1983 was the first to snare the nucleus into halves and bring the fragments out through a sclerocorneal flap valve incision. A wire loop stainless steel snare is a single instrument with 2 cannulas with the wire loop in the tip of the first cannula. While pulling the second cannula, the wire loop constricts. When the wire loop is lassoed around the nucleus and constricted, it divides the hardest of nuclei into 2 pieces.

Sinskey Hook Method

Rao and Lam[25] described an MSICS technique using 2 Sinskey hooks to extract the nucleus from the capsular bag. The 2 Sinskey hooks are introduced through separate paracentesis entry sites. The left-handed hook is slipped under the capsulorrhexis, where it engages, rotates, and elevates the superior pole of the nucleus toward the incision. The second hook held in the right hand is placed beneath the elevated superior pole of the nucleus to prevent it from falling back into the bag as the first hook is retracted.

Visual Outcomes of Manual Small Incision Cataract Surgery

Three randomized prospective studies conducted in developing countries have compared phaco with MSICS. In these, MSICS was comparable to phaco in achieving excellent visual outcomes (Table 1).[26–28] Venkatesh et al[26] randomized 270 consecutive patients with white cataracts to phaco and MSICS and found that uncorrected visual acuity of 6/18 or better was achieved in 87.6% of eyes in the phaco group and 82% of eyes in the MSICS group by 6 weeks postoperatively. The corresponding best corrected visual acuity of 6/18 or better was achieved in 99% from the phaco group and 98.2% from the MSICS group by 6 weeks postoperatively.

Gogate et al[27] compared phaco with MSICS in a prospective randomized trial of 400 eyes and reported that uncorrected visual acuity of 6/18 or better was achieved by 81.08% of the phaco eyes, versus 71.1% of the MSICS eyes at 6 weeks postoperatively. The best corrected visual acuity was 6/18 or better in 98.4% of the phaco group and in 98.4% of the MSICS group at 6 weeks postoperatively. These studies suggest that both techniques achieved similar results in terms of best corrected visual acuity at 6 weeks.

Ruit et al[28] reported longer-term outcomes in a randomized prospective trial of 108 eyes in Nepal. The patients were randomized to MSICS or phaco, with each type of surgery performed by an acknowledged expert in that technique. They reported comparable rates of 98% achieving best corrected visual acuity of 6/18 or better at 6 months postoperatively. Uncorrected visual acuity was comparable at 6 months.

Gogate et al[29] prospectively compared traditional manual large-incision ECCE to MSICS. At 6 weeks postoperatively, MSICS achieved an uncorrected visual acuity of 6/18 or better in a higher proportion of patients compared with ECCE IOL. Slightly higher numbers of MSICS eyes achieved a best corrected visual acuity of 6/18 or better, but this was not statistically significant. A number of other studies[17,29–32] document good postoperative visual outcomes with MSICS (Table 2).

Surgical-Induced Astigmatism

Table 3 reports data from several studies comparing surgically induced astigmatism with phaco and MSICS at 6 weeks and 6 months postoperatively. At 6 months' follow-up, Ruit et al[28] reported mean astigmatism of 0.7 D for the phaco group and 0.88 D for the MSICS group. This difference was not statistically significant. At 6 weeks postoperatively, Gogate et al[27] reported mean astigmatism of 1.1 D for phaco and 1.2 D for MSICS, which was not statistically significant. Both studies used a foldable IOL in the phaco arm. Both Venkatesh et al[26] and George et al[33] reported that phaco caused significantly lesser surgically induced astigmatism compared with MSICS at 6 weeks postoperatively. This would explain the poorer uncorrected visual acuity levels at 6 weeks for the MSICS group. Another randomized trial[34] comparing surgically induced astigmatism associated with phaco and MSICS reported no significant difference at either the 6-week or 6-month follow-up examination.

Other MSICS studies report differences in surgically induced astigmatism based on incision size made and the type of tunnel (Table 4) construction. A prospective Japanese trial comparing 3.2-mm with 5.5-mm MSICS incisions found 0.3-D less surgically induced astigmatism when the smaller incision

TABLE 1. Percentage of Post-Operative Visual Outcomes of Phaco and MSICS

	UDVA						CDVA					
	Venkatesh et al[26] (at 6 wk)		Gogate et al[27] (at 6 wk)		Ruit et al[28] (at 6 mo)		Venkatesh et al[26] (at 6 wk)		Gogate et al[27] (at 6 wk)		Ruit et al[28] (at 6 mo)	
	Phaco	MSICS	Phaco	MSICS	Phaco	MSICS	Phaco	MSICS	Phaco	MSICS	Phaco	MSICS
6/6–6/9	45.1	36.4	36.8	31.6	53.7	31.5	92.0	83.8	77.8	85.6	94.4	88.9
6/6–6/18	42.5	45.3	44.3	38.5	31.5	57.4	7.1	14.5	20.5	12.8	3.7	9.2
6/24–6/60	11.5	16.6	18.4	28.9	14.8	11.1	0.9	1.7	1.1	1.6	1.9	1.9
<6/60	0.9	1.7	0.5	0			0	0	0.5	0		

UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity.

TABLE 2. Percentage of Post-Operative Visual Outcomes of MSICS

		UDVA			CDVA		
Study	Follow-Up	6/6–6/18	6/24–6/60	<6/60	6/6–6/18	6/24–6/60	<6/60
Venkatesh et al[30]	6 wk	43.9	51	5.3	94.4	4.0	1.6
Hennig et al[17]	6 wk	70.5	28	1.5	96.2	3.6	0.2
Trivedy[31]	4 wk	81.8	15.7	5.2	NA	NA	NA
Gogate et al[29]	6 wk	47.9	47.7	4.3	89.8	8.4	1.7
Venkatesh et al[32]	6 wk	78.4	21.5	0	97.1	2.9	0

UDVA, uncorrected distance visual acuity; CDVA, corrected distance visual acuity.

was used.[35] Additional MSICS studies report less surgically induced astigmatism with temporal and superotemporal scleral tunnel incisions compared with those located superiorly.[12,36] Common explanations for this observation are that temporal incisions are less likely to be affected by blinking and gravity.

Many studies conclude that phaco reduces surgically induced astigmatism at 6 weeks' follow-up compared with MSICS, although there is no significant difference in the longer term (Table 3). However, with the use of smaller and tunneled incisions located temporally, the astigmatism caused by MSICS can be lessened to a great extent, thereby improving the uncorrected visual acuity of MSICS in the short term as well (Table 4). Muralikrishnan et al[34] found that surgically induced astigmatism was approximately 1 D with MSICS and phaco, compared with approximately 4 D with ECCE.

Intraoperative and Postoperative Complications

Comparative complication rates reported for phaco and MSICS are presented in Table 5. All 3 prospective studies comparing phaco and MSICS reported their incidence of posterior capsule rupture (PCR) with each of the 2 techniques. In their study of white cataracts, Venkatesh et al[26] reported that PCR occurred in 2.2% of cases performed with phaco compared with 1.4% of cases performed with MSICS. Ruit et al[28] had a 1.85% PCR rate with phaco compared with none in the MSICS group. In a retrospective analysis of safety and efficacy of MSICS for brown and black cataracts, Venkatesh et al[26] encountered PCR in only 2% of their cases. However, Gogate et al[29] reported a slightly higher rate of PCR for MSICS (6%) compared with phaco (3.5%). In this study, a can-opener capsulotomy was used in the MSICS group, whereas Ruit et al[28] used a triangular capsulotomy in the MSICS eyes, whereas a capsulorrhexis was performed in the phaco group in both studies. Hence, capsulorrhexis appears to be best suited for MSICS to have reduced PCR, and MSICS fares better in terms of avoiding PCR compared with phaco.

Posterior capsule opacification (PCO) occurred more often in the MSICS group compared with the phaco group in the study of Ruit et al.[28] In that study, at the 6-month follow-up examination, 26.1% of the MSICS patients compared with 14.6% of the phaco patients had grade 1 PCO. The incidence of grade 2 PCO was 17.4% in the MSICS group and none in the phaco group. In this study, foldable IOLs with a square edge were used in the phaco patients, compared with a rounded-edge PMMA IOL in the MSICS patients, and only the phaco patients had a capsulorrhexis.

Postoperative endothelial cell loss was reported by George et al[33] to be slightly higher with phaco (5.41%) compared with MSICS (4.21%), but the difference was not statistically significant. In a clinical trial investigating the incidence of anterior chamber contamination, microbiological analysis comparing preoperative and postoperative aqueous samples revealed similar contamination rates in both the MSICS group (4%) and the phaco group (2.7%).[37]

The comparative incidence of endophthalmitis for phaco and MSICS has been reported in a retrospective observational series conducted at a single eye hospital.[38] Phacoemulsification had a statistically lower rate of endophthalmitis incidence (0.03%) as compared with MSICS (0.12%). The authors attribute this to the fact that more than 50% of MSICS patients in the study came from poor rural areas, where risk factors for infection, such as poor personal hygiene, malnutrition, poor sanitation, and lack of access to clean water were prevalent. These poor patients predominantly received charitable service, and MSICS was the procedure of choice because of the nonaffordability of phaco. The same study reported the lower incidence of endophthalmitis on private patients who had a better standard of living as compared with charitable patients. This incidence of endophthalmitis between MSICS (0.04%) and phaco (0.02%) was similar among private patients, evidencing that MSICS is as safe as phaco.

Comparing ECCE/IOL to MSICS, the rates of intraoperative and postoperative complications were similar in the 2 groups,

TABLE 3. Surgically Induced Astigmatism of Phaco and MSICS (in Diopters)

	At 6 wk		At 6 mo	
Study	Phaco	MSICS	Phaco	MSICS
Venkatesh et al[26]	0.80	1.20	—	—
Gogate et al[27]	1.10	1.20	—	—
George et al[33]	0.77	1.17	—	—
Ruit et al[28]	—	—	0.70	0.88
Muralikrishnan et al[34]	1.10	1.12	1.11	1.33

TABLE 4. Surgically Induced Astigmatism of MSICS According to the Type of Tunnel Constructed (in Diopters)

Study	Follow-Up	Superior	Superotemporal	Temporal
Venkatesh et al[32]	6 wk	1.08	—	0.72
Kimura et al[35]	6 wk	1.41	1.02	—
Gokhale and Sawhney[12]	12 wk	1.28	0.20	0.37
Reddy et al[36]	12 wk	1.92	—	1.57

TABLE 5. Percentage of Intraoperative and Postoperative Complications Related to Phaco and MSICS

Complications	Study	Phaco			MSICS		
PCR	Venkatesh et al[26]		2.2			1.4	
	Gogate et al[27]		3.5			6.0*	
	Ruit et al[28]		1.85			0	
PCO at 6 mo	Ruit et al[28]	None	1+	2+	None	1+	2+
		85.4	14.6	0	56.5	26.1	17.4
Endothelial cell count	George et al[33]		4.21			5.41	
Anterior chamber contamination	Parmar et al[37]		2.7			4	
Endophthalmitis	Ravindran et al[38]		0.03			0.12	

*Canopener capsulotomy.

except for transient postoperative corneal edema, which was more common following MSICS. However, by 6 weeks, there was no difference between the 2 types of surgery.[29]

Overall, complication rates between MSICS and phaco are comparable, except for the higher incidence of PCO with MSICS. Although not yet clinically studied, it is expected that square-edged PMMA lenses implanted with an overlapping capsulorrhexis would reduce the PCO incidence in MSICS.

Advantages of Manual Small Incision Cataract Surgery in the Developing World

As stated earlier, advanced and complicated cataracts are generally more prevalent in poor populations. The literature reports good visual outcomes and comparatively less complication rates when MSICS is used for complicated cases, such as brunescent cataract,[29] white cataracts,[26,39] and cataracts causing phacolytic and phacomorphic glaucoma.[40,41]

Another consideration in the developing world is the capability of performing higher-volume surgery. In terms of mean per-case surgical times, MSICS takes significantly less time than phaco (Table 6). Ruit et al[28] and Gogate et al[27] reported mean surgical times (including turnover) of approximately 15.5 minutes for phaco and 9 minutes for MSICS. In high-volume delivery systems, mean surgical times can be reduced to less than 4.5 minutes with MSICS.[30,43] In health care systems with limited access to ophthalmologists, improved surgical efficiency can increase the productivity of scarcest resource—the cataract surgeon.

Cost-Effectiveness in US Dollars

The cost per case of providing phaco ranges from $25.55 to $70, compared with $15 to $17 for MSICS (Table 7). The wide variation in the cost of phaco relates to the varying case volumes, over which the fixed costs of expensive instrumentation are spread out. For example, Muralikrishnan et al[44] reported a cost per case of $25.55 for phaco in a high-volume center in India.

The IOL cost also significantly impacts the overall cost per case. For instance, Ruit et al[28] reported a cost of $70 for phaco, of which $52 was the cost of the most expensive foldable acrylic IOL. In comparison, the cost of a PMMA lens used in MSICS was only $5. If a cheaper IOL were used instead of a foldable acrylic IOL, then the cost of phaco as estimated by Ruit et al[28] should be in the $25 range as reported by Muralikrishnan et al[44] and Gogate et al.[42] Compared with phaco, MSICS clearly reduces costs for the health care delivery system.[42] Phaco entails a larger initial capital expense, higher per-case consumable costs (phaco tips, sleeves and tubing), and higher ongoing maintenance costs.[44] Another disadvantage of phaco for some rural developing world settings is the requirement for a dependable source of electricity. In contrast, the only significant capital equipment expense for MSICS is the operating microscope, and this can be powered by a battery or small diesel generator.[44]

Finally, for a surgeon already experienced with manual large-incision ECCE, the learning curve for MSICS is shorter compared with that for learning phaco. Overall, compared with phaco, MSICS is a more cost-effective and financially viable option for many settings in the developing world.

High-Volume Cataract Surgery Using Manual Small Incision Cataract Surgery

The World Health Organization global initiatives have called for a dramatic increase in cataract surgical volumes worldwide.[45] To address the sizable backlog of cataract blindness in the developing world, Natchiar el al[46] advocated a high-volume, high-quality cataract surgery approach to maximize the productivity per individual surgeon. Such a high-volume system utilizing MSICS has been in place at the Aravind Eye Hospital System in southern India for more than a decade. Venkatesh et al[30] published the outcomes of 593 cataract surgeries performed by 3 Aravind surgeons utilizing this approach. The average surgical time averaged 3.75 minutes (16–18 cases/h). The outcomes retrospectively reported were excellent, with best corrected visual acuity of greater than 6/18 achieved in more than 90% of the patients operated on. Intraoperative and immediate postoperative complications occurred in 2% and 12% of

TABLE 6. Mean Duration (in Minutes) of Phaco and MSICS

Study	Phaco	MSICS
Ruit et al[28]	15.5	9
Gogate et al[42]	15.5	8.5
Trivedy[31]	—	4.25
Venkatesh et al[26]	12.2	8.8
Venkatesh et al[30]	—	3.75
Balent et al[43]	—	4

TABLE 7. Provider's Cost in US Dollars of Phaco and MSICS

Study	Phaco	MSICS
Muralikrishnan et al[44]	25.55	17.03
Gogate et al[42]	42.10	15.34
Ruit et al[28]	70	15

the patients, respectively, and the overall endophthalmitis rate was only 0.1%.

Although using MSICS reduces surgical times, maximizing operating room efficiency is equally important in achieving high-volume productivity.[30] For example, Venkatesh et al[30] describe that the Aravind operating room staff supporting a single surgeon includes 3 scrub nurses, 1 orderly, 1 circulating nurse, and 1 nurse to clean and sterilize instruments. To minimize surgical turnover time, the cataract surgeon rapidly alternates between 2 adjacent operating tables. A single floor-mounted microscope can be quickly repositioned to either of the 2 operating tables that it is positioned in between. While 1 patient is undergoing surgery, a second nursing team is positioning and preparing the next patient on the adjacent operating table. Ravindran et al[38] have reported on the asepsis and sterilization protocols followed at one of the Aravind eye hospitals engaged in high-volume cataract surgery. They found that short-cycle steam sterilization was safe and effective in maintaining a rapid turnover of the limited surgical instruments, and the endophthalmitis rate was low despite the high surgical volume.

Good results using high-volume MSICS in makeshift operating rooms in surgical camps have also been reported from other parts of the world.[28,43] With its excellent outcomes and lower surgical times and costs, MSICS demonstrates itself as the most appropriate technique for performing high-volume cataract surgeries, especially in developing countries.

In conclusion, compared with more affluent health care systems, there are a number of disadvantages to using phaco in rural, developing world settings. These include the higher capital, maintenance, and per-case costs; the higher proportion of advanced and mature cataracts; and the steeper learning curve for inexperienced surgeons. For these reasons, MSICS has emerged as a viable and preferable alternative for many such settings. In addition, the shorter procedural and turnover times of MSICS are compatible with high-volume operating room protocols, such as those uniformly used at a number of international eye centers in the developing world.

Several studies have demonstrated superior uncorrected visual acuities compared with large-incision ECCE and comparable uncorrected visual acuities compared with phaco. Complication rates for both routine and mature cataracts are comparable when phaco and MSICS are compared. Manual small incision cataract surgery appears to provide excellent outcomes at a fraction of the cost of phaco and with shorter surgical times. In the future, we need randomized controlled trials comparing MSICS and phaco with long-term follow-up to provide stronger evidence. As a cataract technique for poor, underserved populations with a large burden of cataract blindness, MSICS appears to be the most cost-effective and efficient method of surgery.

CONCLUSIONS

Cataract is still the leading cause of avoidable blindness in the developing world. Unless cataract surgery rates are increased, the magnitude of cataract blindness will continue to increase. The current situation mandates high-volume, high-quality cataract surgery delivered at minimal costs to the underprivileged sections of the community. Manual small incision cataract surgery retains most of the advantages offered by phaco at a miniscule of the cost and hence lends itself to high-volume cataract surgery. We advocate more widespread adoption of this technique to reduce the global backlog of cataract blindness and encourage randomized comparative trials with long-term follow-up to firmly establish MSICS as a safe and effective technique for cataract surgery, especially in the developing world.

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