Review Article

Evolution of manual small-incision cataract surgery from 8 mm to 2 mm - A comprehensive review

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Cataract is the most common cause of reversible blindness worldwide, accounting for approximately 50% of blindness worldwide. Cataract surgery is the most common surgical procedure performed in routine ophthalmic practice. It has undergone tremendous evolution, and the incision size has progressively reduced from 10–12 mm in extracapsular cataract surgery (ECCE) to 6–8 mm for manual small-incision cataract surgery (MSICS) and 2.2–2.8 mm in phacoemulsification. In a developing country like India, with a massive backlog of cataract, everyone cannot afford private surgery like phacoemulsification. Moreover, annual maintenance of the machine, cost of foldable IOLs, need for greater skill, learning curve, and difficulty in performing the surgery in mature and brown cataracts are other barriers. Due to these factors, MSICS is the surgery of choice in the developing world, with profound societal and economic benefits and similar visual recovery compared to phacoemulsification. During the last two decades, MSICS gained popularity in developing countries and has undergone tremendous advances. This article aims to review the various techniques of MSICS and how the surgery has evolved over the years, particularly focusing on the current technique of 2-mm MSICS.

Key words: Blindness, cataract, extra capsular cataract surgery, manual small-incision cataract surgery, phacoemulsification

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Cataract is the most common cause of reversible blindness worldwide. It is reported that 75% of avoidable blindness is secondary to cataract.[1] Cataract surgery is one of the most common ocular procedures performed globally.[2] Since the advent of phacoemulsification by Kelman in 1967, cataract surgery has been on an uphill journey of innovations and improvement.[3] The surgical wound size has decreased from 12 mm for intracapsular surgery to 10 mm for extracapsular surgery to 6–8 mm in manual small-incision cataract surgery (MSICS). The advent of phacoemulsification further decreased significantly to 2.2–2.8 mm.[4] Smaller incision sizes offer advantages such as early wound healing, lesser induced astigmatism, improved postoperative visual recovery, lesser risk of infection, and faster visual rehabilitation.[5]

Phacoemulsification is the accepted standard in the developed world. Recent advances such as Femtosecond laser technology and 3D surgeries are on the rise.[6] However, the limitations of phacoemulsification such as the higher cost, longer learning curve, and higher complication rates make MSICS a better option for the developing world.[7] It is estimated that more than 90% of the visually impaired reside in the developing world. There is a considerable backlog of cataracts in the developing world.[8] The common reasons are lack of access to medical facilities, poor health infrastructure, and lack of funds to sponsor surgeries at subsidized costs.[9] Thus, a technique with an easier learning curve, less time-consuming, and costing comparatively less on pockets with equal visual outcomes would be ideal for middle-income countries.[10] This has raised the need for constant modifications and improvements in an attempt to achieve MSICS results equivalent to phacoemulsification.[11]

Many modifications have focused on minimizing the size of the incision and fragmentation of the nucleus to allow delivery through smaller incisions.[12] Studies have reported less surgically induced astigmatism with phacoemulsification than MSICS.[13] This ultimately results in poorer uncorrected visual acuity following MSICS as compared to phacoemulsification. This has motivated and led the way to constant efforts to find ways to minimize the incision size to get equivalent results with MSICS.[14] The classical MSICS involved a 6-8 mm superior sclerocorneal incision followed by capsulorhexis, nucleus prolapse and delivery, cortex wash, and intraocular lens implant.[15] Some important innovations include the Blumenthal anterior chamber (AC) maintainer, temporal scleral tunnel, continuous infusion of 2% HPMC to protect endothelium,

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manual phacofragmentation by double nylon loop, and Kanas trisector for nucleus fragmentation.[4] Recently, a phacofracture technique using an ophthalmic viscosurgical device (OVD) cannula has been described in conjunction with a 2-mm incision described by Sahu *et al*.[16]

These innovations have helped raise the expectations of SICS surgeons and target results equivalent to phacoemulsification.[17] This is very important for developing countries where minimizing the surgical costs with equal safety will bridge the gaps between demand and need.[18] In this review article, we have tried highlighting various modifications described over time in MSICS and the journey from 7-mm to 2-mm incision size.

Method of Literature Search

A detailed systematic literature search was performed on the PubMed, Google Scholar, ePub, and Cochrane Library databases for recent case reports, series, original articles, review articles, and clinical trials on MSICS. The literature search was performed using the keywords "Manual Small-incision Cataract Surgery," "MSICS review," "Techniques of MSICS," "2 mm MSICS," "Evolution of MSICS," and "Recent advances in MSICS." Articles in languages other than English were excluded. All the relevant articles were compiled and reviewed for relevant literature.

Results

Convention technique of manual small-incision cataract surgery

Conventional MSICS is performed through a superior tunnel.[19] First, the superior rectus bridle suture is applied, followed by conjunctival peritomy from 10 to 2 o clock to expose the sclera. The peritomy is fashioned using conjunctival scissors and forceps.[20]

Scleral incision, shape, and configuration

Approximately 1.5 mm behind the limbus, a partial scleral incision is placed at approximately one-third of the scleral thickness.[21] The incision is placed behind the blue–white junction and varies from 5.5 to 8 mm in length. The length of the incision is governed by the density and hardness of the nucleus.[4] The site of the incision can be superior, temporal, or superotemporal. In temporal incision, the corneal dissection should be more anterior to get a better self-sealing tunnel incision. The incision configuration can be straight, chevron or V-shaped incision, frown incision, Blumenthal side cut, and smile-shaped incision [Fig. 1a–d].[22]

Sclerocorneal tunnel

After putting the scleral incision, the tunnel is fashioned with the crescent blade, and the AC entry is made with a 2-8–3.2-mm keratome.[21] The tunnel is a sutureless triplanar self-sealing tunnel. The dissection extends 1–1.5 mm into the cornea.[23] Approximately 45° scleral pockets are made on either side of the tunnel to facilitate nucleus delivery. After AC entry, OVD is injected, and capsulotomy is done.[24]

Capsulotomy

A capsulotomy is performed using a 26 G needle or Urata's forceps.[25] The capsule is stained with 0.06% trypan blue to facilitate better visualization of the capsule. The capsulotomy can be can-opener, continuous curvilinear, or envelope (linear).[26] The capsulotomy size should ideally be 6–7 mm, depending on the density of the nucleus to facilitate nucleus prolapse. After completing the capsulotomy, hydrodissection is done.[15]

Hydroprocedures

Hydroprocedure, first described by Blumenthal and Faust, is a technique to separate various layers of the cataractous lens.[27] In cortical cleavage hydrodissection, the cortex, epinucleus, and endonucleus are separated from the posterior capsule in toto.[28] The hydro cannula is passed below the anterior lens capsule and advanced 1 mm behind the rhexis margin in the subcapsular plane.[29] The fluid wave is advanced gradually after lifting the anterior capsular margin. As the fluid wave passes behind the lens, it separates the cortex from the capsule. Hydrodileneation is the separation of the epinucleus from the nucleus. This is advantageous in cases with posterior polar cataract.[30]

Nucleus extraction

The nucleus is prolapsed out of the capsular bag by either full hydrodissection or partial hydrodissection and rotation hydrodissection cannula or intracapsular flip or with the help of a Sinskey hook.[31] Once the nucleus is prolapsed in the AC, the nucleus delivery takes place by hydroexpression, viscoexpression, Vectis-assisted delivery, sandwich technique, or fishhook technique.[32]

Cortex wash

After nucleus delivery, cortex aspiration can be performed through the main tunnel or side port with the help of bimanual irrigation and aspiration or Simcoe cannula.[33]

Intraocular lens implantation

A polymethmethylacrylate (PMMA) intraocular lens (IOL) is implanted into the capsular bag through the 6–7-mm tunnel.[34] A foldable IOL can also be implanted if needed. After IOL implantation, the AC is formed using balanced salt solution along with stromal hydration through the side port and intracameral injection of 0.1 mL of 0.5% moxifloxacin.[35]

Modifications of manual small-incision cataract surgery

Sandwich technique

In this technique, all the conventional steps of MSICS are followed except the nucleus delivery. The nucleus extraction is performed by sandwiching it between the irrigation wire Vectis and iris spatula.[36] Bayramlar *et al*.[36] performed manual tunnel incision extracapsular cataract extraction by using the sandwich technique in 37 eyes and found that most achieved a best-corrected visual acuity (BCVA) of 5/10 or better post-operatively. Although some complications were noted, they reported that the sandwich technique is safe, easy, and does not require expensive instruments. Bayramlar *et al*.[37] also described that MSICS with sandwich technique is a better alternative to phacoemulsification in microcornea, hard mature, and brunescent cataract and offers the advantage of endothelial protection.

Modified fishhook technique

This technique was first described at Lahan eye hospital. In this technique, the nucleus extraction is performed using a bent 30-G needle tip (fishhook) that is in the form of a sharp curved hook.[38] This technique has a short learning curve, is cost-effective, has a minimal complication rate, and provides an excellent visual outcome. The rest of the steps are as for conventional MSICS.[39] Hening *et al*.[40] performed MSICS by using the fishhook technique in 500 eyes and found excellent visual acuity post-operatively. Approximately 96% of eyes had

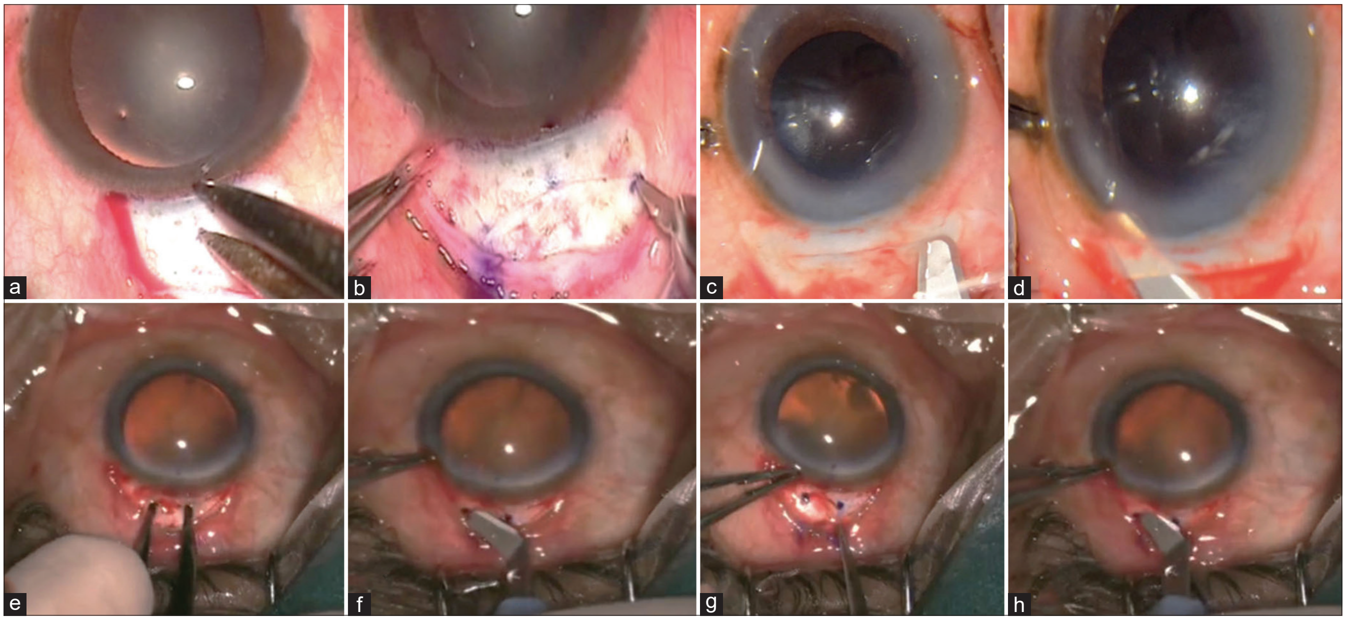

Figure 1: (a) Digital image of 7-mm MSICS depicting marking the incision 1.5–2 mm behind the limbus with calipers. (b) A scleral groove being made over the marked area. (c) Undermining the scleral groove with a cresent blade. (d) A sclerocorneal tunnel being fashioned with the cresent blade. (e) Digital image depicting 2-mm MSICS with scleral incision being marked with calipers. (f) Scleral groove being made with the help of a crescent blade. (g) Vertical limbs being marked at the end of the incision. (h) A sclerocorneal tunnel being fashioned with cresent blade

6/18 better visual acuity at 1 year. Hyphema was noted in 47 eyes (9.4%), and one eye (0.2%) had a posterior capsular tear and vitreous prolapse in the AC.

Irrigation cannula for nucleus delivery

Nishi first described the technique for nucleus delivery using an irrigating cannula. It uses a 20-G needle having a flat insertion plate at 90° to the axis with the flow outlet. The apex of the plate is placed below the nucleus with continuous irrigation, and the nucleus delivery occurs by irrigating solution.[41]

Nucleus bisection and trisection technique

The nucleus can be bisected or trisected inside the AC and can be delivered through a small-incision of 5 mm. The nucleus trisector technique was described by Kansas and Sax; the nucleus was manually trisected using a Kansas trisector and wire Vectis.[42] The resulting small fragments can be delivered through the tunnel by using OVD. Nucleus bisection or trisection avoids stretching the sclerocorneal tunnel during delivery, minimizes astigmatism, and protects the endothelium.[27] Hepşen *et al*.[43] performed MSICS with nucleus trisection in 59 eyes of 54 patients. The BCVA post-operatively was 6/12 or better in 83% of eyes and 6/7.5 or better in 47% of eyes. The most common complication was PCR in 8.4% of eyes and corneal edema in 54% of eyes.

Snare technique

Keener introduced the snare technique in 1983, where the nucleus was snared into a couple of fragments, and the fragments were brought out through a sclerocorneal flap valve incision.[44] The snare is made of stainless steel, having two cannulas with a wire loop in the first loop. While the wire loop is constricted, the nucleus is divided into two halves.[45]

Double sinskey hook technique

Rao and Lam described this technique in MSICS to extract the nucleus out of the capsular bag by using two Sinskey hooks.[46] The two Sinskey hooks are passed through two paracentesis sites. The first Sinskey hook is passed under the capsulorhexis margin, where it lifts the superior pole of the nucleus, and the second Sinskey hook is passed beneath the superior pole of the nucleus to prevent it from falling back.[4]

Two hook technique

A Sinskey hook and a Kuglen's hook can be used to prolapse the nucleus from the AC. In this technique, after capsulorhexis and hydrodissection, the nucleus is prolapsed in the AC.[47] It is extracted by pulling it with a Sinskey hook and pressuring the scleral bed with a Kuglen's hook. Deng *et al*.[47] performed this technique in 1320 eyes and found that 85% had a better visual acuity of 5/10 or more post-operatively.

Nylon loop manual small-incision cataract surgery

In this technique, the nucleus is fragmented by a manual photo fragmentation by using a double nylon loop. Kosakarn first described the technique.[48] This technique can be used to multiply the lens into three parts and deliver through a small-incision of 4–5 mm, and a foldable IOL can be implanted, avoiding any sutures. The double nylon loop is composed of 4-0 nylon and is inserted through a 20-G blunt needle tip. The suture can be used multiple times. This is a less expensive alternative for putting a foldable IOL in developing countries with minimal astigmatism. Kosakarn performed this technique on 120 eyes and found it safe and effective. Only two eyes had complications in the form of corneal edema (0.8%) and hyphema (0.8%). The mean endothelial cell loss at 1 month was 9.19%.[48]

Mininuc technique

This technique is also known as the Blumenthal technique of MSICS. Blumenthal and Moissiev described this technique by using an ECCE AC maintainer.[49] The incision size was reduced to 6.5–7 mm, maintaining the eye in the normotensive state. The straight scleral incision is placed 2 mm posterior to the limbus. Two side ports are fashioned at 6 and 9 o clock, and the rest of the surgical steps are performed with an artificial AC.[4,49] Keskinbora used this technique in 1000 eyes and found that Mininuc is a safe and effective technique that holds the iris and lens plane back, maintains a deep AC, divides the nucleus, and saves the eyes from hypotony. In this way, the risk of suprachoroidal hemorrhage is also minimized.[50] Polat described the convertible Mininuc technique where all the surgery steps were identical except that the sclerocorneal formation was performed as the last step to minimize complications.[51]

Ruit technique

Ruit *et al*. described the modification of MSICS, where a 6.5–7-mm temporal straight scleral incision was placed 2 mm behind the limbus. A V-shaped capsulotomy was performed, and the nucleus was delivered by viscoexpression.[52] The rest of the steps of the surgery remained the same. Ruit *et al*. performed this technique in 62 consecutive eyes of Tilganga Eye Centre in Kathmandu and found that 87.1% had a BCVA of 20/60 or better at 2 months. There were no major intraoperative or postoperative complications. In another set of 207 patients from Chaughada eye camp, 54.5% of patients had an uncorrected visual acuity of 20/60 or better, and 74.1% improved with correction. Six surgical complications were noted in this set of patients.[4,52] There was a single case of an irregular pupil, one shallow AC case which needed wound resuturing, one case had haptic in the AC which required IOL repositioning, one had postoperative hyphema, one case had iris prolapse through the tunnel where revision of wound was needed, and the last case had intraoperative PCR which resulted in vitreous loss and finally needed an AC implant.

Malik's technique

Malik *et al*.[53] described a modified MSICS technique to protect the corneal endothelial cell layer. He placed a continuous infusion of 2% HPMC through the AC maintainer with the help of an assistant to facilitate nucleus delivery. This helped in preventing corneal endothelial cell loss.

miLOOP

MSICS can be performed using a low-cost disposable device called miLOOP. miLOOP has an endocapsular ring made up of nitinol filament. After hydrodissetion, the loop is opened slowly in the AC and passes under the anterior lens capsule.[54] The loop is circled around the nucleus and then passes under the anterior surface. The loop is slowly closed and withdrawn, and this maneuver divides the nucleus into two fragments. More fragments can be done based on the requirement. This is helpful in hard brown and mature cataract cases where the nucleus can be bisected even if the rhexis is tiny; it also reduces the zonular stress. The technique also aids in protecting the endothelium and protects the integrity of the capsule.[55]

Manual small-incision cataract surgery under topical anesthesia

Wagley *et al*.[56] performed MSICS by using topical anesthesia, subconjunctival anesthesia at the site of the peritomy, and intracameral 1% lignocaine anesthesia. Gupta *et al*.[57] performed topical MSICS by using the fishhook technique in 96 patients with senile cataract and used a questionnaire to evaluate the pain, surgical experience, and complications. They reported that 51 had a pain score of zero. Ninety-one patients have mild or no pain. There was only one complication, and the surgeon's experience was favorable in terms of patient cooperation, stability of anterior stability, difficulty performing surgeries, and complications.

Intraoperative optical coherence tomography (OCT)-guided manual small-incision cataract surgery

Recently, the concept of intraoperative OCT was introduced to guide the steps of MSICS. Intraoperative OCT helps delineate dehiscence in posterior polar cataract (PPC) and assess the corneal layers in case of any complication.[58] Intraoperative OCT has also helped assess the depth of the sclerocorneal tunnel and is a vital potential future tool for better patient management and surgical outcome.[59]

2-mm MSICS with phacofracture

In the recent 2-mm MSICS technique, a fornix-based 2-mm curved limbal incision was made 1.5–2 mm behind the limbus, and the corneal entry was extended 1.5–2 mm on either side into the cornea with two pockets on either side. The authors also described a horseshoe-shaped incisional configuration, with vertical limbs of the incision placed radially in the astigmatic Koch's funnel [Fig. 1e–h]. The rest of the steps till the nucleus prolapse in the AC are the same as in conventional MSICS. After injecting the OVD in front and behind the nucleus, the nucleus is bisected or trisected (phacofracture) using a vectic and an OVD cannula. The fragments are extracted through the 2-mm tunnel by using the Vectis and OVD. The rest of the steps are as those for conventional MSICS. Sahu *et al*.,[16] in their retrospective analysis of 66 patients, performed a 2-mm incision with phacofracture. They reported that the mean spherical equivalent astigmatism error changed from −0.51 D to −0.44 D with a mean astigmatism change to 0.14 D cylinder. The mean keratometry change in the steepest and flattest axis of the anterior corneal surface was 0.89–1.39 D. The visual acuity improved from logMAR of 0.27 at 1 week to 0.007 (6/6) at 1 month.

Astigmatism management in manual small-incision cataract surgery

Astigmatism management in MSICS requires a clear understanding of the axis of astigmatism and a conceptual approach for planning the scleral tunnel incision.[22] Astigmatism is directly proportional to the incision size. The smaller the incision, the lesser the astigmatism. The concept gave birth to 2-mm incision MSICS.[4] Burgansky *et al*.[60] showed that increased incision size resulted in increased astigmatism. Small-incisions up to 3 mm do not alter the corneal shape and do not affect the preoperative cylindrical component. Large incisions result in more cylindrical regression. Koch's incisional funnel incisions are considered astigmatically neutral. Temporal incisions induce less astigmatism as compared to the superior tunnel. Thus, astigmatism increases in this sequence: temporal < superotemporal < superior.[21] Kimura *et al*.[61] showed that surgically induced astigmatism was less with an oblique incision than with a superior incision due to the arrangement of fibers in the sclera, which make the sclera rigid and a tunnel with the least induced astigmatism. Smile incisions are easier to construct but result in increased astigmatism. Straight incisions result in moderately induced astigmatism. A frown incision is challenging to construct but causes minimal astigmatism. Blumenthal side cuts result in minimal induced astigmatism, but the tunnel is large. Chevron "V" incisions are difficult to make, with least/nil astigmatism. Incisions placed posteriorly result in less astigmatism. In the case of against-the-rule astigmatism, a temporal or superior approach with sutures reduces astigmatism. In the case of rule astigmatism, a superior approach must be followed. MSICS can be considered a refractive procedure in expert hands to minimize astigmatism permanently. This will reduce the preoperative refractive error maintaining sphericity.[21]

Topography guided astigmatism management in manual small-incision cataract surgery

Besides lenticular astigmatism, corneal astigmatism also holds importance during cataract surgery. Preoperative corneal topography or topographically guided astigmatism management helps plan the cataract surgery with no residual postoperative astigmatism.[62] The site and axis of astigmatism can be planned to nullify corneal astigmatism.[63] Various techniques are available to manage astigmatisms, such as limbal relaxing incisions, on-axis incisions, clear corneal incisions, astigmatic keratectomy (based on nomograms), and toric IOL implantation. Equally good postoperative results can be obtained with MSICS as with phacoemulsification.[64]

Future of manual small-incision cataract surgery

MSICS still holds promise for complex cataract cases in the future, minimizing intraoperative and postoperative complications. Even challenging MSICS cases in expert hands promise an excellent anatomical and functional outcome.[65] Recent modifications and pathbreaking innovations have evolved MSICS from a 8-mm tunnel to a 2-mm incision without compromising the quality and outcome of the surgery. This, in turn, has also reduced surgically induced astigmatism. As advanced and complicated cataract are more prevalent in lower socioeconomic strata, MSICS is still and will remain the surgery of choice in these cases. MSICS has an equally efficient outcome and offers similar advantages to phacoemulsification because of less surgical time, cost-effectiveness, wider applicability, and less complex learning curve in the underdeveloped and developing world. MSICS has been anessential tool in high-volume surgical setup and complex case scenarios to eliminate needless blindness.[66,67]

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Conflicts of interest

There are no conflicts of interest.

References

1. GBD 2019 Blindness and Vision Impairment Collaborators, Vision Loss Expert Group of the Global Burden of Disease Study. Causes of blindness and vision impairment in 2020 and trends over 30 years, and prevalence of avoidable blindness in relation to VISION 2020: The right to sight: An analysis for the global burden of sisease study. Lancet Glob Health 2021;9:e144-60. Erratum in: Lancet Glob Health 2021;9:e408.
2. Micieli JA, Arshinoff SA. Cataract surgery. CMAJ 2011;183:1621. doi: 10.1503/cmaj. 110549.
3. Davis G. The evolution of cataract surgery. Mo Med 2016;113:58-62.
4. Singh K, Misbah A, Saluja P. Review of manual small-incision cataract surgery. Indian J Ophthalmol 2017;65:1281-8.
5. Al Mahmood AM, Al-Swailem SA, Behrens A. Clear corneal incision in cataract surgery. Middle East Afr J Ophthalmol 2014;21:25-31.
6. Benítez Martínez M, Baeza Moyano D, González-Lezcano RA. Phacoemulsification: Proposals for improvement in its application. Healthcare (Basel) 2021;9:1603. doi: 10.3390/healthcare9111603.
7. Gogate P, Optom JJ, Deshpande S. Meta-analysis to compare the safety and efficacy of manual small incision cataract surgery and phacoemulsification. Middle East Afr J Ophthalmol 2015;22:362-9.
8. Isaacs R, Ram J, Apple D. Cataract blindness in the developing world: Is there a solution? J Agromedicine 2004;9:207-20.
9. Weisgrau S. Issues in rural health: Access, hospitals, and reform. Health Care Financ Rev 1995;17:1-14.
10. Hopper AN, Jamison MH, Lewis WG. Learning curves in surgical practice. Postgrad Med J 2007;83:777-9.
11. Sinha R, Agarwal P, Kumar C. Small incision cataract surgery: Review of journal abstracts. Indian J Ophthalmol 2009;57:79–82.
12. Ting DSJ, Chua D, May KO, Aung M, Kumar A, Farook M, *et al*. Modified manual small incision cataract surgery technique for phacoemulsification-trained surgeons. Ther Adv Ophthalmol 2020;12:2515841420977372. doi: 10.1177/2515841420977372.
13. Jauhari N, Chopra D, Chaurasia RK. Comparison of surgically induced astigmatism in various incisions in manual small incision cataract surgery. Int J Ophthalmol 2014;7:1001-4.
14. Warad C, Tenagi A, Satarasi P, Goyal D, Mendpara R, Harakuni U, *et al*. Visual outcome following manual small incision cataract surgery at a tertiary center in South India. Cureus 2021;13:e20687. doi: 10.7759/cureus. 20687.
15. Venkatesh R, Veena K, Ravindran RD. Capsulotomy and hydroprocedures for nucleus prolapse in manual small incision cataract surgery. Indian J Ophthalmol 2009;57:15-8.
16. Sahu A, Bali J, Sahu C, Mishra D, Heda A, Deori N. Early postoperative astigmatism in 2-mm manual small incision cataract surgery with phacofracture. Indian J Ophthalmol 2022;70:1997-2001.
17. Bhargava R, Kumar P, Sharma SK, Kumar M, Kaur A. Phacoemulsification versus small incision cataract surgery in patients with uveitis. Int J Ophthalmol 2015;8:965-70.
18. Akenroye OO, Adebona OT, Akenroye AT. Surgical care in the developing world-strategies and framework for improvement. J Public Health Afr 2013;4:e20. doi: 10.4081/jphia. 2013.e20.
19. Kongsap P. Visual outcome of manual small-incision cataract surgery: Comparison of modified Blumenthal and Ruit techniques. Int J Ophthalmol 2011;4:62-5.
20. Gurung R, Hennig A. Small incision cataract surgery: Tips for avoiding surgical complications. Community Eye Health 2008;21:4-5.
21. Haldipurkar SS, Shikari HT, Gokhale V. Wound construction in manual small incision cataract surgery. Indian J Ophthalmol 2009;57:9-13.
22. Arthur E, Sadik AA, Kumah DB, Osae EA, Mireku FA, Asiedu FY, *et al*. Postoperative corneal and surgically induced astigmatism following superior approach manual small incision cataract surgery in patients with preoperative against-the-rule astigmatism. J Ophthalmol 2016;2016:9489036. doi: 10.1155/2016/9489036.
23. Ang M, Evans JR, Mehta JS. Manual small incision cataract surgery (MSICS) with posterior chamber intraocular lens versus extracapsular cataract extraction (ECCE) with posterior chamber intraocular lens for age-related cataract. Cochrane Database Syst Rev 2012;CD008811. doi: 10.1002/14651858.CD008811.pub2. Update in: Cochrane Database Syst Rev 2014;CD008811.
24. Subudhi P, Patro S, Subudhi BNR. Resident performed sutureless manual small incision cataract surgery (MSICS): Outcomes. Clin Ophthalmol 2021;15:1667-76. doi: 10.2147/OPTH.S290968.
25. Sharma B, Abell RG, Arora T, Antony T, Vajpayee RB. Techniques of anterior capsulotomy in cataract surgery. Indian J Ophthalmol 2019;67:450-60. doi: 10.4103/ijo.IJO_1728_18.
26. Melles GR, de Waard PW, Pameyer JH. Trypan blue capsule staining to visualize the capsulorhexis in cataract surgery. J Cataract Refract Surg 1999;25:7-9.
27. Ravindra MS. Nucleus management in manual small incision cataract surgery by phacosection. Indian J Ophthalmol 2009;57:41-3.
28. Vasavada AR, Raj SM, Vasavada V. Surgical approaches to posterior polar cataract: A review. Eye (Lond) 2012;26:761-70.

29. Taş A. Minimal water-jet hydrodissection. Clin Ophthalmol 2017;12:1-5. doi: 10.2147/OPTH.S152227.
30. Vasavada AR, Vasavada VA. Managing the posterior polar cataract: An update. Indian J Ophthalmol 2017;65:1350-8.
31. Gogate PM. Small incision cataract surgery: Complications and mini-review. Indian J Ophthalmol 2009;57:45-9.
32. Malik KP, Goel R. Nucleus management with Blumenthal technique: Anterior chamber maintainer. Indian J Ophthalmol 2009;57:23-5.
33. Gurnani B, Kaur K. Phacoemulsification. 2021 Dec 31. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2022.
34. Panahi-Bazaz MR, Zamani M, Abazar B. Hydrophilic acrylic versus PMMA intraocular lens implantation in pediatric cataract surgery. J Ophthalmic Vis Res 2009;4:201-7.
35. Hennig A, Puri LR, Sharma H, Evans JR, Yorston D. Foldable vs rigid lenses after phacoemulsification for cataract surgery: A randomised controlled trial. Eye (Lond) 2014;28:567-75.
36. Bayramlar H, Cekiç O, Totan Y. Manual tunnel incision extracapsular cataract extraction using the sandwich technique. J Cataract Refract Surg 1999;25:312-5.
37. Bayramlar H, Karadag R, Yildirim A, Cakici O, Sari U. Manual tunnel incision cataract surgery with sandwich technique in eyes with microcornea. J Cataract Refract Surg 2014;40:1058. doi: 10.1016/j.jcrs. 2014.04.014.
38. Natchiar G. An alternative to instrumental phacoemulsification: Aravind Eye Hospital and Postgraduate Institute of Ophthalmology. Manual Small Incision Cataract Surgery. 2nd ed. Madurai, India: 2004.
39. Hennig A. Nucleus management with Fishhook. Indian J Ophthalmol 2009;57:35-7.
40. Hennig A, Kumar J, Yorston D, Foster A. Sutureless cataract surgery with nucleus extraction: Outcome of a prospective study in Nepal. Br J Ophthalmol 2003;87:266-70.
41. Nishi O. A new type of irrigating cannula for lens nucleus delivery by extracapsular extraction. Ophthalmic Surg 1986;17:47-9.
42. Kansas PG, Sax R. Small incision cataract extraction and implantation surgery using a manual phacofragmentation technique. J Cataract Refract Surg 1988;14:328-30.
43. Hepşen IF, Cekiç O, Bayramlar H, Totan Y. Small incision extracapsular cataract surgery with manual phacotrisection. J Cataract Refract Surg 2000;26:1048-51.
44. Bhattacharya D. Nuclear management in manual small incision cataract surgery by snare technique. Indian J Ophthalmol 2009;57:27-9.
45. Roy P. Comments on: Nuclear management in manual small incision cataract surgery by snare technique. Indian J Ophthalmol 2010;58:348-9.
46. Rao SK, Lam DS. A simple technique for nucleus extraction from the capsular bag in manual small incision cataract surgery. Indian J Ophthalmol 2005;53:214-5.
47. Deng JW, Yang YT, Zeng Y, Tang ZM, Liu XJ, Fu XY. Two-hook technique for nucleus extraction in manual sutureless extracapsular cataract extraction. J Cataract Refract Surg 2013;39:497-500.
48. Kosakarn P. Double nylon loop for manual small-incision cataract surgery. J Cataract Refract Surg 2009;35:422-4.
49. Blumenthal M, Moisseiev J. Anterior chamber maintainer for extracapsular cataract extraction and intraocular lens implantation. J Cataract Refract Surg 1987;13:204-6.
50. Keskinbora HK. Mini-nuc technique. J Cataract Refract Surg 2000;26:1107. doi: 10.1016/s0886-3350 (00) 00628-3.
51. Polat A. Convertible mini-nuc technique. J Cataract Refract Surg 2001;27:491-2.
52. Ruit S, Tabin GC, Nissman SA, Paudyal G, Gurung R. Low-cost high-volume extracapsular cataract extraction with posterior chamber intraocular lens implantation in Nepal. Ophthalmology 1999;106:1887-92.
53. Malik KPS, Goel R. Malik`s technique of continuous 2% hydroxymethylcellulose (HPMC) infusion assisted nuclear delivery in manual SICS. DJO 2016;26:190-1.
54. MSICS and miLoop for Non-phaco Candidates. Available from: https://www.reviewofophthalmology.com/article/msics-and-miloop-for-nonphaco-candidates. [Last accessed on 2021 Jun 26].
55. MSICS Using the miLOOP. Available from: https://www.aao.org/annual-meeting-video/msics-using-miloop. [Last accessed on 2022 June26].
56. Wagley S, Correia M, Kreis A, Verma N, Sharma M. Manual small incision cataract surgery (MSICS) under topical, incisional site sub-conjunctival 2% and intracameral 1% lignocaine anesthesia-an ongoing pilot study. Invest Ophthalmol Vis Sci 2017;58:1816.
57. Gupta SK, Kumar A, Kumar D, Agarwal S. Manual small incision cataract surgery under topical anesthesia with intracameral lignocaine: Study on pain evaluation and surgical outcome. Indian J Ophthalmol 2009;57:3-7.
58. Titiyal JS, Kaur M, Falera R. Intraoperative optical coherence tomography in anterior segment surgeries. Indian J Ophthalmol 2017;65:116-21.
59. Fang W, Li Q, Fan J, Tang N, Yu J, Xu H, *et al*. Microscope-integrated intraoperative optical coherence tomography for anterior segment surgical maneuvers. Transl Vis Sci Technol 2020;9:18. doi: 10.1167/tvst. 9.7.18.
60. Burgansky Z, Isakov I, Avizemer H, Bartov E. Minimal astigmatism after sutureless planned extracapsular cataract extraction. J Cataract Refract Surg 2002;28:499-503.
61. Kimura H, Kuroda S, Mizoguchi N. Extracapsular cataract extraction with a sutureless incision for dense cataracts. J Cataract Refract Surg 1999;25:1275-9.
62. Martinez CE, Klyce SD. Corneal topography in cataract surgery. Curr Opin Ophthalmol 1996;7:31-8.
63. Kanellopoulos AJ, Asimellis G. Distribution and repeatability of corneal astigmatism measurements (magnitude and axis) evaluated with color light emitting diode reflection topography. Cornea 2015;34:937-44.
64. Kaufmann C, Peter J, Ooi K, Phipps S, Cooper P, Goggin M, *et al*. Limbal relaxing incisions versus on-axis incisions to reduce corneal astigmatism at the time of cataract surgery. J Cataract Refract Surg 2005;31:2261-5.
65. Berges AJ, Baam ZR, Zhu A, Sikder S, Yiu S, Ravindran RD, Parikh KS. Addressing the MSICS learning curve: Identification of instrument-holding techniques used by experienced surgeons. Int J Ophthalmol 2021;14:693-9.
66. Eslami Y, Mirmohammadsadeghi A. Comparison of surgically induced astigmatism between horizontal and X-pattern sutures in the scleral tunnel incisions for manual small incision cataract surgery. Indian J Ophthalmol 2015;63:606-10.
67. Gurnani B, Kaur K. Manual Small Incision Cataract Surgery. 2022 Jun 6. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2022 Jan–. PMID: 35881728.