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Review Article

Small incision cataract surgery (SICS) with nucleus fragmentation: A narrative review

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Abstract

Cataract remains the leading cause of blindness globally, with a significant impact on aging populations. Small incision cataract surgery (SICS) with nucleus fragmentation has emerged as a viable alternative to phacoemulsification, particularly in resource-limited settings. This narrative review examines the evolution of cataract surgery techniques, with a focus on SICS and its integration of nucleus fragmentation methods. The review highlights the visual outcomes of SICS, particularly in cases of dense cataracts, and underscores its cost-effectiveness and accessibility in developing countries. Various nucleus fragmentation techniques, including manual, mechanical, and enzymatic approaches, are discussed, along with their respective advantages and challenges. The safety profile of SICS is also reviewed, showing low complication rates and favourable postoperative recovery. The review concludes with recommendations for future research and practice, emphasizing the need for enhanced surgical training, innovation in fragmentation techniques, and continued evaluation of long-term patient outcomes. SICS with nucleus fragmentation stands as a critical tool in reducing cataract-related blindness, especially in underserved regions.

Keywords: SICS, Nucleus fragmentation, Visual outcome.

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1. Introduction

The WHO report shows that worldwide cataract is the leading cause of blindness and accounts for about 51% of blind people.[1] As people age, cataracts are expected to increase affecting mostly elderly adults.[2] Cataract surgery remains the only definite treatment; its development over the past century has been focused on improving visual outcomes, reducing complications and making it more accessible.[3]

Originally, surgery for cataract involved a large incision to remove the entire lens with its capsule during intracapsular cataract extraction (ICCE). Although vision was restored by this method, it had many possible complications.[4] Extracapsular cataract extraction (ECCE) involved removal of the lens while leaving the posterior capsule intact, thus had relatively smaller incisions than those of previous methods but still necessitated relatively larger incisions.[5]

Dr. Charles Kelman introduced phacoemulsification in the 1960s, which completely changed cataract surgery. It is ultrasonic energy driven technique, which emulsifies lens nucleus and then the same can be aspirated through a smaller incision that is normally less than 3 mm.[6] Phacoemulsification had several advantages including quick visual recovery, reduced surgical trauma and lower postoperative astigmatism risk.[7] Nonetheless, this process requires specialized equipment and high surgical skills levels making it hard to become popular within resource constrained environments.[8]

Small incision cataract surgery (SICS) has been introduced as a better alternative in developing world. SICS is a combination of ECCE and small self-sealing incisions with no need for sutures. This makes it easily available and cheaper. Conversely, SICS requires lesser technology than phacoemulsification.[9] The technique involves making a 5-

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7mm incision to extract the lens instead the regular ECCE larger incision.

A major development in SICS has been the nucleus fragmentation techniques. These enable the extraction of the cataractous lens in smaller pieces thus allowing removal through the tiny opening required by SICS. On this note, nucleus fragmentation can be done manually, mechanically or through enzymatic agents based on surgeon's preference and availability. This modification has greatly enhanced the safety and efficacy rates of SICS particularly in cases involving dense mature cataracts.[10]

Studies have been conducted to affirm that the visual outcomes of SICS with nucleus fragmentation are as good as phacoemulsification in terms of postoperative visual acuity and patient satisfaction. Besides, the capability of efficiently managing dense cataracts coupled with its cost-effectiveness has become the preferred option in many low resource areas.[11] In the ongoing advances in cataract surgery, SICS with nucleus fragmentation is one vital technique on a global fight against cataract induced blindness.

2. Materials and Methods

2.1. Literature search strategy

The literature search for this review was conducted using several prominent academic databases and search engines to ensure comprehensive coverage of relevant studies on Small incision cataract surgery (SICS) with nucleus fragmentation. The primary search engines and databases included:

1. PubMed
2. Google Scholar
3. Scopus
4. Web of Science

2.2. Search terms and keywords

A combination of MeSH (Medical Subject Headings) terms and free-text keywords were used to maximize the retrieval of relevant articles. The search terms included:

1. "Small incision cataract surgery" OR "SICS"
2. "Nucleus fragmentation" OR "lens fragmentation"
3. "Phacoemulsification" AND "cataract extraction"
4. "Manual small incision cataract surgery"
5. "Cataract surgery outcomes"
6. "SICS vs phacoemulsification"
7. "Dense cataracts" AND "SICS"
8. "Cost-effectiveness of SICS"
9. "Sutureless cataract surgery"
10. "Postoperative visual acuity in SICS"

The selection of articles was based on the following inclusion and exclusion criteria:

2.3. Inclusion criteria

1. Studies published in peer-reviewed journals.
2. Articles that discussed SICS with or without nucleus fragmentation.
3. Comparative studies between SICS and phacoemulsification.
4. Studies focusing on the outcomes, safety, and cost-effectiveness of SICS.
5. Publications in English.
6. Studies published between 2000 and 2024 to capture the most recent advancements and trends in SICS.

2.4. Exclusion criteria

1. Articles not available in full text.
2. Non-English publications.
3. Case reports, letters to the editor, and opinion pieces.
4. Studies that did not specifically focus on nucleus fragmentation in the context of SICS.
5. Articles with insufficient methodological detail or unclear outcomes.

2.5. Data extraction and synthesis

Data from the selected articles were extracted systematically, focusing on key aspects such as study design, population characteristics, surgical techniques, outcomes, complications, and conclusions. The extracted data were organized into thematic categories to facilitate a narrative synthesis.

3. Results

3.1. Overview of study selection

The first search identified 3250 items in databases. Therefore, the titles and abstracts were scanned for relevance by two reviewers (D.P. and K.L.) before 200 articles finally selected to be read completely as full text. A total of 85 studies, after meeting the inclusion criteria were included in our final analysis. Selected studies included randomized controlled trials (RCTs), cohort studies, case control study systematic reviews and meta-analysis- providing a wide range of evidence on Small incision cataract surgery (SICS) with nucleus fragmentation.

3.2. Surgical techniques and variations in SICS with nucleus fragmentation

Various techniques used in performing nucleus fragmentation during SICS across the reviewed studies methods frequently described were manual fragmentation, in the nucleus is divided using a chopper or a shaper to crack it in anterior chamber and mechanical fracturing as phaco chop techniques tailored for SICS. Further investigations looks at enzymatic nucleus softening chemicals to deliver ambience fragmentation since placing extreme hard cataracts.

Studies have illustrated that manual fragmentation often results in outcomes comparable to mechanical techniques, but the mechanical technique require less intraocular manipulation and requires shorter surgical duration.

Enzymatic methods were used less frequently because of concerns regarding potential toxicity to corneal endothelium.

3.3. Visual outcomes and postoperative recovery

The primary outcome in all types of cataract surgery was the visual acuity. The majority of the studies found a significant postoperative improvement in best-corrected visual acuity (BCVA).[12] One review concentrated on the capability of SICS with nucleus chopping for dense cataracts, particularly in cases where phacoemulsification might be more technical to manage.

In SICS postoperative recovery was fast and the patients could get a functional vision in one week after surgery. The rate of early postoperative complications, like corneal edema and anterior chamber inflammation, was also low (comparable to phacoemulsification). A number of studies have also reported that rehabilitation was quicker among patients undergoing SICS in resource-limited settings.

3.4. Complications and safety profile

The safety profile of the SICS with nucleus fragmentation was investigated in detail. Amongst the intraoperative complications, the two most frequently reported were posterior capsule rupture as well as zonular dehiscence but were rare and compared to phacoemulsification they were found to be of comparable occurrence. The records detailing postoperative endophthalmitis, cystoid macular edema, and posterior capsular opacification were also assessed in this study, and the findings were similar of that reported among patients with phacoemulsification.

Several of them focused on the positive aspects of the use of SICS in the course of surgical interventions and the possibilities of using it in case of intraoperative complications. For instance, SICS required a relatively big-incision to deal with complications such as posterior capsule rupture and lens dislocation than in phacoemulsification. Furthermore, the fact that this surgery was made possible without the use of many equipment probability of equipment malfunction.

The importance of the cost aspects of SICS with nucleus fragmentation was described as the constantly repeated note throughout the literature. The authors stressed in the numerous studies that SICS costs almost three times less than phacoemulsification. These cost savings were owing to less equipment needed, low use of consumables and shorter duration of surgical operation.

On the basis of economic assessment, SICS with nucleus offers the same quality of visual acuity at a much smaller financial expense than phacoemulsification. Researches conducted in the countries like India, Nepal, and from the sub-Saharan African countries highlighted that SICS was important in management of cataract blindness in the resource constrain setting.

3.5. SICS in special populations

When comparing the SICS with the phacoemulsification in patient with dense cataract the results have shown that SICS is easier to perform with less intraoperative challenge and lower risk of complication.

In situations where pseudoexfoliation syndrome is observed and zonular weakness is present SICS offers greater size of incision and higher capacity to deal with possible surgical complications during the operation.

3.6. Patient satisfaction and quality of life

The level of patients' satisfaction and quality of life after surgery was found to be high in most of the studies with many of the patients expressed improved visual activity and self-dependency. Cross-sectional and prospective studies carried out in different environments revealed that patients realized high values in the short postoperative recovery period and the cost effectiveness of the SICS procedure.

The other authors have compared SICS with phacoemulsification; the SICS patients had fewer postoperative visual complaints including glare and halos. SICS was also advantageous in those patients with preexisting corneal pathology since it utilizes a smaller incision and less intraocular energy than can cause corneal edema or other visual changes.

3.7. Comparison with phacoemulsification

Although phacoemulsification is practiced in several developed countries as the popular technique, SICS with nucleus fragmentation has become popular in the developing world. Literature reviews established that SICS and phacoemulsification were equally effective in terms of visual acuity, complication rates as well as patients' satisfaction.

However, the SICS was preferred in the settings of cost constraint, limited availability of the supporting instruments and the expertise of the surgeon in the performance of the technique. Due to these various and demanding cases that were treated by SICS, it was evident that SICS was a useful and versatile surgical technique.

Another factor that has influence on the SICS techniques and their effectiveness is the fact that development of the techniques and improvements of their application does not stop. Recent developments like SICS small incision, better nucleus fractious devices, and latest intraocular lenses have brought SICS and phacoemulsification nearer. Further investigation toward fine tuning these approaches and extending its versatility is still active as the researchers are trying to maximize the consistent result and make the treatment available for the people living in the developing countries.

3.8. Summary of findings

These findings corroborate the bulk of literature on the effectiveness, safety, and economic benefits of SICS with nucleus fragmentation. The given procedure provides similar visual outcomes as those resulting from phacoemulsification, yet can produce some benefits for various subgroups of patients and different practices. With cataract surgery still being a leading public health intervention, the SICS with nucleus fragmentation just remains the key weapon in the fight against blindness due to cataract especially in the developing world.

4. Discussion

In this discussion, we evaluate the role of nucleus fragmentation techniques in Small Incision Cataract Surgery (SICS), by analysing the strengths, limitations, and potential future directions, we aim to highlight the value of these techniques in enhancing surgical outcomes, especially in resource-limited settings.

4.1. Strengths of nucleus fragmentation techniques in small incision cataract surgery (SICS)

1. It can be implemented across numerous operating theatres.
2. Comparing to phacoemulsification the manual SICS with nucleus fragmentation can be easily done with cost effective instruments.
3. Nucleus fragmentation techniques which include mechanical division and use of enzymatic softening agents that can provide numerous benefits in terms of intraoperative complications
4. Mechanical division enables the controlled emulsification of the lens nucleus, and will not be detrimental to the number of posterior endothelial cells.
5. In enzymatic softening of nucleus even more, surgical energy can be reduced which means less chance of thermally damage.
6. When properly employed with nucleus fragmentation, SICS can lead to visual results equivalent to those achieved [through] phacoemulsification.

5. Limitations of Nucleus Fragmentation Techniques

1. Probably the most significant drawback is steep learning curve it may take a surgeon a lot of training and experience to be able to master the techniques of nucleus
2. Enzymes used for softening the lenses may not have a similar effect for all the lens type; this may lead to inconsistency. Additionally, whenever there is dense cataract, mechanical division may prove to be difficult and can be risky in regard to intraoperative complications
3. Postoperative complications: However, they are not very frequent and include, posterior capsule opacificaton (PCO) and corneal endothelial cell loss if the fragmentation is not well done. Such complications may require other treatments, which can cause suffering to the patient.

6. Recommendations for Future Practice

1. Improve the training of surgeons in particular, those who practice SICS in countries where it is popular. Recent advancements in simulation-based training for manual small incision cataract surgery have demonstrated improved surgical confidence and reduced complication rates among ophthalmology trainees, particularly when incorporating nucleus fragmentation steps.[13]
2. These programs should ensure that nucleus fragmentation techniques is made safer and accurate so as to increase the number of successful surgeries.
3. Studies have shown that the degree of nucleus sclerosis (as per LOCS III grading) directly influences the choice of fragmentation technique. Mechanical chopping is more suited for grade III or harder nuclei, while soft nuclei are amenable to visco-fracture or enzymatic methods.[14] Enzymatic softening agents may be further developed and modified to increase the reliability of nucleus softening in various types of cataracts.
4. Another recommendation is the enhancement in the development of instruments and surgery. For instance, development of new and more efficient mechanical fragmenting instruments leading to fewer complications during the operation. Innovations such as blunt-tipped nucleus crackers and nucleus splitting forceps have minimized endothelial trauma during SICS. These instruments provide better grip and control, reducing nucleus mobility and complications. The use of dispersive viscoelastics like hydroxypropyl methylcellulose during fragmentation has been shown to protect corneal endothelium more effectively than cohesive agents, especially in dense cataracts.[15]
5. Need to promote patient information or counseling and follow-up care**.**

7. Limitations of the Study

In conclusion, this review offers a comprehensive overview of nucleus fragmentation techniques in SICS, but it has limitations. The reliance on published literature may not reflect regional practice variations, and the significant variability among studies complicates conclusions about the superiority of any one technique. Additionally, long-term outcomes, including patient satisfaction and quality of life, were not thoroughly covered. Future research should address these gaps with longitudinal studies tracking patient outcomes.

8. Conclusion

The properties of this nucleus fragmentation in SICS are a cost effective alternative to phacoemulsification, particularly for resource limited areas. Although it offers flexibility and good visual outcomes, there are still challenges that can be addressed through improved education and patient care. The core objectives of reducing corneal endothelial damage, protecting the posterior capsule, and minimizing incision size are interrelated and crucial for successful cataract surgery. These techniques need further improvement by future research, their long-term outcome should also be assessed and global applicability appraised.

9. Source of Funding

None.

10. Conflict of Interest

None.

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