Addressing Pupillary Dilation Challenges in Phacoemulsification

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ABSTRACT
Adequate pupillary dilation is a cornerstone of safe and effective cataract surgery. Small pupils increase the risk of intraoperative complications such as iris trauma, capsular tears, and corneal endothelial damage, while reducing surgical efficiency. Despite advances in phacoemulsification techniques, poor dilation remains a common and sometimes unpredictable challenge. This review summarizes the pharmacological, mechanical, and surgical strategies available to manage small pupils, with special emphasis on intraoperative floppy iris syndrome (IFIS). Practical pearls for anticipating, preventing, and addressing pupillary challenges are also highlighted to optimize patient outcomes.

INTRODUCTION
Phacoemulsification has revolutionized cataract surgery, offering rapid recovery and excellent visual outcomes. However, small pupils remain a major obstacle to surgical success, increasing the complexity and risk profile of the procedure.[1,2] A well-dilated pupil ensures optimal visualization, instrument maneuverability, and safety margins during critical steps such as capsulorhexis, nucleus management, and cortical aspiration.[3,4] This review explores the causes of poor dilation and evaluates evidence-based management strategies, ranging from pharmacological agents to mechanical devices.

CAUSES OF POOR PUPILLARY DILATION
Poor pupillary dilation may result from pharmacological factors, underlying ocular pathology, or intraoperative events. Among pharmacological causes, chronic use of miotic agents such as pilocarpine produces a fibrotic and non-compliant iris that responds poorly to mydriatic medications.[3] Systemic medications may also contribute, particularly alpha-1 adrenergic antagonists such as tamsulosin, which are strongly associated with intraoperative floppy iris syndrome (IFIS).[4] Certain antipsychotic medications have likewise been reported to impair pupillary dilation. Inadequate preoperative mydriatic regimens can also result in inadequate pupil dilation at the time of surgery.

Several ocular pathologies are also associated with poor mydriasis. Pseudoexfoliation syndrome (PXF) is a common cause and is frequently accompanied by weak zonular support and reduced pupillary dilation.[1,3] In patients with diabetes mellitus, chronic ischemic changes result in stiffening of the iris stroma, limiting the pupillary response.[2] Chronic uveitis or iritis may produce posterior synechiae that mechanically restrict dilation, while previous intraocular surgery or ocular trauma can similarly impair iris mobility. Pigment dispersion syndrome has also been implicated as a contributing factor.

Intraoperative factors may exacerbate progressive miosis despite adequate preoperative preparation. Excessive manipulation of the iris, prolonged surgical duration, and inadequate anesthesia leading to sphincter muscle spasm have all been associated with deterioration of pupillary dilation during cataract surgery.[1]

PREOPERATIVE PHARMACOLOGICAL STRATEGIES
Effective preoperative pharmacological preparation remains the first step in managing patients at risk of inadequate pupillary dilation. Aggressive mydriasis is commonly achieved by

using a combination of topical phenylephrine 10% and tropicamide 1%.[1] Topical nonsteroidal anti-inflammatory drugs (NSAIDs), initiated 2-3 days before surgery, help to maintain mydriasis by reducing prostaglandin-mediated intraoperative miosis.[2] In patients with a history of chronic miotic therapy, atropine 1% may provide additional cycloplegia and improve dilation, although rebound miosis should be anticipated. For patients receiving alpha-1 adrenergic antagonists, particularly tamsulosin, discontinuation of therapy should be considered when clinically feasible, accompanied by appropriate preoperative planning to minimize the risk of IFIS.[4]

INTRAOPERATIVE PHARMACOLOGICAL STRATEGIES

When pharmacological support is required during surgery, intracameral agents provide rapid augmentation of pupillary dilation and iris stability. Epinephrine, typically diluted to concentrations ranging from 1:4,000 to 1:10,000 in balanced salt solution, is among the most widely used agents and has demonstrated efficacy in maintaining mydriasis throughout surgery.[2,4] Intracameral phenylephrine may also be administered, although its effectiveness is reduced in eyes with fixed or fibrotic miosis. Intracameral lidocaine 1%, either alone or in combination with epinephrine, provides additional anesthesia while contributing modestly to pupillary dilation. Mechanical expansion of the pupil may be further facilitated by the use of dispersive ophthalmic viscosurgical devices (OVDs), which expand the pupil mechanically while protecting intraocular tissues and stabilizing the iris throughout phacoemulsification.[5]

MECHANICAL DILATION DEVICES

When pharmacological methods are insufficient, mechanical pupil expansion devices provide reliable intraoperative exposure. Iris hooks are placed through small peripheral corneal incisions and are typically engaged at three or four equidistant points to retract the iris toward the limbus, producing consistent enlargement of the surgical pupil.[1] Their principal advantage is consistent pupillary enlargement even in severely constricted pupils; however, they require multiple additional incisions and may increase the risk of localized iris trauma.[6]

Pupil expansion rings, such as the Malyugin Ring, have become increasingly popular because they provide a stable, round pupil measuring approximately 6–7 mm throughout surgery.[7] Compared with iris hooks, these devices generally produce less iris trauma while offering excellent intraoperative visualization and exposure. Their primary limitation is that successful insertion and removal require familiarity with the implantation technique and specialized instrumentation.[5]

SURGICAL TECHNIQUES

In selected cases, surgical enlargement of the pupil may be necessary. Stretch pupilloplasty is performed using two Sinskey hooks to stretch the iris sphincter mechanically, thereby increasing pupillary diameter.[1] Alternatively, radial sphincterotomies may be created using microsurgical scissors or a microscalpel to enlarge the pupil.[6] Although this technique does not require specialized expansion devices, it permanently alters pupillary architecture and may result in postoperative glare or dysphotopsia. Consequently, radial sphincterotomies are generally reserved for refractory cases in which other methods have failed.[8]

INTRAOPERATIVE FLOPPY IRIS SYNDROME (IFIS)

Successful management of intraoperative floppy iris syndrome begins with careful preoperative identification of patients receiving alpha-1 adrenergic antagonists and the initiation of topical NSAIDs when appropriate.[4] During surgery, fluidic parameters should be adjusted by reducing aspiration flow and vacuum settings to minimize iris billowing. Cohesive ophthalmic viscosurgical devices may be used to stabilize the iris and maintain anterior chamber configuration.[5] Excessive hydrodissection should be avoided because it may further destabilize the iris. Early deployment of iris hooks or pupil expansion rings should be considered when progressive iris prolapse or miosis is anticipated.[9] If necessary, intracameral epinephrine may be administered as a bolus to

restore iris tone and maintain adequate pupillary dilation.[2]

PEARLS AND PRACTICAL CONSIDERATIONS

Successful management of small pupils during cataract surgery depends largely on anticipation, preparation, and timely intervention. Patients at increased risk, including those with pseudoexfoliation syndrome, diabetes mellitus, or systemic tamsulosin therapy, should be identified during the preoperative assessment.[1,3] Preparation involves ensuring availability of a wide range of pharmacological agents and mechanical expansion devices to allow prompt escalation of management when needed.[4] Early intervention before significant intraoperative miosis develops generally results in safer surgery and reduces the risk of complications.[5] Throughout the procedure, maintaining anterior chamber stability is essential for protecting both the iris and the corneal endothelium.[2] Gentle tissue handling should always be emphasized to preserve iris architecture, minimize surgical trauma, and optimize postoperative visual outcomes.[8]

DISCUSSION

Management of small pupils in phacoemulsification requires a stepwise, individualized approach. Pharmacological methods should be attempted first, escalating to viscoelastic expansion and mechanical devices as needed.[1,5] Pupil expansion rings such as the Malyugin ring provide excellent stability and are associated with favorable safety profiles, though surgeon familiarity is critical.[7] In contrast, pupilloplasty and sphincterotomies are best reserved for severe, refractory cases.[6,8] With appropriate anticipation and technique, most cases of poor dilation can be managed successfully, minimizing complications and ensuring optimal visual outcomes.[10]

CONCLUSION

Small pupils present a frequent and significant challenge in phacoemulsification. Anticipation, thorough preparation, and judicious use of both pharmacological and mechanical interventions are essential for safe and efficient surgery. With skillful planning and execution, the risks associated with poor dilation can be mitigated, leading to improved surgical safety and patient satisfaction.

Conflict of Interest: There is no conflict of interest

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