Aphakia without capsular support: a nonsystematic review

Afacia sem suporte capsular: uma revisão não sistemática

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How to cite:
Bergamasco VD, Santos VR, Moscovici BK , Campos M. Aphakia without capsular support: a nonsystematic review.Rev Bras Oftalmol. 2025;84:e0039.

doi:
https://doi.org/10.37039/1982.8551.20250039

Keywords:
Aphakia; Phacoemulsification; Anterior chamber; Macular edema; Lens, intraocular; Lens implantation, intraocular; Visual acuity; Sutures; Ophthalmologic surgical procedures; Postoperative complications

Descritores:
Afacia; Facoemulsificação; Câmara anterior; Edema macular; Lentes intraoculares; Implante de lente intraocular; Acuidade visual; Suturas; Procedimentos cirúrgicos oftalmológicos; Complicações pós-operatórias

ABSTRACT

This review discusses various surgical techniques for correcting aphakia in patients without adequate capsular support, focusing on lens implantation methods and their associated outcomes. It evaluates anterior chamber intraocular lenses, iris fixation with or without sutures, and scleral fixation techniques, both sutured and sutureless. Each method is assessed for its visual acuity results, complication rates, and long-term stability. The advantages and disadvantages of iris and scleral fixation are compared, addressing risks such as endothelial loss, intraocular lens dislocation, and postoperative complications such as glaucoma and cystoid macular edema. Recent advances, including sutureless scleral fixation using the Yamane technique and specialized intraocular lenses such as the Carlevale lens, are also explored. The review emphasizes the need for consensus on the ideal method for correcting aphakia, given the variability in surgical approaches, ocular comorbidities, and surgeon preferences.

RESUMO

Esta revisão detalha várias técnicas cirúrgicas utilizadas para corrigir a afacia em pacientes sem suporte capsular adequado, com foco nos métodos de implante de lentes e em seus resultados associados. São discutidas lentes intraoculares de câmara anterior, fixação na íris com ou sem suturas e técnicas de fixação escleral, com ou sem suturas. Cada método é avaliado em termos de resultados de acuidade visual, taxas de complicações e estabilidade a longo prazo. As vantagens e as desvantagens da fixação na íris e da fixação escleral são comparadas, incluindo os riscos de perda endotelial, deslocamento da lente intraocular e complicações pós-operatórias, como glaucoma e edema macular cistoide. Avanços recentes, como a fixação escleral sem suturas utilizando a técnica de Yamane e lentes especialmente projetadas, como a lente Carlevale, também são examinados. A revisão destaca a necessidade de consenso sobre a técnica ideal para correção da afacia, considerando a variabilidade nos métodos cirúrgicos, comorbidades oculares e preferências dos cirurgiões.

Received on:
March 28, 2024

Accepted on:
February 6, 2025

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Conflict of interest:
no conflict of interest.

Financial support:
no financial support for this work.

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INTRODUCTION

According to the World Health Organization (WHO), cataracts are the second leading cause of visual impairment worldwide, following uncorrected refractive errors, and account for 33% of visually impaired patients globally. In 2019, the WHO projected an increasing prevalence of avoidable blindness due to cataracts, particularly in individuals aged 50 and older.[1,2]

Patients with cataracts often experience reduced life expectancy and quality of life. As the global population ages, the number of individuals affected by cataract-related visual impairment is expected to rise.[3] Cataract surgery, which is both cost-effective and highly successful,[3,4] is widely recommended in the WHO Global Plan of Action for Eye Health as a treatment for preventable blindness.[1]

By 2020, approximately 30 million individuals had undergone cataract surgery, making it one of the most frequently performed surgical procedures globally.[5,6] Cataract surgery is generally safe and reproducible, but complications can occur. One of the most common complications is posterior capsule rupture, with or without vitreous loss.[7] A multicenter study in the United Kingdom reported a posterior capsule rupture rate of 1.92% and intraocular lens (IOL)-related complications in 0.13% of cases.[6]

A rare but severe complication of phacoemulsification (PHACO) is the inability to implant an IOL due to the absence of capsular support, resulting in aphakia. In addition to impaired visual acuity, aphakia may cause retinal and macular changes, intraocular pressure fluctuations, and corneal endothelial involvement.[8,9]

The literature on unplanned aphakia following PHACO varies significantly in its findings. Differences in methodological design, surgical techniques, and other factors may account for this variation. An Indian study of over 51,000 cases reported a 0.03% rate of aphakia as a complication of cataract surgery.[10] Conversely, a study using Sweden's national database in 2004 found a higher rate of unplanned aphakia after PHACO, revealing that 0.5% of 280,000 reviewed cases resulted in aphakia. The primary risk factors associated with aphakia included preexisting eye diseases and low preoperative visual acuity.[11,12]

Extrapolating from these findings and WHO estimates, tens of thousands of patients worldwide may experience vision impairment due to postoperative iatrogenic aphakia following cataract surgery.[1-12]

Aphakia typically arises from surgical complications that prevent the implantation of an IOL. However, in rare cases – such as congenital cataract removal in infancy, emergency surgery for traumatic injuries, or PHACO for high myopia –aphakia may be an intended outcome.[13,14] Corneal edema, iris prolapse, increased vitreous pressure, and anterior displacement of the iridocapsular diaphragm may all contribute to challenges in IOL implantation during PHACO. Secondary IOL implantation is generally manageable under these conditions if capsular support is preserved.[11,12]

Because of the loss of capsular support, aphakia necessitates correcting residual ametropia using nonsurgical methods, such as glasses or contact lenses, or through surgical techniques involving IOL implantation.[15]

Although keeping a patient without an IOL and recommending nonsurgical optical correction is acceptable under certain conditions, in most cases, providing a definitive surgical solution is desired. All surgical correction techniques for aphakia without capsular support involve placing the IOL outside the conventional position. These methods differ only in the location and method of IOL fixation. This review describes the IOL fixation techniques.

The Research Ethics Committee of the Universidade Federal de São Paulo (Unifesp) approved this study (0760/2016). This study was duly registered on Plataforma Brazil (under number CAAE 56825616.3.0000.5505)

Anterior chamber intraocular lenses

In the early 1950s, before the advent of PHACO, Strampelli[16] initially described anterior chamber lenses resting at the iridocorneal angle. At that time, few techniques for correcting wall cross-sectional area (WCSA) were available. This relatively simple secondary implant technique required large incisions in the cornea or sclera to insert these large-diameter non-folding lenses. Over time, as surgeons gained more experience, anterior chamber lenses supported by the iridocorneal angle became less favored due to the occurrence of several postoperative complications, including glaucoma, hyphema, uveitis, cystoid macular edema, epiretinal membrane, and endothelial loss.[17,18]

Due to the high rate of complications, modifications in the designs and materials were proposed, and these lenses were reconsidered as a treatment alternative for WCSA. The change in the shape of the support haptics, with more open curves referred to as "open loops", was crucial in reducing the complication rates. Several studies have shown that visual acuity outcomes and long-term complication rates with modern lens design are comparable with other WCSA correction options.[19-21]

Iris fixation

The iris can serve as a support structure for fixing the IOL. Fixation can be performed on either the anterior or posterior surface of the iris, with or without sutures. Various techniques have been developed to securely anchor the IOL while minimizing trauma to surrounding ocular tissues.

Iris fixation using sutures

Suture-based iris fixation was first described by McCannel in 1976 to stabilize the capsular bag and IOL complex in cases of zonular weakness. Over time, modifications allowed for direct fixation of the IOL to the iris using sliding knots that are less traumatic. Sutures are passed through the iris tissue to capture the IOL haptics, securing the lens behind the pupil once both haptics are fixed.[22]

Long needles are used to transfix the iris tissue through the anterior portion, capture the IOL haptic, and transfix the iris through the pigment epithelium. The needle is then externalized, and a Siepser slip knot is used for fixation. During suturing, the reverse capture maneuver of the pupil optic zone is performed under drug-induced miosis to stabilize the IOL. Once both haptics are fixed, the capture is undone, and the IOL is positioned behind the pupil.[22-29]

The original technique employed 10–0 polypropylene sutures; however, using 9-0 sutures may present greater long-term stability. This method presents some advantages for scleral fixation, including a lower risk of vitreous hemorrhage and shorter surgical time, making it the preferred technique for many experienced surgeons.[30,31] However, common long-term complications include changes in pupillary anatomy, IOL dislocation, uveitis, glaucoma, refractive instability, and cystoid macular edema.[23,24]

Iris fixation using tissue enclave

The first lens implantation using this technique was performed in 1972 and was considered the least favorable. However, several authors have since evaluated and compared it with other fixation alternatives.

Clasping lenses can be attached to the iris without sutures. Specially designed lenses like the Artisan (Artisan Aphakia®, Ophtec BV, Groningen, Netherlands) have small claws to secure the iris tissue.

This lens type can be fixed to the anterior or posterior portion of the iris. Studies have shown improvements in refractive outcomes and visual acuity and fewer complications compared with iris fixation with sutures or anterior chamber lenses.[25] Retro-iris fixation of this lens type offers better results, with less endothelial cell loss and superior refractive outcomes than anterior fixation.[26] Common complications include cystoid macular edema, ocular hypertension, and lens displacement.[25-27]

This technique is fast, involves minimal tissue manipulation, and results in the physiological positioning of the IOL in the retro-irian portion. However, healthy iris tissue is necessary for successful outcomes.

Scleral fixation

When capsular support is absent, the sclera provides a strong support structure for IOL fixation. Scleral fixation techniques aim to stabilize the IOL in the ciliary sulcus plane, providing reliable long-term results. Sutures are typically used to anchor the IOL to the sclera, although recent advances have introduced sutureless techniques. In traditional scleral fixation, sutures are passed through the sclera to secure the IOL haptics, with care taken to avoid complications such as suture erosion and exposure.

Scleral fixation using sutures

In 1986, Malbran et al.[28] described a technique using 10-0 polypropylene sutures to fix one-piece polymethylmethacrylate (PMMA) lens. Later variations involved different lenses and sutures.[29] When sutures are used, the knots must be covered to prevent erosion during the postoperative period. Techniques such as partial-thickness scleral flaps or scleral pockets, as described by Hoffman in 2006, are employed for this purpose.[30]

The zigzag suture technique eliminates the need for scleral dissection. Here, the suture is passed linearly from one side to the other through the scleral stroma, forming a "Z" shape.[31,32] Complications related to scleral fixation with sutures include changes in intraocular pressure, retinal detachment, vitreous hemorrhage, and IOL displacement due to suture rupture.[24,33-51] Khan et al.[52] reported good outcomes using U-shaped Gore-Tex sutures (W.L. Gore & Associates, Newark, Delaware), noting that they are non-absorbable and may remain intact for decades.

Sutureless scleral fixation

Recently described scleral fixation techniques no longer rely on sutures. In the Handshake technique, reported by Agarwal in 2013, haptics are externalized using micro forceps and inserted into scleral tunnels to prevent exposure.[34]

Yamane et al.[35] described another variant using 30-gauge needles to direct haptics through the sclera and conjunctiva without peritomies or scleral flaps. The ends

of the haptics were reshaped with thermal cautery to prevent slippage.

Recently, a new IOL specifically designed for sutureless scleral fixation using trans-scleral plugs and flexible acrylic material has been introduced. Barca et al. described a technique that uses a hydrophilic acrylic single-piece IOL stabilized without needing haptic manipulation. The surgical steps include creating a scleral flap, performing sclerotomies 2 mm posterior to the limbus, and externalizing T-shaped haptics through the sclerotomies, ensuring stable and self-centering IOL fixation.[36] Similarly, Rossi et al. presented the Carlevale IOL, a hydrophilic acrylic lens that can be injected through a 2.2-mm incision. This technique involves scleral preparation, sclerotomies, and externalization of the haptics, which are then fixed in scleral flaps. Although long-term data are still required, both techniques avoid sutures and offer promising results regarding IOL stability, automatic centration, and reduced complication risks.[37,49]

Ripa et al.[50] reviewed the Carlevale IOL (Soleko SPA, Pontecorvo, Italy), a new hydrophilic foldable acrylic IOL specifically created for sutureless scleral fixation. This IOL demonstrated stability and good visual results. Radice et al.[51] IOL fixation was performed using sleeves to secure three-piece IOL haptics in intrascleral tunnels. At the end of surgery, the sleeves were removed, and sutures were placed in the sclerotomies to prevent leakage. IOL stability and good visual results were noted in a small sample size.

Although scleral fixation techniques without sutures are considered modern, they offer the advantage of long-term stability. However, complications such as scleral erosion, endothelial loss, and haptic extrusion can still occur.[38-47] Shancheng SI et al.[47] performed a one-piece IOL fixation using a transscleral tunnel puncture at the pars plana with an arc-shaped needle and 8-0 polypropylene suture. The suture was guided out of the corneal incision using a 1-mL syringe needle and passed into the inferior haptics of the IOL. It was then cut and heated into a probe with a spherical tip using a monopolar coagulation device to prevent slippage from the haptics. Shancheng SI et al. used this technique on ten eyes, achieving IOL stabilization in nine.

Chen et al.[48] performed a 4-point transscleral suture fixation of a foldable IOL using the double-suture technique with an Akreous IOL (Bausch & Lomb, New York, USA). Byun et al.[49] focused on the leading haptic region of the IOL, which was externalized by pulling forceps through the trocar at the 5 o'clock position. The trailing haptic was inserted into the vitreous cavity and externalized at 11 o'clock. Both haptic ends were then blunted using portable cautery.

As described by Canabrava and Carvalho, the double-flanged polypropylene technique offers a sutureless approach for the scleral fixation of IOLs, reducing complications associated with traditional suturing methods. This technique involves creating flanges at both ends of a polypropylene suture by heating the ends to form bulbous tips that prevent slippage through scleral tunnels. Two scleral tunnels, typically 2 mm posterior to the limbus, are made using a 27-gauge needle, through which the flanged sutures are passed. The IOL is positioned carefully, and the flanges are externalized and buried under the conjunctiva to provide stable fixation and prevent exposure. Canabrava and Carvalho's 5-year study of 71 eyes from 61 patients demonstrated effective and stable outcomes, with a mean follow-up of 28.2 ± 14.3 months. Minimal complications were observed, with exposed flanges in 2.89% of cases and retinal detachment in 4.22%, whereas no cases of endophthalmitis were reported. This technique offers advantages such as reduced surgical complexity and a lower risk of long-term complications than traditional methods. However, precise execution is critical to minimize risks such as flange exposure.[45,53]

The four-flanged intrascleral IOL fixation technique, developed by Canabrava et al.[54] is a sutureless method designed to secure IOLs in aphakic eyes, particularly in the absence of capsular support. This method builds upon the Malbran and Yamane techniques, utilizing a 5.0 polypropylene suture and bipolar cautery to create four flanges – two internal flanges at the IOL eyelets and two external flanges for anchoring in scleral tunnels. These flanges are passed through scleral tunnels without additional supportive measures such as scleral flaps or knots, thus simplifying the procedure and reducing the risk of complications. Clinical outcomes have improved visual acuity, with preoperative corrected distance visual acuity improving from 0. ± 0.17 to 0.67 ± 0.27 postoperatively (Snellen decimal units). This technique provides a stable and effective alternative for IOL fixation, particularly in complex aphakic cases, reducing surgical time and potential complications compared with traditional suturing methods.

Jang et al.[53] compared suture and sutureless fixation and found that sutureless intrascleral fixation was an effective and reliable surgical technique, offering more favorable visual and refractive outcomes than conventional sutured scleral fixation.

Artificial support

De Novelli et al.[40] achieved good optical results, medium-term stability, and low complication rates by creating artificial support for the IOL, using polypropylene threads to transfix the eye in the plane of the ciliary sulcus. The threads were arranged orthogonally to form a network, leading to the technique being dubbed "hashtag" due to the shape generated by the intersecting wires behind the optical zone of the IOL. However, studies have not yet conducted long-term follow-ups on this technique, and the results could be compromised by thread biodegradation and suture dehiscence.[41]

Flaws in WCSA correction techniques

Scleral fixation techniques and their variants are complex and have limited reproducibility, as they depend on the surgeon's skill and experience. The availability of an appropriate IOL model and diopter is critical during surgery for WSCA correction, which may not be pre-planned. The need for conjunctival and scleral dissection may limit options for patients who develop glaucoma and require fistulizing surgery.

Polypropylene sutures, used in the iris, scleral, and hashtag techniques, present a long-term risk of IOL displacement as the material may degrade with light exposure and contact with ocular tissues.[41,42] Long-term studies have shown that 40% to 50% of patients who underwent scleral fixation with polypropylene sutures experienced IOL displacement rates due to suture degradation within 10 years of surgery.[43,44]

Endophthalmitis risk is higher in patients with conjunctival erosion and exposed sutures, which can occur even when covered with a scleral flap.[33] Enclave iris fixations with specially designed IOLs and anterior chamber IOLs are technically less complicated but depend on the immediate availability of costly and inaccessible lenses, often limited by geographical location, local legislation, and regulatory mechanisms.

Several WSCA correction techniques have been described in the literature, but there needs to be a consensus regarding the superiority of any particular modality.[22,24,27] This lack of consensus may result from the many variables involved, including ocular comorbidities, patient age, surgeon preferences and experience, and commercial availability of specific supplies and costs.[43-46]

A recent meta-analysis compared the clinical outcomes and complication rates of iris, intrascleral, and transscleral fixation techniques. Each method had positive and negative aspects: iris fixation resulted in shorter surgical time, less cystoid macular edema, and lower incidences of postoperative glaucoma but was associated with higher endothelial cell loss and corneal decompensation. Conversely, scleral fixation was associated with complications related to haptic and suture exposure and erosion. Caution should be taken when considering iris fixation for younger patients or those with preexisting endothelial alterations. The statistical analysis revealed no significant superiority of one method despite their respective positive and negative aspects.[22]

A recent study reviewed various IOL types for scleral fixation without sutures and analyzed each previously described positive and negative aspects of the technique. The study concluded that no ideal technique has yet been developed, given the number of techniques proposed to address the same problem. Table 1 compares the key techniques described in the literature.[17]

Table 1. Comparison of WCSA surgical correction techniques

Surgical technique	Advantages	Disadvantages
Anterior chamber IOL	Uncomplicated surgical technique Reduced surgical time	Long-term concerns regarding effects on corneal endothelium It requires iris tissue integrity Increased induced surgical astigmatism
Iris enclave IOL	Uncomplicated surgical technique Reduced surgical time	Long-term concerns regarding the effects on the corneal endothelium (pre-pupillary fixation) It requires iris tissue integrity Pupillary anatomy alteration Increased induced surgical astigmatism
Iris fixation of IOL with suture	Physiological positioning Possibility of suturing the displaced IOL	Prolonged surgical time Alteration of the pupillary anatomy Possibility of suture dehiscence It needs iris tissue integrity
Scleral fixation of IOL with suture	Physiological positioning Possibility of suturing the displaced IOL	Prolonged surgical time Possibility of suture dehiscence Suture exposure Increased risk of intraocular hemorrhage Increased risk of suture-related endophthalmitis
Sutureless scleral fixation IOL (intra-scleral)	Physiological positioning Possibility of attaching an offset three-piece IOL New IOL models for scleral fixation	Prolonged surgical time Technically challenging Unsuitable for eyes with large corneas Risk of damage to the haptics Risk of reverse pupillary block Less postoperative refractive predictability

Source: Translated and adapted by the author from Czajka et al.[17]
IOL: intraocular lens.

In 2003, the American Academy of Ophthalmology (AAO) published an extensive literature review that cited over 60 articles. However, the authors refrained from recommending a best practice, as no randomized studies were available to support such conclusions.[46]

For a surgeon facing the unexpected complication of complete capsular support loss during routine surgery – without access to an anterior chamber IOL or an enclaved iris fixation IOL – the IOL that was programmed for implantation inside the capsular bag must be either fixed to the sclera or iris, or a secondary implantation may be performed at a later surgical time, a decision that may cause inconvenience. Even if scleral fixation is chosen simultaneously with PHACO, this option significantly alters the initial surgical plan, adding many steps and technically complex maneuvers, even for experienced surgeons.

Based on the data presented, there is no current "gold standard" for the surgical correction of WCSA.

AUTHORS' CONTRIBUTION

Substantial contribution to conception and design: Vagner Rogério dos Santos, Mauro Campos, Victor Dias Bergamasco; Data acquisition: Vagner Rogério dos Santos, Mauro Campos, Victor Dias Bergamasco, Bernardo Kaplan Moscovici; Data analysis and interpretation: Victor Dias Bergamasco, Bernardo Kaplan Moscovici; Drafting of the manuscript: Victor Dias Bergamasco , Bernardo Kaplan Moscovici; Critical revision of the manuscript for important intellectual content: Vagner Rogério dos Santos, Mauro Campos; All authors have given final approval of the submitted manuscript (mandatory participation for all authors): Bernardo Kaplan Moscovici, Vagner Rogério dos Santos, Mauro Campos, Victor Dias Bergamasco; Administrative, technical, or material support supervision: Vagner Rogério dos Santos, Mauro Campos; Research group leadership: Vagner Rogério dos Santos, Mauro Campos

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