MODERN METHODS OF INTRAOCULAR LENS FIXATION WITH INSUFFICIENT CAPSULAR SUPPORT: A LITERATURE REVIEW

Z. R. Nazirova[1], D. M. Turakulova[2], A. A. Asatillaev[3]
Tashkent State Medical University, Tashkent, Republic of Uzbekistan[123]
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Abstract. *The aim of this study is a comprehensive analysis of existing methods and surgical techniques for intraocular lens (IOL) fixation in cases of insufficient or complete loss of capsular support. Special attention is given to evaluating the clinical effectiveness of different implantation approaches, their advantages, limitations, and potential risks of intra- and postoperative complications. The study includes a systematic review of recent scientific publications by both domestic and international authors on the problem of IOL implantation in aphakia and capsular bag insufficiency. The search and selection of sources were based on relevance, level of evidence, and practical significance of the data presented.*

Keywords: *cataract, intraocular lens implantation, Marfan syndrome, transscleral fixation.*

Introduction

Cataract remains one of the leading causes of visual impairment and blindness worldwide. According to the World Health Organization, lens opacity accounts for more than half of reversible blindness cases, reaching approximately 51% of the global ophthalmologic disease burden. The social significance of this disease is determined not only by its high prevalence but also by its pronounced impact on patients' quality of life, work capacity, and level of social adaptation. Currently, the only effective treatment for cataract is surgical removal of the opaque lens followed by intraocular lens (IOL) implantation. Modern phacoemulsification technologies and improvements in IOL design have significantly increased the safety of the procedure and improved functional outcomes. Nevertheless, clinical practice still faces challenges related to pathology of the lens zonular apparatus. According to various authors, 5–15% of cases show pronounced zonular insufficiency, and up to 20% of patients have subclinical forms of zonular weakness.

Disruption or functional insufficiency of the zonular apparatus complicates the surgical technique, increases the risk of intra- and postoperative complications (IOL dislocation, secondary glaucoma, inflammatory reactions), and may negatively affect the final visual outcome. In cases of insufficient capsular support, traditional IOL implantation in the capsular bag becomes impossible due to a high risk of decentration or lens displacement.

In such clinical situations, alternative IOL fixation methods are used: placement in the anterior chamber or posterior chamber implantation with fixation to the iris or sclera. Each method has its own indications, advantages, and limitations, which underscores the need for further refinement of surgical approaches and the development of criteria for selecting the optimal strategy. Factors contributing to complicated lens extraction may include traumatic eye injuries, primary zonular weakness, capsular bag insufficiency, and systemic or hereditary disorders. Notably, pseudoexfoliation syndrome, characterized by degenerative changes in the anterior segment of the eye, plays a significant role. Congenital connective tissue anomalies, such as those

seen in Marfan syndrome and homocystinuria, are also associated with pronounced zonular weakness, predisposing patients to lens subluxation or dislocation.

Thus, the high prevalence of cataract, combined with frequent zonular pathology, determines the relevance of developing and improving surgical methods for correcting aphakia in the absence of adequate capsular support. Studying this problem has important clinical significance and aims to increase the safety of surgical interventions and improve functional treatment outcomes.

Objective of the study. The objective of this work is a comprehensive analysis of existing methods and surgical techniques for intraocular lens (IOL) fixation under conditions of insufficient or complete loss of capsular support. Particular attention is paid to evaluating the clinical effectiveness of different implantation methods, their advantages, limitations, and potential risks of intra- and postoperative complications.

As part of the study, a systematic review of recent scientific publications by domestic and foreign authors was conducted, focusing on the problem of IOL implantation in aphakia and capsular bag insufficiency. Source selection was based on relevance, level of evidence, and practical significance. A total of 126 bibliographic sources were analyzed, including peer-reviewed journal articles, clinical guidelines, results of multicenter studies, and conference materials. Following a critical assessment of the scientific value of these publications, 58 sources were included in the final review, representing the most comprehensive and up-to-date view of the problem and its development directions.

Thus, the study aims to provide a reasoned understanding of modern approaches to IOL fixation in the absence of adequate capsular support and to identify optimal surgical strategies from an evidence-based medicine perspective. IOL fixation to the iris. One of the historically early approaches to non-standard IOL implantation in complicated cataract surgery was fixation to the iris. This method was applied in situations of insufficient capsular support and involved placing the lens in the pupil plane, anterior chamber angle, or directly fixing it to the iris tissue.

Sutureless Fixation Methods. Sutureless techniques include the use of iris–vitreal models, particularly the Artisan lens, which is based on the “claw” (iris-claw) mechanism. The structural feature of this IOL involves grasping the iris stroma with special fixation elements, providing relative stability of the lens position. Clinical observations indicate that initial implantation outcomes of such models were satisfactory. However, long-term outcome analysis revealed a risk of fixation mechanism splitting in 9.4% of cases, and according to other sources, up to 14% within the first 6–7 months postoperatively.

Anterior chamber IOLs with sutureless support in the angle of the anterior chamber also deserve mention. Despite the technical simplicity of implantation, these designs did not gain widespread adoption. Constant pressure on anterior chamber angle structures and relative lens mobility led to corneal endothelial trauma, chronic uveitis, secondary glaucoma, and corneal dystrophy. According to the literature, the frequency of such complications reached 35–40% of cases.

Sutured Fixation to the Iris. Sutured IOL fixation to the iris has become more widely used, especially in domestic ophthalmology practice. Significant contributions were made by S.N. Fedorov and V.D. Zakharov, who developed the iris-clip lens. The advantage of this design is the possibility of simultaneous correction of traumatic mydriasis. However, notable drawbacks include sphincter pupillae dysfunction, pronounced pigment dispersion, displacement of fixation elements (up to 13.6%), cystoid macular edema, endothelial cell loss, and iridodonesis.

With the introduction of modern flexible hydrophilic and hydrophobic IOL models implanted through small corneal incisions, the technique of suturing the lens to the iris has evolved. In the classical approach, the haptic elements are fixed to the mid-peripheral or peripheral iris using 10/0 polypropylene suture. The surgical procedure involves creating corneal paracenteses, passing the suture under the haptic element, and tying it without excessive tension to avoid tissue ischemia. The knot is buried under the iris to minimize contact with the anterior chamber.

Of particular interest is the 2020 method proposed by D.I. Ivanov, which involves fixation of the "IOL-capsular bag" complex to the iris. This approach demonstrates certain advantages in the long-term postoperative period, especially in cases of pronounced capsular fibrosis, as it avoids lens explantation or replacement, reducing the risk of repeat surgery.

Complications and Limitations. Despite its relative technical accessibility, sutured fixation to the iris is associated with potential complications, including iris atrophy, pigment dispersion, chronic uveitis, and cystoid macular edema. Continuous mechanical impact on the iris tissue may exacerbate postoperative inflammation. Therefore, iris fixation is clinically significant and relatively accessible, but the high frequency of inflammatory and degenerative complications necessitates individualized surgical strategy based on the anatomical and functional state of the anterior segment.

Scleral Fixation of IOLs. The development of methods for scleral fixation of IOLs aimed to minimize trauma to the eye's uveal tissue while maintaining physiologically justified posterior chamber positioning of the lens. Clinical and histopathological studies have shown that posterior chamber implantation offers advantages over anterior chamber placement, including reduced risk of corneal endothelial cell loss, damage to anterior chamber angle structures, pupillary block, and iritis. Moreover, the optical performance of the lens is maximized when placed in a position anatomically close to its natural location.

Posterior chamber fixation is particularly important in correcting aphakia in patients with pre-existing anterior segment pathology, including glaucoma, congenital iris defects (e.g., aniridia), and low corneal endothelial cell density. Satisfactory functional results have also been reported in patients with uveitis, indicating relative biocompatibility and stability of lens position.

Transscleral Fixation: Classification of Approaches. Transscleral IOL fixation can be performed using sutured or sutureless methods. Sutured techniques differ by the direction of the fixation suture: ab externo (outside–in) or ab interno (inside–out). Methods are also classified by the number of fixation points (two-, three-, or four-point stabilization), which affects IOL centration and stability within the ciliary sulcus.

Historical Aspects of Sutured Fixation. One of the first scleral sutured IOL fixation techniques was proposed by E.S. Malbran et al. in 1986. The lens was implanted after intracapsular cataract extraction, with haptics fixed to the sclera approximately 2 mm from the limbus using 10-0 polypropylene suture (ab externo) and a 28G needle. A critical technical consideration was avoiding the projection of long ciliary arteries (traditionally at 3 and 9 o'clock), which reduced the risk of vascular complications.

Further development was associated with J.S. Lewis et al., who popularized the ab externo technique with scleral flap creation and burial of the knot in the scleral bed, minimizing erosion and infection risk. An alternative ab interno approach was proposed by W.E. Smiddy et al. in 1990, in which the suture is passed from inside the eye outward through the ciliary sulcus. Despite no serious complications in their observations, a significant drawback remained—the "blind" passage of the needle about 1 mm posterior to the limbus, increasing the risk of intraocular structure

damage. An anterior vitrectomy was recommended to prevent vitreous entrapment or prolapse into the anterior chamber.

Modern Stage of Sutured Transscleral Fixation. The development of microinvasive technologies and new materials has advanced the technique. A. Hadayer et al. (2019) described an ab interno method using a foldable hydrophilic acrylic IOL implanted through a 2.4 mm corneoscleral incision with Gore-Tex suture. The use of non-absorbable synthetic sutures increases long-term fixation strength and reduces the risk of late suture degradation, a known problem with polypropylene threads.

Thus, transscleral IOL fixation provides anatomically justified posterior chamber positioning and superior optical and biomechanical characteristics compared with anterior chamber models. However, it requires high surgical skill and carries intraoperative risks, including hemorrhage, ciliary body injury, and IOL decentration due to asymmetric suture tension. Improvements in suture techniques, microinvasive access, and modern suture materials make scleral fixation one of the most physiologically favorable and promising methods for correcting aphakia in the absence of capsular support.

Traditional transscleral fixation methods relied on polypropylene sutures attached to haptics and exteriorized through the sclera. Despite technical accessibility, these methods had a significant drawback-the presence of an external suture knot. Gradual erosion through the scleral tissue or conjunctiva created a risk of infection and endophthalmitis, considered one of the most serious late complications.

In 1993, K. Solomon et al. proposed creating triangular scleral flaps in the limbal area to cover 10-0 polypropylene suture knots, aiming to reduce the risk of suture exposure. However, retrospective analysis demonstrated that even with this modification, the frequency of knot erosion reached 73% through the sclera and 17% through the conjunctiva within 9–12 months. The authors concluded that flap creation merely delays the onset of complications rather than eliminating them, which stimulated further refinement of the technique using scleral pockets.

A significant contribution was made by R.S. Hoffman et al. in 2006, who described a technique for creating scleral pockets without conjunctival dissection. This method involved two opposite clear corneal incisions in the limbal area followed by posterior dissection to form pockets within the scleral thickness. A 10-0 polypropylene suture was passed through a paracentesis, fixed to the IOL haptic, and externalized through the scleral pocket using a 27G guiding needle. After tying, the knot was buried inside the pocket, preventing contact with the external environment. The additional use of fibrin glue simplified fixation and ensured watertight closure.

Retrospective analysis by L. Yeung et al. (2018) demonstrated satisfactory functional outcomes using Hoffman pockets to cover knots during transscleral fixation of a foldable one-piece IOL. Among 40 operated eyes, no serious intraoperative complications occurred; minor vitreous hemorrhages, microhyphemas, and transient intraocular pressure elevations were reported. Cystoid macular edema developed in 8% of cases, and IOL decentration in 3%. Over a mean follow-up of six months, no cases of knot exposure or endophthalmitis were recorded.

An alternative approach to prevent suture erosion was proposed by P. Szurman et al. (2010), who developed a zigzag (Z-shaped) suture technique. This method involved passing the suture multiple times (up to five) through the sclera near the original puncture to form a looped fixation without an external knot. After completion, the suture was cut at the scleral level, eliminating the need for scleral flaps or pockets. In a series of 45 eyes, IOL fixation remained stable over a mean follow-up of 22 months, with only isolated cases of transient ciliary

hemorrhage. However, longer-term studies revealed limitations: using 9-0 polypropylene with a mean follow-up of 64 months, the rate of IOL dislocation reached 13.8%. Additional long-term data reported suture rupture in 16.7% of cases over 7.4 years, with an estimated 10-year failure probability of up to 40%.

Thus, the evolution of traditional transscleral IOL fixation methods reflects efforts to minimize the risk of suture erosion and infectious complications while maintaining lens stability. Despite significant technical improvements-from knot coverage with flaps to scleral pockets and Z-shaped sutures—the long-term durability of polypropylene sutures remains an issue, stimulating the search for alternative materials and sutureless fixation techniques.

The variability of transscleral fixation techniques is driven by the goals of enhancing IOL stability, ensuring optimal centration, and improving refractive outcomes. Clinically, methods with one, two, three, four, and even six fixation points have been described. Historically, the first widely used technique was two-point fixation, proposed by E.S. Malbran in 1986. Despite relative ease of performance, two-point stabilization sometimes resulted in IOL tilt or decentration, prompting the development of multi-point fixation schemes.

One advancement was four-point fixation. A.L. Young et al. (2005) proposed a technique using 10-0 polypropylene sutures with implantation of a one-piece polymethylmethacrylate lens into the ciliary sulcus. Knots were tied approximately 2 mm from the limbus and buried within the scleral tissue, with conjunctival closure. Over a mean follow-up of 18.3 months, no complications related directly to the suture material (erosion, twisting, or knot exposure) were reported. However, 20% of eyes experienced mild vitreous hemorrhage, and 10% developed limited choroidal detachment; both resolved spontaneously without intervention.

Further development of four-point fixation incorporated modern foldable IOLs. O.N. Fass et al. (2010) used a specially designed hydrophilic acrylic Bausch & Lomb Akreos® lens with four-point fixation through a 2.75–3.0 mm corneal incision. Despite the minimally invasive approach, 44% of eyes experienced vitreous hemorrhage; all cases were transient and did not require surgical intervention.

To achieve even greater lens stability, six-point fixation without conjunctival dissection was proposed. This method utilized 8-0 double-polypropylene suture and a one-piece hydrophilic acrylic IOL with a closed three-loop haptic design. In a series of 21 patients with a mean follow-up of 8 months, transient corneal edema occurred in 19% of cases, and temporary intraocular pressure elevation in 14.3%. No cases of suprachoroidal hemorrhage, retinal detachment, suture rupture, knot exposure, or significant IOL decentration were reported. The authors emphasized that the closed haptic configuration allows even load distribution and reliable lens centration.

Thus, increasing the number of fixation points enhances the biomechanical stability of the IOL and reduces the risk of tilt. However, expanding the extent of manipulation may prolong surgery and increase the risk of intraoperative trauma. Therefore, the number of fixation points should be determined according to ocular anatomy, IOL type, and clinical context, highlighting the need for an individualized approach in transscleral IOL implantation.

Suture Material in Transscleral IOL Fixation.The choice of suture material is a critical factor influencing the long-term stability of transscleral intraocular lens (IOL) fixation. Traditionally, 10-0 polypropylene sutures have been widely used in ophthalmic surgery due to their adequate elasticity and ease of handling. However, accumulated clinical experience has demonstrated that the material’s tensile strength may decrease over time, increasing the risk of late suture breakage and IOL dislocation.

For improving the fixation durability, stronger suture materials have been adopted, including 9-0 polypropylene and expanded polytetrafluoroethylene (Gore-Tex 8-0). Gore-Tex has been used in cardiovascular surgery for over two decades and is characterized by high tensile strength and minimal tissue degradation, which has driven interest in ophthalmic applications.

For example, M.A. Khan et al. (2016) utilized 8-0 Gore-Tex for fixation of both rigid polymethylmethacrylate and foldable hydrophilic acrylic IOLs. Initially, a 23G vitreoretinal system was used, resulting in a postoperative hypotony rate of 9.4%. Switching to a 27G needle significantly reduced this complication. In a series of 83 eyes with a mean follow-up of 11 months, no suture ruptures were recorded, indicating the material's high mechanical reliability.

Additional retrospective data from 20 patients undergoing four-point fixation of the Akreos IOL model demonstrated statistically significant improvement in visual function ($p < 0.0001$) with minimal postoperative complications. No lens decentration was observed; however, the sample size was limited and the mean follow-up was only nine months.

A Chinese study employing 10-0 polypropylene combined with S-shaped intrascleral suture tunneling reported no suture-related complications in 69 eyes over a mean follow-up of 34 months. Similarly, a prospective study in Spain using 10-0 non-absorbable polyester (Mersilene) sutures found only one case of IOL repositioning required among 25 eyes.

Nevertheless, the issue of late polypropylene suture degradation remains relevant. B.Y. Vote et al. (2006) reported a 28% suture rupture rate over a mean four-year follow-up in two-point fixation with pars plana vitrectomy. Other studies indicate long-term (up to 10 years) erosion and rupture rates of 10-0 polypropylene ranging from 18% to 28%, with unilateral suture rupture occurring in nearly half of cases. These findings emphasize the need for long-term monitoring and support the search for alternative, including sutureless, fixation methods.

Not all studies report high complication rates. G. Bading et al. (2007) observed only 6.3% subluxation over a four-year follow-up for 10-0 polypropylene sutures covered with scleral flaps, concluding the method to be safe and effective when performed correctly. Thus, suture material choice and caliber are critically important for ensuring long-term stability of transscleral IOL fixation and minimizing late complications, including suture rupture, lens decentration, and inflammatory reactions. While 10-0 polypropylene remains widely used due to availability and ease of use, its potential for late failure necessitates careful postoperative monitoring. Stronger materials such as Gore-Tex show promising results but require long-term evaluation to confirm safety and efficacy. Optimal selection of suture material and size should be individualized according to ocular anatomy, IOL type, and comorbidities, underscoring the need for a personalized approach in aphakia correction.

Sutureless Scleral IOL Fixation. The limitations of sutured transscleral fixation, including suture erosion, lens decentration, and inflammatory complications, have driven the development of sutureless techniques. G.B. Scharioth first described sutureless scleral fixation in 2010, creating scleral tunnels to bury the haptics. In a multicenter study involving 63 patients across four European clinics, transient corneal edema occurred in 7.9% of patients, persistent intraocular pressure elevation in 3.2%, IOL dislocation in 3.2%, vitreous hemorrhage in 3.2%, and iris capture in 2%. Three patients required additional surgery to stabilize the lens, but overall functional outcomes were favorable. A posterior approach modification using 23G trocars, proposed by I.L. Prenner, showed that one year postoperatively, IOL displacement occurred in 12% of patients, with statistically significant improvement in visual acuity.

The “double-needle” technique introduced by S. Yamane uses 27G needles to simultaneously externalize both haptics through limbal tunnels. In the original study (35 eyes, 10 months), no significant dislocation was observed; iris capture occurred in 9%, and the mean IOL tilt was 2.3°. The 2017 modification incorporated flange formation with cautery without scleral incision, ensuring stable IOL positioning with minimal complications: iris capture 8%, vitreous hemorrhage 5%, hypotony 2%, and macular edema 1%.

Another sutureless approach uses scleral flaps combined with fibrin glue to cover haptics. A. Agarwal described creating scleral flaps for haptic fixation. Among 53 eyes, IOL decentration was 5%, and cystoid macular edema 7.5%. Y. McKee (2014) modified Agarwal’s technique, reporting transient hypotony in 22% of patients, one case requiring re-sealing of external filtration, iris capture 5.7%, decentration 2.6%, uveitis 0.5%, haptic displacement 2%, and haptic extrusion 0.5%.

B. Todorich proposed transscleral fixation using 25–27G trocar cannulas to externalize haptics of foldable three-piece IOLs (Alcon MA60AC) through scleral ostomies. In a retrospective analysis of 122 patients, vitreous hemorrhage was the most common complication (22%), resolving spontaneously in 67% of cases. Mean follow-up was 1.5 years.

Thus, sutureless fixation techniques demonstrate high effectiveness and favorable functional outcomes, while minimizing conjunctival erosion and complications associated with external sutures. Burying haptics in scleral tunnels, flange formation, and adhesive technologies allow stable lens fixation and reduce long-term complication risks.

Conclusion

No universally optimal method exists for IOL fixation in the absence of sufficient capsular support, highlighting the need for ongoing research. Long-term stability criteria and factors contributing to late suture failure remain unclear. Enhancing the safety and efficacy of aphakia surgery requires a comprehensive evaluation framework for IOL fixation methods, incorporating lens position topography, refractive assessment, and endothelial cell counts. Such an approach would standardize outcome assessment, minimize complications, and optimize surgical technique selection on a case-by-case basis.

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