SURGICAL APPROACHES TO INFERIOR OBLIQUE MUSCLE OVERACTION IN ATYPICAL STRABISMUS: A LITERATURE REVIEW

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Abstract. *Inferior oblique muscle overaction (IOOA) is one of the most frequent motility disorders associated with atypical strabismus, particularly in V-pattern deviations. This condition significantly affects ocular alignment, binocular vision, and quality of life, while also complicating surgical planning and influencing postoperative stability. Several surgical approaches have been developed to correct IOOA and are currently performed by strabismus surgeons. The aim of this article is to summarize the modern surgical techniques used in the management of IOOA based on a literature review. Recent publications, reports, guidelines, and textbooks were analyzed. According to the review, weakening procedures-including recession, myectomy, myotomy, and anterior transposition-are the most widely employed surgical methods. Each technique has its own advantages and limitations, and evidence suggests that surgical success depends on the severity of IOOA, the type of atypical strabismus, and the individual anatomy of the patient. Moreover, combined surgical approaches are increasingly utilized to improve both functional and cosmetic outcomes. In conclusion, although surgical management of IOOA in atypical strabismus is effective, it remains a complex challenge. An individualized approach tailored to each patient is essential for achieving optimal results. Future long-term follow-up studies will play a crucial role in establishing standardized surgical guidelines for IOOA correction.*

Keywords: *inferior oblique muscle overaction, atypical strabismus, surgical management, V-pattern.*

Introduction. Strabismus, defined as both a cosmetic and functional disorder of binocular vision and the oculomotor system, represents a significant ophthalmologic as well as social problem. The prevalence of strabismus in the general population is estimated to range between 2% and 5% [1]. Atypical forms of strabismus are relatively uncommon but clinically significant disorders of ocular motility, often presenting with complex deviations that cannot be explained by simple horizontal or vertical misalignment. Among these, V-pattern strabismus associated with inferior oblique muscle overaction (IOOA) is one of the most frequently observed variants in pediatric ophthalmology. IOOA is clinically characterized by overelevation of the eye in adduction and is reported to occur in approximately 70% of patients with esotropia and 30% of those with exotropia [2]. According to Chang B.L. and Yang S.W. (1988), inferior oblique overaction is considered the most frequent type among all extraocular muscle overactions [3,5].

The presence of this condition may cause abnormal ocular alignment, impair binocularity, and influence psychosocial development in children. From a surgical standpoint, IOOA remains a challenging problem. Although multiple procedures such as recession, myectomy, myotomy, and anterior transposition of the inferior oblique muscle have been introduced, there is still no universal consensus regarding the optimal surgical method [4]. Each approach has distinct advantages and limitations, and the choice largely depends on the degree of muscle overaction, the type of

associated strabismus, and individual anatomical variations (Parks, 1972; Mims, 1993). Furthermore, atypical forms of strabismus are often accompanied by additional motility disorders, which complicate surgical planning and may affect postoperative stability. Therefore, a comprehensive analysis of the existing literature is essential to identify the most effective strategies for managing IOOA in atypical strabismus. The present review aims to summarize current knowledge on surgical approaches for inferior oblique overaction, to compare their reported outcomes, and to underline the importance of individualized surgical planning in achieving optimal functional and cosmetic results.

Materials and Methods. A comprehensive literature search was conducted to identify studies related to inferior oblique muscle overaction (IOOA) and its surgical management in atypical strabismus, particularly V-pattern deviations. The search was performed electronic databases, including Google Scholar, Science Direct, Scopus and PubMed, covering the period from 1980 to 2025. Keywords used were: “inferior oblique muscle overaction”, “IOOA”, “V-pattern strabismus”, “atypical strabismus”, “oblique muscle surgery” “recession” “myectomy”, “anterior transposition”. Only peer-reviewed articles, clinical studies, systematic reviews, and case series published in English and Russian were included. The references of the included studies were also screened to identify additional relevant publications. This approach ensured that the review summarized the most relevant and up-to-date evidence available on surgical strategies for inferior oblique overaction in atypical strabismus.

Results and Discussion. Frequency in the Literature and Clinical Characteristics. Inferior oblique muscle overaction (IOOA) is one of the most frequent ocular motility disorders associated with strabismus. Its prevalence varies depending on the underlying type of deviation and patient population. Several studies have demonstrated a strong relationship between IOOA and horizontal deviations such as esotropia and exotropia, where it contributes to the development of characteristic motility patterns. According to Wilson M.E. and Parks M.M., IOOA was observed in 72% of patients with congenital esotropia at a mean age of 3. 6 years, in 34% of patients with accommodative esotropia at a mean age of 5.2 years, and in 32% of patients with intermittent exotropia, also at a mean age of 5.2 years [3]. These findings highlight that IOOA is not confined to a single form of strabismus but can occur across different subtypes, with particularly high prevalence in congenital esotropia. In atypical strabismus, IOOA most commonly presents in association with V-pattern deviations, both in exotropia and esotropia. In these cases, the deviation decreases in downgaze and increases in upgaze, reflecting the dominant role of the inferior oblique muscles.

IOOA is also frequently encountered in dissociated vertical deviation (DVD), where excessive inferior oblique activity produces an upward and outward drift of the eye. In skew deviation and paretic strabismus, such as trochlear nerve (cranial nerve IV) palsy, weakness of the superior oblique muscle often leads to compensatory IOOA [5]. Additionally, it may occur in more complex atypical patterns, such as A-V, Y, or other irregular motility deviations, where imbalances between multiple extraocular muscles contribute to overelevation in adduction. From a symptomatic perspective, patients may complain of diplopia (double vision), especially in upward and outward gaze, due to abnormal ocular alignment. They can also exhibit limitation of ocular motility, visible strabismus with outward deviation of the eye, and asthenopia or headaches related to muscular strain. To minimize diplopia and visual discomfort, many adopt a compensatory head posture, which can become habitual and affect daily functioning [6]. Taken together, the literature demonstrates that IOOA represents a frequent and clinically significant feature of atypical

strabismus. Its manifestations extend beyond simple overelevation and involve a wide spectrum of motor and sensory dysfunctions, which must be carefully considered in diagnostic evaluation and in planning surgical correction.

Surgical approaches. The surgical treatment of inferior oblique overaction (IOOA) in atypical strabismus represents one of the most debated areas in pediatric ophthalmology. The goal is to restore ocular alignment, minimize abnormal motility patterns such as V-pattern or dissociated vertical deviation (DVD), and improve binocular vision. Over the past decades, various weakening techniques have been described, each with distinct advantages, limitations, and long-term stability profiles. Coats D.K. and Olitsky S.E. (2007) proposed that the choice of weakening procedure for IOOA should be tailored to the degree of overaction: +1 – observation (marginal or complete myotomy may be considered), +2 – recession (tenotomy, myectomy, or complete myotomy), +3 – recession (tenotomy, myectomy), +4 – myectomy (recession or anterior transposition). In cases of significant residual overaction after myectomy or recession, denervation or extirpation may be performed [7,8]. Similarly, Plager D.A. and Buckley E.G. (2004) emphasized that surgical correction of IOOA is primarily indicated in the presence of a pronounced V-pattern: +1 – rarely requires surgery, +2 – occasionally requires surgery, +3 – often requires surgery, and +4 – always requires surgery, with no alternative to surgical treatment [8].

1. Myectomy and Myotomy. Inferior oblique weakening can be achieved through myectomy, which entails excision of a muscle segment, or myotomy, which involves simple transection of the muscle. Both techniques are regarded as straightforward, commonly performed, and effective surgical options, often producing an immediate decrease in inferior oblique overaction. Despite their technical simplicity, long-term results may be inconsistent, largely due to unpredictable muscle reattachment, which can lead to residual overaction or late recurrence [Del Monte & Parks, 1983]. Myectomy is generally indicated for pronounced inferior oblique overaction or in cases associated with dissociated vertical deviation, whereas myotomy is more frequently selected for less severe involvement. Several modified techniques, collectively referred to as edge or marginal myotomy—including I-, Z-, and W-shaped incisions—have been introduced as alternative approaches. Among these, Z-myotomy has received particular interest for the management of mild inferior oblique overaction (+1 to +1.5) [9]. Originally described by De Decker and Kueper in 1973, this method consists of creating two longitudinal cuts along opposite borders of the muscle while preserving its original insertion. The procedure is relatively brief, technically uncomplicated, and carries a low risk of scleral perforation or vortex vein injury, as scleral suturing is not required. Previous studies have demonstrated that Z-myotomy provides sufficient weakening in small-angle yet symptomatic cases, where more aggressive procedures such as recession or myectomy could increase the risk of overcorrection [10]. Nevertheless, both myectomy and myotomy are associated with potential limitations, particularly undercorrection or recurrence over time. Consequently, in complex or atypical forms of strabismus, many surgeons favor combining these procedures with horizontal rectus muscle surgery to enhance surgical outcomes.

2. Inferior Oblique Recession. Inferior oblique recession is regarded as a standard surgical strategy in the treatment of inferior oblique overaction (IOOA) due to its consistent effectiveness and broad clinical acceptance. The principle of this technique is not direct muscle weakening through cutting or removal, but rather functional attenuation achieved by relocating the site of muscular attachment. By shifting the insertion to a position posterior and lateral to that of the

inferior rectus muscle, the vertical elevating force and excyclotorsional contribution of the inferior oblique are substantially diminished, improving ocular alignment.

The extent of muscle displacement is individualized and determined by the severity of overaction observed during clinical assessment. Minimal inferior oblique hyperactivity is typically corrected with a small recession of around 6 mm, while intermediate cases require a greater posterior shift of approximately 10 mm. In situations characterized by pronounced overaction, the recession may be increased to nearly 14 mm. These measurements function as flexible reference values and are routinely modified to accommodate patient-specific anatomical differences and the degree of functional imbalance [11, 12].

In standard practice, recession is usually performed at distances of 10 mm, 12 mm, or 14 mm. During the procedure, the muscle hook is passed beneath the inferior rectus insertion with the globe rotated upward to optimize exposure. Importantly, the eye should not be rotated inward or outward, as this may alter the relative position of the muscle edge. A 10-mm recession positions the anterior edge 3 mm posterior and 2 mm temporal to the lateral border of the inferior rectus insertion; a 12-mm recession places it 6–8 mm posteriorly; while a 14-mm recession locates it 8–10 mm posteriorly and close to the lateral border of the inferior rectus muscle. In the latter case, suturing over the muscle is sometimes necessary due to the proximity of the inferotemporal vortex vein, which poses a potential risk of injury[13].

A specific modification, Fink's recession, involves posterior displacement of the inferior oblique along its anatomical course. In this technique, the anterior border of the new insertion is positioned 6 mm inferior and posterior to the inferior end of the lateral rectus insertion, corresponding to an approximate 8-mm recession. This method provides a predictable and physiologic weakening effect while maintaining the natural vector of the muscle's action [14]. Overall, recession remains the most widely practiced and versatile weakening procedure for IOOA, with advantages of stable alignment, graded weakening potential, and applicability in both isolated overaction and atypical strabismus patterns.

3. Anterior Transposition (Anteriorization). The concept of weakening the inferior oblique (IO) muscle through transposition was first mentioned in the 1940s, although the term transposition at that time was largely applied to traditional recession procedures in cases of marked IO overaction.

A novel approach was introduced in 1981 by Elliot and Nankin, who described anterior transposition for severe bilateral IO overaction [15]. The principle consists of relocating the IO insertion from its natural posterior position to the anterior segment of the globe, thereby changing its plane of action and converting the muscle configuration into a J-shape. In this technique, the Lockwood ligament and the neurovascular bundle act as the axis of rotation. Later, Wright (2007, 2015) proposed a graded anterior transposition depending on the degree of overaction:

+1 IOOA: 4 mm posterior and 3 mm lateral to the inferior rectus insertion,

+2 IOOA: 3–4 mm posterior,

+3 IOOA: 1–2 mm posterior,

+4 IOOA: directly adjacent to the inferior rectus insertion [16, 8].

Several modifications have been described to optimize outcomes and reduce complications:

Full anterior transposition – indicated for severe IOOA with DVD;

Graded anterior transposition – allows individualized weakening;

Modified anteriorization – anterior fibers placed close to the inferior rectus, posterior fibers slightly posterior, minimizing AES;

J-shaped anterior transposition – mainly used for marked bilateral IOOA with DVD.

In clinical practice, anterior transposition is especially valuable for IOOA associated with DVD, where recession alone is often insufficient. However, in V-pattern strabismus, this technique is less advantageous, as other weakening procedures such as recession or myectomy usually provide more stable outcomes [17, 18].

4. Combined Techniques. In recent years, combined surgical approaches have been increasingly applied in the management of inferior oblique muscle (IO) overaction. The primary objective of these techniques is not only to weaken the overacting muscle but also to address associated ocular motility disorders that frequently coexist. The most widely used combinations include:

IO anterior transposition + inferior rectus surgery – indicated in cases of dissociated vertical deviation (DVD), hypertropia in upgaze, and V-pattern deviations. This approach provides better alignment by correcting both vertical deviation and motility imbalance.

IO recession + lateral rectus recession – most commonly applied in V-pattern exotropia, where IO overaction contributes to the pattern deviation and is effectively managed in combination with weakening of the horizontal rectus.

Anteriorization combined with myotomy or partial myectomy – reserved for severe IO overaction, particularly when standard anterior transposition is insufficient. This method further reduces the excessive pulling force of the IO muscle.

Bilateral combined procedures – frequently indicated in bilateral IO overaction with DVD, where symmetric correction ensures improved ocular alignment and preservation of binocular function [19].

In 2015, Tomarchio S. introduced an innovative surgical method known as the equatorial scleral anchor technique. In this procedure, the IO muscle is sutured 11 mm posterior to its insertion at the Gobin point, without detachment of the muscle belly. This modification, considered an anteroposition of the IO with scleral fixation near the equator, has demonstrated favorable outcomes in patients with mild to moderate IO overaction, while minimizing the risks associated with belly dissection [20].

Furthermore, a novel combined surgical approach has been developed for the management of bilateral asymmetric IO overaction. This technique incorporates inferior oblique belly transposition in one eye and contralateral IO recession in the other, aiming to achieve balanced weakening of both oblique muscles. Clinical evidence suggests that this strategy provides effective correction and functional improvement in asymmetric IOOA cases.

The advantage of combined techniques lies in their ability to simultaneously correct complex or atypical forms of strabismus by addressing multiple contributing factors. However, the main limitation remains the increased surgical extent, which can complicate the prediction of postoperative muscle balance and long-term alignment stability [21].

Long-Term Outcomes and Complications. Long-term evaluation of inferior oblique (IO) weakening procedures demonstrates that while most patients achieve satisfactory ocular alignment, the stability of results and the risk of recurrence remain significant considerations. Reoperation rates are not negligible, particularly in cases with severe or asymmetric IO overaction, or when atypical strabismus patterns such as dissociated vertical deviation (DVD) and V-pattern are present [22].

Surgical weakening of the IO is also associated with several important complications. Recurrence of IO overaction is one of the most common, frequently requiring secondary intervention. In the case of IO transposition procedures, the absence of reliable surgical dosing methods often leads to overcorrection of hypertropia, whereas recession and other weakening techniques may produce an insufficient corrective effect. Persistent IO overaction immediately after surgery has been attributed to incomplete dissection of muscle fibers at their scleral insertion, particularly in patients with broad or anatomically variant insertions, such as double or triple fiber bundles. If unrecognized, these anomalies can significantly reduce surgical effectiveness.

The anatomical complexity of the IO muscle and its proximity to vortex veins increase the risk of intraoperative hemorrhage during both recession and transposition procedures. Reports also describe severe retrobulbar hemorrhage that can threaten vision. Furthermore, dissection in the posterior pole carries the risk of damaging Tenon's capsule, which may result in orbital fat prolapse, scarring, and subsequent restriction of ocular motility.

Even after apparently successful transposition, recurrence of hypertropia may occur. This has been linked to chronic stretching of the posterior temporal muscle fibers between the neurofibrovascular bundle and the new insertion site, leading to posterior retraction after suture absorption and weakening of the corrective effect. Additionally, traumatic handling of the muscle fibers during dissection may predispose to slippage.

Among the most serious complications of IO transposition is the development of anti-elevation syndrome (AES). This condition manifests as restriction of elevation in abduction of the operated eye and paradoxical overelevation of the contralateral eye in adduction. The mechanism is believed to involve overstretching of the distal IO fibers and neurofibrovascular bundle during anterior displacement. In some cases, this overstretching may even produce transient paresis of the oculomotor nerve branches, clinically evident as temporary postoperative pupillary dilation [15].

Despite the extensive literature on IO weakening procedures, no single technique has been universally recognized as the method of choice. Future directions should emphasize individualized approaches, including the use of cyclodeviation assessment, advanced diagnostic imaging, and mathematical modeling of IO biomechanics. Development of refined dosing systems would allow surgeons to balance surgical efficacy with safety, minimize iatrogenic complications, and achieve more consistent long-term functional outcomes [23].

Discussion. The present analysis highlights the complexity of surgical management of inferior oblique muscle (IO) overaction, particularly in cases associated with dissociated vertical deviation (DVD), V-pattern strabismus, and other atypical ocular motility disorders. Anterior transposition of the IO has emerged as one of the most widely applied procedures, providing effective weakening of IO overaction and offering substantial benefits in controlling DVD. Various modifications of this technique, including graded anterior transposition and differential positioning of anterior and posterior fibers, have been developed to improve surgical predictability and outcomes.

In recent years, combined surgical approaches have gained increasing importance. For example, IO anterior transposition combined with inferior rectus surgery, or IO recession combined with lateral rectus recession, has been shown to enhance alignment in complex forms of strabismus. These procedures are particularly effective in bilateral IO overaction with asymmetry, where symmetric correction helps restore ocular alignment and maintain binocular function. However, the broader surgical extent involved in combined techniques introduces challenges,

including the risk of overcorrection and the difficulty of predicting postoperative muscle balance [24, 25].

Long-term follow-up studies generally report positive surgical outcomes, with the majority of patients demonstrating adequate correction of hypertropia and improved ocular motility. Despite these encouraging results, certain challenges persist, including ongoing or recurrent inferior oblique overaction, residual vertical deviation, and suboptimal surgical correction. These limitations have been attributed to several factors, such as individual anatomical variability of the inferior oblique muscle, insufficient release at the insertion site, or gradual elongation of posterior muscle fibers after anterior transposition, which may lead to a progressive decline in the effectiveness of the procedure over time [15, 8].

In summary, anterior transposition of the inferior oblique muscle continues to represent a fundamental surgical option for managing inferior oblique overaction. Nonetheless, optimal surgical decision-making requires an individualized approach that takes into account the severity of overaction, coexistence of dissociated vertical deviation, the presence of V-pattern strabismus, and any accompanying horizontal deviations. Further investigations employing standardized assessment protocols, modern imaging techniques, and biomechanical analysis are necessary to refine surgical strategies, minimize recurrence rates, and enhance long-term functional outcomes.

Conclusion. Inferior oblique muscle overaction (IOOA) in the context of atypical strabismus remains one of the most complex and debated issues in pediatric ophthalmology. A wide spectrum of surgical techniques has been described, including myotomy, myectomy, recession, anterior transposition, and various combined approaches. Each of these methods has its own advantages and limitations, and none can be considered universally applicable.

Recession and myectomy are simple and widely practiced procedures, providing predictable weakening in mild to moderate IOOA. Anterior transposition, particularly in graded or modified forms, has demonstrated high effectiveness in severe IOOA and cases associated with dissociated vertical deviation, though it requires careful consideration of postoperative motility. Combined approaches are increasingly employed in complex and asymmetric forms of strabismus, allowing simultaneous correction of multiple deviations.

Despite these advances, long-term outcomes indicate that recurrence, residual overaction, or insufficient correction may still occur. Therefore, the choice of surgical technique must be individualized, taking into account the degree of overaction, type of strabismus pattern, and anatomical variations of the inferior oblique muscle.

Overall, contemporary evidence highlights that successful management of IOOA requires a tailored approach, supported by accurate preoperative assessment and careful intraoperative technique. Further research, particularly long-term prospective studies, is essential to refine surgical methods and improve functional as well as cosmetic outcomes for patients with atypical strabismus.

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