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EVALUATION OF THE EFFECTIVENESS OF EXTRAOCULAR MUSCLE FENESTRATION SURGERY IN THE TREATMENT OF HORIZONTAL SENSORY STRABISMUS

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ABSTRACT

Objective: To evaluate the effectiveness of extraocular muscle fenestration surgery in the treatment of horizontal sensory strabismus.

Subjects and Methods: A prospective descriptive study was conducted on 37 patients diagnosed with horizontal sensory strabismus who underwent extraocular muscle fenestration in the Pediatric Ophthalmology Department at Vietnam National Eye Hospital from December 2024 to July 2025. Both male and female patients aged ≥16 years were included.

Results: The study included 37 patients (mean age 27.2 ± 10.8 years), with the majority aged 16–40 years. The mean preoperative deviation angle was 33.5 ± 12.9 PD in sensory exotropia and 37.7 ± 11.8 PD in sensory esotropia. The surgical success rate (<10 PD) was 83.8% for sensory exotropia and 84.6% for sensory esotropia.

Conclusion: Extraocular muscle fenestration achieved high success in ocular alignment, with 83.8% in sensory exotropia and 84.6% in sensory esotropia. The mean deviation angle significantly decreased from 37.7 PD to 2.9 PD (exotropia) and from 33.5 PD to 6.7 PD (esotropia), with stable postoperative outcomes.

Keywords: Sensory strabismus, extraocular muscle fenestration, amblyopia.

1. INTRODUCTION

Sensory strabismus is a type of ocular misalignment that occurs as a consequence of decreased or lost visual acuity in one or both eyes secondary to ocular diseases [1]. Essentially, any condition that causes unilateral visual impairment or prolonged binocular visual asymmetry can disrupt sensory fusion and binocular vision, leading to ocular deviation [2], [3]. This condition significantly affects patients' quality of life, education, and social interactions.

Strabismus surgery is the only treatment method capable of correcting ocular alignment in patients with sensory strabismus. The main goal of surgery is to restore ocular alignment rather than visual function. Conventional surgical treatment involves recession and resection of the extraocular muscles of the deviating (poorly seeing) eye, followed by reattachment of the muscles to the sclera. However, these procedures carry potential risks, including scleral perforation, suture granuloma formation, and postoperative overcorrection due to muscle slippage. According to a study by Ibrahim Hashim (2021), the incidence of scleral perforation ranges from approximately 0.3% to 7.8%, with a higher risk observed in myopic eyes with thin sclera [4]. A report by Eustis et al. (2004) showed that postoperative granuloma formation occurred in up to 13% of cases using conventional suturing techniques [5].

Recently, the muscle window technique has emerged worldwide as a sutureless alternative for weakening extraocular muscles. This technique was first described by Rageh and colleagues in 2020 and is designed to avoid scleral suturing altogether [6]. The procedure weakens the muscle by excising a central segment posterior to its insertion while preserving two peripheral muscle strips. It is a simple yet promising method that minimizes suture-related complications such as scleral perforation, allergic reactions, and granuloma formation, while also simplifying the surgical process [7].

According to a study by Taher et al. (2022), the muscle window technique demonstrated comparable outcomes

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to standard muscle recession in both horizontal and vertical strabismus [8]. Mohamed H. Elkhawaga (2020) reported that this technique achieved effective alignment in up to 81.25% of patients with sensory esotropia [9]. In a subsequent study (2023), Elkhawaga reported a success rate of 81% for lateral rectus muscle window surgery [10].

Recent studies have highlighted several advantages and favorable outcomes of the muscle window technique compared to conventional recession procedures. However, the association between surgical outcomes and specific clinical characteristics remains unclear. To date, no published study in Vietnam has addressed the muscle window technique in general, or its application in patients with sensory strabismus in particular.

2. MATERIALS AND METHODS

2.1. Study Subjects

The study population comprised patients diagnosed with sensory horizontal strabismus who underwent muscle window surgery in the Pediatric Ophthalmology Department at Vietnam National Eye Hospital from December 2024 to September 2025. Both male and female patients aged 16 years or older were included.

- Inclusion criteria:

+ Diagnosed with sensory horizontal strabismus.

+ Age ≥ 16 years.

+ Best-corrected visual acuity ≤ 2/10 (20/100).

+ Provided informed consent to participate in the study.

- Exclusion criteria:

+ History of previous strabismus surgery.

+ Coexisting ocular diseases such as extraocular muscle palsy or nystagmus.

+ Presence of associated strabismus forms (e.g., vertical deviation, alphabet syndromes).

+ Systemic or neurological disorders affecting ocular motility.

+ Refusal to participate in the study.

2.2. Study Duration and Location

The study was conducted from December 2024 to September 2025 at the Pediatric Ophthalmology Department at the Vietnam National Eye Hospital.

2.3. Study Design

A prospective descriptive study design was employed.

2.4. Sample Size and Sampling Method

A total of 30 patients (n = 30) diagnosed with sensory horizontal strabismus who met the inclusion criteria and were treated at the Pediatric Ophthalmology Department during the study period were selected.

A convenience sampling method was used.

2.5. Data Collection Tools and Methods

- Data were collected by following each patient at specific intervals: preoperatively, postoperative day 1, week 1, month 1, and month 3.

- Data sources included patient medical records from the Pediatric Ophthalmology Department, Vietnam National Eye Hospital.

- All patients underwent muscle window surgery as the treatment technique.

2.6. Data Processing and Statistical Analysis

All data were cleaned, entered, and analyzed using SPSS software version 25.0 (IBM Corp., Armonk, NY, USA). Results were presented as frequencies, percentages, and mean values.

Correlations between quantitative variables were analyzed using the Pearson correlation coefficient.

2.7. Ethical Considerations

This study complied with the ethical principles of biomedical research issued by the Vietnam Ministry of Health.

The study protocol was reviewed and approved by the Master's Thesis Review Committee of the University of Medicine and Pharmacy, Vietnam National University, Hanoi, and by the Scientific and Ethics Committees of the Vietnam National Eye Hospital to ensure scientific validity and feasibility.

The research was conducted solely to improve and protect patient health, with no other intended objectives.

3. RESULTS

A total of 37 patients met the inclusion criteria and were enrolled in the study between December 2024 and September 2025 at the Pediatric Ophthalmology Department, Vietnam National Eye Hospital.

Table 1. Age Distribution of the Study Population

Proportion		
Age group	N	%
≥16-40	34	91,9
>40	3	8,1
Mean ± SD (Min – Max)	27,19 ± 10,806 (16 – 59)	

Among the 37 patients enrolled in the study, the majority were in the 16–40 years age group, accounting for 91.9% of cases. Patients aged over 40 years represented 8.1% of the study population.

Table 2. Preoperative Angle of Deviation

Type of strabismus		
Angle of deviation	Esotropia	Exotropia
< 30 PD	3 (23,08%)	9 (37,5%)
30-40PD	7 (53,84%)	11 (45,83%)
>40PD	3 (23,08%)	4 (16,67%)
Mean ± SD (Min-Max)	37,69 ± 11,835 (25-60)	33,54 ± 12,894 (20-60)
Total	13 (35,1%)	24 (64,9%)

Among patients with esotropia, 23.08% had a mild deviation of less than 30 prism diopters (PD), 53.84% had a deviation between 30–40 PD, and 23.08% had a deviation of more than 40 PD. The mean preoperative angle of esotropia was 37.68 ± 11.84 PD.

Table 3. Postoperative Ocular Alignment Outcomes Over Time in Exotropia

Outcome			
Postoperative Day 1	1 Week	1 Month	3 Month
Good (< 10 PD)			
20 (83,3%)	20 (83,3%)	20 (83,3%)	20 (83,3%)
Fair (10- 20 PD)			
1 (4,2%)	1 (4,2%)	1 (4,2%)	1 (4,2%)
Poor (> 20 PD)			
3 (12,5%)	3 (12,5%)	3 (12,5%)	3 (12,5%)
Total (%)			
24 (100,0%)	24 (100,0%)	24 (100,0%)	24 (100,0%)
Mean postoperative deviation Mean ± SD (Min-Max)			
2,67± 6,211 PD	2,67 ± 6,211 PD	2,67 ± 6,211 PD	2,67 ± 6,211 PD

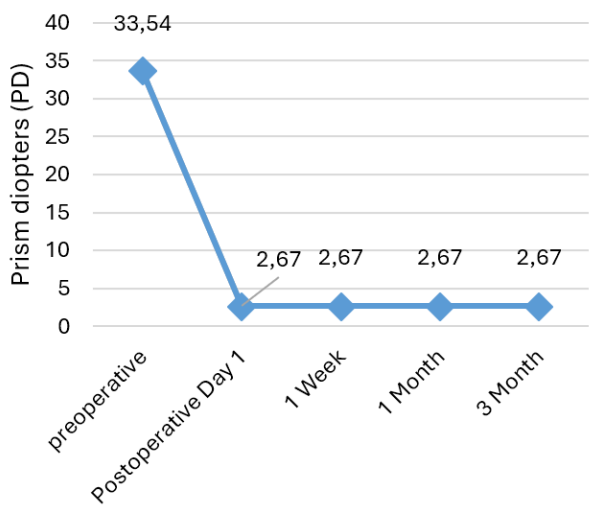

Figure 1. Change in Mean Angle of Deviation Before and After Surgery in Exotropia

Among patients with exotropia, postoperative outcomes recorded at postoperative day 1 showed a good result in 83.8% of cases, a fair result in 4.2%, and a poor result in 12.5%. These outcome proportions remained stable throughout the follow-up period. The mean postoperative angle of deviation was 2.67 ± 6.21 PD.

The mean deviation in patients with exotropia decreased from 33.54 PD preoperatively to 2.67 ± 6.21 PD postoperatively.

Table 4. Postoperative ocular alignment outcomes over time in esotropia

Outcome			
Postoperative Day 1	1 Week	1 Month	3 Month
Good (< 10 PD)			
11 (84,6%)	11 (84,6%)	11 (84,6%)	11 (84,6%)
Fair (10- 20 PD)			
1 (7,7%)	1 (7,7%)	1 (7,7%)	1 (7,7%)
Poor (> 20 PD)			
1 (7,7%)	1 (7,7%)	1 (7,7%)	1 (7,7%)
Total (%)			
13 (100,0%)	13 (100,0%)	13 (100,0%)	13 (100,0%)
Mean postoperative angle of deviation Mean ± SD			
6,67± 8,555 PD	6,67± 8,555 PD	6,67± 8,555 PD	6,67± 8,555 PD

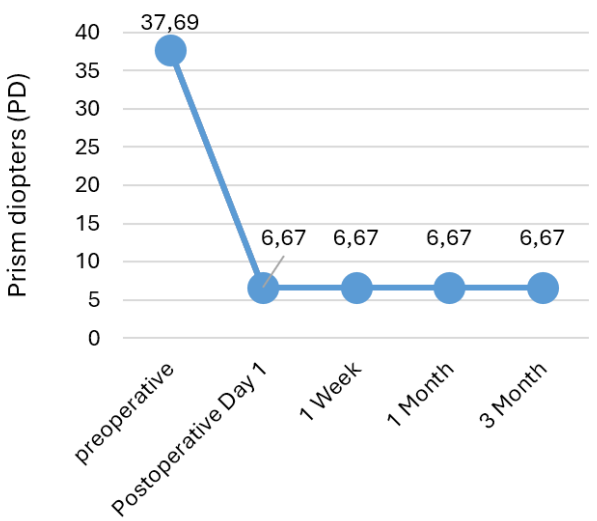

Figure 2. Mean postoperative ocular deviation over time in esotropia

Postoperative outcomes for patients with esotropia showed that, after 1 day, 84.6% achieved good alignment, while 7.7% had fair or poor results. These outcomes remained stable throughout the follow-up period.

The mean postoperative angle of deviation was 6.67 ± 8.56 prism diopters (PD).

The mean preoperative deviation decreased from 37.69 PD to 6.67 ± 8.56 PD after surgery.

4. DISCUSSION

Participants' ages ranged from 16 to 59 years, with a mean of 27.19. We categorized patients into two groups: those aged ≥16–40 years and those >40 years. The proportion of patients aged 16–40 years was 9 times that of patients over 40 years. This finding indicates that younger and middle-aged individuals are more likely to seek treatment for sensory strabismus. This may be

attributed to the greater psychosocial and cosmetic impact of strabismus during working and studying years, as well as its influence on self-confidence and career opportunities, thereby increasing the demand for surgical correction. In contrast, older patients tend to adapt to the deviation, show less cosmetic concern, and are more cautious about surgical risks, resulting in a lower treatment rate. Similar trends have been reported in other studies, highlighting the influence of social and occupational factors in the decision to undergo surgery.

Preoperative deviation

In our study, the preoperative deviation among patients with sensory horizontal strabismus ranged from small to large angles, with the majority falling within the 30–40 PD range. Specifically, in the esotropia group, 23.08% had <30 PD, 53.84% had 30–40 PD, and 23.08% had >40 PD, with a mean deviation of 37.68 ± 11.84 PD. In the exotropia group, 37.5% had <30 PD, 45.83% had 30–40 PD, and 16.67% had >40 PD, with a mean deviation of 33.54 ± 12.89 PD.

Thus, most patients in both groups presented with moderate-to-large deviation angles, mainly between 30–40 PD. This aligns with previous reports that sensory strabismus often manifests with larger deviations compared to other types. Our findings are consistent with those of Akbari et al. (2024), who conducted a 10-year study on 1,017 patients with sensory horizontal strabismus and reported that the mean deviation was higher in sensory esotropia than in sensory exotropia. Similarly, Shafik et al. (2022) studied 54 children with large-angle sensory exotropia (≥40 PD). They observed a progressive increase in deviation over time without surgical intervention, emphasizing that prolonged childhood sensory loss leads to significant exodeviation. Qin et al. (2016) also reported large deviations among pediatric patients, noting that even early-onset visual loss can cause marked ocular misalignment comparable to that in adults.

In general, both children and adults with sensory strabismus may present with large-angle esotropia or exotropia. The direction of deviation, however, may depend on the age of onset: early-onset visual loss is more commonly associated with esotropia, whereas late or prolonged sensory impairment tends to result in exotropia.

Postoperative alignment outcomes

Our results demonstrated encouraging outcomes following muscle window surgery for sensory horizontal strabismus.

For exotropia, after one day, 83.8% of patients achieved good alignment (<10 PD), 4.2% showed fair results (10–20 PD), and 12.5% had poor results (>20 PD). These outcomes remained stable throughout the 3-month follow-up. The mean postoperative deviation decreased from 37.69 ± 11.84 PD to 2.92 ± 6.21 PD.

For esotropia, 84.6% achieved good alignment, while 7.7% had fair or poor results. The mean deviation reduced from 33.54 ± 12.89 PD to 6.67 ± 8.56 PD.

When analyzing the relationship between initial deviation and surgical outcomes, patients with large-angle exotropia (>40 PD) had poorer outcomes (75% poor, 25% good). In contrast, those with minor deviations demonstrated significantly better outcomes — 90.9% for 30–40 PD and 100% for <30 PD. Similarly, in the esotropia group, patients with deviations >40 PD had poorer correction rates (fair and poor outcomes totaling 66.7%), while all patients with deviations ≤40 PD achieved good alignment.

Our findings are in line with those reported by Elkhawaga et al., who applied the muscle window technique in 16 children (aged 5–10 years) with sensory esotropia (20–50 PD). They performed a medial rectus window procedure combined with ipsilateral lateral rectus resection, achieving alignment within 8 PD in 81.25% of cases at 3 months, with no overcorrections observed. Similarly, Awadein & Arfeen retrospectively analyzed 19 patients (mean age ≈19 years) who underwent the same procedure, reporting an average reduction of 13 ± 3 PD.

The favorable results may be attributed to the inherent advantages of the muscle window technique over traditional recession. Unlike complete muscle detachment, which risks slippage or overcorrection, the window approach preserves the insertion point, reducing the risk of postoperative vertical deviation. Moreover, it is a sutureless technique that avoids suture-related complications such as scleral perforation or granuloma formation while maintaining comparable alignment outcomes.

Overall, the magnitude of initial deviation remains a key factor in surgical planning and prognosis. The muscle window technique provides stable and effective correction for small to moderate deviations, achieving success rates above 80%. In contrast, large deviations may require proportionally larger windows or additional procedures for optimal alignment. Multiple international studies across different age groups have confirmed that, when appropriately titrated, the muscle window technique yields alignment comparable to that of conventional strabismus surgery, with the added benefits of being sutureless and minimizing the risk of overcorrection.

5. CONCLUSION

Among patients with sensory horizontal strabismus, those aged ≥16–40 years accounted for a proportion nine times higher than those over 40, reflecting a predominance of younger, working-age individuals.

The muscle window technique achieved a high success rate, with good alignment (<10 PD) in 83.8% of exotropia and 84.6% of esotropia cases. Outcomes remained stable throughout 3 months of follow-up, with no instances of overcorrection or recurrence.

The mean deviation decreased markedly after surgery: from 37.69 ± 11.84 PD to 2.92 ± 6.21 PD in exotropia and

from 33.54 ± 12.89 PD to 6.67 ± 8.56 PD in esotropia.

These results demonstrate that the muscle window technique is a practical, stable, and safe method for the surgical management of sensory horizontal strabismus.

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