Original Article

B-Scan Evaluation of Medial and Lateral Rectus Muscle Thickness in Horizontal Strabismus

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ABSTRACT

Purpose: To evaluate the Medial and Lateral Rectus Muscle Thickness in Horizontal Strabismus.

Study Design: Descriptive observational study.

Place and Duration of Study: University of Lahore hospital, Lahore from July 2025 to October 2025.

Methods: Sixty patients, above 5 years of age with horizontal strabismus were included. Patients with orbital pathology, orbital trauma, previous surgery of extraocular muscles and Thyroid eye disease were excluded. After complete history and examination, B-scan was done to evaluate medial and lateral rectus muscles. IBM SPSS version 26 was used for data analysis.

Results: There were 22 males and 38 females. The mean age was 12.5±1.8 years. Twenty-nine patients had esotropia and 31 had exotropia. Medial rectus muscle was significantly thicker in eyes with esotropia compared to those with exotropia (Mean of 3.82 ± 0.30mm vs. 2.92 ± 0.46 mm; $p < 0.001$). In contrast, the lateral rectus muscle was significantly thinner in esotropic eyes than in exotropic eyes (2.99 ± 0.36 mm vs. 3.85 ± 0.35 mm; $p < 0.001$). These findings demonstrate a clear and statistically robust pattern of rectus muscle asymmetry between the two forms of horizontal strabismus.

Conclusion: B-scan ultrasonography showed that esotropia was associated with a significant increase in medial rectus thickness, whereas exotropia was associated with increase in lateral rectus thickness. Knowledge of muscle thickness can assist surgeons in tailoring the amount of recession or resection. Thicker or hypertrophied muscles may respond differently to standard surgical resection or recessions.

Keywords: Extra ocular Muscles, Esotropia, Exotropia, Eye, Lateral Rectus, Ultrasonography.

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INTRODUCTION

Horizontal strabismus is a common disturbance of ocular motility, arising from imbalance in the functional activity of the medial and lateral rectus muscles. Emerging evidence highlights the relevance of extraocular muscle thickness, particularly the medial rectus, in determining contractile strength and biomechanical behavior.[1,2] Structural changes such as hypertrophy, atrophy, or other pathological alterations may contribute to the development and progression of strabismus.[3] B-scan ultrasonography enables real-time visualization of orbital tissues, including extraocular muscles, and provides reliable quantitative assessment of muscle thickness.[4]

Extraocular muscle size is clinically meaningful in diagnostic evaluation, particularly in patients presenting with diplopia, even when classic signs of orbital disease are not apparent.[5,6] Accurate measurement is essential for distinguishing primary orbital pathology from neuro-ophthalmic causes, a

distinction that directly guides appropriate management.[7,8] Quantitative assessment can also identify early primary myopathic changes, estimate surgical risk, and facilitate postoperative monitoring of muscle integrity.[9,10] Notably, measurable differences in extraocular muscle thickness have been reported between individuals with strabismus and those with normal ocular alignment, offering insights that may refine future approaches to strabismus evaluation and management.[11]

This study was designed to investigate the medial and lateral rectus muscle thickness in patients with horizontal strabismus using B-scan ultrasonography.

METHODS

This cross-sectional observational study was conducted at the University of Lahore Teaching Hospital over four months from July to October 2025. The sample size was calculated using the formula for a paired t-test:$n = \frac{(Z_{1-\alpha/2}+Z_{1-\beta})^2\,\sigma_d^2}{\Delta^2}$where n= required number of paired observations (subjects), $Z_{1-\alpha/2} = 1.96$ for a 5% level of significance (two-tailed), $Z_{1-\beta} = 0.84$for 80% power, σ_d= standard deviation of the paired differences, Δ= expected mean difference in rectus muscle thickness.The sample size was 60 patients (30 esotropia, 30 exotropia), using a non-probability purposive sampling technique. The study was approved by the Institutional review board/Ethical review board **(Reference number: UOL/IREB/25/11/0017).** Patients aged 5 years and above presenting with clinically diagnosed horizontal strabismus (either esotropia or exotropia) were recruited. Patients with a history of thyroid eye disease, orbital trauma, previous extraocular muscle surgery, or known orbital pathology other than strabismus were excluded. After informed consent, participants underwent a detailed ocular examination, followed by B-scan ultrasonography to measure the thickness of the medial and lateral rectus muscles in both eyes. A standardized 10 MHz B-scan probe was used, and longitudinal scans were obtained with the patient's eyes in primary position and in induction movements to optimize muscle visualization. Three readings were taken for each muscle, and the mean value was recorded. Data was analyzed using IBM SPSS Version 26. Descriptive statistics summarized demographic data and muscle measurements. Independent t-tests were used to compare rectus muscle thickness between the esotropic and exotropic groups, with a significance level set at $p < 0.05$, as the data were normally distributed, as indicated by the Shapiro-Wilk Test of normality.

RESULTS

A total of 60 patients were included in the study, comprising 38 females (63.3%) and 22 males (36.7%), with a mean age of 12.5 ± 1.8 years (range: 10–15 years). The distribution of strabismus types was nearly equal, with 29 patients (48.3%) diagnosed with esotropia and 31 patients (51.7%) diagnosed with exotropia. The mean medial rectus muscle thickness was 3.35 ± 0.60 mm (range: 1.70–4.42 mm), while the mean lateral rectus muscle thickness was 3.44 ± 0.56 mm (range: 2.36–4.66 mm).In patients with esotropia, the medial rectus thickness was significantly greater (3.82 ± 0.30 mm) compared with those with exotropia (2.92 ± 0.46 mm; $p < 0.001$). In contrast, study indicates that the thickness of the lateral rectus muscle proves significantly greater among patients with exotropia. Measurements reached 3.85± 0.35 mm. This compares to 2.99±0.36 mm for patients dealing with esotropia. The difference is at a p-value less than 0.001.

In our comparative analysis, the medial rectus muscle was significantly thicker in eyes with esotropia compared with those with exotropia (mean ± SD: 3.82 ± 0.30 mm vs. 2.92 ± 0.46 mm; $p < 0.001$). In contrast, the lateral rectus muscle was significantly thinner in esotropic eyes than in exotropic eyes (2.99 ± 0.36 mm vs. 3.85 ± 0.35 mm; $p < 0.001$). These findings demonstrate a clear and statistically robust pattern of rectus muscle asymmetry between the two forms of horizontal strabismus.

This descriptive table statistics of 60 patients showed that thickness of the medial rectus muscle

Table 1:

Descriptive Statistics	N	Minimum	Maximum	Mean	Std. Deviation
Medial Rectus Thickness (mm)	60	1.70	4.42	3.35	0.60
Lateral Rectus Thickness (mm)	60	2.36	4.66	3.44	0.56
Age	60	10	15	12.52	1.761

went from 1.70 mm up to 4.42 mm. The average came in at 3.35 mm, with a standard deviation of 0.60. That suggests most patients hovered near the upper end of the normal range, which is 2.5, 3.5 mm. The lateral rectus muscle thickness varied between 2.36 mm and 4.66 mm, with a slightly higher mean of 3.44 mm (SD = 0.56). The age of participants spanned 10 to 15 years, with a mean age of 12.52 years (SD = 1.76).

This comparative table of Independent T-Test presents the comparison of extraocular muscle thickness between patients with esotropia and exotropia. For the medial rectus, patients with esotropia had a significantly greater mean thickness (3.82 ± 0.30 mm) compared to those with exotropia (2.92 ± 0.46 mm), with the difference being highly significant ($p < 0.001$). Conversely, for the lateral rectus, the mean thickness was markedly higher in exotropia patients (3.85 ± 0.35 mm) than in esotropia patients (2.99 ± 0.36 mm), again showing a highly significant difference ($p < 0.001$).

Out of the total sample, 38 participants (63.3%) were female, while 22 participants (36.7%) were male, showing that females made up nearly two-thirds of the study population.

Table 2:

Strabismus	Frequency	Percent
Esotropia	29	48.3
Exotropia	31	51.7
Total	60	100.0

This table shows the distribution of strabismus types among the 60 patients studied. Esotropia was observed in 29 patients (48.3%), while Exotropia was present in 31 patients (51.7%).

DISCUSSION

This study demonstrated that horizontal strabismus is associated with distinct structural alterations of the extraocular muscles, as measured by B-scan ultrasonography. Patients with esotropia exhibited medial rectus thickness 3.82 ± 0.30 mm compared to exotropia 2.92 ± 0.46 mm, whereas the lateral rectus in exotropia was 3.85 ± 0.35 mm compared to esotropia 2.99 ± 0.36 mm. These findings suggest direction-specific hypertrophy of horizontal recti that corresponds to the clinical deviation pattern, thereby supporting the role of adaptive structural changes in the pathogenesis of strabismus.

Modern imaging techniques play a significant role in the evaluation of extraocular muscles, allowing detailed visualization of both the muscles and surrounding orbital structures. Computed tomography (CT) is particularly effective for this purpose, providing excellent delineation of muscle enlargement and associated orbital anatomy. Magnetic resonance imaging (MRI) and ocular ultrasonography also offer valuable diagnostic information.[12]

In clinical practice, standardized ocular echography is often used as an initial screening modality. Contact B-scan ultrasonography, in combination with standardized A-scan, is especially useful for detecting extraocular muscle enlargement and assessing tissue characteristics.[13,14] This integrated imaging approach enables clinicians to identify muscle involvement while simultaneously evaluating other orbital abnormalities, making it an essential component of the diagnostic workup for orbital disease.[15]

Findings from echography pair up with the full clinical exam. Together they guide decisions on further tests.[16] With proper technique, imaging of the extraocular muscles serves as an important adjunct in the clinical assessment of complex strabismus. As imaging can reveal critical information not obtainable through clinical examination alone, it should be employed when indicated, particularly in patients with strabismus that extends beyond simple concomitant esotropia or exotropia.[17]

Recognition of imaging features such as muscle enlargement, thinning, or asymmetry provides valuable insight into the underlying cause of ocular deviation and allows a more accurate assessment of its severity. Measurement of the medial and lateral rectus muscles using B-scan ultrasonography in patients with esotropia or exotropia offers objective and clinically relevant information that enhances diagnostic accuracy and supports more precise surgical planning. In addition, generating such data contributes important region-specific evidence, ultimately helping to improve the quality of patient care in our setting.

UBM measurements of vertical rectus muscle insertion showed very good agreement with intraoperative caliper measurements, with most values within ±2 standard deviations and strong correlation (ICC = 0.78; Pearson = 0.85).[18] UBM accurately

measured insertions up to 12 mm from the limbus and was able to distinguish true muscle insertion from pseudo tendon in reoperated cases.

Evaluating medial and lateral rectus muscle thickness in patients with horizontal strabismus has several important clinical implications. Understanding variations in muscle thickness provides insight into the structural basis of esotropia and exotropia, as these changes may reflect chronic overaction, under-action, fibrosis, or adaptive hypertrophy and atrophy—moving beyond simple motility imbalance to reveal the underlying anatomical remodeling.

This structural knowledge has direct surgical relevance. Preoperative assessment of muscle thickness enables surgeons to tailor recession or resection amounts more precisely, since thickened or hypertrophied muscles may respond differently to standard surgical dosages. Such awareness can help reduce the risk of under- or over-corrections. Furthermore, muscle morphology may serve as a predictor of postoperative alignment and stability, particularly in cases of long-standing or large-angle deviations, potentially improving overall success rates.

Beyond individual surgical planning, this study can provide normative and comparative data that support the routine use of imaging modalities—such as ultrasound, CT, or MRI, in selected strabismus cases where atypical muscle anatomy is suspected. Ultimately, establishing a clear association between muscle thickness and the type or magnitude of deviation may pave the way for personalized surgical dosing protocols and further research into the mechanisms of muscle remodeling in strabismus.

Other imaging-based studies using high-resolution MRI demonstrated that the medial rectus in esotropia showed a ~39% increase in cross-sectional area and ~60% greater contractility compared with controls, indicating both hypertrophy and enhanced functional adaptation of the muscle.[19] Similarly, it was also reported that esotropia was associated with significantly shorter medial rectus insertion distances, while exotropia subtypes demonstrated wider medial and lateral rectus insertions. These insertional variations were strongly correlated with the magnitude of deviation, particularly at near fixation.[20] Although their study focused on insertional anatomy, contractility and cross-sectional area, they reinforce our findings that structural strengthening of the medial rectus underlies esotropia, whereas lateral rectus changes predominate in exotropia.

Taken together, these complementary results highlight that both muscle hypertrophy and insertional modifications contribute to the development of horizontal strabismus. Importantly, our study extends this evidence by showing that such alterations can be reliably identified using B-scan ultrasonography, a cost-effective and widely accessible imaging modality. This suggests that B-scan can serve as a practical diagnostic adjunct in both clinical and resource-limited settings, with potential implications for tailoring surgical strategies.

In summary, this research bridges anatomical imaging with clinical decision-making, with potential benefits in diagnosis, surgical planning, and outcome prediction in horizontal strabismus. Future research should focus on longitudinal studies to determine whether muscle hypertrophy precedes or follows the onset of strabismus. Comparative studies using advanced imaging modalities, such as high-resolution MRI, could further validate the findings of B-scan ultrasonography. Additionally, extending the analysis to younger children and adults could help establish age-related variations in muscle adaptation. Incorporating functional outcomes, such as surgical success rates in relation to preoperative muscle thickness, would provide clinically valuable insights.

CONCLUSION

This study confirms that hypertrophy of the medial rectus is characteristic of esotropia, while hypertrophy of the lateral rectus is characteristic of exotropia. B-scan ultrasonography proved to be a reliable tool for detecting these changes, offering a practical and accessible means of evaluating extraocular muscle involvement in horizontal strabismus. These findings contribute to the understanding of strabismus pathophysiology and support the integration of muscle thickness assessment into routine clinical evaluation.

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Conflict of Interest: Authors declared no conflict of interest.

Ethical Approval: The study was approved by the Institutional review board/Ethical review board **(UOL/IREB/25/11/0017).**

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Authors Designation and Contribution

Tahir Shaukat; Optometrist: *Concepts, Literature search, Data analysis, Statistical analysis, Manuscript preparation.*

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