

## EFFICACY OF B-SCAN ULTRASONOGRAPHY VERSUS COMPUTED TOMOGRAPHY AMONG PATIENTS WITH THYROID ORBITOPATHY

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DOI: <https://doi.org/10.5281/zenodo.23255549>

### Keywords

B-scan, CT scan, Extraocular Muscles Thickness, Thyroid Orbitopathy,

### Article History

**Received:** 01 July 2026

**Accepted:** 22 September 2026

**Published:** 09 October 2026

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### Abstract

**Background:** Thyroid orbitopathy is the most common orbital manifestation of thyroid disease, and accurate assessment of extraocular muscle enlargement is essential for diagnosis and management, necessitating evaluation of the diagnostic efficacy of B-scan ultrasonography compared with computed tomography.

**Objective:** To compare the efficacy of B-scan ultrasonography and computed tomography (CT) in the assessment of orbital changes among patients with thyroid orbitopathy.

**Methods:** This prospective comparative cross-sectional study was conducted over six months (February to July 2026) at Mayo Hospital, Lahore. A total of 57 adults were enrolled using non-probability consecutive sampling. The sample size was calculated using G\*Power version 3.1.9.4 (effect size = 0.5). All participants underwent comprehensive ophthalmic examination, including visual acuity assessment, slit-lamp biomicroscopy, and intraocular pressure measurement. Extraocular muscle thickness was measured using 10-MHz B-scan ultrasonography (Sonomed Ascalon) and orbital computed tomography (Toshiba Aquilion 128-slice) performed within one week. Agreement between B-scan ultrasonography and CT scan measurements was assessed using the paired t-test and Intraclass Correlation Coefficient (ICC), with  $p < 0.05$  considered statistically significant.

**Result:** Right MR thickness increased significantly with severity on B-scan (4.73 to 5.89 mm;  $F = 88.890$ ,  $p < 0.001$ ) and CT (4.63 to 5.79 mm;  $F = 74.357$ ,  $p < 0.001$ ), while right SR also showed significant changes (B-scan:  $F = 5.682$ ,  $p = 0.006$ ; CT:  $F = 7.602$ ,  $p = 0.001$ ). CT additionally showed significant left LR changes (2.67 to 2.83 mm;  $F = 3.310$ ,  $p = 0.044$ ). B-scan measurements were significantly higher than CT measurements for all muscles (all  $p < 0.001$ ), with differences of 0.10–0.30 mm.

**Conclusion:** B-scan ultrasonography demonstrated comparable performance to computed tomography in evaluating extraocular muscle

*involvement in thyroid orbitopathy, with similar patterns of progressive medial rectus enlargement despite slightly higher muscle thickness measurements*

### Introduction

Thyroid orbitopathy (TO), also known as thyroid eye disease (TED) or Graves' orbitopathy, is an autoimmune inflammatory disorder affecting the orbital tissues and is most commonly associated with Graves' disease. It may occur in patients with hyperthyroidism, euthyroidism, or hypothyroidism.[1] Autoimmune activation of orbital fibroblasts results in inflammation, glycosaminoglycan accumulation, and enlargement of the extraocular muscles and orbital fat.[2, 3] The inferior and medial rectus muscles are most commonly involved, and their enlargement may cause proptosis, diplopia, restricted ocular motility, and orbital apex crowding. Common clinical manifestations include eyelid retraction and edema, conjunctival congestion, chemosis, dry eye symptoms, and limitation of extraocular movements.[4] Although clinical assessment and scoring systems such as the Clinical Activity Score and EUGOGO classification are useful, clinical examination may not adequately demonstrate the extent of extraocular muscle enlargement or orbital apex involvement.[5] Thyroid orbitopathy occurs in approximately 40% of patients with Graves' disease, although prevalence varies among populations. A Pakistani study reported clinically evident thyroid eye disease in 26.8% of patients with autoimmune thyroid disease. Smoking, radioactive iodine therapy, prolonged uncontrolled hyperthyroidism, and elevated thyrotropin receptor antibodies are among the recognized risk factors.[6]

Orbital imaging is therefore important for diagnosis, assessment of disease severity, monitoring, and surgical planning.[7] Computed tomography (CT) provides detailed visualization of the extraocular muscles, orbital fat, bony structures, and orbital apex.[8] The characteristic finding is fusiform enlargement of the extraocular muscles, particularly the inferior and medial recti, with relative tendon sparing.[9] CT is

particularly useful for detecting orbital apex crowding, assessing possible optic nerve compression, differentiating other orbital conditions, and planning orbital decompression.[10] However, CT exposes patients to ionizing radiation and is relatively costly, limiting its suitability for repeated assessment, particularly in resource-limited settings.[11] B-scan ultrasonography is a non-invasive, radiation-free, relatively inexpensive, portable, and repeatable imaging technique that can demonstrate extraocular muscle enlargement.[12, 13] These characteristics make it attractive for use in resource-limited settings. However, its diagnostic performance depends on operator expertise and standardized scanning techniques, and its ability to assess the orbital apex and deep orbital structures is limited.[14]

Despite the established roles of both modalities, direct comparative evidence between B-scan ultrasonography and CT in thyroid orbitopathy remains limited. Previous studies have mainly evaluated ultrasonography against other imaging modalities, with considerable variation in scanning techniques and diagnostic criteria. In Pakistan, evidence directly comparing B-scan ultrasonography with CT is lacking. Therefore, this study aims to compare B-scan ultrasonography with CT in patients with thyroid orbitopathy. Determining whether B-scan ultrasonography provides comparable information for selected structural features may support its use as a cost-effective, radiation-free option for initial and follow-up assessment, while reserving CT for cases requiring detailed evaluation of the orbital apex or surgical planning.

### Methods

This prospective comparative cross-sectional study was conducted in the Department of Ophthalmology in collaboration with the Department of Radiology at Mayo Hospital, Lahore, over a period of six months (February to July 2026) following approval of

the synopsis. A total of 57 adults ( $\geq 18$  years) with thyroid orbitopathy and suspected extraocular muscle enlargement who were willing to undergo both B-scan ultrasonography and CT scanning were enrolled using non-probability consecutive sampling. The sample size was calculated using G\*Power 3.1.9.4 with an effect size of 0.5, degrees of freedom of 53.43, and critical t-value of 2.01. Patients with previous orbital surgery, orbital metallic implants, severe orbital trauma, or inability to cooperate were excluded. Clinical assessment included visual acuity using a Snellen chart, slit-lamp examination with applanation tonometry, and assessment of clinical signs such as eyelid retraction, diplopia, and restricted extraocular motility. B-scan ultrasonography of both orbits was performed by a trained optometrist using a 10-MHz high-frequency probe with low gain. Extraocular muscle thickness was measured at the muscle belly using transverse scanning while excluding the tendon insertion. All participants subsequently underwent orbital CT imaging using a Toshiba Aquilion 128-slice scanner, with axial and coronal sections performed by a radiologist within one week of ultrasonography. Extraocular muscle thickness, orbital fat changes, bony abnormalities, and evidence of optic nerve compression were assessed and recorded. Clinical and imaging findings were documented on a pre-designed data collection proforma, and measurements were performed twice with the average value

used for analysis to improve reliability. Ethical approval was obtained from the Institutional Review Board, written informed consent was obtained from all participants, confidentiality and anonymity were maintained, and participants were informed of their right to withdraw at any stage without consequences. Data were entered and analyzed using SPSS version 27. Quantitative variables were summarized as mean  $\pm$  standard deviation, while qualitative variables were presented as frequencies and percentages. The Wilcoxon signed-rank test was used to compare paired muscle-thickness measurements obtained by B-scan ultrasonography and CT. The Intraclass Correlation Coefficient (ICC) was used to assess measurement reliability, and a p-value  $< 0.05$  was considered statistically significant.

### Results

In the right eye, B-scan measurements were higher than CT for the SR (3.10 vs. 3.00 mm; median difference 0.10 mm), IR (3.20 vs. 3.00 mm; 0.20 mm), LR (2.80 vs. 2.50 mm; 0.30 mm), and MR (5.00 vs. 4.90 mm; 0.10 mm); all comparisons were significant ( $p < 0.001$ ). In the left eye, B-scan also yielded higher measurements for MR (3.20 vs. 2.90 mm; difference 0.30 mm), LR (2.80 vs. 2.70 mm; 0.10 mm), SR (3.30 vs. 3.10 mm; 0.20 mm), and IR (3.10 vs. 3.00 mm; 0.10 mm), with all differences statistically significant ( $p < 0.001$ ).

Table 1: Descriptive Characteristics of the Study Participants

| Descriptive Statistics |    |         |         |                           |
|------------------------|----|---------|---------|---------------------------|
|                        | N  | Minimum | Maximum | Mean $\pm$ Std. Deviation |
| Age                    | 57 | 23      | 70      | 45.33 $\pm$ 14.21         |
| Duration of Thyroid    | 57 | 4       | 22      | 13.19 $\pm$ 5.33          |
| IOP Right Eye          | 57 | 12      | 20      | 17.02 $\pm$ 2.20          |
| IOP Left Eye           | 57 | 15      | 20      | 18.04 $\pm$ 1.49          |

The descriptive statistics showed that the 57 participants had a mean age of  $45.33 \pm 14.21$  years, with ages ranging from 23 to 70 years. The mean duration of thyroid disease was  $13.19 \pm 5.33$  years, with a minimum of 4 years and a maximum of 22 years. The mean

intraocular pressure (IOP) was  $17.02 \pm 2.20$  mmHg in the right eye, ranging from 12 to 20 mmHg, while the left eye had a slightly higher mean IOP of  $18.04 \pm 1.49$  mmHg, ranging from 15 to 20 mmHg.

Table 2: Comparative Statistics Muscle Thickness between CT scan and B scan in Right Eye

| Study Group | B-Scan       | CT Scan      | Median Difference | Z     | P-Value (95 % CI)   |
|-------------|--------------|--------------|-------------------|-------|---------------------|
|             | Median (IQR) | Median (IQR) |                   |       |                     |
| SR          | 3.10 (0.4)   | 3.00 (0.4)   | 0.10              | -4.77 | < 0.001 (0.07-0.13) |
| MR          | 5.00 (0.95)  | 4.90 (1.0)   | 0.10              | -6.66 | < 0.001 (0.00-0.12) |
| IR          | 3.20 (0.3)   | 3.00 (0.2)   | 0.2               | -6.42 | < 0.001 (0.16-0.22) |
| LR          | 2.80 (0.2)   | 2.50 (0.2)   | 0.3               | -6.34 | < 0.001 (0.16-0.31) |

The comparison of extraocular muscle thickness between B-scan ultrasonography and CT scan showed statistically significant differences for all four muscles. The superior rectus (SR) had a median thickness of 3.10 (IQR 0.4) mm on B-scan compared with 3.00 (IQR 0.4) mm on CT, with a median difference of 0.10 mm ( $Z = -4.77$ ,  $p < 0.001$ ; 95% CI: 0.07–0.13). The medial rectus (MR) measured 5.00 (IQR 0.95) mm on B-scan and 4.90 (IQR 1.0) mm on CT, with a median difference of 0.10 mm ( $Z = -6.66$ ,  $p < 0.001$ ; 95% CI: 0.00–0.12). The inferior

rectus (IR) showed median measurements of 3.20 (IQR 0.3) mm on B-scan and 3.00 (IQR 0.2) mm on CT, yielding a median difference of 0.20 mm ( $Z = -6.42$ ,  $p < 0.001$ ; 95% CI: 0.16–0.22). Similarly, the lateral rectus (LR) measured 2.80 (IQR 0.2) mm on B-scan versus 2.50 (IQR 0.2) mm on CT, with a median difference of 0.30 mm ( $Z = -6.34$ ,  $p < 0.001$ ; 95% CI: 0.16–0.31).

Table 3: Comparative Statistics Muscle Thickness between CT scan and B scan in Left Eye

| Study Group | B-Scan       | CT Scan      | Median Difference | Z     | P-Value (95 % CI)   |
|-------------|--------------|--------------|-------------------|-------|---------------------|
|             | Median (IQR) | Median (IQR) |                   |       |                     |
| MR          | 3.20 (0.36)  | 2.90 (0.37)  | 0.30              | -6.38 | < 0.001 (0.21-0.34) |
| LR          | 2.80 (0.15)  | 2.70 (0.18)  | 0.10              | -5.13 | < 0.001 (0.07-0.13) |
| SR          | 3.30 (0.24)  | 3.10 (0.24)  | 0.20              | -6.34 | < 0.001             |
| IR          | 3.10 (0.18)  | 3.00 (0.16)  | 0.10              | -5.67 | < 0.001 (0.08-0.12) |

For the left eye, comparison of extraocular muscle thickness between B-scan ultrasonography and CT scan showed statistically significant differences for all four muscles. The medial rectus (MR) had a median thickness of 3.20 (IQR 0.36) mm on B-scan compared with 2.90 (IQR 0.37) mm on CT, with a median difference of 0.30 mm ( $Z = -6.38$ ,  $p < 0.001$ ; 95% CI: 0.21–0.34). The lateral rectus (LR) measured 2.80 (IQR 0.15) mm on B-scan and 2.70 (IQR 0.18) mm on CT, with a median difference of 0.10 mm ( $Z = -5.13$ ,  $p < 0.001$ ; 95% CI: 0.07–0.13). The superior rectus (SR) showed median measurements of 3.30 (IQR 0.24) mm on B-scan and 3.10 (IQR 0.24) mm on CT, yielding a median difference of 0.20 mm ( $Z = -6.34$ ,  $p < 0.001$ ; 95% CI: 0.11–0.15). The inferior rectus (IR) measured 3.10 (IQR 0.18) mm on B-scan and 3.00 (IQR 0.16) mm on CT, with a median difference of 0.10 mm ( $Z = -5.67$ ,  $p < 0.001$ ; 95% CI: 0.08–0.12).

0.13). Similarly, the superior rectus (SR) showed median measurements of 3.30 (IQR 0.24) mm on B-scan and 3.10 (IQR 0.24) mm on CT, yielding a median difference of 0.20 mm ( $Z = -6.34$ ,  $p < 0.001$ ; 95% CI: 0.11–0.15). The inferior rectus (IR) measured 3.10 (IQR 0.18) mm on B-scan and 3.00 (IQR 0.16) mm on CT, with a median difference of 0.10 mm ( $Z = -5.67$ ,  $p < 0.001$ ; 95% CI: 0.08–0.12).

**Discussion**

The study population comprised 57 patients with a mean age of  $45.33 \pm 14.21$  years and a mean thyroid disease duration of  $13.19 \pm 5.33$  years, of whom 34 (59.6%) were male and 23 (40.4%) were female. Disease severity was distributed as mild in 29 patients (50.9%), moderate in 19 (33.3%), and severe in 9 (15.8%). Rani et al reported the age of patients as  $35.58 \pm 13.52$  years with majority of the patients being female (82.6%) and severity of orbitopathy was significantly associated with age, smoking and fluctuating thyroid function. Differences between the two regional cohorts and the present cohort (older, and male-dominated) may be related to differences in the referral pathway (imaging-based orbital service versus general endocrinology clinic), sample size, or health-seeking behaviour; caution should be taken in interpreting the differences between the cohorts because of the smaller number of individuals in the present study compared with Rani et al.'s.[15]

In 28 orbits, the superior rectus/levator complex and superior oblique muscle were indeed significantly volumetrically enlarged compared to the medial rectus, suggesting that the MR/IR-dominant model might not apply when muscle bulk is measured volumetrically.[16] In particular, the same authors have reported that the same type of measurement (maximum linear diameter, as used on B-scan and CT in this study) for the diameter of the structures led to the same pattern as the IR and MR, that is, the structures had the largest size. These MR-dominant thickness results could differ from the results of Park et al., because the diameter-based (not volume-based) sub-analysis yielded similar findings, meaning that it is possible that the disagreement in the literature regarding which muscle is "most affected" in thyroid orbitopathy is due to the methods of measurement rather than to the underlying disease biology.[17]

The degree of MR trend enhancement measured by B scan and the direction of trend enlargement, as detected by B scan, is similar to the reported CT findings by Delint et al. in a previous comparative series of B

scan and CT in Graves' orbitopathy, where they also found that the most consistent trend enhancement was for the MRs with enlargement in the direction of the eye, and that B scan ultrasonography was at least as sensitive as CT in detecting orbitopathy despite the fact that B scan offers less anatomical detail than CT.[18] The present study affirmed this previous conclusion, with B-scan tracking the severity gradient of MR almost as well as CT ( $\eta = 0.876$  versus  $0.857$ ), while recognizing that in some muscles (such as the superior rectus), the CT effect size ( $\eta = 0.469$ ) was larger than the corresponding B-scan effect size ( $\eta = 0.417$ ) and was thus superior.

This systematic overestimation of B-scan compared to CT is consistent with a general trend in the literature that the measurements of muscle-belly by B-scan and by CT are not numerically interchangeable, even when both methods reliably detect muscle enlargement.[19] Clinically, the findings support the interpretation offered by the results, and B-scan ultrasonography may well be used instead of CT in serial monitoring, where MR is the muscle of interest, with the same effectiveness and accuracy as CT, and without the radiation and cost issues or access barriers, as reported by Delint et al.[20] that combined A- and B-scan ultrasonography is an effective and accurate means of serial monitoring of the activity of Graves' orbitopathy without the radiation and cost of CT, or the access barriers.

The within-subject paired design used in this study has the advantage of studying each patient with both modalities, eliminating the confounding of comparing two different B-scan and CT groups as in some earlier comparative series.[21] On these parameters, B-scan ultrasonography and CT provided converging evidence that the lateral thickening of the rectus muscles is the most consistent orbital correlate of the severity of thyroid orbitopathy, with a pattern of involvement that is consistent with the classic EOM involvement, as opposed to the heterogeneous pattern reported in more recent volumetric CT literature.[22] B-scan systematically scanned 0.10–0.30 mm higher

than CT within muscles, agreement between the modalities was very good for MR and LR but was relatively poor for SR and IR, which suggests that the two modalities are not completely interchangeable for all muscles.

### Conclusion

The findings of this study demonstrate that B-scan ultrasonography is a reliable and effective imaging modality for the evaluation of thyroid orbitopathy, producing measurements that are broadly comparable to those obtained with computed tomography (CT). B-scan demonstrated clinically relevant extraocular muscle changes and showed patterns of muscle involvement corresponding to disease severity, particularly in the medial rectus muscle. B-scan ultrasonography can therefore be considered a useful, accessible, and non-invasive modality for the assessment and follow-up of orbital involvement, while CT provides a more comprehensive evaluation of orbital anatomy and extraocular muscle changes.

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