Assessment of Choroidal Thickness Changes after Strabismus Surgery Measured by Optical Coherence Tomography

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Abstract
Background: Strabismus surgery can impact choroidal thickness, affecting retinal health. Optical Coherence Tomography (OCT) helps monitor these changes for better outcomes.
Objectives: To evaluate Choroidal Thickness Changes post-Strabismus Surgery using OCT.
Patients and methods: This prospective study included 45 eyes from 30 patients (age 20.27 ± 13.25 years, 53.33% male) with esotropia or exotropia, undergoing surgery at Qena University Hospital. Patients were divided into two groups: Single Muscle Surgery Group (38 eyes) and Dual Muscle Surgery Group (7 eyes). Choroidal thickness was measured pre-operatively and post-operatively at various time points (day 1, week 2, month 1, month 3) using the Heidelberg Spectral OCT system.
Results: Pre-operative foveal thickness was similar between groups (dual: 273.43 ± 28.08 µm, single: 284.37 ± 21.17 µm, P = 0.3909). On day 1 post-op, the dual group showed significant thinning (234.57 ± 25.19 µm vs. 276.08 ± 29.67 µm, P = 0.0054). At 2 weeks and 3 months, thickness differences were insignificant. Temporal and nasal thickness did not vary significantly except for day 1, where T1 thickness decreased in the dual group (230 ± 26.03 µm vs. 270.79 ± 28.26 µm, P = 0.0042).
Conclusion: Strabismus surgery significantly affects choroidal thickness, with initial thinning followed by recovery. Dual-muscle surgery causes a more substantial decrease, indicating a higher impact from the increased surgical intervention. Further OCT-based research is needed.

Keywords: Choroidal thickness; Strabismus surgery; Optical Coherence Tomography; Visual health.

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Introduction

Choroidal thickness alterations following strabismus surgery are a significant focus in ophthalmic research, aiming to elucidate their impact on ocular physiology and visual health. The choroid, situated between the retina and sclera, serves critical functions in providing oxygen, nutrients to the outer retina, and regulating ocular temperature **(Huseyinhan et al., 2023; Guler et al., 2024).** Recent studies underscore its role in various ocular pathologies like myopia, amblyopia, and age-related macular degeneration, highlighting the importance of understanding post-surgical dynamics.

Strabismus surgery involves manipulating extraocular muscles that insert into the sclera **(Kushner et al., 2018).** While primarily addressing eye alignment to prevent amblyopia and achieve cosmetic correction, its secondary effects on adjacent tissues, including the choroid, are less explored. Proximity of muscle insertions, such as the inferior oblique near the macula, raises questions about localized impacts on choroidal thickness and function **(Alis and Alis, 2021).**

Optical Coherence Tomography (OCT) has revolutionized ophthalmology with its non-invasive, high-resolution imaging capabilities, particularly for choroidal assessment (**Katkar et al., 2018).** Advancements in Heidelberg spectral OCT technology enable precise measurements of choroidal thickness, essential for evaluating structural changes post-surgery. Despite its utility, research specifically on choroidal thickness alterations after strabismus surgery is limited, necessitating further investigation to address this gap **(Giannakaki-Zimmermann et al., 2019; Aumann et al., 2019).**

Understanding how strabismus surgery influences choroidal thickness is crucial for clinical Operative. Changes in choroidal thickness may impact visual outcomes post-surgery, refractive error progression, and the development of ocular conditions. Moreover, insights into these changes can refine surgical techniques and optimize patient care strategies, potentially improving long-term visual health and quality of life outcomes **(Evereklioglu et al., 2024; Bokhary et al., 2023; Inan et al., 2018).**

The study aimed to assess Choroidal Thickness Changes after Strabismus Surgery using Optical Coherence Tomography (OCT).

Patients and methods

This prospective study was conducted in the Ophthalmology Department of Qena University Hospital, South Valley University with ethical code SVU-MED-OPH026-1-23-8-700. It involved 45 eyes from 30 patients diagnosed with esotropia or exotropia who were candidates for surgical intervention.

Inclusion Criteria: Patients with esotropia or exotropia indicated for surgery.

Exclusion Criteria: Patients with neurological diseases, nystagmus, orbital pathology, previous ocular trauma, prior surgeries, or children too young to cooperate with OCT were excluded.

A total of 30 patients (45 eyes) underwent surgery for esotropia or exotropia based on inclusion criteria. Surgical techniques included medial and/or lateral rectus recession or resection, performed under general anesthesia by the same surgeon. Patients were divided into two groups based on the number of horizontal muscles operated:

- **Single Muscle Surgery Group (N = 38):** One horizontal muscle (medial or lateral rectus) was either recessed or resected using a limbal conjunctival approach.
    - **Resection Procedure:** Medial rectus muscles were resected in exotropic patients, and lateral rectus muscles in

esotropic patients. Steps included limbal conjunctival incision, muscle identification and hooking, removal of intermuscular septa, and reattachment using 6/0 Vicryl sutures.

- **Recession Procedure:** Medial rectus muscles were recessed for esotropia, and lateral rectus muscles for exotropia. Tendons were detached and reattached after measurement of recession, avoiding muscle bowing.

- **Dual Muscle Surgery Group (N = 7):** Two horizontal muscles were operated on one eye. Exotropic patients underwent lateral rectus recession and medial rectus resection, while esotropic patients had medial rectus recession and lateral rectus resection.

Surgical doses followed Parks' recommendations **(Simon et al., 2015),** considering distance measurements for esotropia and near measurements for exotropia. Postoperative care included topical antibiotics, and steroid eye drops for two weeks.

Optical Coherence Tomography (OCT): Choroidal thickness was measured preoperatively and postoperatively on day 1, week 2, month 1, and month 3 using the Heidelberg Spectral OCT system. Measurements were taken at five points (fovea, 500 µm and 1,000 µm temporal and nasal) by marking boundaries from the retinal pigment epithelium (RPE) to the scleral border.

Statistical analysis

Statistical Analysis: Data from the study were analyzed using SPSS version 20.0. Quantitative variables were expressed as mean ± standard deviation (SD), and qualitative variables as number and percentage. Statistical methods included the student "t" test for comparing means of two independent groups, with significance determined using the student "t" table at a 5% level ($P < 0.05$). The Chi-square test assessed associations between variables.

Results

The study comprised 30 participants with an average age of 20.27 ± 13.25 years. The cohort included 16 males (53.33%) and 14 females (46.67%).

The mean left exotropia was 45° ± 13.42° (30° in 2 participants, 6.67%; 45° in 1, 3.33%; 60° in 2, 6.67%), and the mean right exotropia was 35° ± 18.71° (15° in 2, 6.67%; 30° in 2, 6.67%; 60° in 2, 6.67%). Alternating exotropia averaged 34.5° ± 6.87° (30° in 7, 23.33%; 45° in 3, 10%). For esotropia, the mean left and right esotropia were 52.5° ± 7.5° (45° in 1, 3.33%; 60° in 1, 3.33%). Alternating esotropia had a mean of 36° ± 7.35° (30° in 3, 10%; 45° in 2, 6.67%).

Table 1. Distribution of surgical procedures among study participants

Variables	**Value (N = 30)**
Surgery	
Left Lateral Rectus recession	13 (43.33%)
Right Lateral Rectus recession	14 (46.67%)
Left Medial Rectus recession	5 (16.67%)
Right Medial Rectus recession	6 (20%)
Left lateral rectus recession with medial rectus resection	2 (6.67%)
Right lateral rectus recession with medial rectus resection	2 (6.67%)
Left medial rectus recession with lateral rectus resection	2 (6.67%)
Right medial rectus recession with lateral rectus resection	1 (3.33%)

Among our study of 30 participants, 13 cases (43.33%) had left lateral rectus recession, and 14 cases (46.67%) had right lateral rectus recession. There were 5 cases

(16.67%) who had left medial rectus recession and 6 cases (20%) who had right medial rectus recession. Additionally, 2 cases (6.67%) had left lateral rectus recession with medial rectus resection, and 2 cases (6.67%) had right lateral rectus recession with medial rectus resection. Left medial rectus recession with lateral rectus resection was done in 2 cases (6.67%), while right medial rectus recession with lateral rectus resection was done in 1 case (3.33%). (**Table.1).**

Table 2. Comparison between dual and single muscle surgery groups during follow up

Variables	**Dual muscle surgery (N = 7)**	**Single muscle surgery (N = 38)**	**P. Value**
Choroidal thickness (µm)			
Fovea			
Pre-Operative	273.43 ± 28.08	284.37 ± 21.17	0.3909
1st day	234.57 ± 25.19	276.08 ± 29.67	**0.0054***
2nd week	239.43 ± 26.14	246.74 ± 17.73	0.5302
1st month	245.29 ± 26.88	277.18 ± 25.9	**0.0269***
3rd month	269.71 ± 28.34	284.89 ± 22.71	0.2504
Temporal (T1)			
Pre-Operative	268 ± 27.47	278.58 ± 20.5	0.4062
1st day	230 ± 26.03	270.79 ± 28.26	**0.0042***
2nd week	237.14 ± 26.02	241.82 ± 18.09	0.6847
1st month	264.43 ± 24.69	277.13 ± 21.92	0.1539
3rd month	266.43 ± 25.96	279.32 ± 21.07	0.1632
Temporal (T2)			
Pre-Operative	262.71 ± 27.21	273.42 ± 20.45	0.3393
1st day	225.57 ± 23.74	234.79 ± 17.54	0.3919
2nd week	233.43 ± 23.98	240.71 ± 17.65	0.4986
1st month	261.71 ± 29.17	272.03 ± 20.21	0.4711
3rd month	264.14 ± 29.29	274.24 ± 20.44	0.4614
Nasal (N1)			
Pre-Operative	266 ± 26.94	276.55 ± 20.47	0.3553
1st day	225.71 ± 20.35	237.53 ± 18.18	0.2195
2nd week	230.57 ± 19.52	243.53 ± 18.04	0.1673
1st month	265.86 ± 25.62	275.61 ± 21.02	0.4041
3rd month	268.43 ± 24.85	277.63 ± 21.45	0.418
Nasal (N2)			
Pre-Operative	261.14 ± 27.18	271.5 ± 20.31	0.3802
1st day	223.57 ± 24.06	233.21 ± 18	0.2726
2nd week	226.43 ± 23.66	238.89 ± 18.23	0.2564
1st month	262 ± 25.8	270.34 ± 20.94	0.5309
3rd month	263.29 ± 24.6	272.42 ± 20.63	0.4334

Pre-operative foveal thickness was similar between groups (dual: 273.43 ± 28.08 µm, single: 284.37 ± 21.17 µm, P = 0.3909). On day 1 post-op, dual muscle surgery showed significant thinning (234.57 ± 25.19 µm vs. 276.08 ± 29.67 µm, P =

0.0054). Differences were insignificant at 2 weeks (dual: 239.43 ± 26.14 µm, single: 246.74 ± 17.73 µm, P = 0.5302) and 3 months (dual: 269.71 ± 28.34 µm, single: 284.89 ± 22.71 µm, P = 0.2504). Temporal (T1, T2) and nasal (N1, N2) thickness showed no significant differences pre-operatively or at 3 months across groups, except for day 1 when T1 thickness decreased significantly in the dual group (230 ± 26.03 µm vs. 270.79 ± 28.26 µm, P = 0.0042). All other time points revealed no notable variations between groups (**Table .2).**

Case (1): Choroidal thickness preoperative and post operative in a case of right exotropia (35 years) (**Fig.1-5**). **Case (2):** A case of alternating exotropia (10 years), **(Fig.6-10**).

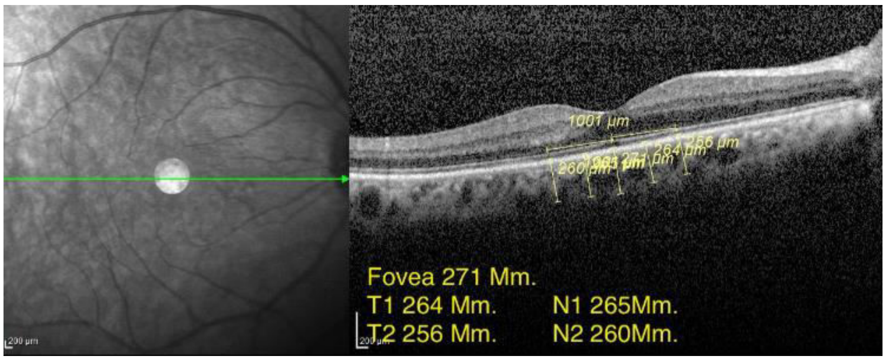

Fig .1. Preoperative measurements of choroidal thickness.

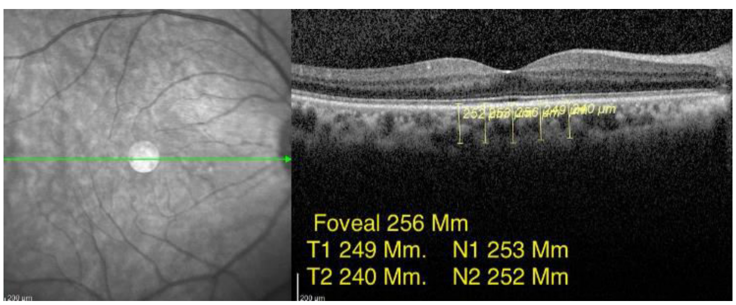

Fig .2. 1st day Post operative

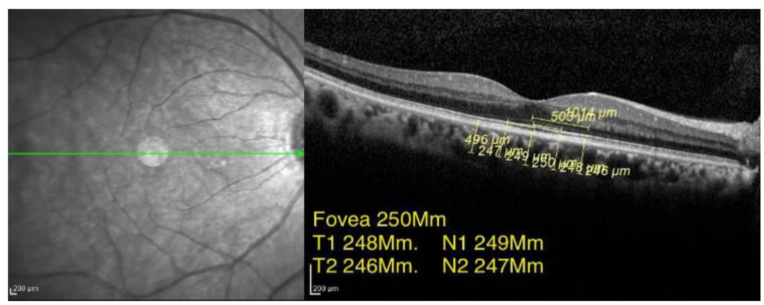

Fig .3. 2 weeks post operative

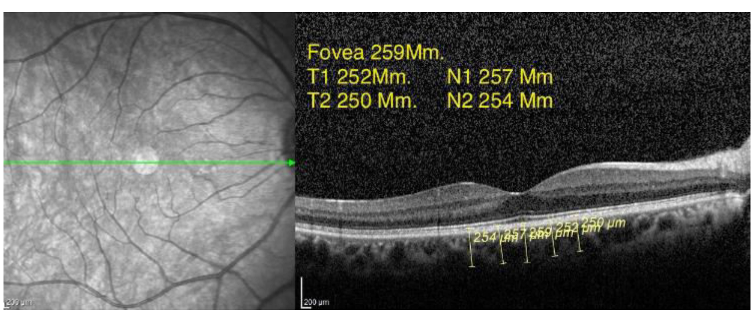

Fig .4. 1 month post operative

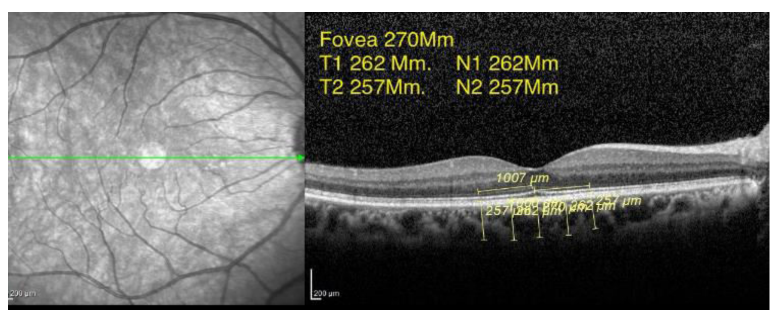

Fig .5. 3 months post operative

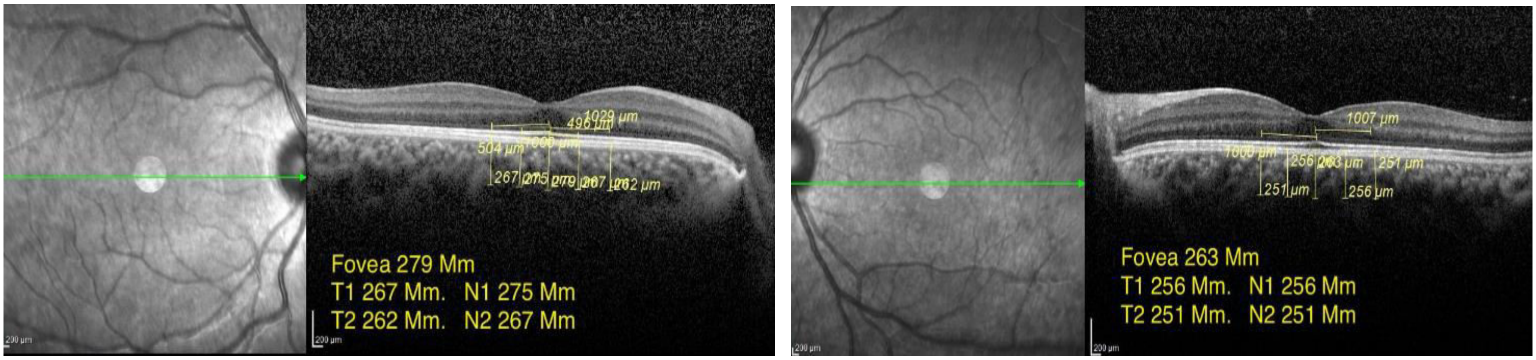

Fig .6. Preoperative

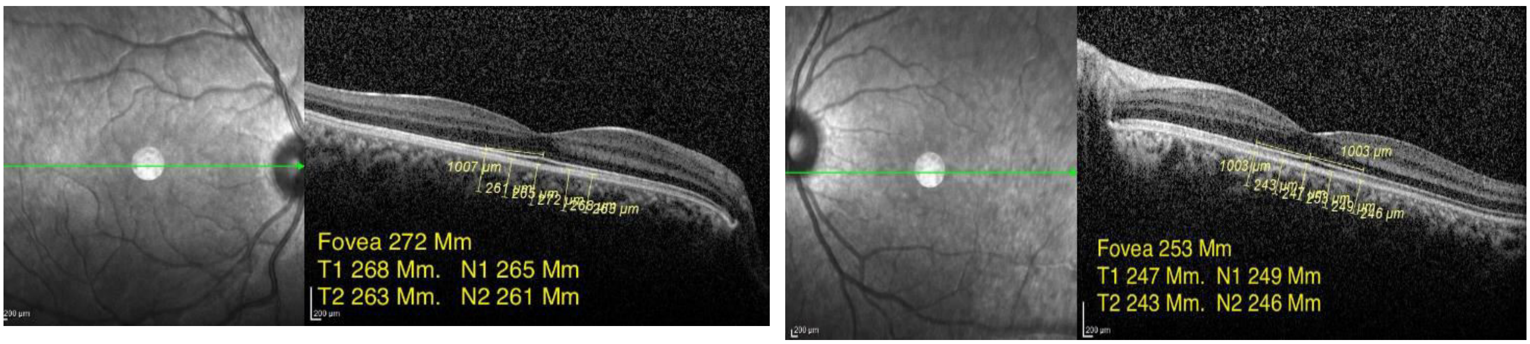

Fig .7. 1st day post operative

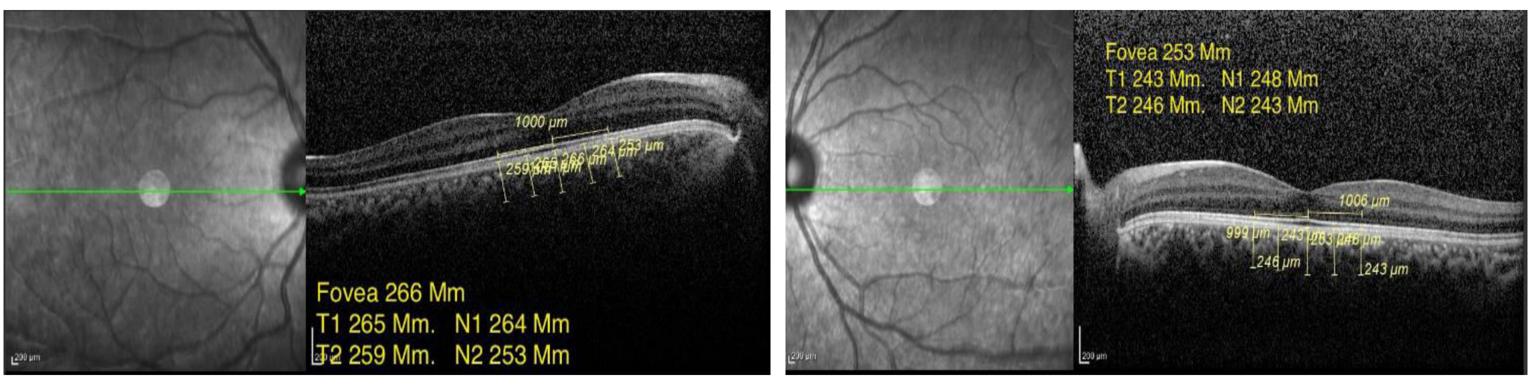

Fig .8. 2nd week post operative

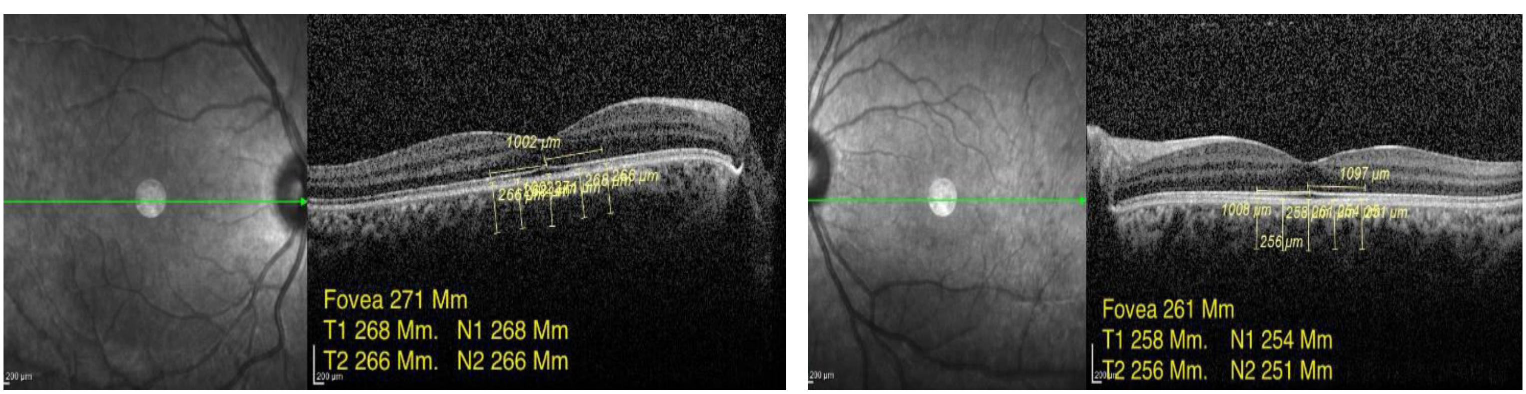

Fig .9. 1 month Post operative

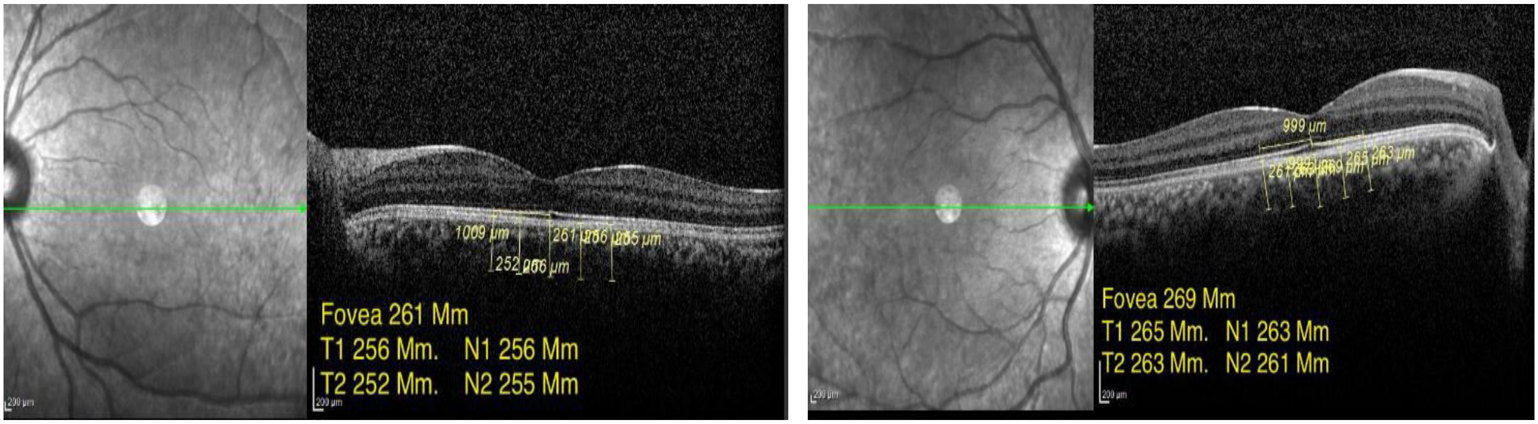

Fig .10. 3 months post operative

Discussion

Our study demonstrated significant postoperative changes in choroidal thickness, with dual-muscle surgery resulting in significantly lower thickness in the fovea and temporal regions compared to single-muscle surgery. This difference persisted for the fovea at one and three months post-surgery, while temporal thickness differences were significant only on day 1. Nasal thickness showed no significant differences at any follow-up point. Both groups experienced an initial significant decrease in choroidal thickness immediately post-surgery, likely due to vasoconstriction and mechanical trauma, followed by gradual recovery and normalization by the third month. These findings align with previous studies **(Entezari et al., 2018; Prousali et al., 2021),** which attribute these changes to vascular dynamics and surgical trauma.

Our findings are consistent with **(Uzun et al., 2024),** who observed lower choroidal thickness in a dual-muscle group (325.55 ± 47.16 μm) compared to a single-muscle group (338.41 ± 47.61 μm) one week post-surgery. At one month, the dual-muscle group maintained lower thickness (312.64 ± 51.05 μm vs. 335.18 ± 51.07 μm). These observations reflect the more extensive vascular disruption and inflammation associated with dual-muscle surgery. Similarly, **(Spaide et al., 2008; Branchini et al., 2012)** noted that baseline subfoveal choroidal thickness reductions post-surgery could result from vascular constriction rather than inflammation, differing from the mechanisms seen in inflammatory diseases.

Interestingly, studies such as **(Mintz et al., 2016)** reported increased central foveal thickness after extraocular muscle surgery, suggesting mechanical factors like muscle traction may influence outcomes differently. Our results diverge slightly in highlighting thickness reductions in dual-muscle procedures, which may reflect procedural complexity and more pronounced vascular responses. Supporting this, **(Atalay et al., 2019)** found distinct patterns of subfoveal thickness changes, with rectus muscle surgery initially increasing CT followed by a significant decrease, while inferior oblique surgery showed minimal early changes due to reduced muscular traction and inflammation.

Contrary to our findings, **(Karska-Basta et al., 2024)** observed no significant thinning in temporal regions after inferior oblique muscle recession, emphasizing a potential inflammatory rather than mechanical etiology. However, **(Inal et al., 2019; Steiner et al., 2019)** reported results aligning with ours, where acute vasoconstriction post-surgery led to initial thinning, followed by gradual recovery as vascular flow normalized. These temporal patterns underscore the dynamic interplay between surgical trauma, vascular responses, and healing in determining choroidal thickness outcomes.

Overall, our study findings emphasize the differential impact of single- and dual-muscle surgeries on choroidal dynamics, with dual-muscle procedures inducing more pronounced and prolonged changes due to greater surgical intervention. These insights, combined with existing literature, highlight the importance of monitoring choroidal thickness as a marker of vascular and structural recovery following strabismus surgery.

Conclusion

In conclusion, our study found that strabismus surgery significantly affects choroidal thickness, with initial decreases followed by recovery by the third month. Dual-muscle surgery caused a more substantial decrease, suggesting a greater impact due to increased surgical intervention. These findings highlight the differential effects of surgical approaches on choroidal thickness, warranting further research using OCT imaging to explore these changes.

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