Retinal nerve fiber layer thickness analysis in suspected malingerers with optic disc temporal pallor

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Purpose: To investigate the value of temporal retinal nerve fiber layer (RNFLtemporal) thickness in the prediction of malingering.

Materials and Methods: This prospective, cross-sectional study was conducted on 33 military conscripts with optic disc temporal pallor (ODTP) and 33 age-and sex-matched healthy controls. Initial visual acuity (VAi) and visual acuity after simulation examination techniques (VAset) were assessed. The subjects whose VAset were two or more lines higher than VAi were determined as malingerers. Thickness of the peripapillary RNFL was determined with OCT (Stratus OCT™, Carl Zeiss Meditec, Inc.). RNFLtemporal thickness of the subjects were categorized into one of the 1+ to 4+ groups according to 50% confidence interval (CI), 25% CI and 5% CI values which were assessed in the control group. The VAs were converted to LogMAR-VAs for statistical comparisons.

Results: A significant difference was found only in the temporal quadrant of RNFL thickness in subjects with ODTP ($P=0.002$). Mean LogMAR-VA increased significantly after SETs ($P<0.001$). Sensitivity, specificity, positive and negative predictive values of categorized RNFLtemporal thickness in diagnosing malingering were 84.6%, 75.0%, 68.8%, 88.2%, respectively. ROC curve showed that RNFLtemporal thickness of 67.5 µm is a significant cut-off point in determining malingering ($P=0.001$, area under the curve:0.862). The correlations between LogMAR-VAs and RNFLtemporal thicknesses were significant; the correlation coefficient for LogMAR-VAi was lower than the correlation for LogMAR-VAset ($r=-0.447$, $P=0.009$ for LogMAR-VAi; $r=-0.676$, $P<0.001$ for LogMAR-VAset).

Conclusions: RNFLtemporal thickness assessment may be a valuable tool in determining malingering in subjects with ODTP objectively.

Key words: Malingering, nerve fiber layer, optic disc temporal pallor, visual acuity

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Functional visual loss (FVL) manifested as visual acuity (VA) loss is one of the most common complaints encountered in ophthalmic practice.[1-6] Many clinical simulation examination tests (SETs) have been described,[7-13] however, it still needs objective criterion.

Optic disc temporal pallor (ODTP) is a fundoscopic appearance characterized by loss of its pink color. Causes may vary (multiple sclerosis, trauma, autosomal dominant optic atrophy, ischemic optic neuropathy, and retinitis pigmentosa), and diagnosing malingering is more troublesome for these patients.

Optical coherence tomography (OCT) is a reproducible and reliable method for assessment of the retinal nerve fiber layer (RNFL).[14,15] Some studies showed relationship between temporal RNFL (RNFLtemporal) thickness and VA levels.[16-19]

The aim of the study was to determine the value of OCT-assessed RNFLtemporal thickness in prediction of malingering.

Materials and Methods

This study was performed at the tertiary-referral hospital between May 2007 and February 2008. Due to nature of the patient population, malingering is always considered among the differential diagnosis of unexplained visual loss at this hospital.

The research followed the tenets of Declaration of Helsinki; IRB approval and informed consents were obtained after explanation of the study. In this study, 33 military conscripts (33 eyes) with ODTP were selected from 199 subjects suspected of malingering or exaggerating visual loss at presentation to the hospital. At presentation, these 33 subjects had fundoscopy appearance of ODTP in one or both eyes, and a complaint of unilateral VA loss which could not be explained on the basis of thorough clinical examination(s) including color vision and visual field tests. Those eyes having ODTP with full vision were not included in this study group. In order to exclude organic causes of the optic disc, fundus fluorescein angiography (FFA), ultrasonography (US), pattern visually...
Evoked potentials (PVEP) testing and color doppler imaging (CDI) were performed when needed; subjects were referred to a neurologist or psychiatrist, and advanced laboratory techniques including MRI were performed when indicated. Diagnosis of ODTP was made if the two authors’ (CM, GF) common decision was confirmed by the experienced retinal specialist (SG) who was masked to the clinical findings of the case with suspected malingering. Age- and sex-matched 33 healthy military conscripts who had no ophthalmic pathology comprised the control group.

All the subjects were male enlisted soldiers between 19 and 27 years old. Mean age was 23.9±3.9 and 24.0±4.6 years in subjects with ODTP and control groups, respectively (P=0.927, not shown in the Table). Spherical equivalent refractive errors varied between -3.25 to +3.50 diopters (D) (not shown in the Table). Individual data of the subjects with ODTP are shown in Table 1.

Routine ophthalmic examinations, including initial best-corrected Snellen acuity (VA), pupillary reactions, biomicroscopy, indirect ophthalmoscopy, and eye movements were performed. The suspicion of malingering was based on the discrepancies between VA and clinical findings. After VA, best-performed VA or VAASET (visual acuity after simulation examination techniques: SETs) was assessed after certain technical procedures and behavioral observations, which use fogging, dissociation, and fixation techniques employed for detection of malingering included pupillary light reflexes, grimacing in front of the subject,[13] prism dissociation test,[7,8] polarizing lenses,[9,10] distance test,[8] bar-reading test (Javal-Cuignet),[6,9] two-perpendicular cylinder test,[6] Harlan test,[6,9] VA repetition test,[6,16,11] hand shaking test,[8] and a new optotype chart introduced by Mojon et al.[12] VA and the VAASET

| Table 1: Individual data of the subjects with optic disc temporal pallor |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| Patient No.     | Initial VA      | After SETs VA   | Clinical diagnosis | RNFLtemporal Thickness | OCT diagnosis | Evaluation   |
| 1               | 0.1             | 0.1             | Nonmalingering     | 50               | 4+            | Nonmalingering | True negative |
| 2               | 0.05            | 0.1             | Nonmalingering     | 65               | 3+            | Nonmalingering | True negative |
| 3               | 0.4             | 0.8             | Malingering        | 77               | 1+            | Malingering    | True positive  |
| 4               | 0.3             | 0.6             | Malingering        | 74               | 2+            | Malingering    | True positive  |
| 5               | 0.2             | 0.6             | Malingering        | 90               | 1+            | Malingering    | True positive  |
| 6               | 0.2             | 0.2             | Nonmalingering     | 80               | 1+            | Malingering    | True positive  |
| 7               | 0.2             | 0.8             | Malingering        | 79               | 1+            | Malingering    | True positive  |
| 8               | 0.2             | 0.3             | Nonmalingering     | 71               | 2+            | Malingering    | False positive |
| 9               | 0.1             | 0.7             | Malingering        | 79               | 1+            | Malingering    | True positive  |
| 10              | 0.01            | 0.6             | Malingering        | 85               | 1+            | Malingering    | True positive  |
| 11              | 0.05            | 0.05            | Nonmalingering     | 63               | 3+            | Nonmalingering | True negative  |
| 12              | 0.2             | 0.3             | Nonmalingering     | 74               | 2+            | Malingering    | False positive |
| 13              | 0.01            | 0.01            | Nonmalingering     | 67               | 3+            | Nonmalingering | True negative  |
| 14              | 0.01            | 0.01            | Nonmalingering     | 47               | 4+            | Nonmalingering | True negative  |
| 15              | 0.1             | 0.5             | Malingering        | 60               | 3+            | Nonmalingering | False negative |
| 16              | 0.1             | 0.2             | Nonmalingering     | 67               | 3+            | Nonmalingering | True negative  |
| 17              | 0.02            | 0.02            | Nonmalingering     | 47               | 4+            | Nonmalingering | True negative  |
| 18              | 0.3             | 0.4             | Nonmalingering     | 59               | 3+            | Nonmalingering | True negative  |
| 19              | 0.4             | 0.9             | Malingering        | 88               | 1+            | Malingering    | True positive  |
| 20              | 0.2             | 0.8             | Malingering        | 76               | 2+            | Malingering    | True positive  |
| 21              | 0.1             | 0.2             | Nonmalingering     | 47               | 4+            | Nonmalingering | True negative  |
| 22              | 0.3             | 0.7             | Malingering        | 77               | 1+            | Malingering    | True positive  |
| 23              | 0.1             | 0.1             | Nonmalingering     | 74               | 2+            | Malingering    | False positive |
| 24              | 0.05            | 0.05            | Nonmalingering     | 62               | 3+            | Nonmalingering | True negative  |
| 25              | 0.1             | 0.5             | Malingering        | 83               | 1+            | Malingering    | True positive  |
| 26              | 0.4             | 0.8             | Malingering        | 68               | 2+            | Malingering    | True positive  |
| 27              | 0.1             | 0.1             | Nonmalingering     | 61               | 3+            | Nonmalingering | True negative  |
| 28              | 0.01            | 0.01            | Nonmalingering     | 52               | 4+            | Nonmalingering | True negative  |
| 29              | 0.01            | 0.01            | Nonmalingering     | 57               | 4+            | Nonmalingering | True negative  |
| 30              | 0.1             | 0.2             | Nonmalingering     | 59               | 3+            | Nonmalingering | True negative  |
| 31              | 0.05            | 0.1             | Nonmalingering     | 63               | 3+            | Nonmalingering | True negative  |
| 32              | 0.4             | 0.5             | Nonmalingering     | 77               | 1+            | Malingering    | False positive |
| 33              | 0.1             | 0.4             | Malingering        | 63               | 3+            | Nonmalingering | False negative |

Sets: Simulation examination techniques; OCT: optical coherence tomography; RNFLtemporal: Temporal retinal nerve fiber layer thickness
were checked by the experienced clinician (SG) unaware of the VAi, and included in the study if the same results were obtained. Any positive result of SETs was accepted enough to reveal malingering. Some of the SETs test only the presence or absence of malingering, but have nothing to do with VA, while others test TEs.

After dilatation with 1% tropicamide (Tropamid®, Bilim Co., Turkey), the OCT device (OCT Stratus™, Carl Zeiss Meditec) with RNFL thickness software (version 4.0) were used to acquire three successive circular 3.4 mm diameter scans centered on the optic disc for each eye’s RNFL measurement (fast RNFL thickness protocol) during the same hours of the day. The RNFL thickness was automatically assessed by the computer using the algorithm to identify the anterior and the posterior margins of the band of reflectance representing the RNFL, marking the margins with 2 white lines in the visual pathway. Throughout the scanning, the subject kept the eyes constantly fixed on an internal target provided by the equipment. Scans were performed by the same experienced OCT technician who was masked to the clinical status of the subject.

The mean of the data was used to express RNFL thickness as a single average value for the whole 360-degree scan (RNFLaverage) and also as RNFL quadrants (superior, nasal, inferior, temporal). The data obtained in the temporal quadrant (316°-45°) was identified as RNFLtemporal. It was taken to evaluate the temporal fiber, in which the papillomacular bundle fibers are included.

In comparing VAi and VAset each subject was classified as a malingerer or nonmalingerer. If the difference between VAi and VAset was ≥2 Snellen lines, that subject was classified as malingerer. In this study, we used the SETs as the gold standard to prove malingering. From the statistical point of view, an abnormal test indicates a positive result. However, in this study, an abnormal OCT (or a thin RNFLtemporal) result indicates a negative result indicating the absence of malingering. OCT’s sensitivity and specificity to diagnose malingering, and predictive values of positive and negative results were calculated. The study design is shown in Fig. 1.

Snellen acuities (SA) were converted to the logarithm of the minimum resolution of angle acuity (LogMAR VA) for statistical analysis (LogMAR VA=−log10 SA). The data were calculated as mean values ±1 SD. The differences between control and malingerers were statistically evaluated with independent samples t test or chi-squared test. In the statistical analysis, P<0.05 was considered significant. The statistics were analyzed using SPSS 10.0 (Statistical Package Program for Windows, SPSS Inc., Chicago, Illinois, USA).

Results

At presentation, all had unilateral VA loss. No organic cause, neither ocular (including anisometropic ambliopia) or systemic origin could be defined in subjects with ODTP in this study group. Similar distributions in refractive errors were observed in the groups (not shown in the Table). Ischiara test revealed 2 of 33 (6%) cases with red-green abnormality. Visual field test (Humphrey® Field Analyzer, Carl Zeiss Meditec) showed constriction of the visual field in the involved eyes of 3 of 33 (9%) cases. None of the subjects in the study group had relative afferent pupillary defect (RAPD). There were 8 of 33 (24%) subjects with bilateral involvement. Among them, abnormalities in latency and amplitude of P100 wave were noted in both eyes of 5 of 33 (15%) subjects. There was no abnormal PVEP value for the rest of the group including 3 of 33 (9%) subjects with bilateral involvement. In medical history, a common complaint of blunt ocular/orbital trauma was present in 13 of 33 (39%) subjects and childhood meningitis in 5 of 33 (15%). Except 3 of 33 (9%) subjects who had SAs of 0.4, 0.6, and 0.7 in the uninvolved eyes which had corneal opacities, 30 of 33 (91%) subjects had SA of 1.0 in the uninvolved eyes. Most (27 of 33 subjects; 81%) subject with bilateral ODTP also had a complaint of visual loss in the right eye. No abnormality was detected in subjects undergone US or FA testing. After SETs, 5 of 33 (15%) cases confessed that they were conscious of ODTP before presentation to our hospital.

When compared to the RNFL thickness values in the control group, there was a significant reduction only in the RNFLtemporal thickness in subjects with ODTP [Table 2].

Fifty percent confidence interval (50% CI), 25%CI, and 5%CI values of RNFLtemporal in the control group were 77.0 µm, 68.0 µm, and 58.0 µm, respectively. The subjects with ODTP were distributed into one of four groups according to their RNFLtemporal values. If RNFLtemporal was thicker than 50% CI value that was assessed in the control group, the probability of malingering according to OCT result was labeled as 1+, if it

![Figure 1: The flowchart representing the study design](image-url)
was between 50% and 25%, the probability was labeled as 2+ and so on. As a result, there were ten 1+, six 2+, eleven 3+ and six 4+ subjects with ODTP [Table 1].

Mean LogMAR VA increased significantly after SETs (LogMAR VA_i: 1.07±0.59, LogMAR VA_set: 0.75±0.67, \(P<.001\)). There were 20 non-malingerers whose VA increased less than 2 Snellen lines or remained stable after SETs. The VAs of the remaining 13 of 33 (39%) subjects increased ≥2 Snellen lines after SETs [Table 1]. On the other hand, RNFL_{temporal} thickness reduction was predictive of non-malingering in most of the subjects. None of the 4+ subject (subjects with thinnest RNFL_{temporal} thickness category) was malingering; however 80% of the 1+ subject (subjects with thicker RNFL_{temporal} thickness) were proved to be malingering by means of SETs [Table 3]. All these malingerers confessed malingering after SETs.

The correlations between LogMAR-VAs (for both VA_i and VA_set) and RNFL_{temporal} thickness were significant. These significance and correlations for LogMAR-VA_set were higher than the significance and correlation for LogMAR-VA_i [Fig. 2].

After these results, we decided to divide the subjects into two groups according to the RNFL_{temporal} thickness values. The subjects with a 1+ and 2+ RNFL_{temporal} thickness were labeled as RNFL_{malingerer}, the subjects with a 3+ and 4+ RNFL_{temporal} were labeled as RNFL_{nonmalingerer} because, we suggested that if a subject with thicker RNFL_{temporal} (1+ and 2+ subjects) should have higher VA than subjects with thinner RNFL_{temporal} (3+ and 4+ subjects). However, definite diagnosis of malingering was made by VA_set after SETs as mentioned previously. Eleven of the 16 subjects with a 1+ and 2+ RNFL_{temporal} were malingerers, however only 2 of the 17 subjects with a 3+ and 4+ RNFL_{temporal} thickness were malingerers [Table 3]. The 1+ and 2+ subjects had significantly high ratio of malingering with respect to 3+ and 4+ subjects (\(P=0.001\), chi-squared test).

Sensitivity of OCT-assessed RNFL_{temporal} thickness in detecting malingering was 11/13 (84.6%). Specificity, positive predictive value (PPV) and negative predictive value (NPV) were 15/20 (75.0%), 11/16 (68.8%), 15/17 (88.2%), respectively [Table 4].

### Table 2: Retinal nerve fiber layer thicknesses in subjects with optic disc temporal pallor and control subjects

|                | RNFL_{superior} | RNFL_{nasal} | RNFL_{inferior} | RNFL_{temporal} | RNFL_{average} |
|----------------|-----------------|--------------|-----------------|-----------------|----------------|
| ODTP           | 131.5±13.8      | 92.8±16.1    | 129.2±22.4      | 67.9±12.0       | 105.4±13.0     |
| Control        | 137.4±16.0      | 90.9±19.3    | 134.3±18.6      | 78.8±14.6       | 110.3±9.6      |
| \(p\)          | 0.117           | 0.669        | 0.316           | 0.002           | 0.081          |

ODTP: optic disc temporal pallor, RNFL: retinal nerve fiber layer, \(p\): independent samples t test

### Table 3: The distribution of malingerers according to RNFL_{temporal} thickness.

| RNFL_{temporal} | Clinical diagnosis (SETs) | Total |
|------------------|---------------------------|-------|
|                  | Nonmalingerer | Malingering |       |
| 1+               | 2            | 8           | 10    |
| 2+               | 3            | 3           | 6     |
| 3+               | 9            | 2           | 11    |
| 4+               | 6            | 0           | 6     |
| Total            | 20           | 13          | 33    |

SETs: Simulation examination techniques

### Table 4: Calculation scheme for predictive value of PVEP

| OCT result | Clinical evalution | Total |
|------------|--------------------|-------|
|            | Malingerer | Nonmalingerer |   |
| RNFL_{malingerer} | 11 (True positive=a) | 5 (false positive=b) | 16 |
| RNFL_{nonmalingerer} | 2 (False negative=c) | 15 (True negative=d) | 17 |
| Total       | 13         | 20          | 33  |

Sensitivity: proportion of true positives (positive test result) among malingerers (\(a/a+c\)); Specificity: proportion of true negatives (negative test result) among nonmalingerers (\(d/b+d\)); Positive predictive value: proportion of true positives among all positive tests (\(a/a+b\)); Negative predictive value: proportion of true negatives among all negative tests (\(d/c+d\))
We used ROC curve analysis to find out the cut-off value of RNFL_{temporal} thickness for the prediction of malingering with the highest sensitivity and specificity. The cut-off value of RNFL_{temporal} thickness was 67.5 µm (sensitivity: 84.6%, specificity: 75.0%; AUC: area under the curve: 0.862, \( P=0.001 \), not shown in the Figure) [Fig. 3].

**Discussion**

ODTP is an ophthalmoscopic finding mostly diagnosed in visual pathway pathology with various causes and in some other conditions such as myopic fundus.[20-24] Sometimes ODTP may be diagnosed in an otherwise normal ophthalmologic examination. One ophthalmologist may diagnose ODTP in a patient; however another may not in the same patient. Malingering and exaggerating any existing ophthalmologic pathology and its relation to medicolegal issues warrants having some objective criteria in diagnosing the disease truly. It’s evident that diagnosis of malingering can be convincingly made in a case of no organic pathology including ODTP. However, this diagnosis is not straightforward in subjects with questionable pathology, and is not rare in demanding jobs like military, railways, roadway etc. In our study group, visual loss presented in the right eye in most (27 of 33 subjects; 81%), even in those with bilateral ODTP. This was most probably due to the traditional belief that right-hand-sided conscript who uses right eye for shooting would be unsuitable for the military. We were not able to find organic etiology for ODTP in our study group. We have to admit that we could not perform molecular analysis of hereditary or acquired disease in the differential diagnosis of ODTP, such as Leber’s optic neuropathy.

Although OCT is accepted as an invaluable tool in the examination of the retina, variability in RNFL measurements, especially that in the quadrants, with Stratus OCT has been reported.[25] Age and ethnicity have been reported to influence RNFL thickness.[26-28] In a mean age of 44.5±16.1 years-old patient population from India, Sony et al.[28] found that age had a significant negative correlation with average RNFL thickness and with average superior and average inferior RNFL thickness; however, there was no significant correlation between age and average nasal or temporal RNFL thickness. In OCT measurements, axial length and refractive errors have to be considered.[29,30] We didn’t examine axial length; however, both groups had similar distributions in refractive errors. Although our population seems to have higher RNFL_{temporal} thickness values, differences in normative database should be considered when evaluating the OCT results from different ethnicities. All the subjects and the controls were male young adults (ranging 19 to 27 years old) and from the similar environment in this study. In order to eliminate the bias in diagnosing we used strict criteria (described in the method section), and to decrease variability in RNFL measurements, we evaluated OCT recordings with signal strength of at least 8. All OCT procedures were performed by the experienced OCT technician during the same hours of the day, to exclude intraday variations among the subjects.

In this study, ROC curve showed that OCT has excellent diagnostic accuracy in defining ODTP; in other words, RNFL measurements in Stratus OCT may discriminate the malingerer from normal in subjects with ODTP. Using a single RNFL_{temporal} thickness cut-off value in the assessment of malingering in subjects with ODTP is, of course, not so logical. We think that if even present, using that single value without support of SETs may result in misdiagnosis of malingering. However, the ophthalmologists who come face to face with malingerers in their practice may benefit greatly from this objective value from OCT in their record for medicolegal issues. The relationship between RNFL_{temporal} thickness and VA has been shown.[16-19] In this study, we used SETs, which are accepted golden standard for diagnosing malingering. Since we aimed to have a cut-off value for diagnosing malingering in suspected malingerers with ODTP objectively, we compared RNFL_{temporal} thicknesses in eyes of malingerers diagnosed with SETs to those of age- and sex-matched healthy controls. The RNFL values of the other eyes with SA of 1.0 in either the involved eye (in bilateral cases) or uninvolved one in the study group were not considered for comparison. Although practically illogical to pretend as normal in our sample population, SA of 1.0 in one of the eye and decreased vision in the other in subjects with bilateral ODTP may suggest negative simulation. This, which was not in the scope of our study, also may complicate intrindividual comparison in the study group. In this study, we defined that RNFL_{temporal} thickness of 67.5 micrometer diagnose malingering with the highest sensitivity and specificity. This means that subjects with RNFL_{temporal} thickness below that value have significantly lower VAs than subjects with higher values. We found that the rate of the malingering decreased with thinning of RNFL_{temporal} thickness [Table 3]. The subjects with thicker RNFL_{temporal} were prone to malingering in the study population.

It is plausible that the subjects with a thicker RNFL_{temporal} thickness (but still thinner than normal) have a less severe pathology, needing exaggeration in reaching secondary gain that is exclusion from the military service. However, subjects with thinner RNFL_{temporal} thickness have more severe disease or enough pathology for exclusion. In this study, we showed that while 69% of subjects with 1+ and 2+ RNFL_{temporal} were malingerers, this ratio was 12% in subjects with 3+ and 4+ RNFL_{temporal} thicknesses.

The sensitivity (84.6%) of OCT in detecting malingering was found to be higher than specificity (75.0%). This finding emphasizes that OCT-assessed RNFL_{temporal} assessment is valuable in detecting malingerers among real malingerers (or clinically proved malingerers by SETs) than in detecting non-malingerers among real nonmalingerers. It should

![Figure 3: ROC curve of temporal retinal nerve fiber layer thickness for detection of malingering in subjects with optic disc temporal pallor](Image)
not be forgotten that 25.0% of real nonmaligners may be misdiagnosed as maligners with this technique. In addition, NPV (88.2%) was higher than PPV (68.8%). This means that if OCT result predicts a subject as nonmaligner, the probability of this subject to be a real nonmaligner is 88.2%. It is apparent that if OCT result predicts a subject as maligner, the probability of this subject being a real nonmaligner is rather high, 31.2% (PPV: 68.8%). So, a negative OCT result (or a higher RNFL thickness) is a more valuable result than a positive (or a thinner RNFL thickness) result in discriminating maligning/nonmaligning. In this study, a true negative result does not mean the absence of optic nerve pathology. However, it means that the RNFL_{temporal} thickness in that subject is thin enough to explain the low VA. This study did not aim to find the significance of RNFL thickness in diagnosing optic nerve pathology. The result of this study has epidemiologic importance in a potentially maligning population, and has to be considered as supportive evidence for maligning in subjects with ODTP.

In a recent study, we have showed a considerable value of pattern visual evoked potentials (PVEP) to five check sizes in detecting malingering. Apart from this study, PPV was more valuable than NPV in that study. It is apparent that using these two modalities together in detecting maligning in patients with ODTP may give more reliable results.

In conclusion, OCT-assessed RNFL thickness may be used as an adjunctive method in determining the existence of maligning in patients with ODTP.

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