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● *Original Contribution*

# EVALUATION OF OPTIC NERVE WITH STRAIN AND SHEAR WAVE ELASTOGRAPHY IN PATIENTS WITH BEHÇET'S DISEASE AND HEALTHY SUBJECTS

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**Abstract—The objective of this study was to investigate the elasticity characteristics of the optic nerve using strain and shear wave elastography in patients with Behçet's disease and to compare the results with those of healthy volunteers. Forty-six optic nerves from patients with Behçet's disease and 54 optic nerves from healthy volunteers were investigated prospectively in this study using strain and shear wave elastography. There was a statistically significant difference in terms of elasticity patterns between patients and healthy volunteers ($p < 0.001$). Elastographic images of healthy volunteers revealed most optic nerves to be type 3 (51.8%); however, type 2 (40.7%) and type 1 (7.5%) were also observed. Elastographic examination of Behçet's disease patients revealed type 2 in 52.2%, type 1 in 43.5% and type 3 in 4.3% of patients. Statistically significant differences were observed between patients and healthy volunteers in the analysis of shear wave elastography values ($p < 0.001$). Receiver operating characteristic curve analysis was perfect (0.933) (95% CI = 0.885–0.980), and a cutoff value of 16.5 kPa shear had very high sensitivity and specificity for the patient group. Strain and shear wave elastography findings for the optic nerves of patients with Behçet's disease were significantly different from those for healthy volunteers. (E-mail: inal_m@hotmail.com)** **© 2017 World Federation for Ultrasound in Medicine & Biology.**

***Key Words:*** **Elastography, Shear wave, Optic nerve, Optic neuropathy, Behçet's disease.**

## INTRODUCTION

Elastography is a non-invasive method for measuring the degree of tissue softness and hardness qualitatively or quantitatively. There are two basic methods in elastography: strain elastography (SE), in which external tissue compression is applied, and shear wave elastography (SWE), in which waves are produced by transducers. In studies conducted in recent years, the connection between tissue elasticity and histologic characteristics has been pointed out (Çebi Olgun et al. 2014; Vural et al. 2015). Elastography has been used to investigate lesions of lymph nodes, breasts, thyroid glands, prostate, testis, kidneys and liver (Chaudhry et al. 2017; Çıracı et al. 2015).

Behçet's disease (BD) is a chronic autoimmune disease manifested clinically by a wide range of symptoms and signs characterized by multisystem vasculitis of unknown origin. Clinical characteristics include recurrent oral aphthous ulcers; genital ulcerations; skin lesions; uveitis; and gastrointestinal, renal, vascular and neurologic findings (Kidd 2013; Koçer et al. 1999). Ocular complications of the disease involve relapsing, remitting panuveitis, retinal vasculitis, retinitis, retinal hemorrhage, macular edema and retinal vascular occlusion and necrosis (Ucar et al. 2015; Voros et al. 2006). Optic nerve involvement may develop as a result of occlusion of small vessels that supply the optic nerve and spread of inflammatory changes backward from the uveal tract (Cetin et al. 2011; Kidd 2013; Voros et al. 2006). In the literature, there are only a few studies that have examined the optic nerve with elastography (Vural et al. 2015). According to our information, there is no study that has examined the optic nerve with strain or shear wave elastography in patients with BD.

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The aim of this study was to analyze the elasticity characteristics of the optic nerve with strain and shear wave elastography in patients with BD and to compare with healthy volunteers. Thus, conclusions could be reached as to whether elasticity properties can be used as a contributing finding to the early diagnosis of ocular involvement in BD.

*Methods*

The study was managed in line with the ethical standards of the Declaration of Helsinki and received approval from the ethics committee of our hospital. Written informed consent was obtained from all volunteers to participate in the study.

We investigated 46 optic nerves of 23 BD patients (24 women and 22 men; mean ± SD age, 40.48 ± 9.41 y; range, 21–63 y) and 54 optic nerves of 27 healthy volunteers (26 women and 28 men; mean ± SD age, 41.30 ± 9.57 y; range, 20–55 y). In total, 100 optic nerves were investigated prospectively in this study with SE and SWE, and the results of the two groups were compared.

Dermatologic examination of the patients was carried out by the Dermatology Department and ophthalmologic examinations were performed by the Ophthalmology Department. The diagnosis of BD was made according to criteria established by the International Study Group (Wechsler et al. 1992). Patients with systemic disease, such as hypertension, multiple sclerosis and diabetes mellitus, or with any history of ophthalmic surgery were excluded from the study.

*Equipment and scanning*

Gray-scale ultrasonography (US) and elastographic examinations of all volunteers were performed by one of two radiologists who had 10–15 y of experience with conventional sonography and 1–5 y of experience with elastography. Patients were in the supine position for all studies, which were performed with the digital sonography device scanner (LOGIQ E9, GE Healthcare, Wauwatosa, WI, USA.) regulated with real-time tissue elastography software, using a linear 6- to 9-MHz multifrequency transducer.

Optic nerve sheath diameter was measured 3 mm behind the optic nerve head between the external hypoechogenic borders in the transverse plane in supine position with eyes kept in an almost neutral position (Ballantyne et al. 2002; Ueda et al. 2015).

The surface of the eyelid was covered with a coupling gel to obtain images, and participants were told to keep their eyes closed and not to move during the examination. The probe was placed so that it would be in contact the eyelid. The user-adjustable rectangular or square region of interest (ROI) box was set on the optic nerve to reduce elasticity heterogeneity, and the surrounding tissue was adequately imaged. Small rhythmic compressions were performed during SE and was repeated until a stable image of the optic nerve was obtained. Compression was not applied during SWE. The protocol for scanning the optic nerve was completed after confirming that several sequential images depicted almost the same color map.

During the elastography examination, both elastographic and gray-scale images were displayed simultaneously side by side as two different images. SE images were laid over the gray-scale images in a color scheme: red (largest strain, softest tissue), green (mean strain, intermediate tissue) and blue (lowest strain, hardest tissue) (Çıracı et al. 2015). The pressure quality factor, which ranges from 1 to 7, was displayed, and images were obtained only when optimal pressure was in the range 5–7 bar (Tan et al. 2013). The participants underwent gray-scale US and SWE simultaneously; measurements and images were recorded in the axial plane through the equator of the eyeball. Static and mobile images (at least 5 s per case) were also recorded digitally on the device for later examination.

*Data analysis*

After all images were obtained, the phase of compression for SE in transverse planes was reviewed by visual inspection from the motion video sequences to assess the optic nerve elasticity pattern. Afterward, two authors together decided on three main types and two subtypes according to the elasticity pattern, and these patterns were adapted from the SE pattern described by Tan et al. (2012).

Optic nerves were classified into three main types on the basis of elasticity features: type 1, blue (hardest tissue); type 2, blue/green (hard tissue); type 3, green (intermediate tissue). Also, two subtypes were additionally determined, only when consisting of related color(s) (a), and if there were yellow and red colors (b) (Fig. 1, Table 1).

After assessment of the SE pattern, quantitative measurement of optic nerve stiffness in real time with SWE was analyzed in kilopascals (kPa) in the display range of elastic modulus values (0–150 kPa) by placing a circular ROI box, as illustrated in Figure 2. The ROI was obtained with at least three measurements in the range 2–4 mm for each optic nerve, and an average was recorded for statistical analysis.

*Statistical analysis*

Statistical analyses were performed using the SPSS software package program (Version 20.0, IBM, Armonk, NY, USA). Numeric variables are expressed as either the mean ± standard deviation or number (percentage), where suitable. The differences between genders and