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ORIGINAL RESEARCH

Medicine Science 2017;6(3):498-503

Medicine Science International Medical Journal

Comparison of diffusion-weighed MRI findings of the testis in patients with the advanced stage unilateral testicular varicocele

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Received 06 March 2017; Accepted 24 March 2017

Available online 30.03.2017 with doi: 10.5455/medscience.2017.06.8607

Abstract
The aim of this study was to compare the testicular apparent diffusion coefficient (ADC) values of the patients with unilateral advanced stage varicocele and healthy volunteers. Twenty-seven patients with unilateral advanced stage varicocele and twenty-seven healthy volunteers were included in the study. Those with a diagnosis of clinical varicocele and the healthy volunteers were examined clinical and color Doppler ultrasonography. Patients with a unilateral (left) varicocele clinically grade III, color Doppler ultrasound grade IV-V were included in the study. All the patients and healthy volunteers were obtained ADC values. Mean values were calculated and statistical comparison was performed. ADC values were analysed by using an independent t test for each participant. Pearson's correlation test was used for the comparison of left pampiniform venous diameter and both testicular parenchymal ADC values. Left testicular ADC values were observed to be significantly lower when a comparison of the testicular parenchymal with left advanced stage varicocele and healthy volunteers revealed significantly low left testicular ADC values in patients ($p<0.05$) Furthermore, a negative correlation was detected between the increase in the left testicular venous diameter and parenchymal ADC values of the bilateral testis in patients with left advanced stage varicocele (left p= -624, right p= -0.382). Diffusion weighted magnetic resonance imaging may be beneficial in defining the testicular damage in patients with varicocele.

Keywords: Testis, varicocele, MRI, diffusion weighted MRI

Introduction

Varicocele is the abnormal dilatation of the pampiniform plexus, and is observed in 15% of the adolescents and 10-15% of the adult males [1-3]. It has been detected in 20-40% of the infertile men and is the main cause of male infertility [2-4]. Since infertility-related varicocele may be treated, radiological diagnosis is very important in the detection of this disease.

Color Doppler ultrasonography is the most important radiological diagnostic tool in the detection of varicocele. However, with the recent advances in functional magnetic resonance imaging (MRI) techniques, varicocele and testicular parenchymal tissue may be evaluated as well [4-6]. Diffusion-weighted imaging (DWI) is a functional MRI technique, and is the measurement of the decrease and increase of microscopic water movements within the tissue A reduction of movement of water molecules in tissue is defined as the diffusion restriction [7,8].

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Restriction of the water movements may be quantitatively calculated with ADC. Diffusion restriction may be observed as a result of inflammation, trauma, ischemia, tumor or fibrosis [7,9]. Investigating the ADC values is a promising radiological method in determining testicular fibrosis in patients with varicocele [3,10]. To our knowledge, there is only one study in the literature on the testis diffusion in patients with varicocele, and in that study, the testicular ADC values of patients with varicocele and healthy volunteers were found to be different [3].

The aim of our study was to compare the testicular ADC values of the patients with unilateral advanced stage varicocele and healthy volunteers. This may show us if DWI can be useful in determining the testicular damage in patients with varicocele in the future.

Materials and method

Study population

This prospective study was approved by the institutional review board at our institution and written informed consent was obtained from each participant**.** Local Ethics Committee was taken. The mean age with unilateral advanced varicocele (n=27) was 27.37 ± 8.87 and the mean age with healthy volunteers (n=27) was 30.62 ± 5:25.

Healthy volunteers were selected among individuals with no genitourinary complaint and abnormality in the sonography. Those with suspicious varicose sonography findings were excluded. Additionally, those with a previous history of varicocele repair, scrotal surgery, hernia operation, urogenital infection, single testis, testis torsion, trauma, or drug used for infertility treatment were excluded since they might interfere with the ADC values in DWI.

Equipment and Scanning

For diagnosis of varicocele, the patients who have admitted with complaints of pain, infertility or both were physically examined by a urologist in standing and lying positions and in valsalva maneuver as well. The grading of varicocele was performed according to the clinical classification of varicocele by World Health Organization (WHO); grade 0: no varicocele, grade I: varicocele palpable by valsalva maneuver, grade II: palpable varicocele without valsalva maneuver, grade III: visible varicocele [11]. Color Doppler ultrasound of varicocele grading can be done variably. The most elaborate and accepted grading was given by Sarteschi; grade IV : dilated veins even in supine position (venous diameter larger than 3 mm), reflux during valsalva maneuver, grade V: dilated veins (venous diameter larger than 3 mm), reflux without valsalva maneuver [12.13]. Patients clinical grade III, color Doppler ultrasound grade IV-V were included in the study (Fig. 1a).

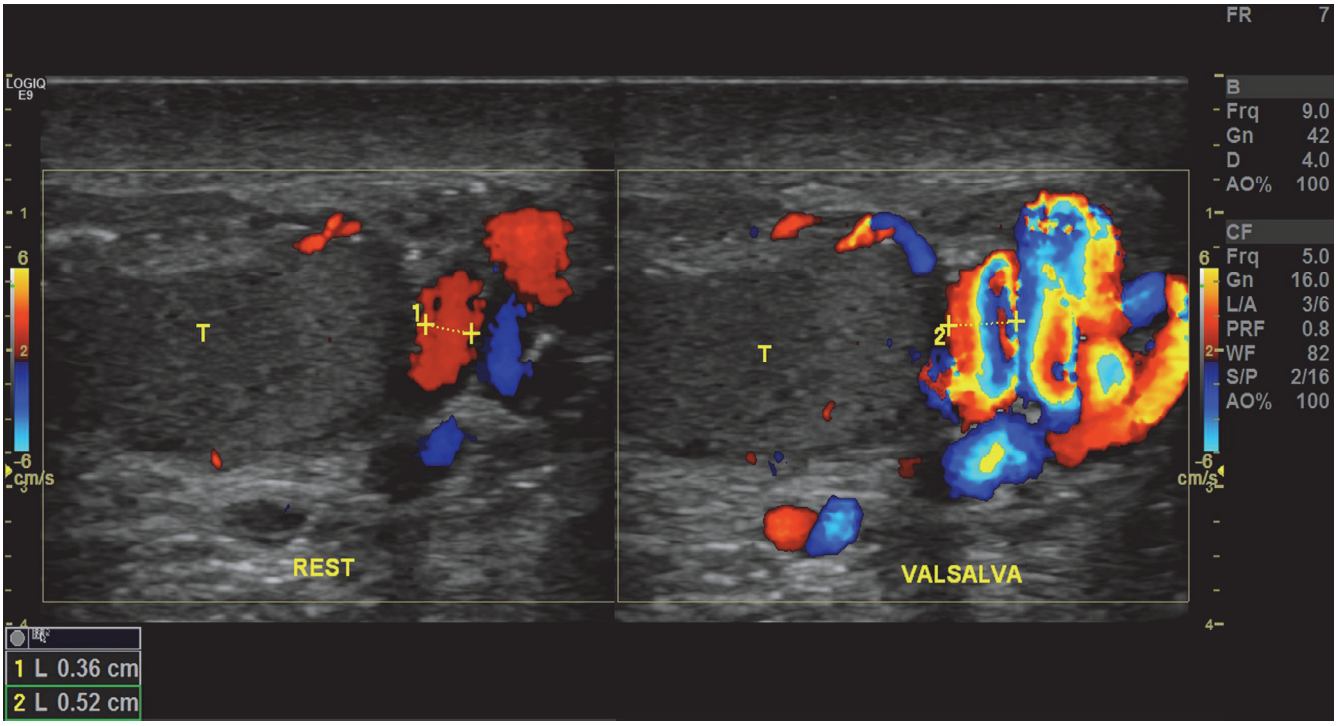

Fig 1a : Unilateral (left) varicocele patient with advanced stage, rest and during valsalva maneuver color Doppler sonography view was presented (rest vein diameter 3.6 mm, after the Valsalva maneuver vein diameter 5.2 mm) reflux during valsalva maneuver (T: testis).

Patients with a diagnosis of clinical varciocele and healthy volunteers were undertaken color Doppler ultrasonography by the same, experienced abdomen radiologist. Sonographic examinations were performed using ultrasound equipment with a 5–12 MHz linear probe (Toshiba Aplio500, Tokyo). Doppler spectral wave forms were obtained in the lowest pulse repetition frequency level to avoid "aliasing" artifact, the highest profit level to avoid noise, the lowest wall filter (50 Hz) and the smallest possible Doppler window. Color Doppler sonography was performed when bilateral pampiniform plexus of all the participants were visualized in the level of inguinal canal and the superolateral aspect of the testis with the testicular artery and vein in the same window. Patients were investigated with regard to the venous diameters and reflux flows during rest and valsalva maneuver.

DWI-MRI images of all the patients were obtained by using 16 channel Q-Body coil with a Achieva 1.5T MRI system (Philips Medical Systems, Best, The Netherlands).in the supine position and Single-shot spin-echo, echo-planar diffusion images with a b value of 1000s/mm2, images with imaging parameters: TR/TE, 6000/88; FOV, 180 mm; matrix, 128x256; section thickness: 4 mm, inter-sectional space 25%, a number of sections: 20 and more were obtained [14]. Diffusion weighted data were collected automatically in the ADC mapping working station. Bilateral testes of healthy

volunteers and patients with the right testis vein diameter, Doppler ultrasound and MRI images that are more than 2 mm in diameter were excluded from the study.

Data Analysis

All measurements were intra-observer performed by the same blinded radiologist. ROIs were drawn onto the ADC values by the software system supplied with the MR equipment. The data were obtained from distal testicular parenchyma distant from the capsule, avoiding artifacts. The ROI fields were set to approximately mm^2 during measurement. All ROI were elliptical, 40-50 mm^2 in testicular parenchyma. Three separate measurements were obtained form bilateral ADC values of patients with varicocele and healthy volunteers, and mean values were calculated (Figs. 1b and 2). The mean values were calculated and used for statistical comparisons.

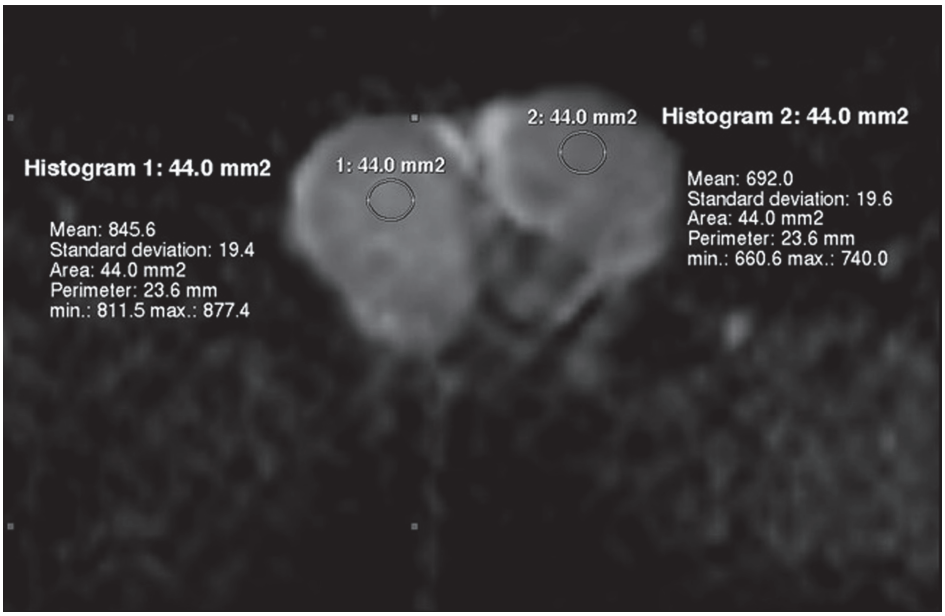

Fig 1b :ADC values were measured (ADC values : right testis; 845.6 $x10^{-3}$ mm^2/s, left testis; 692 $x10^{-3}$ mm^2/s).

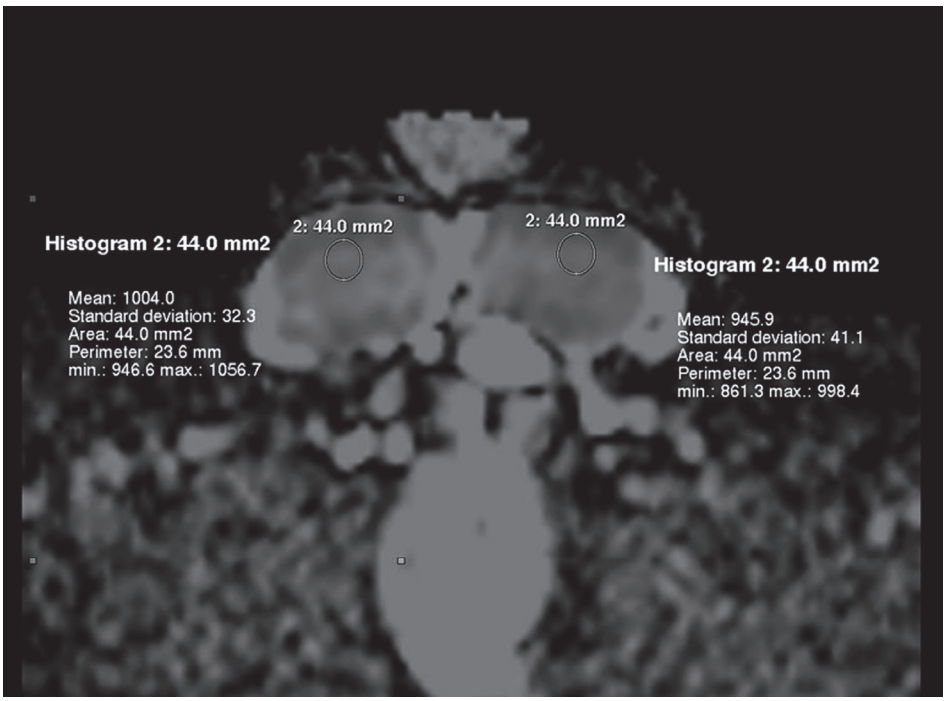

Fig 2 :Healthy volunteer ADC maps were demonstrated. ADC values were measured (right testis; 1004 x 10^{-3} mm^2/s, left testis; 945.9 x 10^{-3} mm^2/s).

Statistical Analysis

Microsoft Windows, SPSS (Statistical Package for the Social Sciences) software program package was used for the statistical analyses. ADC values were analysed by using an independent t test for each participant. The Pearson correlation test was used to compare left pampiniform vein diameter with left and right testicular parenchyma ADC values. Percentage, mean and standard deviation were used to evaluate the study data for descriptive statistics. A p value lower than 0.05, was accepted as statistical significance.

Results

A total of 54 males was included in the study. Group 1 (n=27) included patients with unilateral (left) advanced stage varicocele and group 2 (n=27) the control group consisted healthy volunteers. Unilateral (left) advanced stage varicocele (group 1) mean age was 27.37 ± 8.87 years, control group (group 2) mean age was 30.62 ± 5.25 years. There was no statistically significant difference between the groups in terms of age (p=0.351).

In Group 1, widest venous diameter of the left testicle was 4.03 ± 0.575, mean right testicular ADC value was 992.37 ± 105.58 10^{-3} mm^2/s, and mean left testicular ADC value was 924.62 ±95.68 10^{-3} mm^2/s (Table). In Group 2, venous diameter of bilateral testicles was below 2 mm, mean right testicular ADC value was 1057 ± 152.87 10^{-3} mm^2/s, and mean left testicular ADC values was 1058.96 ±149.68 10^{-3} mm^2/s (Table 1).

Left and right testicular ADC values in group 1 were observed to be significantly lower than left and right testicular ADC values in group 2 ($p<0.05$). Furthermore, a negative correlation was detected between the increase in the left testicular venous diameter and parenchymal ADC values of bilateral testis in patients with left advanced stage varicocele (left p=-624, right p= -0.382) (Figs. 3a and b).

Table 1: Advanced stages of unilateral varicocele patients (group 1), a control group of healthy volunteers (group 2) between: age, bilateral testicular apparent diffusion coefficient ADC values and left vein diameter means distribution.

	Group 1 (n=27) varicocele patients	Group 2 (n=27) healthy volunteers	P value
Age (mean±standard deviation).	27.37 ± 8.87	30.62 ± 5.25	P=0.351
Right testis mean ADC values (x10^{-3} mm^2/s)	992.37 ± 105.58	1057 ± 152.87	P<0.05
Left testis mean ADC values (x10^{-3} mm^2/s)	924.62 ±95.68	1058.96 ±149.68	P<0.05
Left testis vein diameter range and mean (mm±standard deviation)	3.2-5.3), 4.03±0.57	2 ≤	

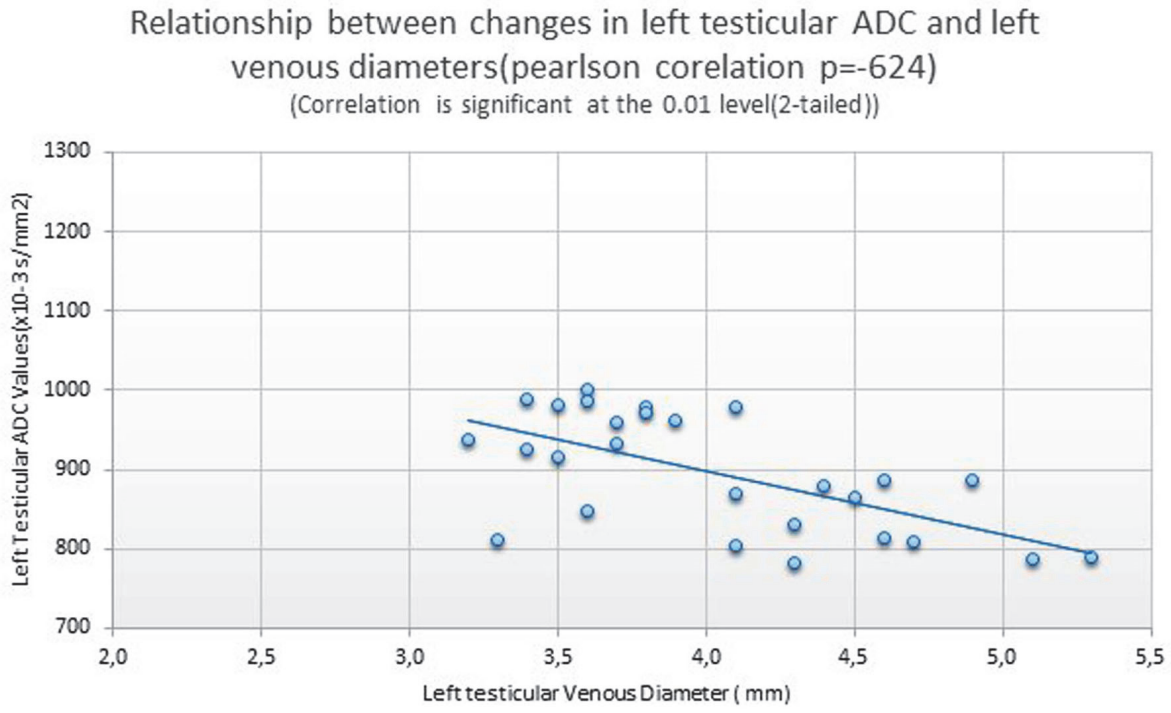

Fig 3a : The relationship between changes in left testicular apparent diffusion coefficient(ADC) values and left venous diameters in patients with varicocele.

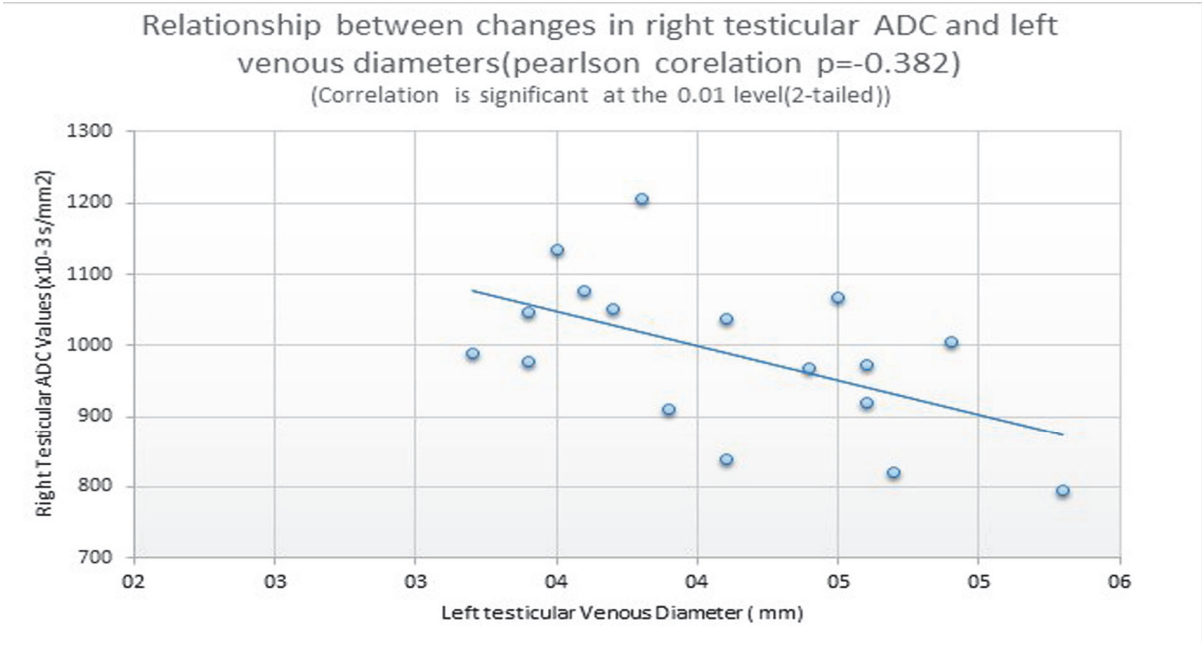

Fig 3b: The relationship between changes in right testicular apparent diffusion coefficient(ADC) values and left venous diameters in patients with varicocele.

Discussion

DWI- MRI provides unique quantitative data on the soft tissues [8,12]. However, to our knowledge only one study has been reported on the evaluation of testicular tissues in patients with varicocele in medical literature. Our study showed that ADC values of patients with varicocele and healthy volunteers differ.

Karakas et al. [3] has compared the right and left parenchymal ADC values in patients with unilateral or bilateral varicocele, and detected a reduction in the ADC values of the testis with varicocele and contralateral testis parenchymas. Kangasniemi et al. [15] has detected an 18 % and 20 % reduction in the ADC values obtained from mice testicles compared to the control group in 1st and 2nd hours respectively . Maki et al. [5] have observed a reduction in the ADC values of patients with testis torsion and obtained an 82% accuracy with DWI. Gulum et al. [16] have reported reduced ADC values due to the ischemia and the fibrosis in patients with hydrocele.

In this study, the ADC values of patients with left advanced stage varicocele and healthy volunteers were compared, and a reduction in left parenchymal ADC values of the patients was detected. A reduction in the contralateral testicular parenchyma was observed as well, and a negative correlation was detected between the increase in left pampiniform venous diameter and right testicular parenchymal ADC values.

Dilatation of pampiniform veins with varicocele is characterized by stasis and high pressure. As a result of increased pressure, high testicular temperature, testicular hypoxia and reduced testicular blood flow, spermatogenesis are reduced, tubular membranes and blood vessel walls are thickened, and interstitial fibrosis are developed in the testis [17,18]. We believe that the reduced ADC values observed in patients with varicocele may be related to these histopathological alterations. Unilateral varicocele has been known to cause an increase in both testicular temperature secondary to autoimmune and hormonal effects, according to the literature [19-21]. The reduced contralateral ADC values observed in our study may possibly be appearing as a result of these effects.

Our study has several limitations. The first one is the ADC images of testicular parenchyma, especially between b-0 and b-800 may lead to artifacts and small mistakes in ADC measurements [22-25]. The second one is the absence of standard reference points that may show the outcomes of present alterations such as histopathological diagnosis.

As a conclusion, we observed that ADC values of both ipsilateral and contralateral testicular parenchymas of patients with unilateral advanced stage varicocele were reduced. DWI may provide useful information on the testicular damage.

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