

# Increased Vertebral Artery Tortuosity Index is associated with first-ever and recurrent events in patients with spontaneous cervical artery dissection

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## BACKGROUND AND PURPOSE

The mechanisms leading to spontaneous cervical artery dissection (sCeAD), the most frequent cause of ischemic stroke (IS) at young age, are poorly understood but may include inherent abnormalities of arterial structure. These anomalies marked by having more elongations, kinks, twists, and loops (tortuosity) have been described in patients with CeAD as well as in a variety of inherited connective tissue disorders including arterial dissection in their clinical phenotype. We hypothesized that tortuosity of arteries that seem unaffected on standard vascular imaging is increased in patients with sCeAD compared with those with stroke because of other causes or stroke-free individuals. Therefore, we aimed to quantify and compare cerebral arterial tortuosity in these groups.

## METHODS

We performed a retrospective analysis of a cohort of consecutively-recruited patients with sCeAD, as well as a control group composed of age and sex-matched patients with IS of a cause other than CeAD (non-CeAD) and of stroke-free subjects. Using a volume-rendered angiogram, vertebral arteries were measured along the curvature of the vessel (actual length) and linearly (straight length), and distance factor was calculated using the formula:  $[(\text{actual}/\text{straight length}-1) \times 100]$ . Each subject's maximum distance factor was considered [Vertebral Tortuosity Index (VTI)]. The VTI was compared among the 3 groups. Follow-up MR examination was performed 3 to 6 months after the initial diagnosis in all CeAD patients.

**RESULTS:** One hundred-two patients with sCeAD (mean age,  $44.7 \pm 7.1$  years; 37.4% women), 102 patients with non-CeAD IS, and 102 stroke-free subjects qualified for the analysis. VTI was higher in the group of patients with CeAD ( $10.99 \pm 11.20$ ) as compared to those in the group of non-CeAD ( $5.66 \pm 6.57$ ) and in the group of stroke-free individuals ( $4.36 \pm 2.17$ ;  $p < 0.001$ ). VTI was independently associated to the group of sCeAD (OR, 1.20; 95% CI, 1.10 – 1.31) in a multivariable logistic regression model including traditional risk factors, migraine history, connective tissue signs, and BMI as covariates. Recurrent CeAD was documented in 6 patients (5.9%) at follow-up MR examination. Higher VTI was observed in this subgroup as compared to that of CeAD patients who did not experience recurrences ( $22.41 \pm 17.99$  vs  $9.87 \pm 9.83$ ;  $p = 0.008$ ).

**CONCLUSIONS:** In patients with CeAD, cerebral arteries demonstrate increased tortuosity. Arterial tortuosity, quantified by VTI, may represent a clinically relevant imaging biomarker of vascular biology as well as a promising predictor of the risk of recurrence in these patients.

	CeAD (n = 102)	non-CeAD IS (n = 102)	Stroke-free subjects (n = 102)	p-value
Age, yrs, mean $\pm$ SD	44.7 $\pm$ 7.8	44.0 $\pm$ 8.8	43.4 $\pm$ 7.5	0.502
Sex, M	67 (65.7)	67 (65.7)	67 (65.7)	1.000
Height, cm	171.6 $\pm$ 8.6	169.4 $\pm$ 8.8	171.2 $\pm$ 9.2	0.180
Weight, Kg	70.3 $\pm$ 13.1	74.2 $\pm$ 14.4	72.9 $\pm$ 13.5	0.142
Body Mass Index, kg/m <sup>2</sup>	23.7 $\pm$ 3.4	25.7 $\pm$ 4.2	24.7 $\pm$ 3.5	<0.001
Hypertension	25 (24.5)	35 (34.3)	11 (10.8)	<0.001
Diabetes mellitus	1 (1.00)	6 (5.9)	2 (2.0)	0.090
Hypercholesterolemia	18 (17.6)	34 (33.3)	19 (18.6)	0.012
Smoking	27 (26.5)	38 (37.3)	25 (24.5)	0.099
Any migraine	40 (39.2)	28 (27.5)	17 (16.7)	0.002
MO	29 (28.4)	13 (12.75)	12 (11.8)	0.002
MA	11 (10.8)	15 (14.7)	5 (4.9)	0.065
Connective signs, sum score, mean $\pm$ SD	4.5 $\pm$ 3.5	2.3 $\pm$ 0.2	1.6 $\pm$ 1.5	<0.001
<b>Dissected vessel</b>				
Internal carotid artery	79 (77.4)			
Vertebral artery	29 (28.4)			
Multiple vessels*	21 (20.6)			
<b>Presenting Symptom</b>				
Stroke	72 (70.6)			
TIA	6 (5.8)			
Local symptoms†	52 (51.0)			
Retinal ischemia	0 (0.0)			
SAH	0 (0.0)			
<b>Cause of stroke‡</b>				
Large-vessel disease		8 (7.8)		
Cardiac embolism		40 (39.2)		
Small-vessel disease		6 (5.9)		
Other determined etiology	60 (83.3)	11 (10.8)		
Undetermined origin				
Multiple possible etiologies	12 (11.7)	7 (6.9)		
Complete evaluation		30 (29.4)		
Incomplete evaluation		0 (0.0)		

Table 1. Demographic and clinical characteristics of the study group.

Figure 1. Measurement of Vertebral Tortuosity Index (VTI)

Actual length (left panel) and straight length (right panel) of vertebral arteries are measured in 3D space from origin of vessel to level of C2. For this left vertebral artery, actual length = 17.6 cm, straight length = 7.8 cm. Distance factor =  $[(\text{actual}/\text{straight length}-1) \times 100] = 126$ . The maximum distance factor is designated the VTI.

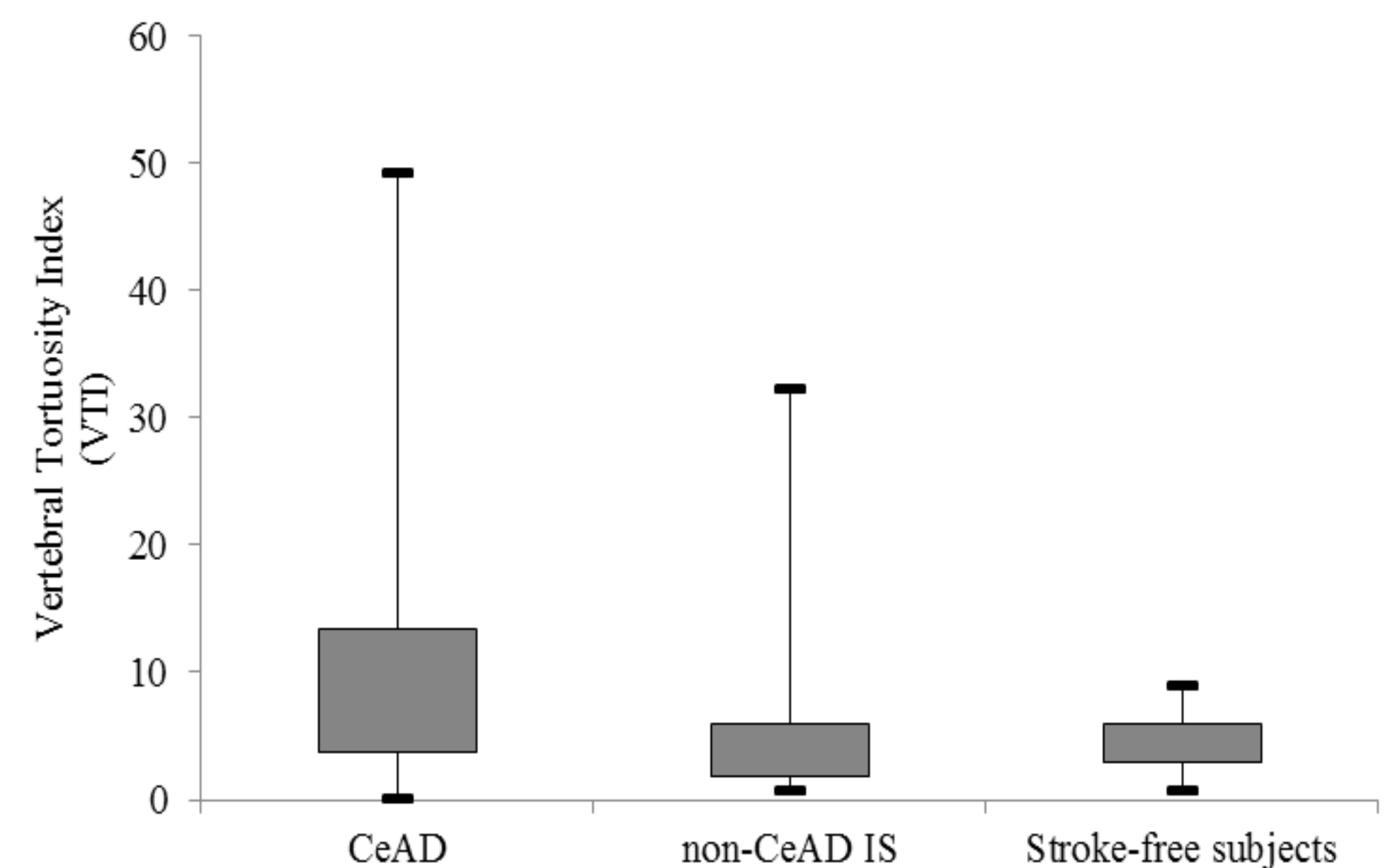
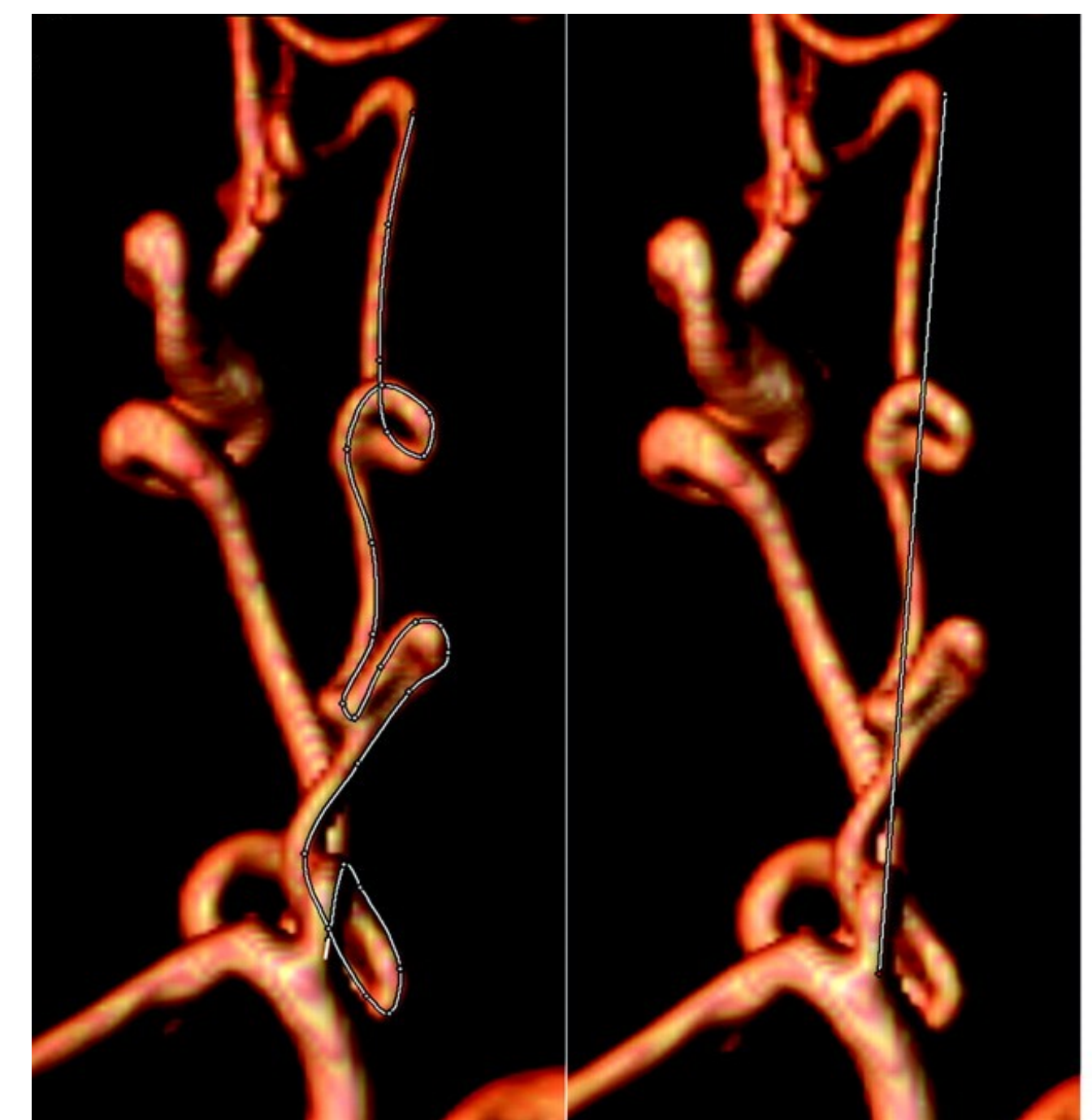


Figure 2. Mean values of Vertebral Tortuosity Index (VTI) in patients with spontaneous cervical artery dissection (CeAD), patients with ischemic stroke unrelated to cervical artery dissection (non-CeAD IS), and stroke-free subjects.

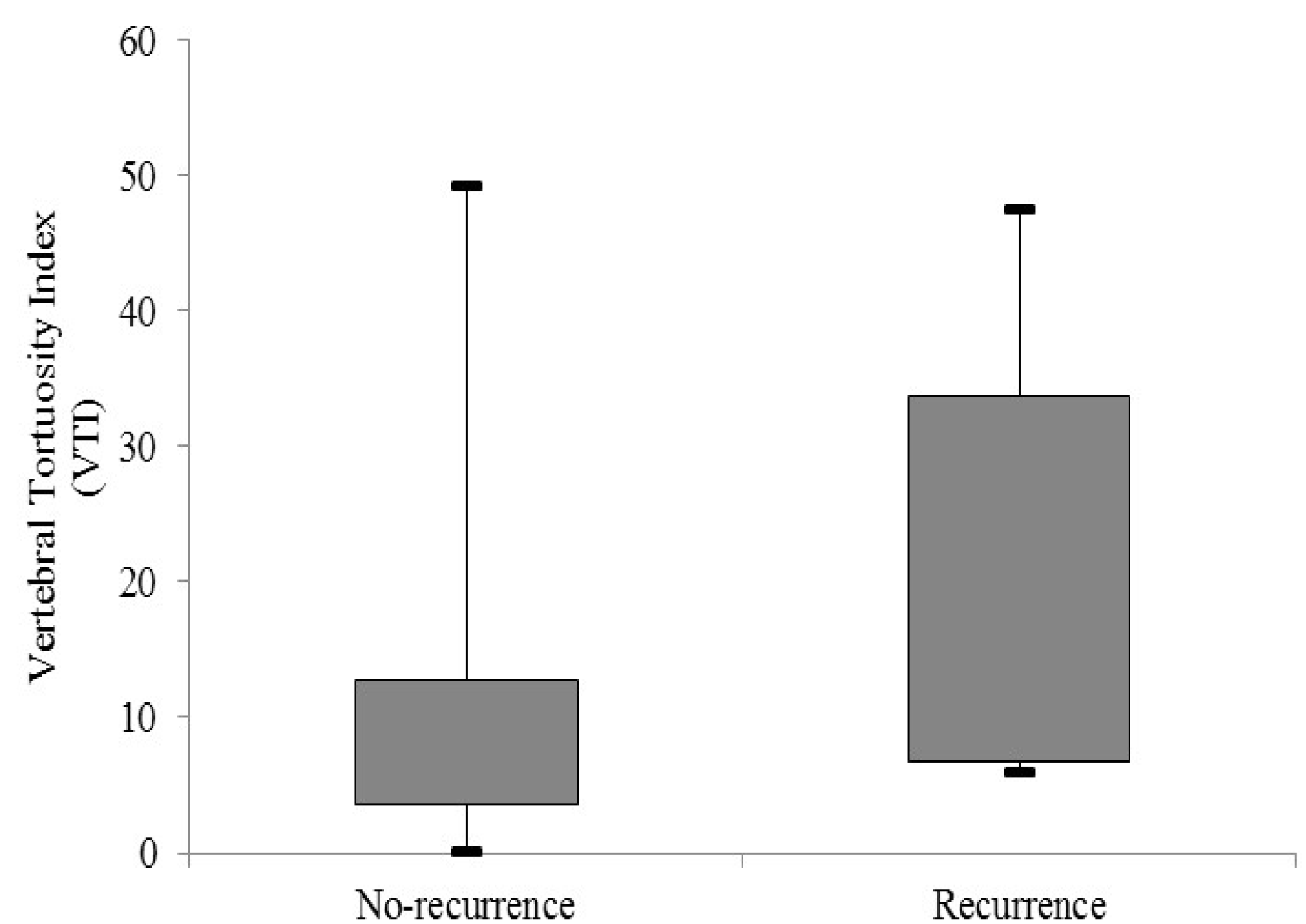


Figure 3. Mean values of Vertebral Tortuosity Index (VTI) in patients with spontaneous cervical artery dissection who experienced recurrent events (Recurrence) and in those without recurrence (No-recurrence).

## REFERENCES

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