Structural Abnormalities of the Trigeminal Root Revealed by Diffusion Tensor Imaging in Patients with Trigeminal Neuralgia Caused by Neurovascular Compression Before and 4-Year After Microvascular Decompression

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Introduction

- Strong evidence suggests that the neurovascular compression (NVC) is the principal cause of classic trigeminal neuralgia (TN), justifying microvascular decompression (MVD) as the first neurosurgical option. However, little information is available about the nature of the underlying nerve lesion.

- As Diffusion Tensor Imaging (DTI) is able to assess tissue integrity, we used diffusion to detect abnormalities in Trigeminal Nerves (TGN) in patients with TN caused by NVC that underwent MVD.
Using DTI sequencing in a 3T-MRI scanner, we measured the Fraction of Anisotropy (FA) and the Apparent Diffusion Coefficient (ADC) of TGN in 10 patients who had undergone MVD for TN and 6 normal control subjects.

We compared data between the affected nerves of TN (ipsilateral-TN), unaffected nerves of TN (contralateral-TN) and both nerves in normal subjects (controls).

We also compared data between ipsilateral-TN and contralateral-TN before and 4-year after MVD.
Results

Measurements of FA Before and 4-year after MVD

Figure 1. Before MVD, the mean of FA in the ipsilateral-TN (0.37 ± 0.08; n = 10) is significantly lower (p<0.05) than the mean FA in the contralateral-TN (0.48 ± 0.08; n = 10) and the mean FA in both sides of the controls (0.52 ± 0.04; n = 12). Four-years after MVD, the mean FA in the ipsilateral-TN (0.41 ± 0.08; n = 10) was also significantly lower (p<0.05) than the mean FA in the contralateral-TN (0.51 ± 0.07; n = 10) and the mean FA in both sides of the controls (0.52 ± 0.04; n = 12).
Results

Measurements of ADC Before and 4-year after MVD

Figure 2. Before MVD, the mean of ADC of the ipsilateral-TN (5.6 ± 1.10 mm$^2$/s; n = 10) is significantly higher (p<0.05) than the mean ADC of the contralateral-TN (4.26 ± 0.74 0.89 mm$^2$/s; n = 10) and the mean ADC of both sides of the controls (3.84 ± 0.63 0.89 mm$^2$/s; n = 12). Four-years after MVD, the mean ADC of the ipsilateral-TN (4.24 ± 1.06 mm$^2$/s; n = 10) was similar (p>0.05) than the mean ADC of the contralateral-TN (4.01 ± 1.04 mm$^2$/s; n = 10) and the mean ADC in both sides of the controls (3.84 ± 0.43 mm$^2$/s; n = 12).
Results
FA and ADC Variations between unaffected and affected trigeminal nerves of patients before and 4-year after MVD

Figure 3. The loss of FA in the affected TGN compared to the unaffected TGN of patients before surgery (23%) was similar (p>0.05) than the loss of FA after procedure (19%). The increase in ADC in the affected TGN compared to the unaffected TGN of patients before surgery (31.4%) was higher (p<0.05) than the increase in ADC after procedure (7.4%).
Results
Correlations between loss of anisotropy and the corresponding ADC increase of affected TGN of patients before and 4-year after MVD

Figure 4. A) Before MVD, the Spearman correlation coefficient showed a strong negative correlation ($r=-0.7295; \ p=0.0202$) between loss of anisotropy and the corresponding increase in ADC in ipsilateral TN compared to contralateral TN. B) Four-year after MVD, the Spearman correlation coefficient did not evidence correlation ($r=-0.3697; \ p=0.2931$) between loss of anisotropy and the corresponding increase in ADC in ipsilateral TN compared to contralateral TN.
Results

Images of Patient 6 showing the NVC compressing the left TGN and trigeminal regions of interest for measurements of FA and ADC

Figure 5. A) Axial 3-D DRIVE, B) 3-D TOF-MRA and C) 3-D T1-Gad images showing the loop of the superior cerebellar artery (SCA) compressing the left TGN (white arrow) in patient 6. D) Operative view of NVC in the left TGN. Note that the vascular loop exerts pressure, leading to a deformation at the supero-lateral aspect of the TGN. E) Pre-operative and F) Post-operative T2-weighted DTI of patient 6 showing examples of box-shaped regions of interest used for quantitative analysis of FA and ADC in the trigeminal root entry zone.
Conclusions

- DTI revealed loss of anisotropy and an increase in diffusivity in affected nerves before surgery. Decreased FA values of TGN can be attributed to pathological changes such as demyelination caused by damage at the root entry zone by pulsation and/or compression of the attached vessel, in turn leading to a diffusion hindrance and finally causing a high ADC.
- The loss of FA was significantly correlated with increased ADC in the affected nerves before surgery.
- After removal of the compression, loss of FA remained, but ADC normalized in affected nerves, suggesting improvement in diffusion of the trigeminal root and probably in neuro-edema.