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Manual magnetic resonance imaging measurements in multiple sclerosis: a study on reproducibility and disability

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Aims

To (i) assess the reproducibility of manual linear measurements of brain volume using magnetic resonance imaging (MRI) in a cohort of patients with multiple sclerosis (MS) and (ii) explore correlations between manual brain measurements and disability.

Methods

Thirty-six MS patients were selected based on a baseline scan (including an axial T1 sequence) done during the 3 months prior to starting or subsequent 24 months after commencing a disease-modifying treatment, availability of at least one other axial T1 sequence performed after an interval of at least 12 months and consent for clinical data to be used for research. NeuRoi imaging analysis software was utilised to carry out linear measurements (in millimetres, mm) of frontal horn width (FHW), third ventricular width (TVW) and inter-caudate distance (ICD) by a medical student. The measurements were repeated after 5 days by the same medical student and by a consultant neurologist to evaluate intra- and inter-observer reproducibility, assessed by calculating the coefficient of variation expressed as a percentage (CV%). Analysis of variance (ANOVA) for intra- and inter-observer reproducibility was also calculated between repeated measurements of FHW, TVW and ICD. Spearman's rank correlation coefficient was used to analyse the association between manual brain measurements (annualised percentage change in FHW, TVW and ICD) and disability (annualised change in Expanded Disability Status Scale, EDSS). All data were analysed using Microsoft Excel 2016.

Results

High intra- and inter-observer reproducibility ($p<0.05$) was demonstrated for all linear measurements. CV% for intra-observer reproducibility were 1.6%, 3.3% and 7.8% for FHW, TVW and ICD, respectively and CV% for inter-observer reproducibility were 2.4%, 7.7% and 5.1% for FHW, TVW and ICD, respectively. An increase in mean values for manual measurements from baseline to last follow-up scan were observed as 34.3 mm and 34.5 mm for FHW, 5.0 mm and 5.5 mm for TVW and 13.5 mm and 13.7 mm for ICD. Mean % change (from baseline) in linear measurements were: 1% for FHW, 14% for TVW and 2% for ICD. Annualised changes in linear measurements were found to correlate with EDSS ($r = 0.0034$, 0.0434 and 0.3296 for FHW, TVW and ICD, respectively).

Conclusion

Linear measurements of FHW, TWV and ICD were demonstrated to be highly reproducible and correlated with disability. Despite advances in brain imaging and computerised volumetric analysis, manual linear measurements of brain atrophy remain relevant as they are simple, fast (with each set of measurements taking under 10 minutes), reproducible and can be performed on non-digitised data. Additionally, linear two-dimensional methods do not require extensive training or expensive and time-intensive computer software necessary for complex quantitative and volumetric analyses. Furthermore, imaging protocols do not always include three-dimensional brain imaging (required for voxel-based morphometry) due to time constraints while two-dimensional scans have shorter acquisition times and are easily available. For these reasons, simple linear measurements are applicable to clinical practice, especially in regions with no access to advanced imaging technology. ■

Conflict of interest statement

The authors declare that they have no conflict of interest.

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