Frameless multimodality image integration using vessel tree segmentation for stereotactic targeting of arteriovenous malformations

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Abstract

Objectives: The aim of this study is to validate a frameless approach for the integration of two-dimensional (2D) digital subtracted angiography (DSA) images with three-dimensional (3D) computed tomography angiography (CTA) and magnetic resonance angiography (MRA) datasets using vessel tree segmentation for image registration for arteriovenous malformation (AVM) radiosurgery. This new frameless approach was benchmarked against the well-known frame-based approach using the localizer box with external coordinates for image registration.

Methods: A retrospective analysis of 28 AVM patients with DSA, CTA and MRA imaging was performed. Vessel tree segmentation of CTA/MRA was used to register these 3D-image sets with 2D DSA. AVM contouring on DSA is projected on the CTA/MRA and used as a guide to segment and delineate the lesion on CTA and MRA. Based on these contours, the localization accuracy and similarity were evaluated comparing the new vessel tree-based image registration (frameless approach) with external coordinates localization (frame-based approach).

Results: In all 28 cases, a vessel tree could be mapped out of CTA and MRA datasets and used to register with DSA. DSA contouring resulting in a 3D AVM contour on CTA showed a mean volume of 1.60 cc for both approaches. The targeting accuracy of the new application with vessel tree segmentation was found 0.4 ± 0.3 mm, 0.5 ± 0.3 mm and 0.3 ± 0.3 mm for the CC, LAT and AP direction, respectively, resulting in an overall 3D vector of 0.8 ± 0.4 mm. The agreement ratio, which reflects the similarity between the two approaches, was 0.75 ± 0.12.

Conclusions: This study showed that the SmartBrush Angio element achieves submillimetric targeting accuracy using vessel tree segmentation, comparable to the frame-based approach enabling frameless registration between 2D and 3D datasets. This approach allows the integration of multiframe DSA imaging to guide nidus targeting on CTA and MRA. The SmartBrush Angio element could be integrated clinically in a frameless treatment approach for AVM, including DSA, for which stereotactic frame fixation is no longer necessary.