



Stereotactic Radiosurgery for Dural Arteriovenous Fistulas without Cortical Venous Reflux

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■ **BACKGROUND:** The rationale for treatment of dural arteriovenous fistulas (dAVFs) without cortical venous reflux is symptomatic resolution. Most studies of dAVF treatment, including those for stereotactic radiosurgery, have focused on angiographic obliteration instead of clinical symptomatic outcome.

■ **METHODS:** The authors evaluated their institutional experience with stereotactic radiosurgery for cerebral dAVFs without cortical venous reflux from 1991 to 2016, evaluating angiographic and clinical outcomes, focusing on the course of pulsatile tinnitus and/or ocular symptoms after treatment. They subsequently pooled their results with those from a systematic literature review.

■ **RESULTS:** Pooled outcomes data from 349 low-risk dAVF (120 patients with pulsatile tinnitus and 229 patients with ocular symptoms) were analyzed. Over a mean follow-up of 2.6 years, 77% of patients presenting with pulsatile tinnitus experienced resolution and an additional 21% had improvement, with an angiographic obliteration rate of 70.9%. Among 229 patients with ocular symptoms from carotid-cavernous dAVFs, improvement or resolution of symptoms occurred in 95% of those with chemosis, 90% of those with ophthalmoparesis, and 96% of those with proptosis. The angiographic obliteration rate was 76.2%. There were six permanent complications in 349 total treated low-risk dAVF (1.7%).

■ **CONCLUSIONS:** Rates of clinically significant symptomatic improvement/resolution of symptoms referable to “low-risk”

dAVFs are even greater than their angiographic obliteration rate, an important factor in patient counseling and when considering the optimal treatment approach for these dAVFs.

INTRODUCTION

Although angiographic obliteration has served as the primary outcome in most series evaluating dural arteriovenous fistula (dAVF) treatment, it is secondary in importance to symptomatic outcome when considering dAVFs without cortical venous reflux. These fistulas do not pose a risk of symptomatic venous hypertension or hemorrhage and only very rarely go on to develop cortical venous reflux.^{1,2} As such, the rationale for treatment is largely to alleviate symptoms. Proper counseling of patients should therefore focus on rates of symptomatic resolution in lieu of simply angiographic obliteration as a means to most appropriately risk stratify treatment versus no treatment for these lesions.

The vast majority of series describing the treatment of dAVFs have focused on angiographic obliteration, including series and review articles of stereotactic radiosurgery (SRS).³⁻⁸ The purpose of this article is to review our own institutional experience in the treatment of “low-risk” dAVFs (those without cortical venous reflux) with a focus on clinical outcome. We then pool our results with those extracted from previous reports in the literature.

METHODS

The authors reviewed their institution’s prospectively collected Gamma Knife database for cerebral dAVFs treated with SRS from

Key words

- Arteriovenous fistula
- dAVF
- Dural arteriovenous fistula
- Radiosurgery
- SRS
- Tinnitus

Abbreviations and Acronyms

- dAVF:** Dural arteriovenous fistula
MRI: Magnetic resonance imaging
SD: Standard deviation
SRS: Stereotactic radiosurgery

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January 1991 through December 2016. Pretreatment angiograms were reviewed, and patients with dAVFs with cortical venous reflux were excluded from this analysis. Patient age, sex, presentation modality, dAVF location, previous embolization, marginal dose, target volume (cc), procedural complications, and clinical and radiographic follow-up were extracted from the medical record. The clinical course of patients' pulsatile tinnitus and/or ocular symptoms was noted at last follow-up.

To provide a broader analysis of symptomatic improvement rates across a larger patient cohort, a pooled literature analysis was performed. The PubMed database was queried with the terms "stereotactic," "radiosurgery," "dural arteriovenous," and "dAVF" (Figure 1). References within selected articles were also perused and incorporated for completeness. We only included articles in our analysis that provided clinical results for pulsatile tinnitus and/or ocular symptoms specifically for dAVFs without cortical venous reflux. Studies that did not provide clinical results or those that provided overall pooled results for low- and high-risk fistulas without data stratification were excluded. Case reports and duplicated data sets also were excluded. From these studies, we extracted mean patient age, sex, dAVF location, treatment complications, clinical course of pulsatile tinnitus and/or ocular symptoms, and angiographic results at follow-up. These results were then pooled with our own.

RESULTS

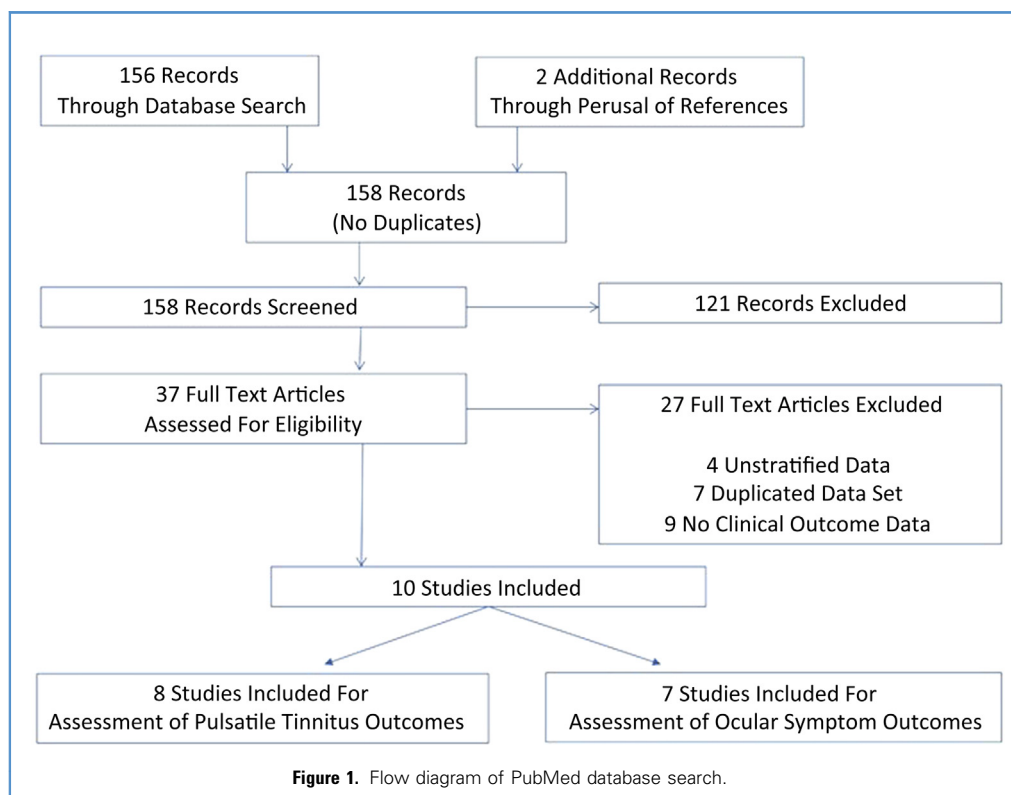
Institutional Cohort

Of 61 dAVFs treated via SRS over the reviewed period, 19 did not have cortical venous reflux (31%). Mean patient age was 54 years

(standard deviation [SD] 13 years), and 58% of patients were female. Twelve fistulas were along the transverse and/or sigmoid sinus (63%), 6 at the cavernous sinus (32%), and 1 at the marginal sinus (5%). Fifteen patients had pulsatile tinnitus (79%), 4 patients had headaches (21%), and 4 patients had ocular symptoms (21%). All patients with transverse/sigmoid dAVFs in this series had pulsatile tinnitus along with 2 patients with cavernous sinus dAVFs and the 1 patient with a marginal sinus dAVF. Of 4 patients with headaches, 3 harbored transverse/sigmoid dAVFs and 1 had a cavernous sinus dAVF. All patients with ocular symptoms harbored indirect carotid-cavernous fistulas; 3 patients had chemosis, 3 had proptosis, and 2 had vision loss.

Fourteen patients underwent adjunctive, partial embolization (74%). Before 2008, 8 patients underwent partial embolization with particles. After 2008, 6 patients underwent adjunctive embolization with Onyx. Although in some cases before 2012, embolization was performed before SRS, since then, 3 patients treated with adjunctive embolization underwent embolization after SRS. There were no symptomatic complications from embolization although one patient sustained an asymptomatic cerebellar infarct found on magnetic resonance imaging (MRI).

For treatment, the mean marginal dose was 20 Gy (median 20, SD 1.7, range 17–25). The mean maximal dose was 40 Gy (median 40, SD 3.4, range 34–50). The mean target volume was 3.0 cc (median 2.2, SD 2.2, range 0.3–8.2). There were no treatment-related complications. Eleven patients had angiographic follow-up at a mean of 2.2 years after treatment; 9 patients had angiographic obliteration of their dAVF (82%). There were 5 additional patients who did not have angiographic follow-up but



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