Additional Role of 3D ASL Perfusion in Skull Base Lesions

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Abstract

Background   Arterial spin labeling (ASL) perfusion imaging is widely used since its main advantage is that no intravenous contrast is needed. Given that perfusion is a crucial biological characteristic for identifying tumor lesions, the qualitative non-contrast perfusion characteristics of these lesions were examined.

Aim   We attempted utilizing the three-dimensional (3D) ASL technique to characterize skull base lesions and to highlight its crucial role in differentiating lesions.

Methods and Material   3D ASL imaging of 20 patients with posterior skull base lesions was performed in a 3-T magnetic resonance (MR) system (Siemens Healthineers, Skyra, Erlangen, Germany). The common differential diagnoses of skull base lesions could be distinguished based on this qualitative evaluation.

Results and Conclusions   Glomus tumor has a strikingly increased perfusion when compared to meningiomas. The perfusion characteristics of metastasis depends on the primary tumor. Chondrosarcomas have a heterogeneously increased perfusion. Chordomas have variable perfusion, which helps in prognosticating the tumors. ASL benefits pediatric patients and in renal failure as well since it avoids the ethical ambiguity associated with contrast agents.

Keywords
► arterial spin labeling
► chondrosarcoma
► glomus tumor
► meningioma

Introduction

Angiogenesis is a major factor in the growth of solid tumor lesions. Dynamic susceptibility contrast magnetic resonance imaging (DSC-MRI) is the gold standard method for analyzing angiogenesis. Even though conventional contrast-enhanced perfusion imaging is now a crucial component of the tumor investigation procedure, investigating extra-axial skull base lesions using this method is still difficult because of air–bone interface artifacts. The purpose of this study is to describe how three-dimensional (3D) arterial spin labeling (ASL) can characterize skull base lesions without the administration of contrast material. This method's significance keeps growing because it is noninvasive and enables the examination of patients with renal failure.

Materials and Methods

A cross-sectional study was conducted in which 20 patients with skull base lesions were studied. Informed written consent was acquired from every subject after explaining the details of this study. 3D ASL perfusion was done in addition to standard institute MRI protocol with added MR contrast sequences for certain cases in 3-T magnetic resonance scanner (Siemens Healthineers). Pre- and postcontrast fat-suppressed T1-weighted images and 3D magnetization prepared rapid gradient echo (MP RAGE) sequences were used for contrast imaging.

Extended ASL—continuous ASL (CASL) provides the largest ASL signal change, greatest signal-to-noise ratio (SNR), and can be advantageous.

Continuous labeling of the blood water is done during its passage through a label plane. Labeling is typically performed continuously for 1 to 2 seconds, after which a postlabeling delay is inserted before imaging. This delay allows the labeled blood to reach the region of interest in the brain and lets it clear from the feeding arteries.

The main disadvantage of ASL perfusion is the relatively longer acquisition time, resulting in potential motion artifacts.

Results

The 3D ASL technique is very helpful for identifying and differentiating skull base lesions by classifying the lesion's vascularity based on the qualitative evaluation. Meningiomas show increased perfusion when compared to schwannomas. The glomus tumors have a strikingly increased perfusion when compared to meningiomas. Chondrosarcomas have a heterogeneously increased perfusion. Chordomas have a variable perfusion that helps in prognosticating the tumors. The perfusion characteristics of metastasis depends on the primary tumor.

Discussion

ASL imaging can be effectively used to distinguish between hypervascular and nonhypervascular lesions of the skull base by visually evaluating the characteristics of perfusion. We have highlighted cases at specific locations like the cerebellopontine angle cistern and Meckel's cave where meningiomas and schwannomas can be differentiated based on subjective perfusion evaluation. The qualitative characterization of the lesions allows for highly accurate diagnosis. An essential biological factor in the characterization of tumor lesions is perfusion evaluation.[1] While contrast enhancement makes it feasible to evaluate the blood–brain barrier disruption, perfusion patterns enable evaluation of the lesion's neoangiogenesis and microvascularization.[2] ASL was already used to assess the cerebral blood flow in cases of brain tumors, cerebrovascular abnormalities, and degenerative diseases.[3] Additionally, it was demonstrated to be a powerful replacement for the DSC-MRI technique and, more importantly, to provide more consistent blood flow measurement findings.[4,5] ASL has a lower susceptibility to artifacts, so using it to image the base of the cranium can eliminate the issue with air–bone interface artefacts.[6] According to prior studies, the DSC-MRI technique could be used to distinguish between meningioma and schwannoma because the former has a more venous nature (►Figs. 1–3). Studies of meningioma using ASL and DSC-MRI produced similar findings. When compared to meningiomas, ASL indicated that esthesioneuroblastomas had a comparatively less perfusion (►Figs. 4 and 5). Further, chondrosarcomas of the sphenoid can occasionally be mistaken as a metastasis or chordoma based on morphological imaging. We think that ASL makes it simple to distinguish between the aforementioned kinds of lesions because metastasis (►Fig. 6) and chordoma (►Figs. 7 and 8) both exhibit variable perfusion, while chondrosarcomas exhibit a heterogeneously increased perfusion (►Fig. 9). The ASL sequence is useful in predicting postoperative hemorrhage in
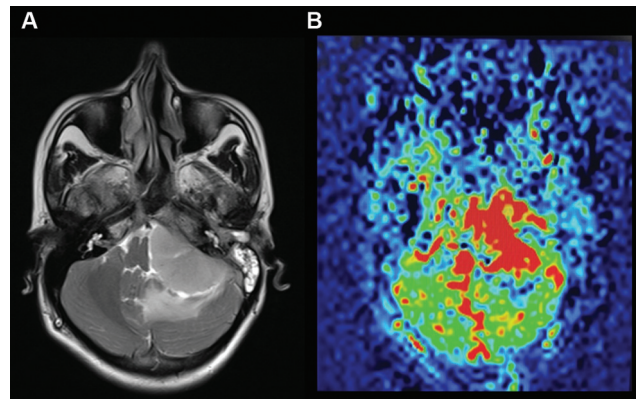

Fig. 1 (A, B) Cerebellopontine angle meningioma (left) shows homogenously increased arterial spin labeling (ASL) perfusion.
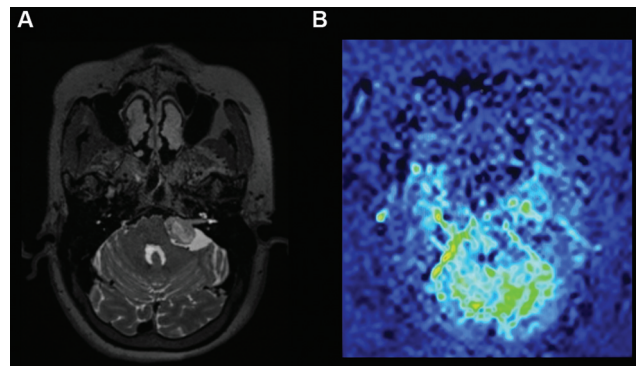

Fig. 2 (A, B) Cerebellopontine angle schwannoma (left) shows relatively reduced arterial spin labeling (ASL) perfusion.

pituitary adenoma in the pituitary region. Our results demonstrate that despite individual variations in adenoma perfusion, this tumor can be successfully differentiated from a meningioma by means of ASL since meningiomas are highly hyperperfused (►Figs. 10 and 11), while adenomas are nonperfused or weakly perfused. However, based solely on the ASL pictures, we were unable to distinguish between a metastasis and a meningioma, since hypervascularity is encountered with few metastatic lesions, depending on the histologic type. Glomus tumors (►Fig. 12) have a strikingly increased perfusion when compared to meningiomas. Additionally, even though the long-term effects of repetitive gadolinium-based contrast agent injections are debatable, contrast-free techniques are increasingly preferred.

The main limitations of this article are that only continuous ASL was used and so quantification could not be done and only limited numbers of lesions in each category were present (►Table 1).

Conclusion

Subjective evaluation of 3D ASL perfusion images yields information about perfusion characteristics in skull base tumors, which helps not only in highlighting the lesions like glomus tumors but also in differentiating other lesions like meningiomas from schwannomas. This pictorial depiction of the value of ASL perfusion stresses that 3D ASL perfusion when available
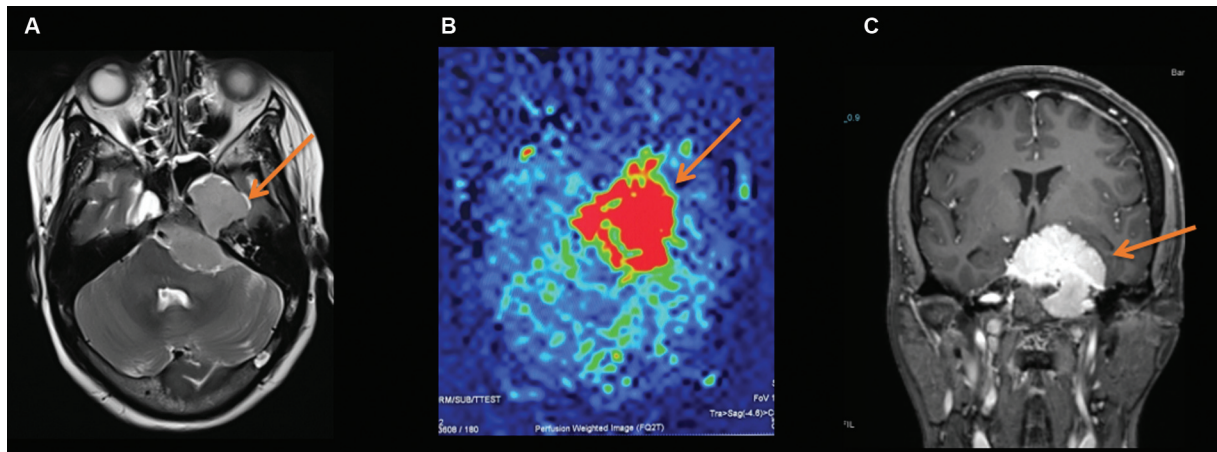
Fig. 3 (**A–C**) The dumbbell-shaped schwannomalike lesion in the left Meckel cave had increased perfusion in arterial spin labeling (ASL), and postcontrast imaging corroborated the same findings.
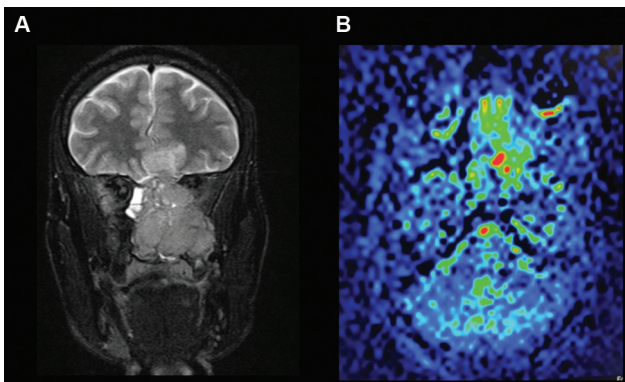

Fig. 4 T2 space coronal and arterial spin labeling (ASL) perfusion images of esthesioneuroblastoma (**A, B**) show moderate ASL perfusion.
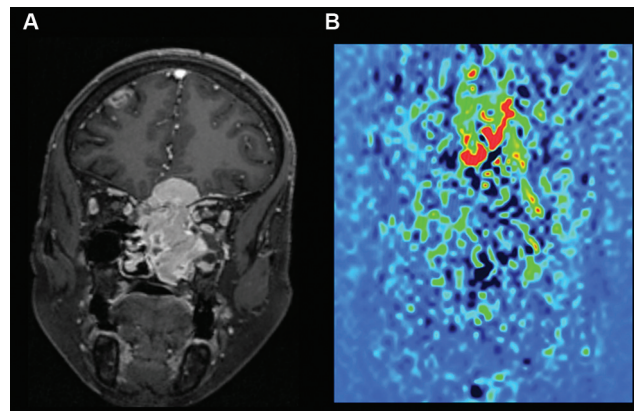

Fig. 5 T1 fs postcontrast coronal and arterial spin labeling (ASL) perfusion images of meningioma (**A, B**) show homogenous increase in ASL perfusion.
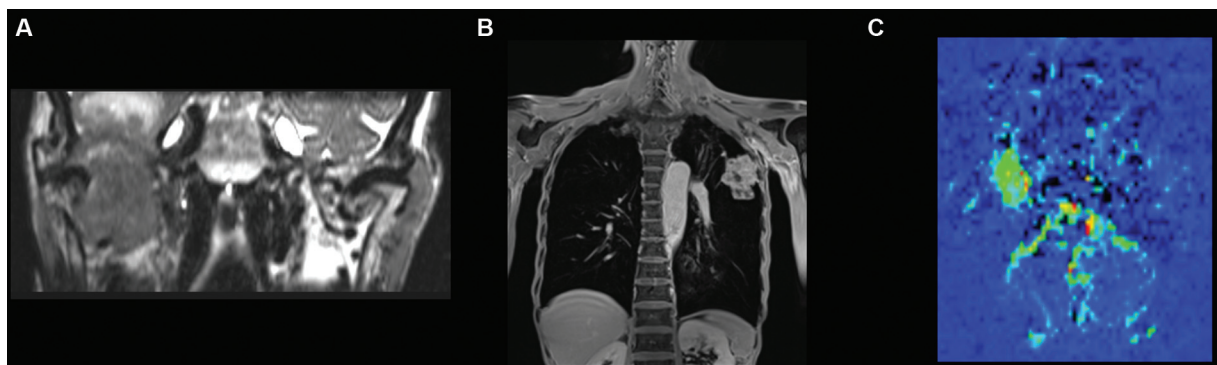

Fig. 6 T2 coronal images show a isointense lesion in the right sphenoid wing with (**A, B**) reduced perfusion and with (**C**) a mass in the left upper lobe, which suggests metastasis.
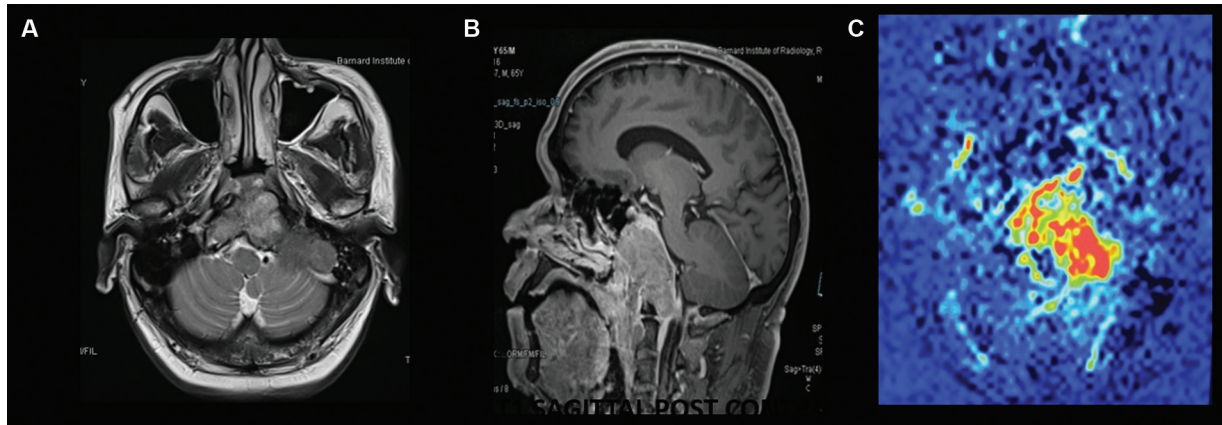
Fig. 7 (A–C) T2 axial and T1 fat-saturated (fs) postcontrast sagittal sections of a clival chordoma with increased ASL perfusion suggest poor prognosis.
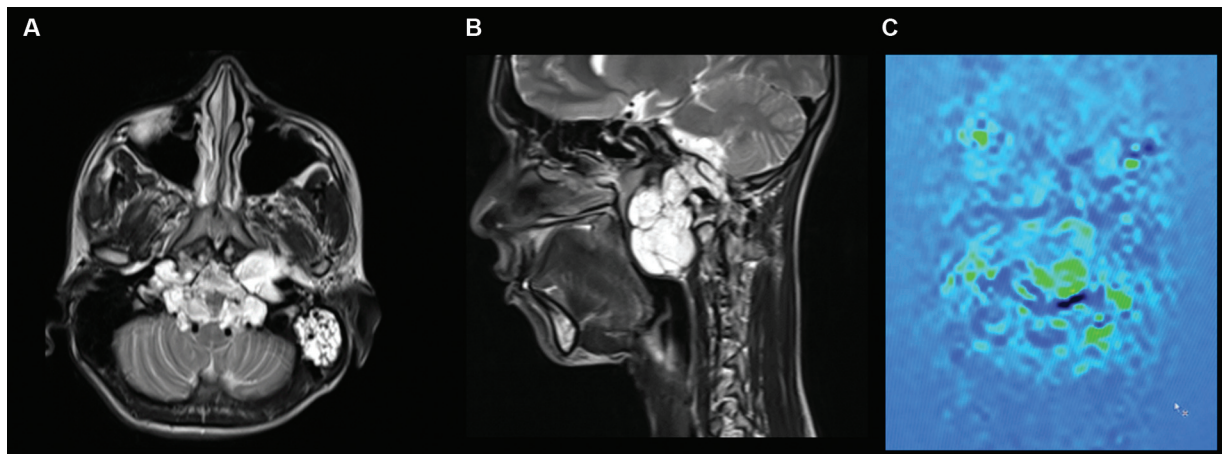

Fig. 8 (A–C) T2 axial and sagittal sections of a clival chordoma with reduced arterial spin labeling (ASL) perfusion suggest better prognosis.
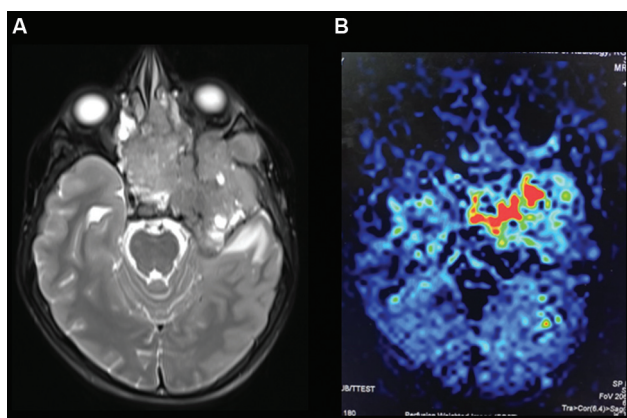

Fig. 9 (A, B) T2 axial and arterial spin labeling (ASL) perfusion images showing heterogeneously increased ASL perfusion in chondrosarcoma.
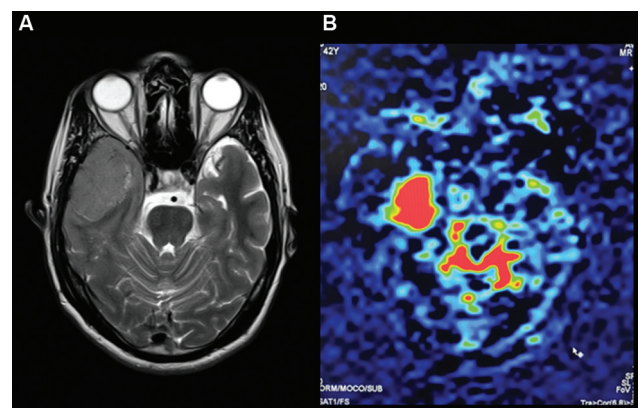

Fig. 10 (A, B) T2 axial image and corresponding arterial spin labeling (ASL) perfusion image show homogenously increased ASL perfusion in the right temporal meningioma.
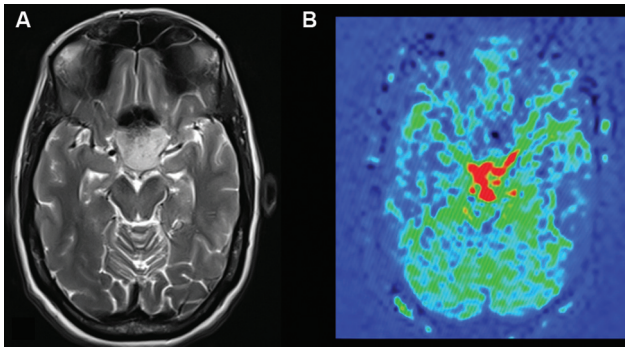
Fig. 11 (A, B) T2 axial section with corresponding arterial spin labeling (ASL) perfusion image show homogenously increased ASL perfusion in the planum sphenoidale meningioma.
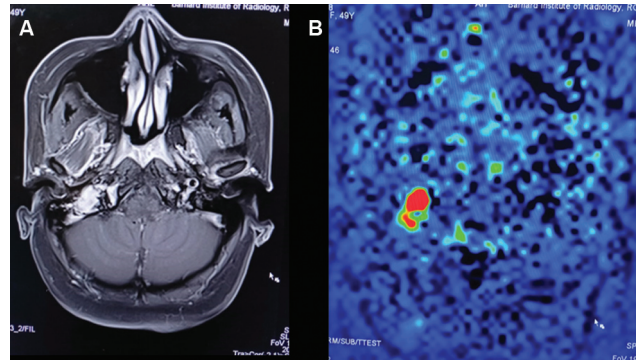

Fig. 12 (A, B) Increased perfusion in the right glomus jugulare that has both blood products and increased vascularity.

Table 1 An overview of the cases mentioned in this article

Figures	Findings	ASL perfusion color maps	Diagnosis
1	T2 axial and extra-axial T2 hyperintense lesion in the left cerebellopontine angle with mass effect over the brainstem and cerebellum	Homogenously increased ASL perfusion	Left cerebellopontine angle meningioma
2	3D space T2 axial section reveals a small extra-axial T2 hyperintense lesion in the left cerebellopontine angle	Reduced ASL perfusion	Left cerebellopontine angle schwannoma
3	T2 axial and T1 fs postcontrast coronal images reveal homogenously enhancing dumbbell-shaped lesion in left Meckel's cave	Homogenously increased perfusion	Left Meckel's cave meningioma
4	3D space T2 coronal section shows a hyperintense anterior skull base lesion with epicenter in the nasal cavity and intracranial extension	Moderate ASL perfusion	Esthesioneuroblastoma
5	Postcontrast T1 fs coronal image shows an intensely enhancing anterior skull base lesion	Homogenously increased ASL perfusion	Anterior skull base meningioma
6	T2 coronal image shows a heterointense lesion in the right sphenoid wing with a mass in the left upper lobe	Reduced ASL perfusion relative to other tumors	Skull base metastasis
7	T2 axial and T1 fs postcontrast sagittal sections show a hyperintense soft tissue replacing the clivus	Reduced ASL perfusion relative to other tumors	Clival chordoma
8	T2 axial and sagittal sections show a similar hyperintense soft tissue replacing the clivus	Reduced ASL perfusion relative to other tumors	Clival chordoma
9	T2 axial section shows a heterogeneously hyperintense lesion replacing the sphenoid	Heterogeneously increased ASL perfusion	Chondrosarcoma
10	T2 axial image shows extra-axial T2 isointense lesion in the right temporal region	Homogenously increased ASL perfusion	Right temporal meningioma
11	T2 axial section shows a hyperintense lesion in the sphenoid	Homogenously increased ASL perfusion	Planum sphenoidale meningioma
12	T1 fs postcontrast axial in the right jugular foramen shows an enhancing lesion	Increased ASL perfusion	Right glomus jugulare

Abbreviations: ASL, arterial spin labeling; fs, fat-saturated.

can be a useful adjunct in the evaluation of skull base lesions and to differentiate between hypervascular and nonhypervascular lesions.

Availability of Data and Material
The data are taken solely from our institution.

Authors' Contributions
J.F.N. did the major writeup of this case series. The majority of the cases in this review article were diagnosed by S.B.P. and followed up by J.F.N. The work was carried under the guidance of S.B.P. who provided us with insight and knowledge to diagnose indeterminate lesions with imaging alone.

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