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Feasibility Study of Flow Compensation to Improve Diagnostic Quality of T1 Post Contrast Spin Echo MRI Through the Posterior Fossa

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Abstract

Purpose : Pulsation related artifacts commonly occur in the posterior fossa on brain MRI secondary to pulsation from the arteries and dural sinusesat the skull base. The purpose of this study is to examine the effectiveness of flow compensation (FC) pulsation artifact reduction in the posterior fossa on post-contrast imaging as rated by two blinded neuroradiologists.

Methods: T1 post-contrast images of the brain with and without FC were obtained on a subset of patients undergoing brain MRI from August 1, 2013 to October 1, 2013.Over two reading sessions, two blinded neuroradiologists retrospectively scored each non-FC and FC post-contrast T1 sequence on a four-point scale as follows: 4: None to minimal pulsation artifact. 3: Mild flow artifact. 2: Prominent pulsation artifact. 1: Poor image quality, not interpretable.

Results: Twenty-five of 42 studies (60%) were rated as demonstrating prominent pulsation artifact (score =2) in non-FC technique versus 6/42 studies (14%) in the FC group.For non-FC cases 17/42 (40%) received a score of 3 or 4 whereas 36/42 cases utilizing FC (85%) received a score >=3.The image quality score was statistically significantly higher ($F=106.502$, $p<0.0001$) for FC technique compared to non-FC technique. The Spearman rank correlation and 95% CI for image quality scores between readers were 0.64, 95% CI 0.25-0.73 for FC and 0.56, 95% CI 0.20-0.67 for non-FC technique.

Conclusion: This retrospective study by blinded neuroradiologist readers suggests that FC algorithms significantly reduced pulsation artifact in the posterior fossa on visual assessment.

Key words: Pulsation artifact, flow compensation, posterior fossa.

1. Introduction

Phase related pulsation artifact in the posterior fossa and/or CSF can result from physical movement, arterial pulsations, swallowing, peristalsis and respiratory motion, thereby limiting diagnostic confidence on MRI [1,2].

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Pulsation artifacts occur when movement or vascular flow traverses the imaging plane and produces signal fluctuations along the MRI phase encoding direction that may obscure relevant anatomy or mimic pathology.Pulsation related artifacts commonly occur in the posterior fossa on post-contrast brain MRI secondary to pulsation from the common carotid arteries at the central skull base and from basilar artery, transverse and sigmoid sinuses in the posterior fossa.

Flow compensation (FC) correction algorithms have been developed to minimize pulsation related artifacts in the posterior fossa but are not yet in widespread clinical use.While several FC correction techniques by various vendors have been studied for reduction of posterior fossa pulsation artifacts [3-7], to our knowledge the effectiveness of FC techniques on post-contrast T1 weighted imaging has not yet been reported. The purpose of this study is to examine the effectiveness of FC pulsation artifact reduction in the posterior fossa on post-contrast imaging as rated by two blinded neuroradiologists.

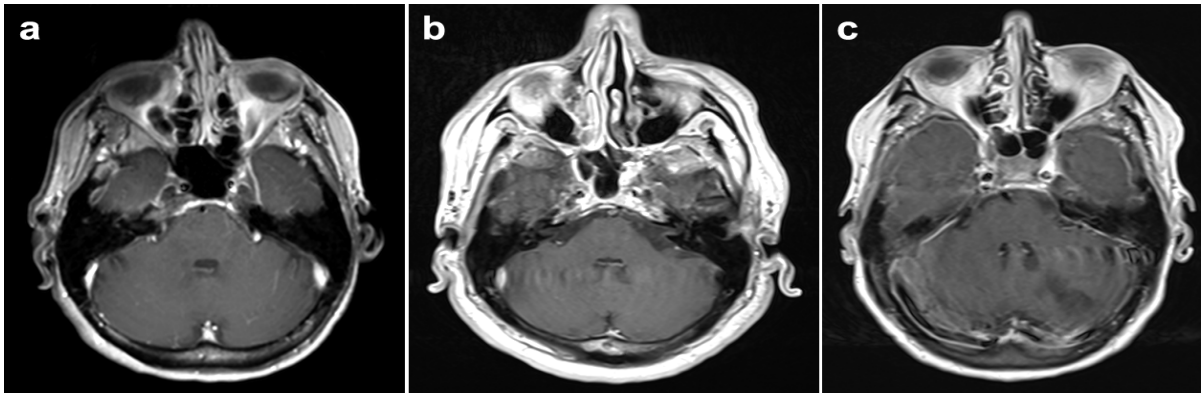
2.1. Methods

This study is HIPPA compliant and institutional IRB approved.T1 post-contrast images of the brain with and without flow compensation were obtained on 42 consecutive patients undergoing contrast enhanced brain MRI from August 1, 2013 to October 1, 2013.These FC studies were retrospectively identified by a non-reading author for blinded review by two board certified radiologists with fellowship training including certificate of added qualification in neuroradiology with 7 and 11 years of practice experience respectively.

Images were prepared prior to review by two non-reading, proctoring authors to remove all identifying information as well as image labeling that could indicate the presence or absence of flow-compensation technique.During the first reading session, each neuroradiologist was presented with a FC or non-FC post-contrast image chosen at random for each patient.The second reading session occurred 7-10 days later during which the companion image for each patient (i.e.-image not presented in the first reading session) was presented to each reader.For example, if the reader was initially shown a patient's FC image during the first reading session, they were subsequently presented with the same patient's non-FC image during the second session.Review sessions for each reader were conducted independently and at separate times.

Reviewers scored each non-FC and FC post-contrast T1 sequence on a four-point scale as follows: 4: Excellent image quality, none to minimal pulsation artifact. 3: Mild flow artifact; no signal that can be confused for a lesion and less than six slices with pulsation artifact. 2: Prominent pulsation artifact, with signal that may be confused for a lesion; or pulsation artifact on six or more slices. 1: Poor image quality, not interpretable (see examples in **Figure 1**). The blinded readers did not have access to any clinical information including patient clinical history or imaging reports.Readers were instructed to make judgments only on presence or absence of pulsation artifact independent of any other imaging findings or pathology that may have been present.

Fig. 1



Images demonstrating pulsation artifact on post-contrast T1-weighted images for a score of 4 (excellent image quality, none to minimal pulsation artifact) (Fig 1a), score of 3 (mild flow artifact; no signal that can be confused for a lesion and less than six slices with pulsation artifact) (Fig 1b), and a score of 2 (prominent pulsation artifact, with signal that may be confused for a lesion or pulsation artifact on six or more slices) (Fig 1c).No study received a score of 1 (poor image quality, not interpretable)

2.2. Statistical analysis:

Data were analyzed with ANOVA using the ratings as the dependent variable and condition (FC versus non-FC) and reader as independent variables.Interobserver agreement was tested with Spearman rank correlation. Statistical significance was set at $p = 0.05$.

2.3. Technical parameters:

Our study utilized an FC spin echo algorithm provided by Siemens Medical Systems (Erlangen, Germany) and images were acquired on 1.5T (Aera) and 3.0T (Skyra) Siemens MRI systems.FC T1 post-contrast imaging was performed with a TR of 535 ms and a TE of 18 ms, with FC in the read direction. The standard non-FC T1 post-contrast turbo spin-echo was performed with a TR of 550 ms and a TE of 7.7 ms; echo train length = 4; parallel acceleration = 2; bandwidth = 500Hz/px; and averages = 2. Other imaging parameters were kept equivalent (256 x 205 matrix, FOV = 220mm, ST/gap = 4mm/1mm). Post contrast imaging was performed with 0.1 mmol/kg of gadolinium, which was administered by a power injector (Bracco) at a rate of 1.5cc/s, or by hand.Average scan time for the FC sequence was 3 minutes and 52 seconds compared to non-FC average scan time of 2 minutes and 7 seconds.PACS was utilized for image review.

3. Results

FC and non-FC sequences were obtained on 42 patients (29 F, 13 M, mean age 53 years old (range 6-82 years)).For non-FC imaging, readers rated 25 of 42 cases (60%) as demonstrating prominent pulsation artifact (score =2) compared to 6 of 42 cases (14%) in the FC group.No case in either group received a rating of 1 (non-interpretable).For non-FC cases 17 of 42 studies (40%) received a score of 3 or 4 compared to 36 of 42 FC cases (85%) received a score >=3 **(Table 1)**.

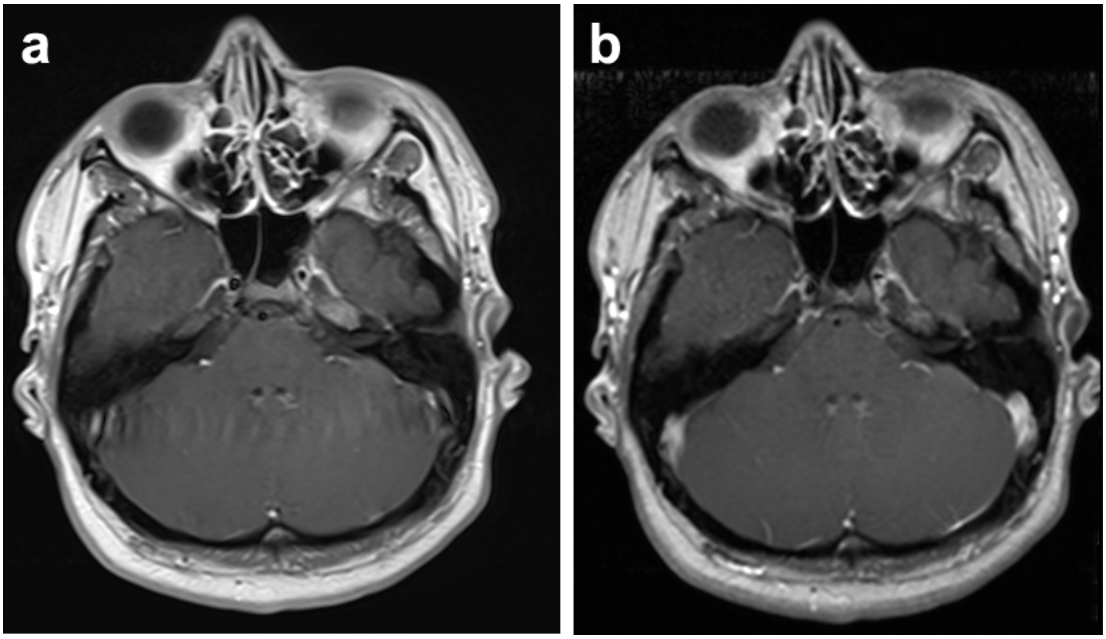
Image Quality Score		
SCORING	**NON-FC TECHNIQUE**	**FC TECHNIQUE**
4	0/42 (0%)	12/42 (28.6%)
3	17/42 (40.5%)	24/42 (57.1%)
2	25/42 (59.5%)	6/42 (14.3%)
1	0/42 (0%)	0/42 (0%)

Table 1:

Combined image quality scores following review of flow compensation and non-flow compensation T1 post-contrast images by two blinded neuroradiologist readers. Scoring system: 4: Excellent image quality, none to minimal pulsation artifact. 3: Mild flow artifact; no signal that can be confused for a lesion and less than six slices with pulsation artifact. 2: Prominent pulsation artifact, with signal that may be confused for a lesion; or pulsation artifact on six or more slices. 1: Poor image quality, not interpretable.Abbreviations: FC=flow compensation.

The image quality score was significantly higher ($F=106.502$, $p<0.0001$) for FC technique compared to non-FC technique (examples of pulsation artifact reduction on FC compared to non-FC images are shown in **Figure 2**).The mean image quality scores were 2.12 (sd = 0.41) for non-FC and 3.04 (sd = 0.63) for the FC technique.The Spearman rank correlation and 95% CI for image quality scores between readers were 0.64, 95% CI 0.25-0.73 for FC and 0.56, 95% CI 0.20-0.67 for non-FC technique.

Fig. 2:



Reduction of flow-related pulsation artifact on flow compensation images compared to post-contrast T1 weighted imaging without flow compensation.Prominent pulsation artifact from the sigmoid sinus on image without flow compensation (Fig 2a) is no longer appreciated after application of flow-compensation algorithm (Fig 2b).

4. Discussion

Retrospective imaging review by blinded neuroradiologist readers suggests that FC algorithms on post-contrast imaging significantly reduced pulsation artifact in the posterior fossa on visual assessment.Utilizing FC in clinical practice may therefore improve imaging evaluation of the posterior fossa.

Because FC increases the minimum echo time, FC imaging time was approximately 1 minute and 30 seconds longer than the corresponding non-FC technique.The increased imaging time for FC was primarily secondary to foregoing parallel imaging on FC versus non-FC technique.Future studies would be needed to determine the degree of potential negative fiscal impact and/or impact on patient discomfort from slightly longer scanning and patient-turnaround times.This knowledge may be particularly important if FC is utilized in the emergency setting where high patient throughput is often required and time to imaging diagnosis can be critical.

Our study did not assess for effect on lesion detection between FC and non-FC techniques. Our findings demonstrate that FC imaging improves visualization of posterior fossa structures on visual assessment but whether this translates into improved lesion detection in the posterior fossa is unknown.Future research should assess for differences in lesion detection between FC and non-FC postcontrast imaging of the brain.

5. Conclusions

Performing FC algorithms on post-contrast imaging of the posterior fossa significantly reduced pulsation artifact on visual assessment which can be very helpful in evaluation of cancer patients and patients with suspected posterior fossa pathology.However, the improved visualization of posterior fossa on FC imaging technique was associated with slightly longer imaging time (1 minute 45 secs more) compared to non-FC technique with FC technique.

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