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Feasibility and image quality of Bright-blood and black-bLOOD phase SensiTive inversion recovery (BOOST) sequence in clinical practice using for left atrial visualization in patients with atrial fibrillation --Manuscript Draft--

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Abstract:	Objectives: Visualizing left atrial anatomy including the pulmonary veins (PV) is important for planning the procedure of pulmonary vein isolation with ablation in patients with atrial fibrillation (AF). The aims of our study are to investigate the feasibility of the 3D whole-heart bright-blood and black-blood phase sensitive (BOOST) inversion recovery sequence in patients with AF scheduled for ablation or electro cardioversion, as well as to analyze the correlation between image quality and heart rate and rhythm of patients. Methods: BOOST was performed for assessing pulmonary veins (PV) both with T2-preparation pre-pulse (T2prep) and MT-preparation (MTC) in 45 patients with paroxysmal or permanent AF scheduled for ablation or electro cardioversion. Image quality analyses were performed by two independent observers. Qualitative assessment was made using Likert scale, for quantitative analysis signal to noise ratios (SNR) and contrast to noise ratios (CNR) were calculated for each PV. Heart rate and rhythm was analyzed based on standard 12-lead ECGs. Results: All MTC-BOOST acquisitions achieved diagnostic quality in the PVs, while a significant proportion of T2prep-BOOST images were not suitable for assessing PVs. SNR and CNR values of the MTC-BOOST bright-blood images were higher if patients had sinus rhythm. We found a significant or nearly significant negative correlation between heart rate and the SNR and CNR values of MTC-BOOST bright-blood images. Conclusion: 3D whole-heart MTC-BOOST bright-blood imaging is suitable for visualizing the PVs in patients with AF, producing diagnostic image quality in 100% of cases. However, image quality was influenced by heart rate and rhythm.	
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Title: Feasibility and image quality of Bright-blood and black-bLOOD phase SensiTive inversion recovery (BOOST) sequence in clinical practice using for left atrial visualization in patients with atrial fibrillation

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Abstract

Objectives: Visualizing left atrial anatomy including the pulmonary veins (PV) is important for planning the procedure of pulmonary vein isolation with ablation in patients with atrial fibrillation (AF). The aims of our study are to investigate the feasibility of the 3D whole-heart bright-blood and black-blood phase sensitive (BOOST) inversion recovery sequence in patients with AF scheduled for ablation or electro cardioversion, as well as to analyze the correlation between image quality and heart rate and rhythm of patients.

Methods: BOOST was performed for assessing pulmonary veins (PV) both with T2-preparation pre-pulse (T2prep) and MT-preparation (MTC) in 45 patients with paroxysmal or permanent AF scheduled for ablation or electro cardioversion. Image quality analyses were performed by two independent observers. Qualitative assessment was made using Likert scale, for quantitative analysis signal to noise ratios (SNR) and contrast to noise ratios (CNR) were calculated for each PV. Heart rate and rhythm was analyzed based on standard 12-lead ECGs.

Results: All MTC-BOOST acquisitions achieved diagnostic quality in the PVs, while a significant proportion of T2prep-BOOST images were not suitable for assessing PVs. SNR and CNR values of the MTC-BOOST bright-blood images were higher if patients had sinus rhythm. We found a significant or nearly significant negative correlation between heart rate and the SNR and CNR values of MTC-BOOST bright-blood images.

Conclusion: 3D whole-heart MTC-BOOST bright-blood imaging is suitable for visualizing the PVs in patients with AF, producing diagnostic image quality in 100% of cases. However, image quality was influenced by heart rate and rhythm.

Clinical relevance statement: The novel 3D whole-heart BOOST CMR sequence needs no contrast administration and is performed during free-breathing, therefore it is easy to use for a wide range of patients and is suitable for visualizing the PVs in patients with AF.

Keywords: cardiac magnetic resonance, atrial fibrillation, pulmonary veins, image quality, non-contrast 3D imaging

Key points:

- The applicability of the novel 3D whole-heart BOOST sequence to pulmonary vein imaging in clinical practice is unknown.
- MTC BOOST imaging is suitable for visualizing the pulmonary veins in patients with atrial fibrillation with excellent or good image quality.
- BOOST CMR sequence is easy to use for a wide range of patients as it needs no contrast administration and is performed during free-breathing.

Abbreviations and acronyms

3D	3 dimensional
AF	atrial fibrillation
BOOST	bright-blood and dark-blood phase sensitive inversion recovery
bSSFP	balanced steady state free precession
CMR	cardiac magnetic resonance
CMRA	cardiac magnetic resonance angiography
CNR	contrast to noise ratio
ECG	electrocardiography
FOV	field of view
GRE	gradient echo
ICC	intraclass correlation coefficient
iNAV	image navigation
IR	inversion recovery
LA	left atrium

LGE	late gadolinium enhancement
MTC	magnetization transfer
Obs	observer
ROI	region of interest
PSIR	phase sensitive inversion recovery
PV	pulmonary vein
SD	standard deviation
SI	signal intensity
SNR	signal to noise ratio
T2-prep	T2 preparation

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1. Introduction

Imaging of left atrium (LA) in atrial fibrillation (AF) can provide insights into the etiology, risk stratification, and influences the therapeutic management of patients. Assessment of LA function and structure has a predictive value in the occurrence of AF and the risk of stroke (1). Thromboembolism is the most severe complication of AF. To exclude LA appendage thrombus before an electro cardioversion or ablation therapy of AF is particularly important (2,3). Visualizing LA anatomy including the pulmonary veins (PV) is important for planning the procedure of pulmonary vein isolation with ablation (4). The PV anatomy is conventionally assessed before ablation using computer tomography or 3 dimensional (3D) contrast-enhanced cardiac magnetic resonance (CMR) imaging (5,6).

CMR imaging is an excellent method for evaluating cardiac anatomy and function. 3D contrast enhanced CMR angiography (CMRA) is applicable for the assessment of LA dimensions and PV anatomy, whereas 2D cardiac cine imaging are useful for evaluating LA function. Contrast-enhanced CMRA acquisitions are performed during the patient's breath-holding and are taken in time with the first-pass of a contrast agent. Inadequate timing of image acquisition or problems with the patient's breath-holding may result in poor image quality. Another option is a contrast-enhanced electrocardiographic (ECG) and respiratory gated 3D (balanced steady state free precession – bSSFP or gradient echo – GRE) sequence, which helps to depict the pulmonary veins even if the patient is unable to hold their breath (7). The biggest downside of this technique is the quite long and unpredictable acquisition time which highly depends on the patient's breathing pattern. Due to the long scan time, this acquisition cannot be repeated when the image quality is poor.

A novel MRI sequence, a 3D whole-heart bright-blood and black-blood phase sensitive (BOOST) inversion recovery sequence that needs no contrast administration and is performed during free-breathing using image-based navigation has been introduced recently (8,9). One of

1 the biggest advantages of BOOST is that it acquires 2 differently weighted bright-blood
2 volumes in an interleaved fashion. The two bright-blood images can be combined using a
3 subtraction based approach (iT2prep) (10) or a Phase Sensitive Inversion Recovery (PSIR)-like
4 reconstruction in order to provide both bright- and black-blood volumes. Initial validation has
5 proven the clinical applicability of the technique, showing that simultaneous bright- and black
6 blood whole heart MRI with T2 preparation (T2-prep) can help to identify the coronary lumens
7 and thrombi (9). The same study tested the feasibility of BOOST for simultaneous black-blood
8 late gadolinium enhancement (LGE) assessment and bright-blood coronary angiography (11).
9 Additionally, magnetization transfer (MTC) prepared BOOST (MTC-BOOST) is possible for
10 the imaging of PVs, which provide excellent image quality and offer good depiction of the
11 intracardiac and vascular anatomy at congenital heart disease patients which is comparable the
12 standard T2-prep bSSFP sequence, as shown by earlier studies (12). MTC-BOOST was
13 compared with the standard T2-prep bSSFP technique in pulmonary vein visualization, where
14 MTC-BOOST overperformed the standard technique. This study was based on the examination
15 of 11 healthy subjects and only 4 patients with AF (8) and they concentrated to present the
16 advantages of non-rigid motion corrected algorithms. Nevertheless, there is limited data
17 available on the applicability of the BOOST sequence in clinical practice based on studies of
18 larger numbers of patients.

19 The aim of our study are to investigate the feasibility of the BOOST sequence in patients with
20 AF scheduled for ablation or electro cardioversion, analyze the image quality with both
21 quantitative- and qualitative methods and compare the results with those patients who had sinus
22 rhythm. Finally, we want to investigate the correlation between image quality and heart rate
23 and rhythm of patients.

2. Methods

2.1. Patients

1 Informed consent was obtained from each patient. Ethical approval was obtained from the
2 Medical Research Council (IV/4962-3/2021/EKU), and this study was performed in accordance
3 with the ethical standards in the 1964 Declaration of Helsinki and its later amendments.
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8 Forty-five patients with paroxysmal or permanent AF scheduled for ablation or electro
9 cardioversion in the Heart and Vascular Center of Semmelweis University were prospectively
10 involved in the study between May 2021 to December 2021. Patients with pacemakers or
11 implanted cardioverter defibrillators, or with any contraindications of CMR examination were
12 not involved in the study.
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17 A standard 12-lead ECG (25 mm/s and 10 mm/mV) was obtained within one hour before or
18 after the CMR examination while all patients were in a supine position during quiet respiration.
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20 Thirty patients had sinus rhythm, 12 patients had AF, two patients had atrial flutter and one
21 patient had atrial tachycardia at the time of the CMR examination. Patients with AF, atrial
22 flutter and atrial tachycardia were analyzed together as a group of patients with atrial
23 tachyarrhythmias.
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34 35 36 **2.2. CMR protocol**

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38 CMR examinations were performed on a 1.5 T MR scanner (MAGNETOM Aera, Siemens
39 Healthcare). An ECG triggered 3D whole-heart bright-blood and black-blood bSSFP (BOOST)
40 prototype sequence was performed both with T2-preparation pre-pulse (T2prep) and MT-
41 preparation (MTC) as previously described (8,9). Image navigation (iNAV) was used for
42 respiratory motion estimation and compensation which allows measurements to be taken under
43 free-breathing conditions and ensures 100% scan efficiency and predictable scan time (13).
44
45 Imaging parameters included: subject-specific mid-diastolic ECG-triggering, coronal
46 orientation, resolution: 1.4x1.4x1.4mm, Field of View (FOV): 320x320x64-96mm, flip angle:
47 90°, TR/TE= 3.5ms/1.6 ms, MTC preparation as described in (8). In order to define the phase
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1 during a cardiac cycle with least motion we applied an automated cardiac resting-phase
2 detection algorithm (14), which was based on a free-breathing 4 chamber view. The image
3 acquisition window was 100 msec at each patient. The BOOST measurements were performed
4 with the coverage of LA including the ostia of PVs and the appendage. The non-rigid motion
5 corrected magnitude T2Prep inversion recovery (IR) BOOST and reference T2Prep BOOST
6 volumes were combined in a PSIR reconstruction (15) to obtain a PSIR BOOST black-blood
7 volume (11). Similarly, the magnitude MTC-IR BOOST and reference MTC BOOST volumes
8 were combined in a PSIR-like reconstruction to obtain a black-blood PSIR BOOST (Figure 1)
9 (8).

2.3. Image analysis

10 Image quality analyses were performed by two independent observers (Obs1 and Obs2) who
11 were blinded to the heart rate and rhythm of patients. Qualitative assessment was made using
12 Likert scale as follows: 1 point indicated poor image quality, PVs are not detected, 2 points
13 indicated good image quality, artifacts in the PV(s), and 3 points indicated excellent image
14 quality, no artifacts (Figure 2).

15 For quantitative analysis regions of interest (ROI) were signed in all four PVs to measure signal
16 intensities (SI). The mean background SI and the standard deviation (SD) of background SI
17 were measured in the lung tissue. Signal to noise ratio (SNR) were calculated in each PVs:
18 $\text{SNR} = \frac{\text{mean SI of a PV}}{\text{SD of background SI}}$. Contrast to noise ratio (CNR) were also calculated in
19 each PVs: absolute value of $(\text{mean SI of a PV} - \text{mean background SI}) / \text{SD of background SI}$.

20 The image quality analyses were performed both on the bright-blood magnitude and black-
21 blood PSIR images.

2.4. Statistical analysis

Continuous data are expressed as the mean $\pm$ standard deviation (SD). The normality of the distribution of the data was investigated with the Shapiro-Wilk test. Group characteristics were compared with an independent t-test or Mann-Whitney test, as appropriate. The correlation between heart rate and the SNR and CNR values was calculated with Spearman's correlation analysis. The interobserver agreement was examined with the intraclass correlation coefficient (ICC score). Differences were considered statistically significant when $p < 0.05$. All analyses were performed by using MedCalc software (version 17.9.5).

3. Results

3.1 Image quality of T2prep BOOST

A significant proportion of T2prep BOOST images were not suitable for assessing PVs, or artifacts were in the PVs. Only a small proportion of the images had excellent image quality without artifacts in the PVs (Figure 3). Because of this result, further quantitative image quality analysis was not performed on the T2prep BOOST images.

3.2 Qualitative assessment of image quality of MTC BOOST

Among the MTC BOOST images examined, there were no images of poor quality in which the PVs could not be adequately assessed. Both observers rated 42% of the bright-blood magnitude images as excellent image quality without artifacts (Likert scale 3) and 58% as good image quality with artifacts (Likert scale 2) in the PVs. Obs1 rated 89% of the black-blood PSIR MTC images as good image quality with artifacts in the PVs and 11% as excellent image quality without artifacts, while Obs2 rated 51% of the black-blood PSIR MTC images as good image quality with artifacts in the PVs and 49% as excellent image quality without artifacts (Figure 4).

An image quality analysis was performed with respect to heart rate and presence of sinus rhythm during the measurement. In the case of sinus rhythm based on an ECG obtained within

one hour before or after the CMR examination, the Observers gave a higher proportion of 3 points compared to atrial tachyarrhythmia cases (Table 1). A tendency of lower heart rates was found for cases rated with 3 points (Table 2), nevertheless we didn't find significant differences except for magnitude images with Observer 1.

3.3 Quantitative assessment of image quality of MTC BOOST

The results of quantitative assessments of image quality showed that the SNR and CNR values of the bright-blood magnitude images were higher if patients had sinus rhythm in the majority of measurements. For some measurements the difference was not statistically significant, but the trend was similar (Table 3).

We did not find a significant difference in SNR and CNR values between patients with sinus rhythm and atrial tachyarrhythmia on the black-blood PSIR images (Table 4).

We found a significant or nearly significant negative correlation between heart rate and the SNR and CNR values of bright-blood magnitude images. The SNR and CNR values of black-blood PSIR images did not correlate with the heart rate (Table 5).

3.4 Interobserver agreement

We found excellent or good agreement between the two observers in the signal intensity assessments both on the magnitude and PSIR images. (Supplement 1).

4. Discussion

Previously, BOOST sequence was successfully applied to identify the coronary lumens, thrombi, congenital diseases, etc. MTC BOOST outperformed the standard T2-prep sequence in pulmonary vein isolations, nevertheless this study was based on only 11 healthy volunteers and 4 patients with atrial fibrillation (8). In our study we focus on the feasibility of MTC measurement in clinical practice and investigate the performance of the sequence in patients

1 with sinus rhythm and atrial tachyarrhythmia. We applied both the T2-prep- and MTC sequence
2 to compare them and determine their feasibility.
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5 The main finding of this study is that MTC BOOST is applicable for assessing pulmonary vein
6 independently of the patients' heart rate and rhythm. In the study population, 30 patients had
7 sinus rhythm and 15 patients had atrial tachyarrhythmia at the time of the CMR examination,
8 and none of them had images of poor quality in which the PVs could not be adequately assessed.
9
10 These results are very promising, especially considering the use of a fixed diastolic acquisition
11 window (100 ms). This setting is not optimal at higher heart rates, but our experience is that the
12 images are still well evaluated, and using this setting is comfortable and shortens the
13 measurement time.
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16 For MTC images, the image quality was affected by heart rate and rhythm. With subjective
17 qualitative analysis, the Observers rated images as excellent image quality with higher
18 proportion in case of sinus rhythm, moreover, a tendency of lower heart rate was found for
19 cases rated as excellent image quality. The difference was significant only at bright-blood
20 magnitude image analysis and only at Observer 1.
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23 The SNR and CNR values of bright-blood magnitude images were higher in case of sinus
24 rhythm. However, for some measurements the difference was not statistically significant, but
25 the trend was similar which can be explained by the relatively small sample size. A negative
26 correlation was found between heart rate and the SNR and CNR values of bright-blood
27 magnitude images in the majority of the measurements. Based on these results, the image
28 quality of bright-blood magnitude images is influenced by the heart rate and rhythm, and it is
29 better if patients had sinus rhythm and lower heart rate. Analyzing the black-blood PSIR
30 images, no differences were found in the SNR and CNR values between sinus rhythm and atrial
31 tachyarrhythmia, and the SNR and CNR values showed no correlation with the heart rate. These
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1 results suggest that the image quality of black-blood PSIR images is less affected by heart rate
2 and rhythm.
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5 Surprisingly, T2-prep BOOST quality was under our expectation, and we found poor,
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7 non/diagnostic image quality at a large portion of the patients. We found that T2prep BOOST
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9 is not suitable for visualizing the PVs (8). On the other hand, previously it was demonstrated
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11 that T2prep BOOST is applicable for thrombus visualization without contrast administration
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13 (9) which has a high clinical relevance as excluding LA appendage thrombus before an electro
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15 cardioversion or ablation therapy of AF is particularly important. However, in visualizing the
16
17 LA appendage, there is no widely accepted CMR technique. With cine movies and late
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19 enhancement images there is a risk of overlooking small but relevant LA appendage thrombi
20
21 due to slice thickness and difficulties of proper angulation. Therefore, in the future, T2prep
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23 BOOST imaging may play a role in the exclusion of LA appendage thrombus.
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29 30 **5. Study limitations**

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32 One limitation of our study is that it was a single-center study, which might limit the
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34 generalizability of our conclusions. Another limitation is the relatively small sample size which
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36 can explain that some of our results were statistically not significant. Last, but not least we think
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38 that the quantitative image analysis would be more precise if we can segment the pulmonary
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40 veins and calculate the means and standard deviations from the entire vein. Taking into account
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42 that our main aim was to investigate the clinical feasibility of BOOST imaging, we dispense
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44 from that analysis.
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50 51 **6. Conclusion**

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53 3D whole-heart MTC BOOST imaging is suitable for visualizing the PVs in patients with AF
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55 with excellent or good image quality and no cases in the current study in which the PVs could
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57 not be adequately assessed. However, the overall image quality of bright-blood magnitude
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1 images can be influenced by the heart rate and rhythm, with slightly better image quality if
2 patients are in sinus rhythm and have lower heart rate.
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Table and Figure legends

Table 1: Qualitative assessment of image quality and heart rhythm. Number of cases classified by the two Observers on the Likert scale in case of sinus rhythm and atrial arrhythmia.

Table 2: Qualitative assessment of image quality and heart rate. Heart rate of patients divided by the rating on Likert scale.

Table 3. SNR and CNR values of magnitude images according to heart rhythm

Abbreviations: LIPV – left inferior pulmonary vein, LSPV – left superior pulmonary vein, RIPV – right inferior pulmonary vein, RSPV – right superior pulmonary vein

Table 4. SNR and CNR values of PSIR images according to heart rhythm

Abbreviations: LIPV – left inferior pulmonary vein, LSPV – left superior pulmonary vein, RIPV – right inferior pulmonary vein, RSPV – right superior pulmonary vein

Table 5. Correlations between heart rate and the SNR and CNR values of Magnitude and PSIR images

Abbreviations: LIPV – left inferior pulmonary vein, LSPV – left superior pulmonary vein, RIPV – right inferior pulmonary vein, RSPV – right superior pulmonary vein, r – correlation coefficient

Supplement 1. Interobserver agreement examined with the intraclass correlation coefficient

Figure 1. BOOST imaging of left atrium. A) bright-blood magnitude image of MTC BOOST, B) black-blood PSIR image of MTC BOOST, C) bright-blood magnitude image of T2prep BOOST, D) black-blood PSIR image of T2prep BOOST

Figure 2. Qualitative image quality analysis of BOOST images with Likert scale. 1 point: poor image quality, PVs are not detected, 2 points: good image quality, artifacts in the PV(s), and 3 points: excellent image quality, no artifacts

Figure 3. Qualitative assessment of image quality of T2Prep BOOST. Proportions of image quality ratings of magnitude and PSIR images by the two Observers.

Figure 4. Qualitative assessment of image quality of MTC BOOST. Proportions of image quality ratings of magnitude and PSIR images by the two Observers.

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Table1

		Obs1		Obs2	
	Likert scale	sinus rhythm	atrial tachyarrhythmia	sinus rhythm	atrial tachyarrhythmia
Magnitude	2 points	14	12	13	13
	3 points	16	3	17	2
		p<0.05		p<0.01	
PSIR	2 points	25	15	12	11
	3 points	5	0	18	4
		p=0.10		p<0.05	

Table2

Heart rate (bpm)				
		2 points	3 points	p
Obs1	Magnitude	82 ± 29	64 ± 14	<0.05
	PSIR	77 ± 26	59 ± 8	0.08
Obs2	Magnitude	81 ± 30	66 ± 14	0.15
	PSIR	81 ± 31	68 ± 15	0.1

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Table3

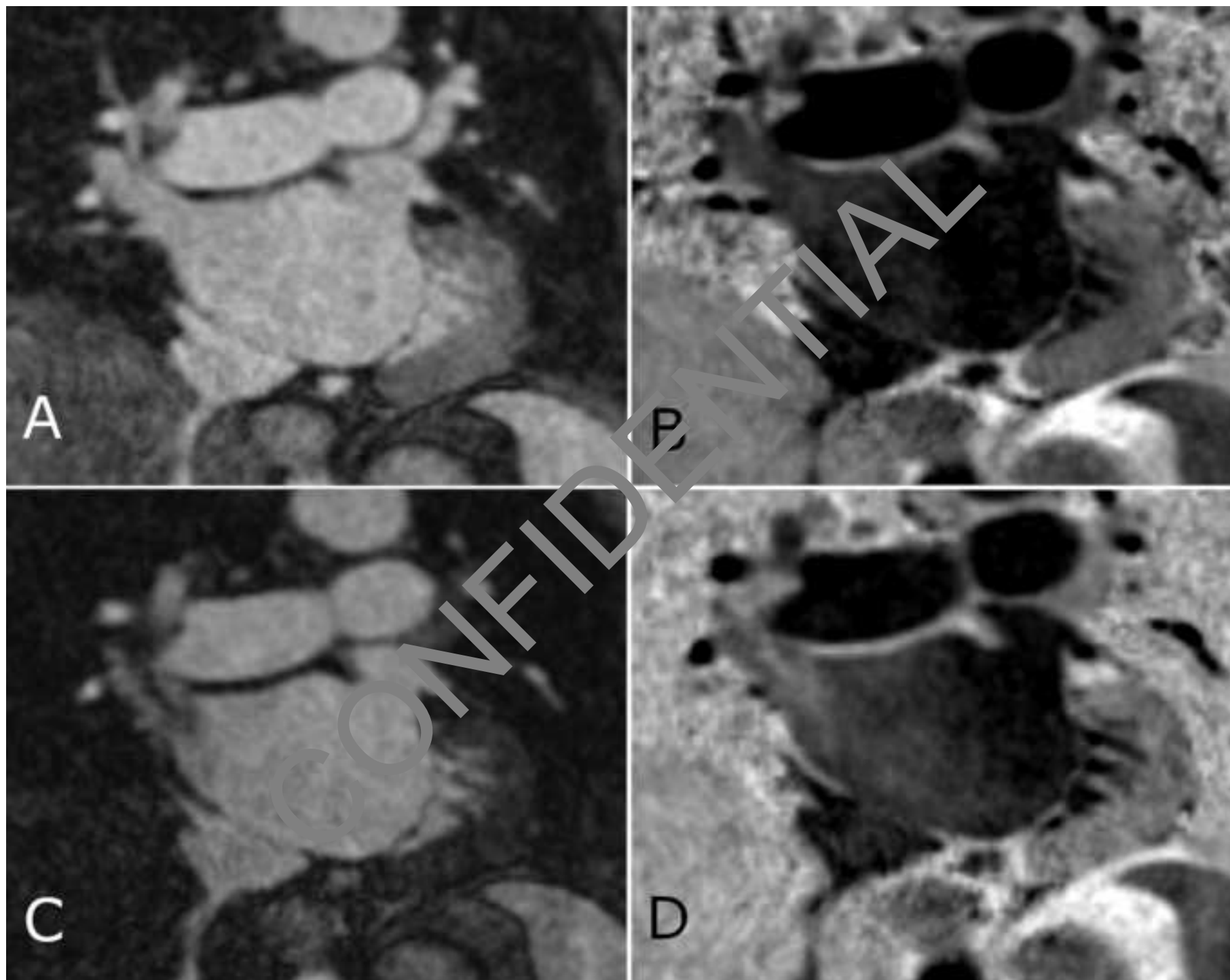
		Sinus rhythm	Atrial tachyarrhythmia	p
SNR				
Obs1	LIPV	27 ± 10	21 ± 5	<0.05
	LSPV	25 ± 7	22 ± 4	0.10
	RIPV	26 ± 8	23 ± 7	0.10
	RSPV	25 ± 7	21 ± 4	<0.05
Obs2	LIPV	26 ± 8	20 ± 4	<0.01
	LSPV	26 ± 8	21 ± 4	<0.01
	RIPV	28 ± 10	21 ± 5	<0.05
	RSPV	25 ± 8	20 ± 5	<0.01
CNR				
Obs1	LIPV	25 ± 10	19 ± 4	<0.05
	LSPV	22 ± 7	19 ± 4	0.17
	RIPV	24 ± 8	21 ± 6	0.19
	RSPV	22 ± 7	18 ± 4	0.07
Obs2	LIPV	24 ± 8	18 ± 4	<0.01
	LSPV	24 ± 8	18 ± 4	<0.01
	RIPV	25 ± 10	19 ± 5	<0.05
	RSPV	23 ± 7	17 ± 5	<0.01

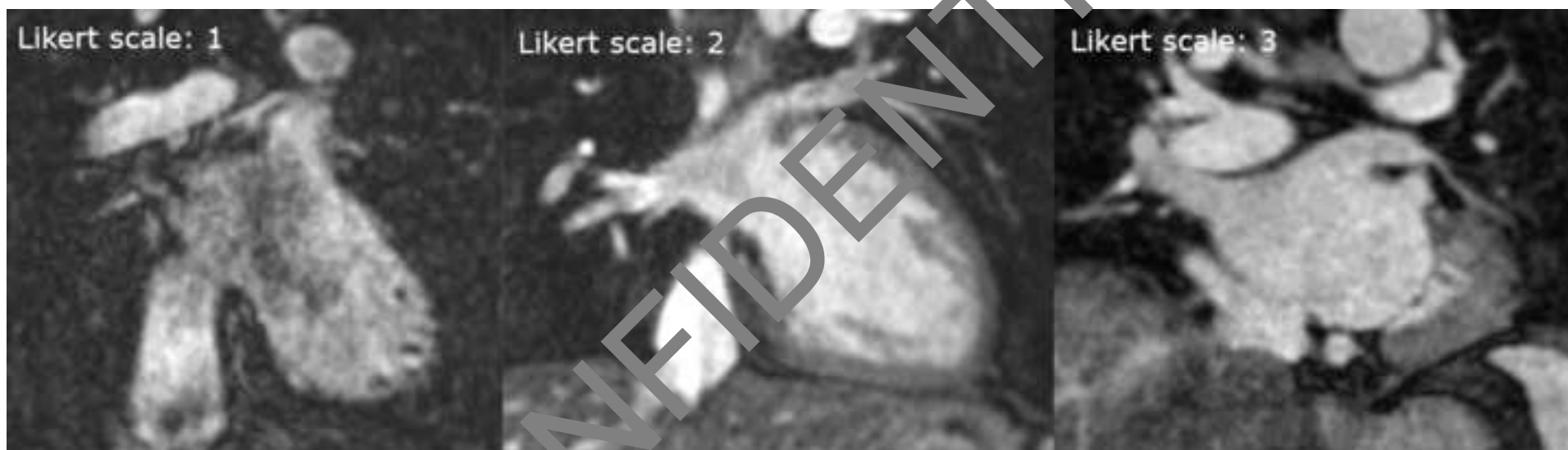
Table4

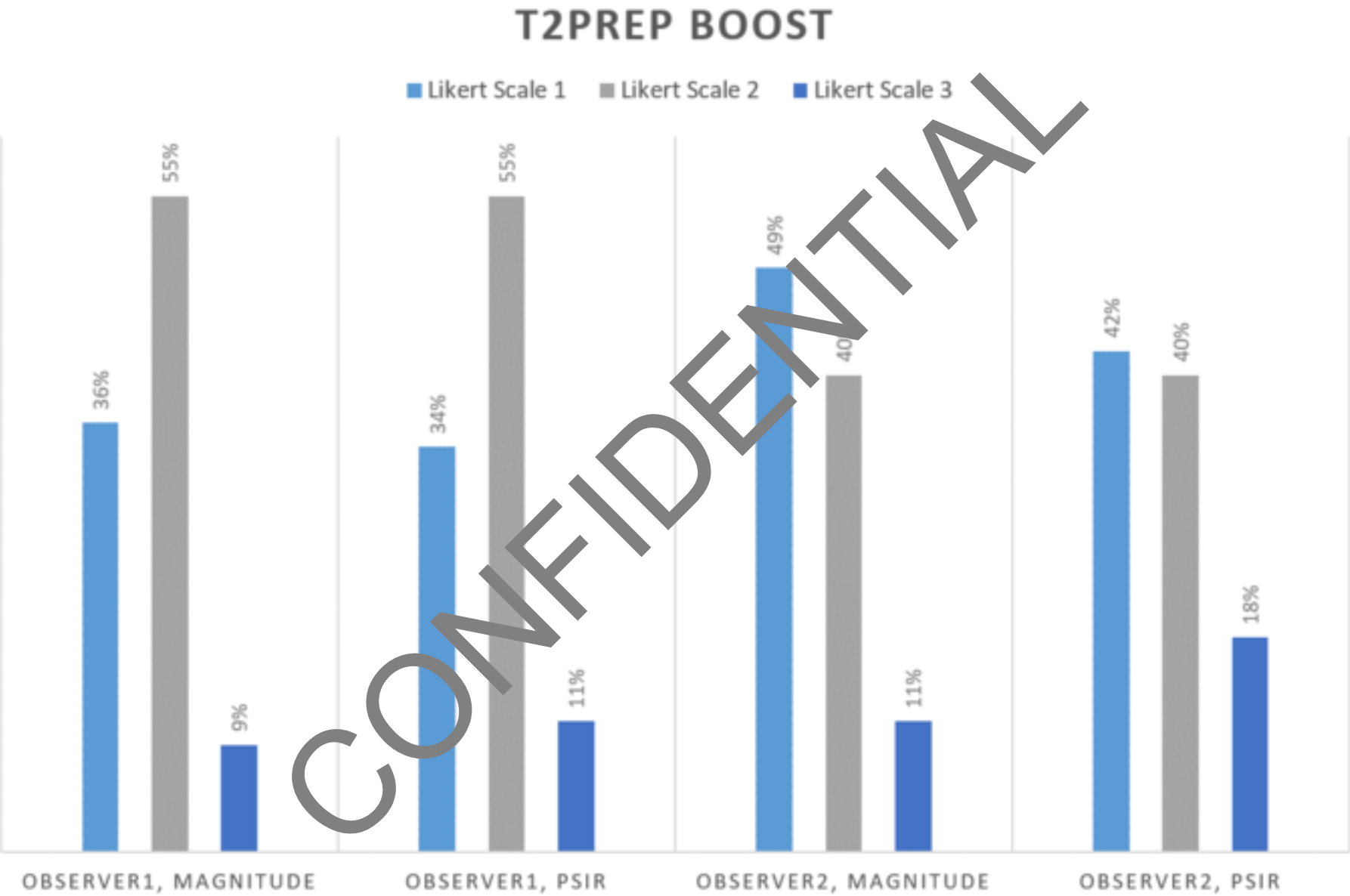
		Sinus rhythm	Atrial tachyarrhythmia	p
SNR				
Obs1	LIPV	18 ± 5	18 ± 4	0.89
	LSPV	19 ± 6	18 ± 5	0.70
	RIPV	18 ± 5	18 ± 5	0.80
	RSPV	19 ± 6	19 ± 5	0.71
Obs2	LIPV	18 ± 5	18 ± 4	0.89
	LSPV	19 ± 5	19 ± 5	0.95
	RIPV	18 ± 5	18 ± 5	0.85
	RSPV	19 ± 6	19 ± 5	0.85
CNR				
Obs1	LIPV	4.9 ± 1.8	5.3 ± 1.8	0.48
	LSPV	3.5 ± 1.2	3.9 ± 1.4	0.36
	RIPV	4.3 ± 1.5	4.4 ± 1.4	0.78
	RSPV	3.5 ± 1.1	3.8 ± 1.4	0.36
Obs2	LIPV	5.1 ± 1.6	5.3 ± 2.1	0.82
	LSPV	4.2 ± 1.6	3.9 ± 1.0	0.56
	RIPV	4.6 ± 1.6	4.7 ± 1.5	0.89
	RSPV	4.0 ± 1.2	4.1 ± 1.1	0.81

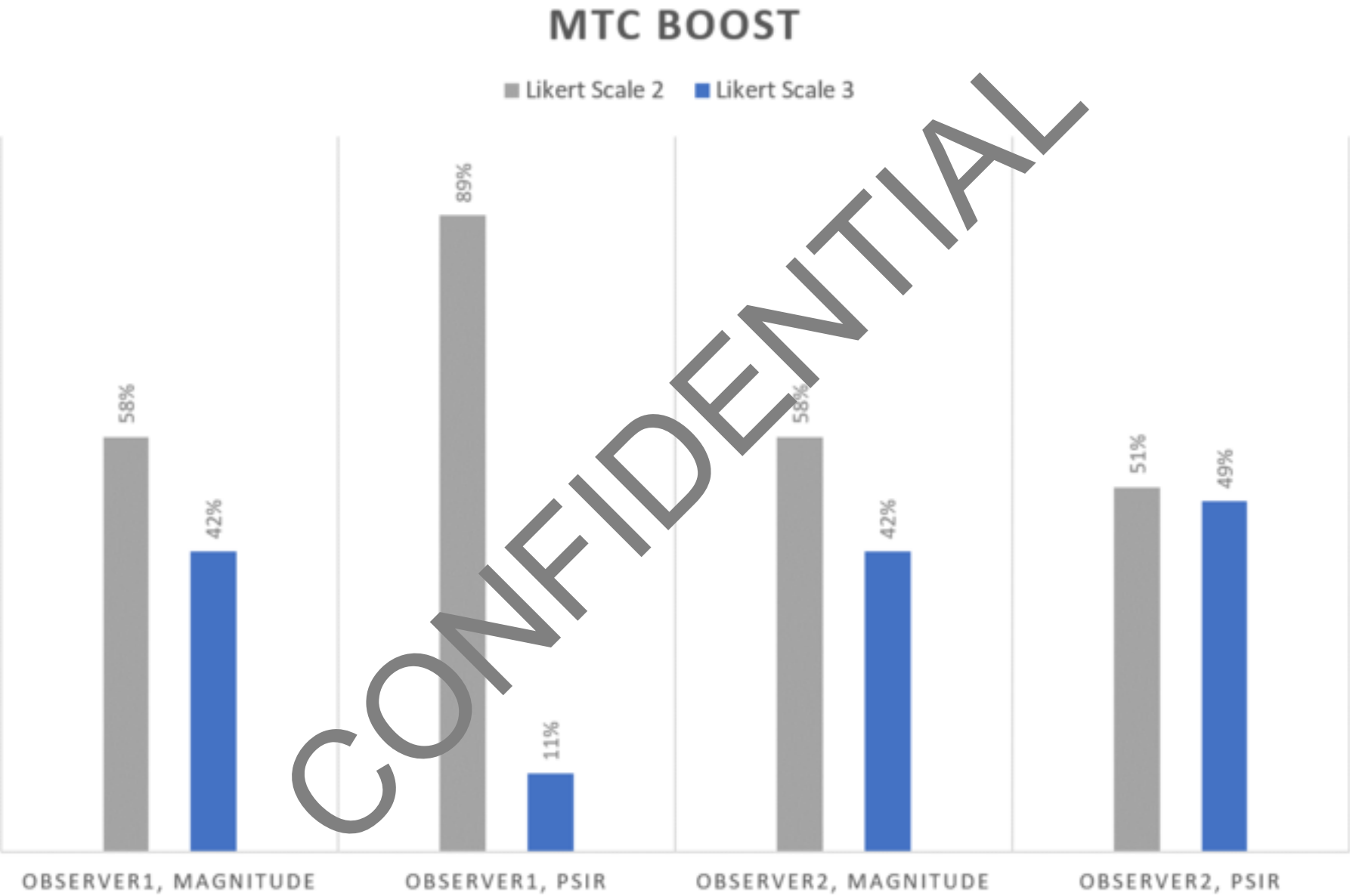
Table5

		Magnitude				PSIR			
		SNR		CNR		SNR		CNR	
		r	p	r	p	r	p	r	p
Obs1	LIPV	-0.22	0.14	-0.19	0.22	0.02	0.90	-0.12	0.48
	LSPV	-0.37	<0.05	-0.36	<0.05	0.18	0.24	-0.18	0.25
	RIPV	-0.24	0.11	-0.23	0.13	0.18	0.25	-0.19	0.21
	RSPV	-0.45	<0.01	-0.44	<0.01	0.17	0.27	-0.24	0.12
Obs2	LIPV	-0.30	<0.05	-0.30	<0.05	0.10	0.53	-0.17	0.31
	LSPV	-0.38	<0.01	-0.37	<0.05	0.27	0.08	-0.15	0.32
	RIPV	-0.31	<0.05	-0.30	<0.05	0.24	0.11	-0.23	0.13
	RSPV	-0.46	<0.01	-0.45	<0.01	0.25	0.11	-0.22	0.16









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Compliance with Ethical Standards

2. Guarantor:

The scientific guarantor of this publication is Hajnalka Vágo.

3. Conflict of Interest:

The authors of this manuscript declare relationships with the following companies: Karl Kunze, Radhouene Neji and Mate Kiss are employee of Siemens Healthineers.

4. Statistics and Biometry:

No complex statistical methods were necessary for this paper.

5. Informed Consent

Only if the study is on human subjects:

Written informed consent was obtained from all subjects (patients) in this study.

6. Ethical Approval:

Institutional Review Board approval was obtained. Ethical approval was obtained from the Medical Research Council (IV/4962-3/2021/EKU)

7. Study subjects or cohorts overlap:

No study subjects or cohorts have been previously reported.

8. Methodology

Methodology:

- prospective
- observational
- performed at one institution

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