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METAL ARTEFACT REDUCTION AND ITERATIVE RECONSTRUCTION METHOD ADAPTIVE STATISTICS V IN REDUCING METAL ARTEFACT IMAGES

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KEYWORDS	ABSTRACT
MAR, ASIR-V, Image Quality, CT Scan of head and neck	CT scan images with metal artefacts may reduce the image quality and diagnosis of CT scan images. Metal Artefact Reduction (MAR) can effectively reduce artifacts caused by metal implants. ASIR-V plays a role in reducing noise and improving image quality. To prove the reduction of metal image artefacts and optimization of CT scan image quality after the application of MAR and ASIR-V (30,60,90) of Head and Neck CT Scan by finding the value of SNR, CNR, anatomical information and the level of metal artefact interference after metal artefact reduction. Quasi-type experimental research design with pre-post test only without control group design. The study sample was 15 CT scan images of head and neck with purposive sampling. SNR and CNR measurements were quantitatively analyzed using the Wilk test, followed by the Wilcoxon test. Anatomical information assessment was performed qualitatively by two radiologists and analyzed by kappa test. Anatomical information and the level of metal artefact interference with CT scan images were carried out by the Friedman test, followed by the Wilcoxon test. There is a difference in SNR Pvalue (p=0.000<0.05), CNR Pvalue (p=0.000>0.05), anatomical information Pvalue (p=0.000<0.05), level of metal artefacts Pvalue (p=0.000<0.05) after using MAR and ASIR V. The use of MAR and ASIR-V methods can reduce metal artefacts in images that contain artefacts with the use of MAR + ASIR-V 90% the most optimal.
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INTRODUCTION

Hospitals are health service institutions that provide comprehensive individual health services that provide inpatient, outpatient and emergency services (Ministry of Health of the Republic of Indonesia, 2020). Clinical Radiology Services are medical services that use all modalities that use ionizing and non-ionizing radiation sources for diagnosis and therapy with imaging guidance (Ministry of Health of the Republic of Indonesia, 2020).

CT components include an X-ray source, detector, and reconstruction algorithm. X-rays are generated by the source and collected by the detector after passing through the sample to be imaged (Piovesan, Vancauwenberghe, Van De Looverbosch, Verboven, & Nicolaï, 2021). Computed tomography (CT) is considered one of the good diagnostic tools for evaluating organs because of its low cost, comprehensive viability, good tissue penetration, efficiency, and good spatial and density resolution (Khademi et al., 2018). As a non-invasive diagnostic tool, CT provides 3-dimensional anatomical information of tissues and organs (Dong et al., 2019). CT scans are the gold standard reference for detecting bone damage, including bone erosion, new bone formation, calcification, bone erosion, new bone formation, calcification and sclerosis (Østergaard & Boesen, 2019). CT can help doctors diagnose and track diseases that occur in parts of the human body (Aslan, Ceylan, Koç, & Findik, 2020).

The development of CT technology increases the rotational speed of the gantry, adds more rows to the detector panel, and improves the performance of the x-ray tube, which provides higher spatial resolution, lower image noise, and improved multi-energy capabilities and algorithm engines for image preprocessing (Speed et al., 2020). Computed tomography obtains two-dimensional (2D) radiographic images of objects viewed from various directions. The calculated reconstruction algorithm is then used to create a stack of cross-sectional slices from 2D radiographic projections of the object (Withers et al., 2021). By applying segmentation algorithms, for example, by setting a threshold grey value, air can be separated from solid materials, and information about internal porosity can be extracted (Hermanek & Carmignato, 2017). The CT reconstruction algorithm is that x-rays are absorbed by matter according to the Beer-Lambert Law, which relates the intensity of the x-rays emerging from the sample to the intensity of the incident x-ray beam (Brisard et al., 2020). The development of computed tomography (CT) reconstruction algorithms continues to be active in academia and industry. This improves CT examinations at lower radiation doses while maintaining acceptable image quality (Solomon, Lyu, Marin, & Samei, 2020).

Computed tomography displays 2-dimensional and 3-dimensional sections of the human body by determining the x-ray attenuation coefficient for each pixel. However, patients with metal implants may not receive the benefits of CT scans due to their quality (Park, Choi, & Seo, 2017). The reduction in image quality caused by metal can make it difficult or even impossible to evaluate the interface between the implant and adjacent bone or soft tissue (Bolstad, Flatabø, Aadnevik, Dalehaug, & Vetti, 2018). Image quality can be determined by selecting appropriate input parameters before scanning, such as tube current, tube voltage, rotation time, *pitch*, reconstruction type, and reconstruction filter (Anam, Naufal, Sutanto, Adi, & Dougherty, 2022). *Computed tomography (CT)* image quality decreases in patients with metallic materials known as metallic artefacts. These artefacts hinder or even prevent radiologists from evaluating the interface between metallic materials and adjacent tissue (Greffier et al., 2019).

Metal-related artefacts have limited the diagnostic value of computed tomography (CT) images. Artefacts caused by metal implants, such as dental fillings, surgical clips, coils, wires, and orthopaedic hardware, appear as light and dark streaks on reconstruction images (Katsura, Sato, Akahane, Kunimatsu, & Abe, 2018). Dental fillings or implants in the oral cavity are often present in patients with head and neck cancer and cause a decrease in image quality (Rousselle et al., 2020). Research results from Felix Feldhaus (2019) show that objective image quality indicators are significantly different for CT images reconstructed using *Smart* MAR in addition to standard (iterative) reconstruction. Attenuation and Standard Deviation of the tumour and adjacent soft tissue (as a potential correlation for reducing artefacts and *noise*) are reduced; additionally, we found lower SD values for air rounding as an indicator of reduced background noise (approximately 30% reduction) (Feldhaus et al., 2019). The severity of metal artefacts on CT depends on the atomic number, shape, and size of the metal implant. Larger implants and metals with higher atomic numbers produce more significant metal artefacts (Kohyama, Yoshii, Okamoto, & Nakajima, 2022).

In CT scans, severe artefacts are produced if metal implants are present. The extent of artefacts depends on the size, shape, and density of the metal object. This phenomenon can reduce image quality and even affect image interpretation and diagnosis. Metal artefact reduction (MAR) techniques can effectively reduce artefacts caused by metal implants (Chou et al., 2020). Six main groups of MAR techniques: Metal Implant Optimization, Enhancement Acquisition, Physics-based

PreprocessingPreprocessing, Projection Completion, Iterative Reconstruction, and Image Post-processing (Gjesteby et al., 2016).

Iterative techniques Metal artefact reduction (MAR) in CT can be achieved with different approaches, including beam hardening correction, segmentation with interpolation, or dual-energy CT (Aissa et al., 2017). MAR algorithms used in image processing aim to reduce or eliminate artefacts, improving image quality (Nascimento et al., 2021). The MAR algorithm aims to interpolate missing projection data using neighbouring data by replacing damaged data from the nearest slice information (Peng et al., 2017). In research conducted by Ohira S (2018), Metal artefact reduction software (MARS) (GE et al., Milwaukee, Wis) uses information from spectral energy data that shows a reduction in beam hardening effects. MARS software uses information from spectral energy data that shows reduced beam hardening artefacts to segment detector regions, which indicate photon starvation. Reduction in metallic tooth artefacts and improvement in image quality in the buccal and tongue regions using MARS (Ohira et al., 2018). Research conducted by Daniel Troeltzsch (2021) states that more advanced CT technology includes iterative reconstruction (IR) for lower radiation exposure and metal artefact reduction (MAR) techniques. Therefore, the use of iterative reconstruction and MAR SEMAR (Canon et al.), IR and MAR are easy to implement in routine clinical settings and improve image evaluation by reducing artefacts and image noise while decreasing radiation exposure (Troeltzsch et al., 2021).

Adaptive statistical iterative reconstruction-V (ASIR-V) and Veo. The ASIR algorithm works on sinogram data with statistical modelling of photons and some noise-related properties of the scanned object. It can be used with different levels of FBP-ASIR mixing (Barca et al., 2021). ASIR-V iterative reconstruction is an updated version of vendor-specific hybrid IR that requires a less complex model than MBIR that de-emphasizes the system optics, enabling much faster image reconstruction .In research, he compared the image quality of the results of iterative reconstruction of FBP, ASIR (80%), Veo 3.0, and ASIR-V (30%, 60%, 90%), ASIR-V Series 30% and ASIR 60% provides the best combination of qualitative and quantitative, the ASIR-V Series has been shown to reduce noise and improve image quality demonstrating improved contrast to *noise* ratio (CNR) and spatial resolution in demonstrating the potential for additional radiation dose reduction (Martin et al., 2017). The ASIR-V IR algorithm uses a probabilistic method, deriving a statistical cost function by combining X-ray physics modelling and computed tomography (CT) optics and computed tomography (CT) optical modelling to reduce noise and artefacts (Greffier et al., 2019).

Head CT Scan examination, the patient's position is adjusted with the head made comfortable, entering the head first on the *dressing* for most standard head CT protocols, sometimes can also be used for neck protocols. When the head mount is not used, a moulded sponge is placed directly on the scanning table, and the patient's head is positioned within the sponge. In all cases, the patient should be made as comfortable as possible and restrained as effectively as possible to prevent motion artefacts on the images. In the head examination, *helical* CT is used primarily for the purpose of producing three-dimensional reformation or to minimize motion-related artefacts. A neck examination is usually performed with the patient supine and the neck slightly extended. Most often performed in a *helical mode*, the patient should be instructed to lower the shoulders as much as possible, which lowers the image in the lower neck to reduce artefacts (Romans, 2018).

Researchers made observations at the radiology installation at the Tangerang District Hospital, with CT scan data ranging from 350 to 400 per month. After searching, there were metal objects on the patient's body in the form of metal plates, false teeth, braces and drill bits, amounting to 5% of the total examination. The metal objects that appear most often are braces and dentures, which most disturb the CT scan image in the oral cavity area. RSUD KAB Tangerang has a GE 128 *slice* CT Scan tool which has metal artefact reduction (MAR) software and *adaptive statistical iterative reconstruction V* (ASIR-V), which can reduce noise and improve image quality, showing an increase in contrast-to-*noise ratio* (CNR) and spatial resolution. In practice, the use of MAR is rarely used because the CT scan equipment at Tangerang District Hospital is still relatively new, and the available parameters only activate MAR for some scanning examinations.

The use of ASIR–V can basically reduce patient dose, reduce image noise, and improve image quality and spatial resolution. Basically, the ASIR-V value starts from 0% to 100%. In practice, the use of ASIR-V varies depending on the object being examined. After the researchers conducted a study of several previous studies, such as those conducted by research using a *Spatial Filter*, the organ studied was the abdomen, using *slice thicknesses of* 5 mm and 10 mm. Researchers tested all MAR products from the Manufacturer and combined them with DECT devices. The organs studied *are musculoskeletal.* Filter *unsharp mask* on CT and uses mAS variations, slice thickness of 2.5 and 1.5 mm. The organ studied is the facial bones. Filters on *the Matlab platform.* All simulations were carried out for the same image from a resolution of 1024 X 768 pixels to a *grayscale image*—Jaju Prashant (2013) Cone beam *computed tomography* (CBCT) of the *oral maxillofacial organs*. No one has yet performed a CT scan of the head and neck using MAR and ASIR-V.

After identifying the above problems, the researcher became interested in conducting research on the *Metal Artifact Reduction* and *Reconstruction Method of adaptive statistical iterative* V (ASIR-V) in reducing the image of metal artefacts in CT scan images of the head and neck at the Tangerang District Hospital.

This study aims to prove that there is a reduction in image artefacts containing metal and optimization of CT scan image quality after applying *Metal Artifact Reduction and Reconstruction Iterative Statistical Adaptive* V (ASIR-V) 30%, 60%, 90% Head and Neck CT Scan Examination and knowing the differences in image quality in image quality containing metal artefacts in CT scan images of the head and neck before and after the application of *Metal Artifact Reduction and Reconstruction Iterative Statistical Adaptive* V (ASIR-V) 30%, 60%, 90%. Knowing the differences in anatomical information in images containing metal artefacts in CT scan images of the head and neck before and after the application of *Metal Artifact Reduction and Reconstruction Iterative Statistical Adaptive* V (ASIR-V) 30%, 60%, 90%. Determining the optimal image for images containing metal artefacts in CT scan images of the head and neck after applying *Metal Artifact Reduction and Reconstruction iterative adaptive statistical* V (ASIR-V) 30%, 60%, and 90%. Produce a design for operational procedures for using *Metal Artifact Reduction and Reconstruction Iterative Adaptive Statistics* V (ASIR-V) in hospitals.

The benefit of this research is to increase the author's and reader's insight and knowledge regarding the use of *Metal Artifact Reduction and Reconstruction Iterative Adaptive Statistics* V (ASIR-V) in hospitals. Can assist Radiographers in designing operational procedures for *Metal Artifact Reduction and Reconstruction iterative adaptive statistical* V (ASIR-V) in clinical head and neck examinations to produce more optimal and helpful information for hospital services.

The main goal of this research is to develop methods or techniques that can significantly reduce metal artifacts in medical images. This will help improve the quality of the image and make the diagnosis more accurate.

METHOD

Method of Metal Artifact Reduction and Reconstruction Iterative Statistical Adaptive V (ASIR-V) at RSUD KAB Tangerang. In this research, this research was carried out by administering MAR and three variations of ASIR V. 30%, 60%, and 90% of the resulting images were compared with the before and after images. Using MAR and ASIR V. The population of this study was all head and neck CT scan images with metal artefacts. Image measurements were carried out before using MAR and ASIR-V and after using MAR and ASIR-V. The number of samples that will be used is 15 images in one group. The independent variables in this research are the application of MAR and ASIR V 30%,60 %, and 90%. The dependent variables in the study included metal artefacts and head and neck image information. Confounding variables in the study include Exposure factor, FOV, Picth, Scan Mode, CT Scan anatomical image information, and matrix size.

RESULTS AND DISCUSSION

Univariate Analysis

Data characteristics of patients who underwent MAR and ASIR-V testing are included in the table below.

Table 1 Patient age distribution

Age	*Frequency*	*Percentage*
< 20 Years	2	13.3
20 – 40 Years	5	33.3
< 40 Years	8	53.3
Total	15	100%

Table 1 shows that the frequency of 13.3 % of patients in the range <20 years and the frequency of patients in the age range 20 - 40 years is 33.3%, while for those aged <40 years, the percentage is 53.3%.

Bivariate Analysis

Bivariate analysis was carried out to test the differences in SNR, CNR values and anatomical information on images containing metal artefacts on CT-Scan images of the head and neck between each treatment group before and after the use of MAR and ASIR-V 30%, MAR and ASIR-V 60%, MAR and ASIR-V 90%. Before bivariate testing, a test was first carried out using Shapiro-Wilk.

1. Difference in SNR values
   The difference in SNR values in CT scan images of the head and neck containing metal artefacts before and after using MAR and variations in ASIR-V is shown in Figure 1 below.

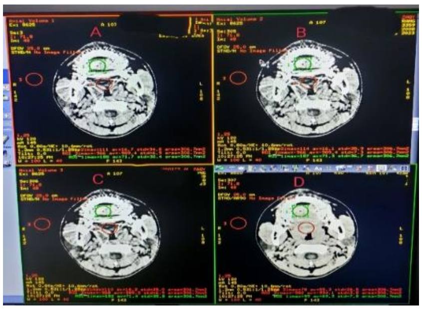

Figure 1 CT Scan image before and after use of MAR+ASIR-V. Image A is the image before using MAR+ASIR-V, Image B is MAR and ASIR-V 30%, Image C is MAR+ASIR 60%, Image D is MAR+ASIR V 90%.

The difference in SNR values before and after using MAR and ASIR-V.

Table 2 Differences in SNR before and after application of MAR and ASIR-V variations The image shows metal artefacts in the head and neck area.

CT scan image of the head and neck	SNR value			
	Pre	MAR + ASIR V 30%	MAR + ASIR V 60%	MAR + ASIR V 90%
Data 1	3.77	4.23	4.75	5.28
Data 2	1.94	1.83	1.96	1.96
Data 3	0.84	1.09	1.09	1.09
Data 4	1.63	1.73	1.85	1.96
Data 5	1.4	1.35	1.39	1.44
Data 6	1,2	1.16	1.21	1.28
Data 7	1.96	1.94	1.98	8.88
Data 8	1.02	2.97	3.07	3.16
Data 9	1.39	2.20	2.29	2.38
Data 10	3.38	3.33	3.52	3.86
Data 11	1.57	1.87	1.57	1.92
Data 12	2.14	3.06	3.39	3.37
Data 13	1.27	2.58	2.69	310
Data 14	1.27	2.11	2.23	2.56
Data 15	2.21	2.42	2.43	3.22

The data normality test is used to determine whether the data is normally distributed (p-value>0.05) if the data is not normally distributed (p-value <0.05).

Table 3 Normality test of SNR data

Image	Shapiro-Wilk		
	Statistics	df	Sig.
Pre	,945	15	,453
SNR 30%	,953	15	,565
SNR 60%	,983	15	,985
SNR 90%	,305	15	,000

The results from the output table of the data normality test the significance value before using MAR, AND ASIR-V is .453; for the 30% SNR value, the significance value is .565, and the 90% SNR value is .000, so the P value is <0.05, the data is not normally distributed.

Tests to assess differences in SNR values of images containing metal artefacts on CT scans of the head and neck between each treatment group before and after applying MAR and variations of ASIR-V were carried out using the Shapiro-Wilk test and the Wilcoxon test.

Table 4. Differences between analysts in SNR values for each image after processing application of MAR and ASIR-V

No	Image	*Mean*	Standard Deviation	*Shapiro Wilk's* P value	*Wilcoxon significance*	Percentage increase
1	Pre	1.56	,729	,453		
2	MAR+ ASIR-V 30%	2.25	,864	,565	,012	0.44%
3	MAR+ ASIR-V 60%	2.27	1,134	,985	,009	0.45%
4	MAR+ASIR-V 90%	23.39	79.31	,000	,005	13.99%

The output table shows that the average SNR for the image before using MAR and ASIR-V is 1.56, with a standard deviation value of 0.729. In contrast, the output average SNR value for the image using MAR+ASIR-V is 30%, the average value is 2, 25 with a standard deviation value of

0.864 for a P value of *0.565* for a *Wilcoxon significance value* of 0.12, there was a percentage increase in the SNR value of 0.44% after using MAR+ASIR-V 30%, while the average value of the image SNR using MAR+ASIR-V 60% is 2.27 with a standard deviation value of 1.134 for The P *value* is 0.985 for the results of the Wilcoxon significance of 0.012, there is a percentage increase in the SNR value of 0.45% from before using MA +ASIR-V, while the average value of MAR+ASIR-V 90% is 23.39 with a standard deviation value of 79 .31 for a P value of *.000, the Wilcoxon significance* value is 0.005, there is a percentage increase in the SNR value of 13.99% of the image before using MAR+ ASIR-V. The *Wicoxon significance* P value is 0.012 0.009 0.005, and this value is smaller than 0.005 (p=0.000<0.05), so Ho is accepted. The conclusion is that there is a significant difference between images before and after using ASIR-V.

2. Difference in CNR values

   The CNR value of each CT-Scan image of the head and neck containing artefacts before and after variations in the use of MAR and variations in ASIR-V.

Table 5 Differences in CNR before and after application of MAR and ASIR-V variations The image shows metal artefacts in the head and neck area.

CT scan image of the head and neck	CNR value			
	Pre	MAR + ASIR V 30%	MAR + ASIR V 60%	MAR + ASIR V 90%
Data 1	6.36	4.94	6.12	7.11
Data 2	7.2	2.29	2,4	2,4
Data 3	44.3	31.96	33.9	37.6
Data 4	5,6	6.75	7.92	9.15
Data 5	4.87	3,2	3.61	3.89
Data 6	11.81	2.67	3.19	3.79
Data 7	7.9	7.56	8	3.6
Data 8	3.24	6.84	6.94	7.70
Data 9	3.06	3.02	3.10	3.28
Data 10	2.6	2.42	2.62	2.82
Data 11	11.14	10.42	13,14	12.07
Data 12	4.04	3.17	3.70	4.37
Data 13	4.72	5.21	5.33	6.20
Data 14	4.14	5.55	5.80	7.85
Data 15	5.01	5.23	5.40	6,10

The data normality test is used to determine whether the data is normally distributed (p-value>0.05) and if the data is not normally distributed (p-value <0.05).

Table 6 CNR data normality test

Image	Shapiro-Wilk		
	Statistics	df	Sig.
before	,515	15	,000
CNR30%	,561	15	,000
CNR60%	,588	15	,000
CNR90%	,565	15	,000

output results of the data normality test before using MAR and ASIR- V .000 for CNR 30% were .000 for CNR 60% were .000 and CNR 90% were .000 P value < 0.05 the data was not normally distributed.

Tests to assess differences in CNR values of images containing metal artefacts on CT scans of the head and neck between each treatment group before and after applying MAR and ASIR-V variations were carried out using the Shapiro-Wilk test and the *Wilcoxon* test.

Table 7 Differences in CNR analysis before and after application of MAR and ASIR-V variations on images containing metal artefacts in the head and neck area.

No	Image	*Mean*	Standard Deviation	*Shapiro Wilk's P value*	*Wilcoxon significance*	Percentage reduction
1	pre	8,399	10,299	,000		
2	MAR+ ASIR-V 30%	6,748	7,337	,000	,191	0.196%
3	MAR+ ASIR-V 60%	7,411	7,840	,000	,955	0.117%
4	MAR+ASIR-V 90%	7,862	8,656	,000	,955	0.0639%

The output table shows that the average CNR for the image before using MAR and ASIR-V is 8.399, with a standard deviation value of 10.299. In contrast, the output average CNR value for the image using MAR+ASIR-V is 30%. The average value is 6.748 with a value of standard deviation of 7.337 for a P value *of* 0.000 for a percentage decrease in CNR value of 0.196% after using MAR+ASIR-V 30%, while the average value of CNR images using MAR+ASIR-V 60% is 7.411 with a standard deviation value of 7.840 for a P value *of 0.000 for a Wilcoxon significance* result of 0.955, there was a percentage decrease in the CNR value of 0.117% after using MA +ASIR-V, while the average value of MAR+ASIR-V 90% was 7.862 with a standard deviation value of 8.656 for the P value .000, the value of *the Wilcoxon significance* is 0.955, there is a percentage decrease in the CNR value of 0.0639% of the image before using MAR+ ASIR-V. The *Wicoxon significance* P value is 0.191 0.955 0.955, and this value is more significant than 0.005 ($p=0.000<0.05$), so Ho is rejected. Conclusion: There is no significant difference between images before using MAR+ASIR-V and after using ASIR-V.

3. Difference between SNR and CNR values

The differences in SNR and CNR values are shown in Table 5.

Table 8 Differences in CNR and SNR analysis after the application of MAR Moreover, ASIR-V variations in images containing metal artefacts in the head and neck area.

CT scan image	SNR MAR+ASIRV 30%	SNR MAR + ASIR V 60%	SNR MAR+ASIRV 90%	CNR MAR+ASIR V 30%	CNR MAR+ASIRV 60%	CNR MAR+ASIRV 90%
Data 1	4.23	4.75	5.28	4.94	6.12	7.11
Data 2	1.83	1.96	1.96	2.29	2,4	2,4
Data 3	1.09	1.09	1.09	31.96	33.9	37.6
Data 4	1.73	1.85	1.96	6.75	7.92	9.15
Data 5	1.35	1.39	1.44	3,2	3.61	3.89
Data 6	1.16	1.21	1.28	2.67	3.19	3.79
Data 7	1.94	1.98	8.88	7.56	8	3.6
Data 8	2.97	3.07	3.16	6.84	6.94	7.70
Data 9	2.20	2.29	2.38	3.02	3.10	3.28
Data 10	3.33	3.52	3.86	2.42	2.62	2.82
Data 11	1.87	1.57	1.92	10.42	13,14	12.07
Data 12	3.06	3.39	3.73	3.17	3.70	4.37
Data 13	2.58	2.58	3.10	5.21	5.33	6.20
Data 14	2.11	2.23	2.56	5.55	5.80	7.85
Data 15	2.42	2.43	3.22	5.23	5.40	6,10

Wilcoxon test was carried out to assess differences in the SNR and CNR values of images containing metal artefacts on CT scans of the head and neck between each treatment group after MAR and ASIR-V variations were applied.

Table 9 Differences in CNR and SNR analysis after application of MAR and variations ASIR-V on images that contain metal artefacts in the head and neck area.

Group	*Mean*	Amount of data	Standard deviation	*SigWilcoxon*
SNR 30%	2,258	15	,864	,002
CNR 30%	6,748	15	7,337	,002
SNR 60%	2,354	15	,991	,001
CNR 60%	7,411	15	7.84	,001
SNR 90%	3,054	15	1.96	,011
CNR 90%	7,862	15	2.40	,011

Table 6 output results obtained an average SNR MAR+ ASIR-V 30% with a value of 2.258 standard deviation 0.864 value of Wilcoxon *significance* 0.02 compared to the average value of CNR MAR+ ASIR-V 30% with a value of 6.748 value standard deviation 7.337 value of *Wilcoxon significance* 0.002. The output result is an average SNR MAR+ ASIR-V 60% with a value of 2.354, a standard deviation value of 0.991, a result of a *Wilcoxon* significance of 0.001 compared to an average CNR MAR+ ASIR-V 60% value of 7.411, a standard deviation of 7.84, a result of *a Wilcoxon significance* of 0.001. The output results obtained were an average SNR MAR+ ASIR-V of 90% with a value of 3.054 standard deviation 1.96, a result of *Wilcoxon significance* of 0.011 compared to an average value of CNR MAR+ ASIR-V 90% with a value of 7.862 standard deviation of 2.40 value of significance. *Wilcoxon* 0.011 The value of the P *value of Wicoxon significance* is 0.002 0.002 0.001 0.001 0.011 0.011. This value is smaller than 0.005 ($p=0.000<0.05$), so Ho is accepted. The conclusion is that there is a significant difference between the SNR and CNR values after using MAR and ASIR-V.

4. Anatomical Information Discrepancy Analysis

   Analysis of differences in anatomical information assessed by radiologist respondents by comparing images before and after using MAR+ ASIR-V can be seen in the image below.

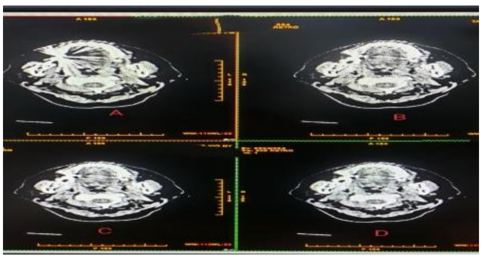

Figure 2 Assessment of differences in information from images containing image artefacts A (Pre), B (MAR+ASIR-V30%), C (MAR+ASIR-V 60%), D (MAR+ASIR-V 90%).

The results of Figure 2 show an illustration of the improvement in the information value of images containing artefacts after using MAR+ASIR-V. This can be proven by the increase in information value in images containing metal artefacts. The image displayed in image A before using MAR+ASIR-V contains artefacts which significantly interfere with the assessment of anatomical image information. In image B, there is a difference in the value of the image information, which still needs to be optimal; in image C, there is a clear difference from before using MAR+ASIR-V. Figure

D shows that optimal image quality can be demonstrated by reducing metal streaks and increasing SNR values.

a. Validity and Reliability Test of the questionnaire

The validity test is used to determine the suitability of the questionnaire used by researchers in measuring and obtaining research data from respondents.

Table 10 Validity test for respondent A

Image	*Siq*
Pre	0.005
MAR+ ASIR-V 30%	0.005
MAR+ ASIR-V 60%	0,000
MAR+ASIR-V 90%	0.001

The results of the validity test *output* for respondent A on the image before using MAR+ASIR-V, the signification value was 0.005, while on the MAR+ASIR-V image 30% the signification value was 0.005 on the MAR+ASIR-V image 60% signification value was 0.000 for the MAR image +ASIR-V 90% signification value is 0.001, overall the P *value* is <0.005, so the data is said to be valid.

The data reliability test is used to see whether the questionnaire has consistency if measurements are carried out using the questionnaire repeatedly.

Table 11 Reliability test for Respondent A

Cronbach's Alpha	*N of Items*
,728	4

The reliability test results show an N value of 4; if *Cronbach's Alpha value is > 0.6*, then it can be said to be reliable.

Table 12 Validity test for Respondent B

Image	*Siq*
Pre	0.002
MAR+ ASIR-V 30%	0.034
MAR+ ASIR-V 60%	0,000
MAR+ASIR-V 90%	0.005

The results of the validity test *output* for respondent B on the image before using MAR+ASIR-V, the signification value was 0.002, while on the MAR+ASIR-V 30% image, the signification value was 0.034 on the MAR+ASIR-V 60% signification image, the signification value was 0.000 for the MAR image +ASIR-V 90% signification value is 0.005, overall the P *value* is <0.005, so the data is said to be valid.

Table 13 Reliability test for Respondent B

Cronbach's Alpha	*N of Items*
,652	4

The reliability test results show an N value of 4; if *Cronbach's Alpha value is > 0.6*, then it can be said to be reliable.

b. Analysis between Respondents

Analysis between respondents was carried out on the results of assessing anatomical information on images containing metal artefacts. CT-Scan head and neck image samples were assessed by two radiology specialists with more than seven years of experience in the field of CT-Scan. The results of the assessment were carried out using the *kappa test* and are shown in Table 7.

Tabel 14 *Kappa* test for assessing information on head CT scan images and a neck containing metal artefacts

NO	Head and Neck Image	Level of Agreement		Amount	Information
		Respondent A	Respondent B		
1	Citra Pre	,000	,000	15	Not good
2	MAR and ASIR V 30 images	,000	,031	15	Not good
3	MAR and ASIR V 60 images	,111	,154	15	Pretty good
4	MAR and ASIR V 90 images	,000	,000	15	Good

The results of the Kappa test on the assessment of information on CT-Scan images of the head and neck containing metal artefacts were obtained by respondents A and B for pre-0.000 and 0.000 images. This shows that there is sufficient conformity in providing answers between respondents.

c. Analysis of differences in anatomical information before and after application of MAR and ASIR-V variations

Analysis of differences in anatomical information was carried out on the results of assessing anatomical information on images containing metal artefacts. CT-Scan head and neck image samples were assessed by two radiology specialists with more than seven years of experience in the field of CT-Scan—evaluation of image data assessed by respondents with the identity of the patient disguised. The results of the image assessment were analyzed; Table 7 shows the results of the anatomical information assessment by respondents.

Table 15 Differences in the value of anatomical information on CT-Scan images of the head and neck containing metal artefacts

NO	Level of Metal Artifact Disruption to Organ Anatomy	Image *slice thickness* 1.25 mm Image to -														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Image of the tongue area before MAR and ASIR-V	1	2	1	1	2	1	1	1	2	2	1	1	2	1	2
2	Tongue area image MAR and ASIR-V 30%	2	3	2	2	3	2	1	2	2	2	2	3	2	2	2
3	Tongue region image MAR and ASIR-V 60%	2	3	3	2	3	3	2	2	2	3	2	3	3	3	3
4	Tongue area image MAR and ASIR-V 90%	4	5	4	3	4	4	4	3	3	4	4	4	4	4	5

Table 16 Differences in the value of anatomical information on CT-Scan images of the head and neck containing metal artefacts

NO	Level of Metal Artifact Disruption to Organ Anatomy	Image *slice thickness* 1.25 mm Image to -														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Image of the tongue area before MAR and ASIR-V	1	2	1	2	2	1	1	1	1	2	2	1	1	1	1
2	Tongue area image MAR and ASIR-V 30%	2	3	2	2	2	3	1	2	2	2	3	2	2	2	2

3	Tongue region image MAR and ASIR-V 60%	3	3	2	3	3	3	2	2	2	3	3	3	2	2	3
4	Tongue area image MAR and ASIR-V 90%	4	5	3	3	5	4	5	4	3	5	4	5	3	4	4

Tests to assess differences in the value of anatomical information on images containing metal artefacts on CT scans of the head and neck between each treatment group before and after applying MAR and variations of ASIR-V were carried out using the Wilcoxon test.

Table 17 *Wilcoxon* test assessing anatomical information on CT scan images of the head and neck containing metal artefacts

	Image	*Mean*	Standard deviation	*Sig Wilcoxon*	percentage
1	Pre	1.5600	,729		
2	MAR +ASIR V 30%	2,258	,864	0.002	0.44%
3	MAR +ASIR V 60%	2,354	,991	0.003	0.508%
4	MAR + WATER V 90%	23,393	79,312	0.005	13.99%

Wilcoxon test for assessing anatomical information on CT scan images of the head and neck containing metal artefacts was obtained for the pre-image, an average value of 1.56 with a standard deviation of 0.729. Meanwhile, the average MAR+ASIR-V 30% output is 2.258 with a standard deviation value of 0.864, a value of *Wilcoxon significance* of 0.002, and a percentage increase of 0.44. Meanwhile, for MAR+ASIR-V 60%, the average value is 2.354 with a standard deviation of 0.991, the value of the *Wilcoxon significance* is 0.003, and there is a percentage increase of 0.508%. Meanwhile, for MAR+ASIR-V 90%, the average value is 23.393 with a standard deviation value of 79.312, the *WLcoxon significance value* is 0.005 with a percentage increase of 13.99, so the average value can be concluded that there is an increase in the value of information after using MAR+ASIR-V. *The output* of *Wilcoxon significance* is 0.002 0.003 0.005. This value is smaller than 0.05 ($p=0.000<0.05$), so Ho is accepted. The conclusion is that there is a significant difference between the value of anatomical information before and after reduction with MAR+ASIR-V.

d. Analysis of Determining the Best Anatomical Information Image After Application of MAR and Variations of ASIR-V
   Friedman test analysis was carried out to test the difference in the increase in the value of anatomical information on CT-Scan images of the head and neck, which contained metal artefacts. The images assessed were after treatment with MAR and ASIR-V at 30%, MAR and ASIR-V at 60%, and MAR and ASIR-V at 90%.

Table 18 Test results *Friedman* assessment of anatomical information on head CT scan images and a neck containing metal artefacts

NO	Head and Neck Image	*Mean Rank*		Amount	*sig*
		Respondent B	Respondent A		
1	Citra Pre	1.13	1.20	15	,000
2	MAR and ASIR V 30 images	2.13	2.10	15	,000
3	MAR and ASIR V 60 images	2.77	2.70	15	,000
4	MAR and ASIR V 90 images	3.97	4.00	15	,000

The results of the Friedman test show that the mean rank output table from the reading results of respondent A and respondent B shows that the use of MAR+ASIR-V has increased as shown by the Mean Rank value for using MAR+ASIR-V 30%, the value is 1.13 - 1.20 in MAR+ASIR-V image 60% Mean Rank value of 2.13 22.10 on MAR+ASIR-V image 90% Mean Rank value of 3.97 4.00

with a significance value of .000 on all images after using MAR=ASIR -V. The conclusion is that if the sig value <0.05 Ho is accepted, there is a difference in increasing the use of MAR+ASIR-V in reducing metal artefact interference.

Wilcoxon test analysis was carried out to test differences in the value of anatomical information on CT-Scan images of the head and neck containing metal artefacts. The images assessed were after treatment with MAR and ASIR-V at 30%, MAR and ASIR-V at 60%, and MAR and ASIR-V at 90%.

Table 19 *Wilcoxon* test results (*post hoc*) on 3 CT scan images of the head and neck about the best anatomical information

No	Image	*Mean*	Standard deviation	*sig*
1	MAR+ASIR-V 30%	2,258	,864	0.001
2	MAR+ASIR-V 60%	2,354	,991	0.001
3	MAR+ASIR-V 90%	3,054	1,964	0.001

output results regarding the value of anatomical information are as follows: MAR+ASIR-V 30% average value 2.258 with a standard deviation of 0.864 while MAR+ASIR-V 60% average value 2.354 standard deviation value 0.991 while MAR+ASIR-V 90% average value is 3.054 with a standard deviation of 1.964 so it can be concluded that the 90% MAR+ASIR-V image is the best.

5. Analysis of the Level of Metal Artifact Interference on Head and Neck CT Scan Images
   The results of using MAR+ASIR-V can be shown in the image below.

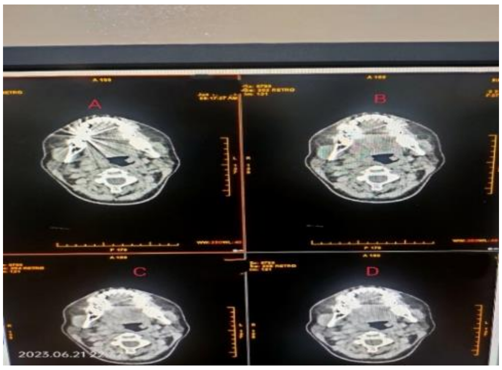

Figure 3 Assessment of the level of artefact interference on image A (Pre), B (MAR+ASIR-V30%), C (MAR+ASIR-V 60%), D (MAR+ASIR-V 90%).

The results of image 3 show an overview of the changes that occur after using MAR+ASIR-V, a gradual reduction in the metal artefact beams displayed; in image A, before using MAR+ASIR-V, there are artefact beams that interfere with the CT Scan image. Image B shows the reduction in metal beams, which is still disturbing; image C has begun to reduce the metal beams in the CT scan image. Figure D shows that the optimal reduction in the metal beam can be demonstrated by repairing images damaged by metal artefacts.

Analysis of differences in levels of metal artefact interference on images was carried out on the results of metal artefact interference in images containing metal artefacts. CT-Scan head and neck image samples were assessed by two radiology specialists with more than seven years of experience in the field of CT-Scan. Evaluation of image data assessed by respondents disguised the patient's identity. The results of the image assessment were analyzed; Table 12 shows the results of the level of metal artefact interference by respondents.

Table 20 Results of levels of metal artefact disturbance by respondents.

No	Level of Metal Artifact Interference with the Image	Image *slice thickness* 1.25 mm Image to - 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Citra Pre	2	2	1	1	2	1	1	1	1	2	1	1	2	1	2
2	MAR+ASIR-V 30%	2	2	2	1	3	2	1	2	2	2	2	2	2	2	2
3	MAR+ASIR-V 60%	2	3	2	2	3	3	1	2	2	2	2	3	3	3	3
4	MAR+ ASIR-V 90%	3	4	3	3	4	4	4	3	3	3	3	3	3	4	4

Table 21 Results of levels of metal artefact disturbance by respondents.

No	Level of Metal Artifact Interference with the Image	Image *slice thickness* 1.25 mm Image to - 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Citra Pre	2	2	1	2	2	1	1	2	1	2	1	1	1	2	1
2	MAR+ASIR-V 30%	2	3	2	2	2	2	1	2	1	2	2	2	2	2	2
3	MAR+ASIR-V 60%	2	3	3	3	3	2	2	3	2	3	2	3	3	3	3
4	MAR+ASIR-V 90%	3	4	4	3	4	4	4	3	2	4	3	4	3	4	3

Tests to assess differences in the level of increase in artefact interference in images containing metal artefacts on CT scans of the head and neck between each treatment group before and after MAR and variations of ASIR-V were applied and were carried out using *Friedman*.

Tabel 22 *Friedman test for* optimal increase versus reduction artefact interference in the image

No	Head and Neck Image	*Mean Rank* Respondent B	Respondent A	Amount	sig
1	Citra Pre	1.30	1.33	15	,000
2	Image of MAR+ASIR V 30	1.87	2.03	15	,000
3	Image of MAR+ASIR V 60	3.03	2.70	15	,000
4	Image of MAR+ASIR V 90	3.80	3.93	15	,000

The results of the Friedman test show that the Mean Rank output table shows that the use of MAR+ASIR-V before and after shows the value of respondent A and respondent B's assessment of the level of metal artefact interference on the image with the value of the image before MAR+ASIR-V being 1, 30 1.33 on MAR+ASIR-V image 30% value 1.87 2.03 on MAR+ASIR-V image 60% value 3.03 2.70 90% value 3.80 3.93 value on Friedman significance shows .000 on all images both before and after the application of MAR+ASIR-V. The conclusion is that if the sig value <0.005 Ho is accepted, there is a difference in increasing the use of MAR+ASIR-V in reducing metal artefact interference.

A test to assess the level of differences in image interference with metal artefacts on CT scans of the head and neck between each treatment group before and after applying MAR and ASIR-V variations was carried out using the Wilcoxon test.

Table 23 Different levels of metal artefact interference in images containing artefacts metal after applying MAR and ASIR-V.

No	Head and Neck Image	*Mean* Respondent B	Respondent A	Amount	*sig*
1	Citra Pre	1.4667	1.4000	15	0.005
2	MAR and ASIR V 30 images	1.9333	1.9333	15	0.001
3	MAR and ASIR V 60 images	2.6667	2,4000	15	0,000
4	MAR and ASIR V 90 images	3,4000	3,4000	15	0,000

The results of the Wilcoxon test showed that the Mean output table shows that the use of MAR+ASIR-V before and after shows the value of respondent B and respondent A's assessment of the level of metal artefact interference in the image with the value for the image before MAR+ASIR-V being 1.4667. 30%, the value is 1.9333 1.9333 on the MAR+ASIR-V image 60%, the value is 2.6667 2.4000 on the MAR+ASIR-V image 90% the value is 3.4000 3.4000 value The significance shows .005 0.001 0.000 0.000 on all images both before and after the application of MAR+ASIR-V. The conclusion is that if the sig value <0.005 Ho is accepted, there is a significant difference in the use of MAR+ASIR-V in reducing metal artefact interference.

Table 24 Test *Wilcoxon (post hoc)* to see differences in levels of interference artefacts on the image.

No	Image	*Mean*	*Standard deviation*	*Sig Wilcoxon*	amount
1	Pre	1.4000	,50709		15
2	MAR +ASIR V 30%	1.9333	,45774	,002	15
3	MAR +ASIR V 60%	2,4000	,63246	,001	15
4	MAR + WATER V 90%	3,4000	,50709	,001	15

output results regarding metal artefact interference with the image are as follows: MAR+ASIR-V 30% average value 1.4000 with a standard deviation of .50709 while MAR+ASIR-V 60% average value 1.9333 standard deviation *value* .45774 while MAR+ASIR-V 90% has an average value of 3.4000 with *a standard deviation* of .50709 so it can be concluded that the MAR+ASIR-V 90% image is the best.

Univariate Analysis

The age characteristics of patients who had metal artefacts with the highest percentage were over 40 years. 53.3% of the artefacts came from dental fillings or false teeth, and the minor age was less than 20 years, with 13.3% having dental fillings.

Bivariate Analysis

Differences in SNR values in CT scan images of the head and neck containing metal artefacts before and after using MAR and ASIR-V

Measurement of the SNR value on CT scan images of the head and neck containing metal artefacts before and after using MAR and ASIR-V 30%, MAR and ASIR-V 60% and MAR ASIR-V 90%. The first step is to test the normality of the data before testing the difference in SNR values. Because numerical data is used, the *Shapiro-Wilk* test is used to determine whether the data used is standard or not.

The signal-noise ratio assesses that there is a significant difference between the image before using MAR and ASIR-V and after using MAR and ASIR-V. The average SNR value increased after using MAR and ASIR-V on CT scans of the head and neck, which contained metal artefacts. There was an increase in the percentage value of SNR after improvements in the signal passing through objects that were previously affected by the metal artefact beam becoming visible. This is based on more X-ray energy passing through each *voxel*. *Signal Noise Ratio* (SNR) is SNR defined as the ratio between the average CT number and its standard deviation. SNR is also closely related to the amount of X-ray energy used per pixel in the image. Several previous studies that support the research results will be explained below.

Research conducted on chest CT scan examination. Image *noise* (SD) and SNR values of fat, muscle and aorta between different ASIR-V series (from 10 to 100% with an increase of 10%), and for all ASIR-V images, the SD values of fat, muscle and aorta decreased, and the SNR values increased as the percentage of ASIR-V increased (Zhao et al., 2021).

In the MDCT study scans were reconstructed using the following ASiR-V increments: noise values of 0%, 20%, 40%, 60%, 80%, and 100% decreased significantly, significant increases in SNR values were associated with increases in ASIR-V percentage (Rotzinger et al., 2018).

The conclusion regarding SNR in this study is that the SNR value increases after using MAR and ASIR-V, where the function of MAR itself is to reduce or even eliminate metal artefacts that cause image damage. Iterative Reconstruction *ASIR* -V is able to improve the impact of using MAR, such as black lines. Another role of SNR in improving image quality is increasing the contrast-*to-noise ratio*.

Differences in CNR values in CT scan images of the head and neck containing metal artefacts before and after using MAR and ASIR-V

Differences in CNR values in CT scan images of the head and neck containing metal artefacts before and after using MAR and ASIR-V. Measurement of the CNR value on head and neck CT scan images containing metal artefacts before and after using MAR and ASIR-V 30%, MAR and ASIR-V 60% and MAR ASIR-V 90%. The first step is to test the normality of the data before testing the difference in SNR values. Because numerical data is used, the *Shapiro-Wilk* test is used to determine whether the data used is standard or not.

Wilcoxon test on the value results from CT scan images of the head and neck, which contained metal artefacts before and after using MAR and variations of ASIR-V. This research concludes that there is an improvement in the CNR value of images containing metal artefacts after using MAR and ASIR-V. The average CNR value decreased by 0.196% after using MAR and ASIR-V 30%; there was a decrease in the percentage value of CNR *by* 0.117 % after using MAR+ASIR-V 60%, the percentage decrease in CNR value was 0.0639% from after using MAR +ASIR-V 90%. In research conducted by Johannes Kahn (2015) on multiple trauma cases, there was a decrease in the CNR values of several organs assessed. However, the assessment of image quality was still optimal. (Troeltzsch et al., 2021)

In research conducted by researchers a phantom was scanned using a pediatric head CT protocol. The results showed that the CNR value decreased in the *centrum semiovale area* under three years old, *the ganglia ward area* under three years old, *and the cerebellum* from 3 years to 15 years old. It shows higher differentiation and sharpness of grey-white matter and still maintains overall diagnostic quality in images with ASIR-V. (Kim, Lee, Lee, Kim, & Kim, 2017)

In research conducted by researchers, standard pediatric head CT without ASIR-V reconstruction was compared using ASIR-V reconstruction. Respectively, the CNR of the ASIR group with both ASIR-V percentages of 60% and ASIR-V 80% tested in the current study showed comparable results to the CNR of the non-ASIR group. Use with ASIR-V reconstruction demonstrated significantly lower CNR than the non-ASIR-V group. The ASIR-V algorithm is a promising technology for practical pediatric head CT dose reduction while maintaining diagnostic image quality (Sherif, Said, Elsayed, & Elmogy, 2020)

So, the conclusion in the SNR and CNR assessment, which discusses the MAR and ASIR-V methods in reducing images containing metal artefacts in head and neck examinations, is that there are differences before and after using MAR and variations of ASIR-V. *Noise* is defined as image *noise, which* is the unwanted fluctuation of pixel values in an image of a*n accurate homogeneous material*. In CT, the number of X-ray photons detected per pixel is also often referred to as the *signal-to-noise ratio* (SNR). SNR compares the desired signal level to the standard deviation level. Image quality in images containing metal artefacts can be improved by reducing the difference in SNR and

CNR values before and after using MAR and ASIR-V. The focus of this research is only on images that contain metal artefacts in the mouth area.

Analysis of differences in anatomical information before and after application of MAR and ASIR-V variations

Based on the *Friedman test*, the mean rank output table shows that the use of MAR+ASIR-V 90% shows the most optimal improvement with the highest mean rank value compared to the others. The conclusion is that if the sig value <0.05 Ho is accepted, there is a difference in increasing the use of MAR+ASIR-V in reducing metal artefact interference.

Based on the *Wilcoxon* test *output for assessing anatomical information on head and neck CT* scan images containing metal artefacts, images were obtained before and after using MAR+ASIR-V. There is a significant difference between the anatomical information value after reduction, and MAR+ASIR-V appears to increase the image information value.

In research conducted by researchers shows that the use of Smart MAR can improve the image and diagnostic quality of patients with metal oral implants undergoing clinical CT scans in the head and neck area. The results of this study also show that objective image quality parameters are significantly different for CT images reconstructed using *Smart* MAR as an adjunct to ASIR-V reconstruction (Feldhaus et al., 2019)

In research conducted by researchers, our research shows that the noise value of all images has a reduced correlation with the percentage of post-ASiR-V values, the SNR and CNR of all images have a positive correlation with the percentage of post-ASiR-V values. Image *noise* decreases, and SNR and CNR values increase as the percentage of post-ASiR-V levels increases. The reconstructed CNR increased `when the post-ASiR-V percentage was 80%. The high *percentage of* ASiR-V (90%) changes the noise component, resulting in a better image than the *smooth method*, affecting the diagnosis(Zhao et al., 2021)

In this study, the reduction of metal artefacts in the image of the mouth area, especially the image that was assessed was in the tongue area; there was a reduction in metal beam artefacts, metal emissions, and lines caused by metal artefacts could be reduced or even eliminated in this study. In this study, the image of the mouth area can be improved through the use of MAR+ASIR-V, thereby increasing the visual and diagnostic reading of the information value of images affected by metal artefacts. In this research, the most optimal image is using MAR+ASIR-V 90% to reduce optimal metal beams and improve good image quality.

Analysis of the level of artefact interference in CT scan images containing metal artefacts

Based on the Friedman test, it shows that the use of MAR+ASIR-V 90% shows the most significant reduction; the highest *mean rank value indicates this compared to the others.* The conclusion is that there is a significant difference in the use of MAR+ASIR-V in reducing metal artefact interference. Testing with the Wilcoxon test shows that the use of MAR+ASIR-V before and after there is a significant difference with the most optimal use of MAR+ASIR-V 90%; this is based on the highest average results.

Metal artefact reduction software is a solution to reduce artefacts caused by metal. To remove these artefacts, the MAR algorithm modifies the process used to reconstruct the image. A common approach is to repair or replace damaged projection data in *a sinogram* directly. *A sinogram* is a collection of all line attenuation measurements obtained for an image. *Interpolation*-based sinogram correction and MAR approaches use this category of techniques because of their ease and fast implementation. This technique consists of two steps: first, the identification of metal traces, where the damaged sinograms, i.e. missing projection *sinograms*, are identified, and second, the interpolation of the missing projection data.

In research conducted by researchers shows that iMAR reconstruction significantly reduces artefacts near metal and surrounding tissue while also enabling accurate diagnosis. IMAR impacts high and low-density artefacts in surrounding tissue (Neroladaki et al., 2019)

In research conducted by researchers Computed Tomography (CT) includes iterative reconstruction (IR) algorithm and metal artefact reduction (MAR) techniques. Our study provides important information regarding the performance of CT of the head and neck. CT scans with advanced reconstruction tools, such as SEMAR and iterative reconstruction, show superior performance compared with standard CT diagnostics in terms of detection of primary and recurrent tumours in the head and neck area containing metal artefacts.

In research conducted by researchers on the head and neck area using metal artefact reduction (SEMAR) can improve the quality of CT scan images by reducing artefacts in the oral cavity area caused by dental fillings. SEMAR is a type of MAR algorithm; it implements iterative reconstruction (IR) and can be classified into iterative. This algorithm produces regenerated images by removing metal artefacts. SEMAR algorithm is an IR algorithm based on raw data and can be applied to single-energy CT after scanning (Oshima, Tsuchiya, & Tateishi, 2019).

In research conducted by researchers on head and neck CT scans containing metal artefacts using the MAR and ASIR-V methods, there were advantages in reducing images containing metal, especially in the case of dentures and dental fillings. Metal artefacts that appear in the form of beams of light can be reduced or even eliminated in cases where clinical tumours or cancer have spread to the oral cavity in patients who have false teeth or dental fillings. CT scan images damaged by metal artefacts can be repaired using the MAR method and ASIR-V; with the use of MAR+ASIR, 90% is the best in reducing metal artefacts.

According to the researchers, the shortcomings in this research are as follows: firstly, the use of the MAR and ASIR-V methods is less effective for artefacts caused by braces. The resulting image still contains artefacts that interfere with anatomical information. Its use still needs to be optimal in reducing artefacts. Secondly, the use of the MAR+ASIR-V method in reducing images containing metal artefacts in head and neck examinations from the experiment using MAR+ASIR-V 30%, MAR+ASIR-V 60% and MAR+ASIR-V 90% are the most optimal in reducing artefacts. However, the organ being studied and the type of artefact are different. In that case, the value of using MAR+ASIR-V will also be different so that future research can be carried out.

The conclusion from using MAR and ASIR-V on images containing metal artefacts in this research is that using MAR+ ASIR-V can improve image quality by reducing metal artefacts in the image; the image of metal beams can be reduced or even eliminated in some instances. The combination of using the MAR method and ASIR-V 90% is the most optimal in reducing metal artefact images on CT scans of the head and neck. This research can improve the quality of CT scan images containing metal artefacts.

CONCLUSION

Based on the results of the research carried out, it can be concluded that there are differences in the value of metal artefacts in CT scan images of the head and neck after applying MAR and ASIR-V at 30%, 60% and 90%—the use of MAR+ASIR-V results in a reduction in metal artefact bands on head and neck images. Even metal artefacts can be eliminated in some instances—the most optimal use of MAR+ASIR-V is 90% in image reduction. There are differences in the value of anatomical information in CT scan images of the head and neck after applying MAR and ASIR-V 30%, 60% and 90%. The combination of MAR+ASIR-V 90% is the best value in improving image quality. The higher the ASIR-V percentage value, the more optimal it is in improving image quality. There was an improvement in information on Head and Neck CT Scan images containing metal artefacts after applying MAR and ASIR-V, as evidenced by a decrease in metal artefact emission beams in head and neck CT scan images and an increase in subjective assessment of the level of metal artefact interference in the image. They are creating a standard operation for CT Scan services for examining the head and neck, which contains metal artefacts, creating a new *protocol* on the CT Scan display by activating MAR and ASIR-V 90% automatically so that no manual settings are made anymore.

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