RESEARCH ARTICLE

# Impact of fixed dental prosthesis on neuroimaging: assessment of artefacts

Syed Murtaza Raza Kazmi[1], Raima Kaleemi[2], Wafa Zehra Jamal[3], Muhammad Azeemuddin[4], Farhan Raza Khan[5]

## Abstract

**Objective:** To determine the frequency and extent of artefacts in magnetic resonance imaging and/or computed tomography scans of head caused by fixed dental prosthesis.

**Method:** The retrospective study was conducted at Aga Khan University Hospital from July to December 2021, and comprised magnetic resonance imaging and/or computed tomography scans from January 2015 to December 2020 of the head of individuals with existing fixed dental prosthetic work at the time of exposure. They were analysed for the presence of artefacts. The association between artefacts and the presence of fixed dental prosthesis was explored. Data was analysed using SPSS 23.

**Results:** Of the 297 images evaluated, 173 (58%) were magnetic resonance imaging scans, and 124(42%) were computed tomography scans. The most common artefacts was grade I 148(49.8%), followed by grade II 140(47.1%) and grade III 9(3%). There was no significant association between fixed dental prosthesis and the artefacts ($p>0.05$).

**Conclusion:** There should be no reservations in placing fixed metal prosthesis in individuals on account of future brain scans.

**Key Words:** Fixed dental prosthesis, Imaging, CT scan, MRI, OPG, Artefacts.

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## Introduction

Computed tomography (CT) and magnetic resonance imaging (MRI) are diagnostic tools that enable visualisation of soft and hard tissues of the body. Both imaging techniques are non-invasive, relatively safe, and, hence, are widely practised in the healthcare.[1] Common to all imaging modalities, an artefact can occur, compromising the investigation.

While MRI has the added benefit of no radiation exposure, the presence of fixed prostheses, such as crowns, bridges, orthodontic appliances or implants, may cause significant magnetic field distortion, resulting in artefacts.[2,3] The excessive magnetic field interactions caused by the presence of metallic objects can particularly be dangerous for the patient undergoing MRI.[3,4] Generally, the metal conductivity and magnetism in the prosthesis correlates with the extent of image artefact.[1, 5] There is a lack of information regarding magnetic susceptibility and metal conductivity for most of the materials used in dental prosthesis.[5] An object can be, diamagnetic, paramagnetic or ferromagnetic.[4]

Diamagnetic substances, such as gold, copper and zinc, are poorly magnetised. They do not have unpaired electron in the outermost orbit and, thus, they have smaller influence on the image quality in MRI. Paramagnetic substances, such as titanium, chromium, manganese and aluminium, are weakly magnetised. They do have unpaired electron in the outermost orbit and can generate some artefacts on the MRI scan. Lastly, ferromagnetic substances, such as cobalt and nickel, can produce highest artefacts on MRI.[3,4]

An artefact can arise due to the presence of dental prosthesis and may cause loss of valuable information on the image that otherwise could have been gained. Literature suggests that there is no evidence of hindrance in medical diagnosis in the head region. However, the assessment of soft and hard tissues around such foreign bodies could be challenging.[6] Some dental materials known as safe to be used and are compatible with MRI of the head and neck can severely affect the quality of imaging.[7] However, compared to CT scan, MRI is preferred due to its lower susceptibility to dental artefacts, and that is why MRI compatibility to dental materials is of growing importance.[8]

In CT scans, the presence of metallic or ceramic prosthesis in the body could lead to the phenomena of beam hardening, streak artefact and photon starvation.[1,9] All of this significantly deteriorates the quality of image. The extent of distortion depends on the position, shape and

[1,3]Department of Dentistry, Aga Khan University, Karachi, Pakistan, [2,4]Department of Radiology and Imaging, Aga Khan University, Karachi, Pakistan, [5]Department of Operative Dentistry and Endodontics, Aga Khan University, Karachi, Pakistan.

**Correspondence:** Farhan Raza Khan. Email: farhan.raza@aku.edu

**ORCID ID.** 0000-0002-5650-6268

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size of the prosthesis.[10] Although the use of artefact reduction algorithm is common these days, which can partially reduce the incidence of artefacts, if main region of observation is near the metal tissue interface, it may still remain unobservable for the clinicians.[11]

There can be a loss of valuable information or misinterpretation of the image caused by the artefacts. It is, therefore, imperative to understand the influence of fixed dental prosthesis on neuroimaging techniques.

To our knowledge, there is no local data on the influence of fixed dental prosthesis on neuroimaging. The current study was planned to fill the gap in literature by determining the frequency and extent of artefacts in MRI and/or CT scans of head caused by fixed dental prosthesis.

## Materials and Methods

The retrospective study was conducted at Aga Khan University Hospital, Karachi from July to December 2021, and comprised MRI and/or CT scans from January 2015 to December 2020 of the head of individuals with existing fixed dental prosthetic work at the time of exposure. Data of individuals with an existing record of orthopantomogram (OPG), MRI and/or CT scans of the head was extracted from the radiographic database. OPGs were evaluated by two trained dentists for the presence of any sort of fixed dental prosthesis, including implants, crowns, bridges and fillings, and their corresponding MRI and CT scans were scored by two experienced radiologists for the presence of artefacts.

The study was a census of all the patients who underwent CT/MRI scans for neurological indications and also had OPG done for fixed dental prosthesis. As such, the sample size was not calculated, and all eligible images of patients of either gender aged >17 years, having an OPG and MRI/CT scan of the head region with a confirmed presence of fixed dental prosthesis were included. The OPG exposure had to precede the MRI and/or CT scan. Individuals with duplicate data, auricular or any other extraoral prosthesis and whose imaging was done outside the institution were excluded.

The MRI scans were reviewed to score the artefacts employing T1, T2 weighted standard sequences and fluid-attenuated inversion recovery (FLAIR) sequences. On 3Tesla MRI machine (Toshiba Titan Vantage), the image acquisition parameters were: T1W sequence echo time (TE) was 10.0ms and repetition time (TR) was 400ms; T2W images had TE 84ms and TR 4467ms; while FLAIR sequence had TE 120ms and TR 10,000ms.12 On 1.5Tesla machine (Seimens Magnetom Avanto 1.5 Tesla (D13D), the image acquisition parameters were: T1W sequence TE was 7.8ms and TR was 550ms; T2W images had TE 98ms, TR 4,620ms; while FLAIR sequence had TE 109ms and TR 9,000ms. The CT machines used in the study were Toshiba 640 Slice CT and General Electric 128 Slice CT machine.[12]

The artefacts on MRI and CT scans were graded by two radiologists on a Likert scale of 1- 5 to score the overall image quality, with 1 denoting perfectly normal and 5 being uninterpretable. The five-point ordinal scale was adapted from McCauley et al. to score the overall image artefacts (Table 1, Figure 1).[13]

**Table-1:** Classification of artefacts on MRI & CT scans.

| Scan | Interpretation | Artefact Score |
|---|---|---|
| **MRI scan** | | |
| | Perfectly normal | 1 |
| | Focal signal loss not extending up to base of skull | 2 |
| | Signal loss extending to base of skull | 3 |
| | Signal loss extending intra-cranially on major sequences | 4 |
| | Un-interpretable | 5 |
| **CT scan** | | |
| | Perfectly normal | 1 |
| | Focal distortion / artefacts not extending up to base of skull | 2 |
| | Distortions / artefacts extending to base of skull | 3 |
| | Distortion / artefacts extending intracranially but partially interpretable | 4 |
| | Un-interpretable | 5 |

MRI: Magnetic resonance imaging, CT: Computed tomography. *McCauley criteria was employed.[13]

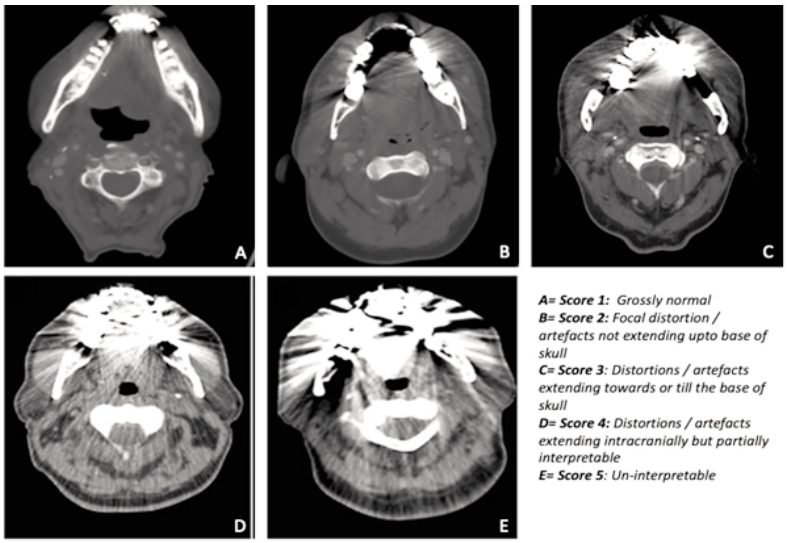


**Figure-1:** Images representing various artefacts in neuroimaging.

Approval from the institutional ethics review committee (Ref #2021-5836-15390) was obtained, and the data was recorded in a stepwise manner. Presence of fixed dental prosthesis was initially marked on the odontogram on the pre-set proforma, followed by artefact evaluation by the radiologists. All data of patient records were kept strictly confidential, and de-identified data was used for the analysis.

Data was analysed using SPSS 23. For intra-examiner reliability, 5% of the images were subjected to agreement and Kappa score for the agreement was 0.95. Chi-square test was used to explore the association between type of dental prosthesis and the artefacts. P<0.05 was considered significant.

## Results

Of the 297 images evaluated, 173(58%) were MRI scans, and 124(42%) were CT scans (Figure 2). Among the patients, 105(35.5%) were aged <50 years, and 18(6.1%) were aged >80 years.

For MRIs, the most common clinical indication was neuro-degenerative diseases 67(95.7%), while for CTs, it was tumour 64(62.1%) (Table 2). The most common artefact was grade I 148(49.8%), followed by grade II 140(47.1%) and grade III 9(3%). There was no significant association between fixed dental prosthesis and artefacts (p>0.05) (Table 3).

**Table-2:** Indications of MRI and CT scans (n=297).

| Reasons for getting the head scan | MRI n(%) | CT n(%) | Total n |
|---|---|---|---|
| Tumours | 39(37.9%) | 64(62.1%) | 103 |
| Neuro-degenerative diseases | 67(95.7%) | 3(4.3%) | 70 |
| Pain and others | 43(69.4%) | 19(30.6%) | 62 |
| Infections | 5(21.7%) | 18(78.3%) | 23 |
| Trauma | 1(16.7%) | 5(83.3%) | 6 |
| Stroke | 5(100%) | - | 5 |
| Indication not mentioned in the patient file | 13(46.4%) | 15(53.6%) | 28 |
| **TOTAL** | **173(58.2%)** | **124(41.8%)** | **297** |

MRI: Magnetic resonance imaging, CT: Computed tomography.

**Table-3:** Distribution of the artefacts scores according to age and gender (n=297).

| Variables | All n (%) | MRI/CT scan score * | | | p-value** |
|---|---|---|---|---|---|
| | | Score 1 n (%) | Score 2 n (%) | Score 3 n (%) | |
| **Gender** | | | | | |
| Male | 161(54.2%) | 76(47.2%) | 80(49.7%) | 5(3.1%) | NS |
| Female | 136(45.8%) | 72(52.9%) | 60(44.2%) | 4(2.9%) | |
| **Age (years)** | | | | | |
| 18- <63 | 180(60.6%) | 97(53.9%) | 81(45.0%) | 2(1.1%) | NS |
| >64 < 80 | 99(33.3%) | 44(44.4%) | 48(48.5%) | 7(7.1%) | |
| >80 | 18(6.1%) | 7(38.9%) | 11(61.1%) | 0(0.0%) | |

MRI: Magnetic resonance imaging, CT: Computed tomography, NS: Non-significant. * McCauley criteria was employed; no reading in the study had score 4 or 5.

** Chi square test was applied at 0.05 level of significance.

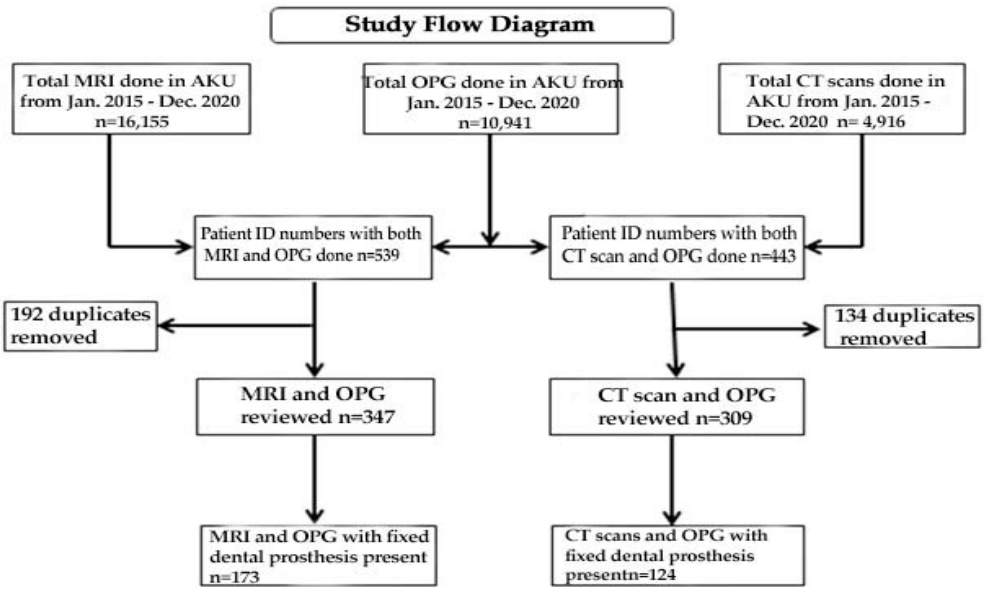


**Figure-2:** Study flowchart
MRI: Magnetic resonance imaging, CT: Computed tomography, OPG: Orthopantomogram, AKU: Aga Khan University

The highest artefact score in CTs was 3, which was observed in 1(0.8%) scan. That patient had right buccal mucosa carcinoma, compromising its radiological interpretation by causing significant artefacts that were extending to the base of the skull. However, a dental implant was present on the left side, which made the radiologist to extract some knowledge though the artefact caused interpretation limitations.

## Discussion

MRI and CT scan images are used for diagnostics, treatment planning and monitoring of patient progress. As almost all radiographic imaging can be affected by metallic and magnetic objects in the field,[14] artefacts can have a serious impact on patient care.

Studies have indicated that artefacts caused by fixed metal prosthesis cause issues in MRI and CT scans.[1,2,8,15] These studies have primarily focussed on the artefacts observed in the maxillofacial region and their influence on the technical image quality in the oral region. Phantom heads,[1,15] animal models16 and human review charts[2,17] have been used to evaluate and analyse the artefacts due to dental prosthesis. Some sequences of MRI are more sensitive than the dental prosthesis or appliances, thus producing artefacts. Usually, this is not mentioned in studies.[3]

The present study found that MRI and CT scans of brain did not have any artefact due to fixed dental prosthesis that hindered any diagnostic information related to the intracranial region. Costa et al. documented artefacts in the maxillofacial area in the brain scan arising from metallic dental prostheses and orthodontics appliances.[2] The improvements regarding absence of artefacts in contemporary imaging can be attributed to the use of metal artefact reduction algorithm or software.[18] The earlier images taken with older versions of CT scan and MRI machines could result in greater artefacts than images taken with newer versions of such machines.[19]

For the present study, the CT machine Toshiba 640 Slice CT employed an artefact reduction algorithm using Single Energy Metal Artefact Reduction (SEMAR) software. In the General Electric 128 Slice CT machine, Adaptive Statistical Iterative Reconstruction (ASIR) artefact-reducing software was installed whereas no metal artefact-reducing algorithm was present with the MRI machines Seimens Magnetom Avanto 1.5 Tesla (D13D) and Toshiba Titan Vantage 3 Tesla.

In terms of limitations, the present study had an eligibility criteria of age >17 years because of which the sample did not include individuals with orthodontic appliances, and, hence, the effect of fixed braces on the extent of artefacts could not be studied well. Also, since an ordinal scoring criterion was adopted, some degree of subjectivity and observer bias was inevitable. To account for this bias, inter-observer reliability was assessed for 50% of the sample, for the reading of MRI/CT scan artefact scoring, which turned out to be 98% reliable. Another limitation of the study was the intraoral status at the time of OPG exposure, which may have changed by the time the MRI/CT scans were exposed. To cater to this limitation, the closest possible readings were taken.

Regarding the distribution of age, no definitive cut-off was employed. In fact, arbitrary categories (18-63 years and 64 years or above) were made. There was also a lack of real-time patient examination to correlate radiological findings with intraoral findings. Since only the CT and MRI scans of brain were included, the study results could not be generalised to MRI and CT scans done for pharyngeal and parapharyngeal regions, which is usually the case with maxillofacial and neck oncology surgeries. These images could be affected by artefacts due to the presence of fixed dental prosthesis.

## Conclusion

Within the limitations of the study, it could be inferred that artefacts caused by fixed dental prosthesis has no significant impact on the quality of MRI and CT scans of head for neurological indications.

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**Author's Contributions**

**SMRK:** Conception, design, discussion and review.
**RK:** Data collection, interpretation (radiology input) and literature review.
**WJ:** Data collection, interpretation (dental input) and literature review.
**MAU:** Design, discussion and review
**FRK:** Conception, data analysis and critical review.