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RESEARCH ARTICLE

ARTIFACTS IN MRI DUE TO DENTAL RESTORATIONS: FACT OR MYTH

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Abstract

Purpose: To identify presence of artifacts if any due to the presence of dental restorations in patients requiring MRI of head and neck.

Method: The medical records of total three hundred patients who required MRI were gathered over a period of one month and of them patients requiring MRI in head and neck region were screened for the presence of dental restorations. Forty percent of them had head and neck MRI done. Twenty one patients among them had dental restorations done. The MRI were interpreted by radiologist and artifacts in the MRI were identified.

Results: Dental composite resin, amalgam alloys, glass ionomer cements and zirconia crowns were not the source of artifact. These have been shown to have little influence in MRI, while metallic crowns have shown significant distortion if present in more than one tooth.

Discussion: Magnetic Resonance Imaging (MRI) is a diagnostic technique that uses magnetic field and radio waves to produce a detailed image of the body's soft tissue and bone. The presence of high attenuation metal objects in the field of view can cause artifacts. Recognizing the artifacts caused by dental restorations will help clinicians in treatment planning and decision-making.

Introduction:-

Magnetic resonance imaging (MRI) is an imaging technique which enables the visualization of soft tissue contrast without the use of ionizing radiation considered a powerful diagnostic method using a strong uniform static magnetic field and radiofrequency pulses[1,2]. The occurance of artifacts can be present in all image modalities which results in degradation of quality of image compromising imaging evaluation. When any substance is placed in a magnetic field, it gets magnetized according to their magnetic susceptibility. For dental treatment many kinds of materials and metal alloys are used. Metallic sources used for orthodontic purpose, dental restorations, dental crowns or metallic splints can lead to large magnetic field distortion and signal loss, reducing the quality of image in MRI of maxillofacial region. There is a correlation between the magnetism of a metal and the magnitude of an imaging artifact during MRI. Shape, position, orientation and the number of object can effect the damage in image. There are several articles describing the effects of metallic objects on MRI interpretation, very few have addressed these problems in clinical situations. The purpose of this study was to overview the artifacts in patients reporting for MRI over a period of one month in a testing centre having dental restorations of different kinds.

Image artifact is something observed in a scientific investigation that is not naturally present but occurs as a result of the investigative procedure (Oxford dictionary). MRI induced artifact is defined by pixels that do not optimally or properly represent the tissue components under study. A MRI induced artifacts is directly proportionate to the

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ferromagnetic content of a material. Many types of artifacts may occur in magnetic resonance imaging. Artifacts in magnetic resonance imaging are typically classified as: physiologic (motion, flow),hardware (electromagnetic spikes, ringing) or inherent physics (chemical shift, susceptibility, metal).Today, in the dental treatment, various kinds of materials such as metal alloys, composites, acrylics, porcelain and ceramics as filling materials and in dental prostheses like crowns, dental bridges and dentures are used. [8]

Review Of Literature:-

Georg Eggers et al (2005) had conducted a study to investigate whether magnetic resonance imaging(MRI) of the oral cavity would be less affected than CT by artifacts caused by typical dental restorative alloys. In order to assess the extent of artifact generation, corresponding MRI scans of the same anatomic region with and without dental metal restorations were matched using a stereotactic frame. MRI imaging of the oral and maxillofacial region could be performed without reduction of the image quality by metallic dental restorations made from titanium, gold or amalgam. Dental restorations made from titanium, gold or amalgam did not reduce the image quality of the MRI sequence used in imaging of the oral and maxillofacial region for dental implant planning. In this respect MRI is superior to CT in implant planning. [8]

Sherin Jose Chockattu et al (2018) had done a review based on the current available evidence, recommendations for dentists and radiologists regarding the safety and appropriate management of dental materials during MRI in patients with orthodontic appliances, maxillofacial prostheses, dental implants, direct and indirect restorative materials, and endodontic materials. They found that the magnetic field and radiofrequency pulses generated within the magnetic resonance imager interact unfavorably with these dental materials that have magnetic properties. These variations in the magnetic field strength that occur at the interface between dental materials and the adjacent tissue can lead to spatial distortions and signal loss, thereby generating an artifact in the image.Apart from artifact formation, other unwanted effects of MRI are radiofrequency heating (a physical effect) and magnetically-induced displacement (a mechanical effect) of the dental material.[2]

Methodology:-

The medical records of total three hundred patients who required MRI were gathered over a period of one month and of them patients requiring MRI in head and neck region were screened for the presence of dental restorations. 40% (one hundred and twenty) of the patients among them required head and neck MRI. Patients needed MRI for the following reasons: traumatic brain injury (TBI), intracranial hemorrhage, subdural hematoma, extradural hemorrhage, intracerebral hemorrhage, soft tissue tumor of head and neck, brain injury or concussion. Out of the 120 patients examined for the presence of restorative dental work, 21 patients were found to have dental restorations. It was observed; patients who were screened had the following restorations in their mouth. Composite resin restorations were present in six patients, of which the first patient had the restoration in relation to 11, 21, the second patient had the composite restoration in 46 and 47. 11, 12 were restored with composite in the third and fourth patient and the last patient had 12, 21 restored with composite. Among five patients having amalgam restorations, four of them had the restorations in relation to 36, 46 and one had the amalgam restorations in relation in relation to 36, 47, glass ionomer cement restorations were present in two patients of which one had restorations in relation to 13, 14, 15, 23, 24, 25 and the other one had the glass ionomers cement restored in 11, 12. Multiple metal ceramic crowns were present in six patients. The first patient had the crowns in 31, 32,33, 34, 41, 42, 43, 44, second patient had them in 44, 45, the third patient got his metal ceramic crown in 13, 14, 15, 16, fourth patient had crowns in 13, 14, 15, 23, 24, 25 and the last patient them in 33, 34, 35, 44, 45, 46. Multiple metal crowns were present one patient in his 36, 46, 47 and zirconium crown was present in 16,26, and 36 of a patient. The MRI was done by a radio technician and results were interpreted by radiologist. The affected imaging planes were identified and sources of artifacts were described and divided into categories: a) Metal ceramic crowns and b) Metal crowns. All images presented in this study were recorded on a 1.5 Tesla, GE Signa magnetic resonance imager. Specific acquisition parameters were sagittal head and neck, 5 mm Thick, flip angle= 180degree, SE, TR/TE = 600/14 ms, 1 Nex, 256x192 matrix, matrix 200 x 350, field of view (FOV)=26 x 26cm.

Observation:-

During the study period it was found that three hundred MRI scans of head and neck were performed. Forty percent (one hundred twenty) of them had head and neck MRI done. Twenty one patients among them had dental restorations done(Fig. 1-7). Artifacts were observed in thirty three percent (seven) scans (Table 1).

Discussion:-

The dimensionless proportionality constant that indicates the degree of magnetization of a material in response to an applied magnetic field is the magnetic susceptibility of that material which is caused by the interactions of electrons and nuclei with the externally applied magnetic field. The magnetic field of metal-based materials are created by their own and such strong susceptibility gradients result in signal loss which dramatically alter precession frequencies of protons in the adjacent tissues. The substances are characterized based on their magnetic susceptibility as paramagnetic, diamagnetic, and ferromagnetic. The highest potential among them is by ferromagnetic substances which are strongly attracted by a magnetic field. Diamagnetic substances have a very weak and negative susceptibility to magnetic field. Paramagnetic materials have positive susceptibility and augment the external field. Both diamagnetic and paramagnetic materials are far less likely to cause artifact.[1] In dentistry the metal alloys used are ferromagnetic substance. [6] These ferromagnetic components induces magnetic field and tissues adjacent to these components become influenced by the induced magnetic field of the metal, Hence they do not generate a useful signal because they either fail to process or do so at a different frequency.[5] The artifacts caused by metallic objects are a common problem in MRI scans. These artifacts due to metals usually lead to areas of signal blackout, with rims of high signal strength around the offending object. [6]

In this study, it was found that dental composite resin, amalgam alloys, glass ionomer cements and zirconia crowns were not the source of artifact. These have been shown to have little influence in MRI, while metallic crowns have shown significant distortion if present in more than one tooth. The artifacts produced by metals correlates with variables like composition and number of metal crowns. Extensive metallic artifacts in the oral cavity and other areas (TMJ, posterior cerebral fossa, maxillary sinus), were produced in patients with multiple metal ceramic crowns. Patients having seven to ten metal ceramic crowns were potential source of artifacts in MRI,that made image interpretation impossible. Major artifact was found in patients with multiple metal crowns. The artifact was faint or limited in patients with less than three metal based crowns. Dental amalgam is composed of several metals, but the absence of artifact caused by amalgam maybe explained by the presence of silver, a nonferromagneticmetal.

To deal with the distortion for imaging near metals, various techniques have been proposed. These techniques can be categorized to two and three-dimensional approaches. The slice encoding for metal artifact correction (SEMAC) technique, which includes the VAT gradients, is based on two dimensional multi slice SE imaging, and uses additional slice encodings to deal with the through plane distortion. The multi acquisition variable resonance image combination (MAVRIC) technique is based on the three dimensional acquisition, and acquires multiple images with different center of excitation frequency to deal with a broad field perturbation. These techniques have different approaches of reducing the image artifact including the through plane distortion, but all are revealing that MRI near metal prostheses is possible in imaging. The combination of the MAVRIC and SEMAC technique is known as MAVRIC-SL. Also, metal artifact reduction sequence (MARS), WARP (Siemens Healthcare, Munich, Germany) and slice encoding for metal artifact correction are recommended to reduce the size and intensity of susceptible artifacts resulting from magnetic field distortion.

Other methods of artifact correction involves: pulse sequence optimization, post processing hardware improvement and scan parameter. The orientation of the metallic object, alloy used and magnetic field strength, as well as use of metal-suppression techniques can be intended to reduce the artifacts caused due to metallic crowns. [11-12]

Conclusion:-

The results of this study demonstrate that the origin of dental artifacts is most likely from metal and metal ceramic crowns but the effect is insignificant if less than three in continuation and if not in the field of area of interest. They lead to large areas of artifacts, making imaging interpretation difficult. But high end equipment (3Tesla) have the option of increased number of channels which reduce artifacts. In order to anticipate complications and take precautions prior to MRI in patients with the aforementioned dental materials, It is critical that the radiologist and dental practitioners are aware of the potential of these dental restorations to cause adverse interactions during MRI scans. Dental practitioners must be acquainted with the composition of restorative materials and its effect on the diagnostic quality of MRI scans. The influence of other dental work in the mouth like wire splints, metallic orthodontic braces, implants may be studied for more complete knowledge.

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