European Review for Medical and Pharmacological Sciences 2022; 26: 4274-4278

Reciprocal actions of Magnetic Resonance Imaging with dental prostheses and oral tissues – awareness among the dentists

A. BHARDWAJ[1], S. ALDHUWAYHI[1], Y.A.M. DEEBAN[1], S.S. BHARDWAJ[2], R.B. ALAMMARI[1], T. ALMURAIKHI[1], A. ALZUNAYDI[3], A.A. ALTERAIGI[4], M.A. ALAMOUDI[4]

[1]Department of Prosthodontics, [2]Department of Preventive Dental Science, College of Dentistry, Majmaah University, Al Majmaah, 11952, Saudi Arabia
[3]Ministry of Health, Al Artawiyah General Hospital, Al Artawiyah, Riyadh Province, 15719, Saudi Arabia
[4]College of Dentistry, Majmaah University, Al Majmaah, 11952, Saudi Arabia

Abstract. – OBJECTIVE: MRI (Magnetic Resonance Imaging) does not use ionizing radiation and provides a comparatively better resolution. It is an important tool for the diagnosis of problems related to the head and neck area. It has various applications in dentistry, including MRI-based planning for implant placement. Previously, studies have been performed to assess its medical use, but very few studies have been conducted on its applications in dentistry.

MATERIALS AND METHODS: A pre-validated online questionnaire was distributed through various messenger groups and social media. The questionnaire comprised two sections to collect demographics and assess the knowledge and awareness among dentists about the interactions between dental prostheses and materials with MRI.

RESULTS: In the present study, 63.20% of respondents indicated that MRI provided a good view of the implant sites, TMJ and salivary gland tumours, but the majority believed that metallic and titanium implants do not interact or cause artefacts on MRI imaging.

CONCLUSIONS: We concluded that dental undergraduates and graduates had limited knowledge of the interactions of dental materials and prostheses with MRI. Dentists should be aware of interactions of MRI with the various dental materials and prostheses and possible image distortion to ensure the safety of the patient.

Key Words:
Dental implant, Restoration, MRI (magnetic resonance imaging), Temporomandibular joints (TMJ), Artefacts, Dental prostheses, CBCT (cone-beam computed tomography).

Introduction

Magnetic resonance imaging (MRI) is utilized due to its increased accessibility, as it does not use ionizing radiation and has a comparatively better resolution than other imaging techniques. MRI has significant potential to solve relevant clinical problems[1]. Dentists often have doubts as to whether MRI is safe for individuals with dental prostheses and implants[2]. This uncertainty causes tension in patients[3] and raises the question as to whether the use of MRI in patients with metallic prostheses or implants is safe and acceptable[4]. MRI has emerged as a very important diagnostic tool for the head and neck region. Patients with dental prostheses and restorations often require MRI of the head and neck region. Dental restorations usually contain precious metals such as gold, silver, and platinum and nonprecious alloys such as chromium, cobalt, molybdenum, nickel and other metals such as titanium and its alloys. Prostheses, such as dental implants and dental crowns composed of metal, may decrease the quality of images obtained using MRI due to the distortion caused by a large magnetic field and possible loss of signal. Dentists should be aware of interactions of MRI with the various dental materials and the possible image distortion and dislodgement of the dental prosthesis, which may cause injury in the oral cavity to the adjacent tissues[5]. The use of MRI for planning surgical guides before implant placement is very reliable and frequently used[6]. MRI is a non-invasive method

Corresponding Author: Smita Singh Bhardwaj, MDS; e-mail: s.bhardwaj@mu.edu.sa

to differentiate soft and hard tissues within the human body. MRI is used in the dental field for the diagnosis and treatment of temporomandibular joint (TMJ) problems that might lead to disc degeneration and examinations of salivary glands and the maxillary sinus, along with identifying early bone changes, fractures, tumors and hematomas. These changes, along with the growth of jaws, have also been analyzed with the help of MRI. MRI has applications in implant dentistry and provides precise information related to bone height, density and contour[7]. It uses the magnetic field formed by the scanner where the patient is positioned. As a result, images are usually created by "signals" from the protons that are created by the magnetic field and subsequently measured. However, differences that might occur between the different dental materials with respect to their magnetic field strength in relation to the adjacent oral tissues may lead to spatial distortions and loss of signal, creating artefacts in the obtained images. Other effects of MRI are radiofrequency, heating, and magnetic field-induced displacement of a few dental materials[8]. Dental MRI represents a radiation-free, 3D and higher resolution imaging modality with good hard and soft tissue contrast[9].

Dental applications of MRI have been less compared to applications in the medical field. Most of the work in the field of MRI use in dentistry has focused on the imaging of soft tissues along with the planning of implants and the analysis of TMJ function and morphology[10].

MRI is applicable for most of the areas in which CBCT (Cone-beam computed tomography) is currently being used. Its applications include the planning of dental implants, various inflammatory diseases of the tooth, and problems in the bone and periodontium[11].

Dentists must always evaluate the patient and decide whether to change the field strength to ensure patient safety[12].

Materials and Methods

Study Population and Study Site

This study was performed in Saudi Arabia using a questionnaire along with the consent form. The inclusion criteria were that all undergraduate, graduate and postgraduate dental students and dental practitioners within the age group of 18-60 years were selected. All those who did not provide consent were excluded from the study. Sample selection was performed by simple random sampling.

Study Design and Sampling

With a confidence interval of 95%, a margin of error of 5% and a response distribution of 50%, the sample size was estimated to be 381. Assuming a 20% dropout rate, the total sample size was increased to 481.

Ethical Considerations

This observational, cross-sectional study was performed according to the World Medical Association Declaration of Helsinki and approved by the Institutional Review Board of Majmaah University: MUREC-Dec.02/COM-2021/14-3.

Data Collection

A Google Form was used to prepare an online questionnaire and the consent form was attached to it. The questionnaire was sent to the dentists through WhatsApp and email. After the participants provided consent, they responded to a set of questions. A pilot study that involved 50 participants was performed before the main study to assess the validity of the questionnaire.

Statistical Analysis

The data were entered into Microsoft Excel 2007 and then analyzed using SPSS statistical software Version 23.0 for Windows (IBM Corp., Armonk, NY, USA). The descriptive statistics included frequency and percentages. The level of significance for the present study was fixed at 5% (p-value ≤ 0.05). Intergroup comparisons between two independent groups were performed using the Chi-square test.

Results

Supplementary Table I shows the descriptive analysis of knowledge regarding the use of MRI. The present study was performed to analyze the knowledge of the study subjects regarding the use of MRI in dental practice. A total of 45.11% of the subjects considered MRI a valid alternative to CT. A total of 52.18% were aware that MRI does not use ionizing radiation and hence can be used for repeated examinations. In our study, 61.12% of respondents knew that MRI can be used to diagnose jaw lesions. A total of 56.34% of the study subjects believed that MRI is used to adequately analyze the soft tissue

pathology and jawbone. In the present study, 63.20% of respondents indicated that MRI provided a good view of the implant sites, TMJ and salivary gland tumors, but the majority believed that metallic implants do not interact or cause artefacts on MRI. The majority of the subjects were unaware of the fact that retentive wires can produce artefacts. **Supplementary Table II** shows the intergroup comparison between sexes regarding knowledge of MRI. In the present study, the difference between males and females regarding the responses to the questions on knowledge of the use of MRI in dental practice was statistically non-significant for the majority of the questions, except that a higher percentage of females indicated an awareness that MRI does not use ionizing radiation and hence can be used for repeated examinations and that the metallic dental implants placed in the oral cavity interact with MRI. **Supplementary Table III** shows the intergroup comparison between age groups regarding knowledge of MRI. The difference between age groups regarding the responses to the questions on knowledge of the use of MRI in dental practice was statistically non-significant for the majority of the questions. A higher percentage of the subjects in the age group of 50 years and older believed that the metallic base or framework and metallic restorations in the oral cavity interact with MRI and that the metallic dental implants in the oral cavity interact with MRI. A higher percentage of the subjects in the younger age group knew that MRI can be used to diagnose jaw lesions and that MRI can successfully be used for adequately analyzing soft tissue pathology and the jawbone. **Supplementary Table IV** shows the intergroup comparison between groups with different educational qualifications regarding knowledge of MRI. Regarding educational qualifications, a higher percentage of the subjects with PhD and Master's degrees had good knowledge regarding the use of MRI compared to graduates and undergraduate subjects. The difference was artistically significant when analyzed using the Chi-square test.

Discussion

MRI performed in patients with metallic implants has the risk of dislodgment. However, other authors have documented that patients with certain metal implants and materials can safely undergo MRI if the implants do not have or have a low ferromagnetic property, show minimal deflection or the deflection forces are insufficient to dislodge the implant or material[13].

MRI is able to differentiate between cysts and granulomas very well[14]. In our study, the majority of respondents were aware that MRI can be used to diagnose jaw lesions. A total of 56.34% of the study subjects believed that MRI is used to adequately analyze the soft tissue pathology and jawbone.

Researchers have reported that MRI is very important for the imaging of zirconia implants. Although titanium implants may cause a distortion, zirconia implants cause much less distortion[15]. Some authors[16] have indicated that MRI is not suitable for titanium implants but good for ceramic implants. In the present study, the majority of respondents indicated that MRI provides a good view of the implant sites, TMJ and salivary gland tumors. Most of the respondents believed that metallic and titanium implants do not interact or cause artefacts on MRI. Hence, more awareness of this fact is needed.

Various studies[8,17-22] have been performed regarding the compatibility of dental materials with MRI. In one study[17], the materials that were shown to be MRI-compatible were resin-based sealer, gutta-percha, glass ionomer cement, composite, zirconium dioxide, gold alloy, amalgam, and gold-ceramic crowns, while stainless steel orthodontic appliances and cobalt-chromium showed poor compatibility. In another study[18], metal-based restorative materials produced fewer artefacts in MRI, while elements such as ytterbium trifluoride that are present in composites caused artefacts in MRI. Few authors[19] have suggested that CAD/CAM retainers cause fewer MRI artefacts. Others have shown that NiTi and stainless-steel arch wires caused large artefacts. Additionally, gold crowns and titanium along with composite, amalgam and gold ceramic crowns produced minor artefacts. GIC restorations, resin-based sealer, gutta-percha and zirconium dioxide produced no distortions on MRI[20]. Some authors[21] have indicated that among the various metals and alloys, Zr-14Nb (zirconium 14-niobium) alloy is more frequently used due to its low magnetic susceptibility. A few other researchers have suggested that resin-based sealer, gold crowns, ceramic implants and prostheses along with gutta-percha do not produce distortions, but GIC, composite, polycarboxylate, amalgam, modified dimethacrylates and zinc phosphate produce distortions. Additionally, removable prostheses caused major distortions along with the possi-

bility of movement during MRI imaging[8]. In our study, the majority of the subjects were unaware of the fact that retentive wires may generate artefacts, and most of them were unaware of any relation between composite resins, glass-ionomer, zinc phosphate and polycarboxylate cement, as well as metallic restorations or restorations of metal-ceramic that often contain nickel alloys with the generation of artefacts on MRI. Previously, a study[22] reported that 63.4% of dentists believed that dental materials produce artefacts in MRI, and 36.6% did not know how to prevent it. In the present study, the majority of the respondents did not know the interactions between dental restorations and materials with MRI.

MRI scans are preferred over CT but have the drawbacks of a long scanning time and high costs[23]. In the present study, most of the respondents considered MRI over CT and knew that it does not use ionizing radiation, but 80.25% of the subjects considered the high cost and the long scanning time as the drawbacks of using MRI.

MRI has been proven to be useful in evaluating soft tissue changes and internal disc derangement in relation to TMJ[24]. Most of the participants in our study knew this fact.

MRI provides a good and clear image of pulp and root canals[25]. In the present study, most of the respondents were aware of this property. MRI is used for adequately analyzing the soft tissue pathology and jawbone[26].

MRI is used to analyze jaw lesions, plan implant treatment, diagnose TMJ diseases, and for endodontic and orthodontic treatment to obtain a better prognosis[7]. MRI has many applications in dentistry and can transform diagnostic imaging[27]. A thorough understanding of the basics of MRI is needed to understand the interaction of dental materials in relation to MRI scanners[1].

Conclusions

In the present study, dentists had knowledge of the applications of MRI in dentistry, but dental undergraduates and graduates had limited knowledge of the interaction of dental materials with MRI and the various interactions of dental prostheses while recording MRI scans. This scenario might be changed by creating awareness of this topic through an increase in the availability of the related reading material, as well as attending seminars and conferences related to the same topic in dentistry.

Conflict of Interest

The Authors declare that they have no conflict of interests.

Acknowledgements

The authors would like to thank the Deanship of Scientific Research at Majmaah University for supporting this work under project number R - 2022-152.

Funding

The authors declare that no funding was received for the publication of this paper.

Authors' Contribution

Atul Bhardwaj, Sami Aldhuwayhi, Yahya Ahmed M Deeban: conception of study, data acquisition, final approval. Smita Singh Bhardwaj, Rawan Bakr Alammari, Turki Almuraikhi: data interpretation, article writing. Ayoub Alzunaydi, Abdullah Ali Alteraigi, Mohammed Abdulrhman AlAmoudi: data acquisition, drafting of article.

Data Availability Statement

The datasets generated during the current study are not publicly available due ethical issues but are available from the corresponding author on reasonable request.

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Ethical Approval

The research protocol was reviewed and approved by the Institutional Review Board of Majmaah University: MU-REC-Dec.02/COM-2021/14-3.

References

1) Wilson BJ, O'Hare PE, Zacariah J. Implications and considerations of dental materials in MRI: a case report and literature review. Case Rep Dent 2020; 2020: 8891302.
2) Honda E, Prince JL, Fontanella VRC. State-of-the-art digital imaging in dentistry: advanced research of MRI, CT, CBCT, and digital intraoral imaging. Biomed Res Int 2018; 2018: 9057120.
3) Steinbacher J, McCoy MR, Klausner F, Wallner W, Oellerer A, Machegger L. Do patients with implants experience strong sensations that lead to early termination of MRI examinations? Concepts Magn Reson Part A Bridg Educ Res 2019; 2019: 1-6.
4) Kim YH, Choi M, Kim JW. Are titanium implants actually safe for magnetic resonance imaging examinations? Arch Plast Surg 2019; 46: 96-97.

5) Mishra SK. Awareness among dentist about interactions between metallic dental prosthesis and magnetic resonance imaging–a questionaire based survey. Guident 2018; 11: 14-16.

6) Hilgenfeld T, Juerchott A, Jende JME, Rammelsberg P, Heiland S, Bendszus M, Schwindling FS. Use of dental MRI for radiation-free guided dental implant planning: a prospective, in vivo study of accuracy and reliability. Eur Radiol 2020; 30: 6392-6401.

7) Niraj LK, Patthi B, Singla A, Gupta R, Ali I, Dhama K, Kumar JK, Prasad M. MRI in dentistry-a future towards radiation free imaging-systematic review. J Clin Diagn Res 2016; 10: ZE14-ZE19.

8) Reda R, Zanza A, Mazzoni A, Cicconetti A, Testarelli L, Di Nardo D. An update of the possible applications of magnetic resonance imaging (MRI) in dentistry: a literature review. J Imaging 2021; 7: 75.

9) Hövener JB, Zwick S, Leupold J, Eisenbeiß AK, Scheifele C, Schellenberger F, Hennig J, Elverfeldt DV, Ludwig U. Dental MRI: imaging of soft and solid components without ionizing radiation. J Magn Reson Imaging 2012; 36: 841-846.

10) Yetimoglu N, Kamburoglu K. Magnetic resonance imaging in dentistry. OMICS J Radiol 2014; 3: e125.

11) Ludwig U, Eisenbeiss A-K, Scheifele C, Nelson K, Bock M, Hennig J, von Elverfeldt D, Herdt O, Flügge T, Hövener JB. Dental MRI using wireless intraoral coils. Sci Rep 2016; 6: 23301.

12) Mew J. Jaw surgery alternatives. Br Dent J 2013; 214: 376.

13) Shellock FG. MR imaging of metallic implants and materials: a compilation of the literature. Am J Roentgenol 1988; 151: 811-814.

14) Juerchott A, Pfefferle T, Flechtenmacher C, Mente J, Bendszus M, Heiland S, Hilgenfeld T. Differentiation of periapical granulomas and cysts by using dental MRI: a pilot study. Int J Oral Sci 2018; 10: 17.

15) Duttenhoefer F, Mertens ME, Vizkelety J, Gremse F, Stadelmann VA, Sauerbier S. Magnetic resonance imaging in zirconia-based dental implantology. Clin Oral Implants Res 2015; 26: 1195-1202.

16) Geibel MA, Gelißen B, Bracher AK, Rasche V. Artifact properties of dental ceramic and titanium implants in MRI. RöFo 2019; 191: 433-441.

17) Tymofiyeva O, Vaegler S, Rottner K, Boldt J, Hopfgartner AJ, Proff PC, Richter EJ, Jakob PM. Influence of dental materials on dental MRI. Dentomaxillofac Radiol 2013; 42: 20120271.

18) Klinke T, Daboul A, Maron J, Gredes T, Puls R, Jaghsi A, Biffar R. Artifacts in magnetic resonance imaging and computed tomography caused by dental materials. PLoS One 2012; 7: e31766.

19) Roser C, Hilgenfeld T, Sen S, Badrow T, Zingler S, Heiland S, Bendszus M, Lux CJ, Juerchott A. Evaluation of magnetic resonance imaging artifacts caused by fixed orthodontic CAD/CAM retainers-an in vitro study. Clin Oral Investig 2021; 25: 1423-1431.

20) Chockattu SJ, Suryakant DB, Thakur S. Unwanted effects due to interactions between dental materials and magnetic resonance imaging: a review of the literature. Restor Dent Endod 2018; 43: e39.

21) Kajima Y, Takaichi A, Tsutsumi Y, Hanawa T, Wakabayashi N, Kawasaki A. Influence of magnetic susceptibility and volume on MRI artifacts produced by low magnetic susceptibility Zr-14Nb alloy and dental alloys. Dent Mater J 2020; 39: 256-261.

22) Mathew C, Maller S, Maller U, Maheshwaran M, Valarmathi S, Karrunakaran B. Evaluation of awareness among dentists about magnetic resonance imaging and their interactions with restorative dental materials: a survey among dentists in three districts of Tamilnadu. J Indian Acad Dent Spec Res 2016; 3: 6-9.

23) Tekale PD, Mhaske AR, Chitko SS, Parhad SM, Bhandari AP, Patil HA. MRI and dentistry-a contemporary. EJBPS 2014; 1: 490-503.

24) Jeon KJ, Lee C, Choi YJ, Han S-S. Comparison of the usefulness of CBCT and MRI in TMD patients according to clinical symptoms and age. Appl Sci 2020; 10: 3599.

25) Drăgan OC, Fărcăşanu AŞ, Câmpian RS, Turcu RVF. Human tooth and root canal morphology reconstruction using magnetic resonance imaging. Clujul Med 2016; 89: 137-142.

26) Flügge T, Hövener J-B, Ludwig U, Eisenbeiss A-K, Spittau B, Hennig J, Schmelzeisen R, Nelson K. Magnetic resonance imaging of intraoral hard and soft tissues using an intraoral coil and FLASH sequences. Eur Radiol 2016; 26: 4616-4623.

27) Idiyatullin D, Corum C, Moeller S, Prasad HS, Garwood M, Nixdorf DR. Dental magnetic resonance imaging: making the invisible visible. J Endod 2011; 37: 745-752.