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Abstract of Thesis

Name (Wiranut Kitisriworapan)

Title: Force and torque effect of MRI scanner on dental metals
(歯科用金属に与えるMRIスキャナによる力とトルクの影響)

Background:

Imaging diagnosis using MRI is becoming increasingly important in medical and dental treatment. With MRI, there is no exposure to ionizing radiation, and a superior soft tissue contrast is obtained, making it an indispensable modality for diagnosing oral and maxillofacial lesions. MRI scan uses the static magnetic field, the radiofrequency electromagnetic field, and the spatial-encoding magnetic fields. These necessary factors can affect the human body. Examples include magnetically induced displacement force and torque by the static magnetic field, temperature rise by the radiofrequency electromagnetic field, and neural stimulation by the spatial-encoding magnetic fields.

In MRI examinations in dentistry, dental metals are subjected to and affected by various influences. Therefore, removable metals such as dentures should be removed before the MRI examination. Still, there are cases where the patient forgets to remove them, there is no instruction from the doctor, or it is unknown whether or not they can be removed. Previous studies have shown the displacement force and torque applied to metals such as dental metals. However, there were many limitations, such as the limited number of metals tested and limited measurement locations.

Objective:

This study aimed to measure the magnetically induced displacement force and torque on materials, including dental materials and household items, at each spatial point in the examination room for an MRI scanner with a static magnetic field strength of 3 Tesla and to examine a relationship between the displacement force and torque and a magnetic flux density.

Material and Method:

The device used in this study was a 3 Tesla superconducting MRI scanner Premier (GE HealthCare, USA). The magnetic flux density outside the scanner was measured, and the measuring points were two-dimensionally 25 cm grid intersection at the heights -100 (ground level), 0 cm (patient table level), and 50 cm (patient height level). Then, the magnetic flux density inside and outside the scanner was measured along the gantry centerline.

The materials tested were 29 dental materials and 15 household items for displacement force measurement and 12 dental materials and two household items for torque measurement. The displacement force outside the scanner at the same height levels as the magnetic flux density measurement was measured according to ASTM F2052-15 by measuring the deflection angle. The displacement force along the gantry centerline inside and outside the scanner was

also measured. Then, for all materials, the displacement force was measured at the two positions, 25 and 50 cm away from the gantry entrance. Torque was measured according to ASTM F2213-17 at six positions inside the gantry. All measurements were performed six times, and Tukey's test was performed statistically.

Result:

The magnetic flux density at the isocenter of the scanner was 3.000 Tesla and remained the same within 30 cm from the isocenter. However, the magnetic flux density along the gantry centerline outside the scanner was decreased while the distance from the isocenter was increased. At the patient table level, the magnetic flux density outside the scanner was symmetrical horizontally.

Within 150 cm away from the gantry, the displacement force outside the scanner decreased rapidly and was symmetrical horizontally at the height of patient table level. At the isocenter inside the scanner, the displacement force was zero. The displacement forces measured at the two positions outside the gantry of the household items and extraoral dental appliances made of stainless steel showed a similar tendency. At 25 cm, many exhibited deflection angles of more than 90 degrees, and the displacement force could not be calculated. For intraoral dental materials, the displacement forces at the position of 25 cm of a keeper for the magnet denture, stainless steel orthodontic wires, and brackets were 0.005 N, less than 0.03 N, and less than 0.005 N, respectively.

The torque at the six positions inside the scanner was the same for each tested material; the values were within 5.75 N·cm for the household items and within 0.14 N·cm for the stainless steel wires. The other titanium, nickel, or niobium wires showed no torque.

Conclusion:

The magnetic flux density outside the gantry was the largest and bilaterally symmetrical at the height of the patient table. It rapidly decreased with the increasing of the distance from the edge of the gantry. The displacement force is related to the product of the magnetic flux density and the spatial gradient of the magnetic field and reached the maximum at the gantry entrance. However, near the isocenter of the gantry, the spatial gradient of the magnetic field became zero, and the displacement force also became zero. Because of the uniform magnetic flux density around the isocenter inside the gantry, the torque on each tested material remained at the same.

Inadequately fixed intraoral stainless steel and magnetic dental appliances are affected by magnetically induced displacement force and torque. Therefore, the status of the fixation in the oral cavity should be confirmed before and after the MRI examination.

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論文審査の結果の要旨及び担当者

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論文審査の結果の要旨

本研究は、MRI スキャナの磁場による歯科用金属等への吸引力やトルクの影響について検討したものである。その結果、吸引力はガントリの開口部で最大で、対象とした歯科用金属では最大 0.03 N であった。トルクはガントリの中央部で最大で、その最大値は 0.14 N・cm であった。

以上の研究結果から、MRI スキャナの磁場による歯科用金属への吸引力やトルクに関しては、臨床の現場においては特段の配慮の必要性はないと結論づけた。ただし、鉄製の日用品には十分な注意が必要である。

本研究によって、日常の MRI 検査においての歯科用金属に対する対応方法が明らかとなった。

よって、博士（歯学）の学位論文として価値のあるものと認める。