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Magnetic resonance imaging of the temporomandibular joint in patients with metal structures

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High-quality visualization of the temporomandibular joint (TMJ) allows to choose the most optimal tactics for conservative or surgical treatment. Performing magnetic resonance imaging (MRI) in patients with metal structures in the maxillofacial area is a pressing issue in ensuring quality diagnostics. In the presented clinical case, a methodology of performing diagnostically significant MRI of the TMJ in the presence of metal structures in the region of interest (ROI) was clearly demonstrated and described.

Keywords: artifacts; metal; temporomandibular joint

Conflict of interest. The authors declare no conflict of interest. The study had no sponsorship.

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Introduction

Temporomandibular joint (TMJ) disorders are widespread and occur in 25–65% of the population [1]. Clinical signs in the joint are characterized by a pain radiating to the eye and temporal region. Typically, the pain intensifies with a wide opening of the mouth, leading to a reflex spasm of the masticatory muscles and, as a result, severe discomfort for the patient. TMJ assessment is necessary to determine a cause of the pain syndrome, as well as to plan orthodontic and orthognathic treatment, and their control [2, 3].

Magnetic resonance imaging (MRI) is a gold standard for imaging soft tissues of the TMJ [4, 5]. The advantage of this method is a high contrast allowing to fully evaluate the anatomical structures of the joint, and, most importantly, the intra-articular disc. A possibility of additional functional MRI of the joint in real-time mode allows visualizing dynamics of the arbitrary process of opening and closing the mouth in motion [6–8]. Overall, MRI helps establish a presence of joint dysfunction, reflecting the relative position of intra-articular structures, synchrony or asynchrony of movements of the condyle and disc [9, 10]. A disadvantage of the method is a presence of pronounced artifacts or distortions in the images from non-removable metal structures. Most often, these are dental implants, braces, etc. Being in the scanning zone, they lead to inhomogeneity of constant (B0) and alternating (B1) magnetic fields and, as a consequence, to rapid dephasing and incoherence of spins within a single voxel, incorrect spatial registration, and etc. [3, 11]

The number of indications for MRI of the TMJ is growing, which is partly due to increase in patients with dental or orthopedic implants, crowns, bridges, prostheses, etc. There is a recommended scanning protocol, however, in patients with metal structures in the maxillofacial region (MFR), performing MRI is a challenge and it requires non-standard approaches [8, 11]. Using the example of the presented clinical case, a performance of diagnostically significant MRI of the TMJ in patients with metal structures of the dentofacial system is clearly demonstrated.

Case description

A 29-year-old female patient, during the ongoing treatment for bite correction and the braces installation, came to the clinic with complaints of discomfort in the TMJ area when chewing and a feeling of jaw locking.

MRI was performed on a scanner with a magnetic field induction of 1.5 T (GE, Optima MR 360) without considering the presence of dental metal structures. MRI protocol included a localizer in three mutually perpendicular planes, a static part in the closed and open mouth positions (Table 1).

When interpreting the obtained data, there was no opportunity to assess adequately the articular disc, ligaments, and components of the bilaminar zone due to pronounced signal loss artifacts and geometric distortions (Fig.1). The study protocol included sequences sensitive to magnetic field inhomogeneity (namely, gradient echo (GRE) sequences), which led to the appearance of artifacts from the metal structure and loss of a diagnostic value of the study.

In order to eliminate artifacts' effect, we decided to repeat the study using pulse sequences which are less sensitive to magnetic field inhomogeneity. The study was carried out using a high field scanner with the magnetic field induction of 1.5 T (Siemens, MAGNETOM_ESSENZA) in another clinic. In order to correct artifacts, the study was performed according to a protocol considering metal structures in the scanning area (Table 2).

Table 1. MRI protocol for TMJ without considering metal structures in the ROI

Static closed-mouth position	a.	AX T2
	b.	COR PD FSE
	c.	SAG T2
	d.	SAG PD FSE
	e.	SAG T2* 3D GRE
	f.	SAG T1 FSE
Static open mouth position	a.	SAG PD GRE
Slice thickness		4 mm
Field of view		130 × 130
Bandwidth		40

To reduce the area of artifacts in the images, sequences based on Spin Echo were chosen instead of Gradient Echo. In order to change the artifact localization, we changed a direction of signal encoding and increased the receiver bandwidth. The slice thickness and field of view (FOV) have also been reduced.

Due to the application of all the above approaches, signs of the TMJ dysfunction were identified – flattening of the articular discs, as well as an asymmetrical position of the articular processes of mandible in the joint cavity in the dental occlusion (Fig. 2, 3).

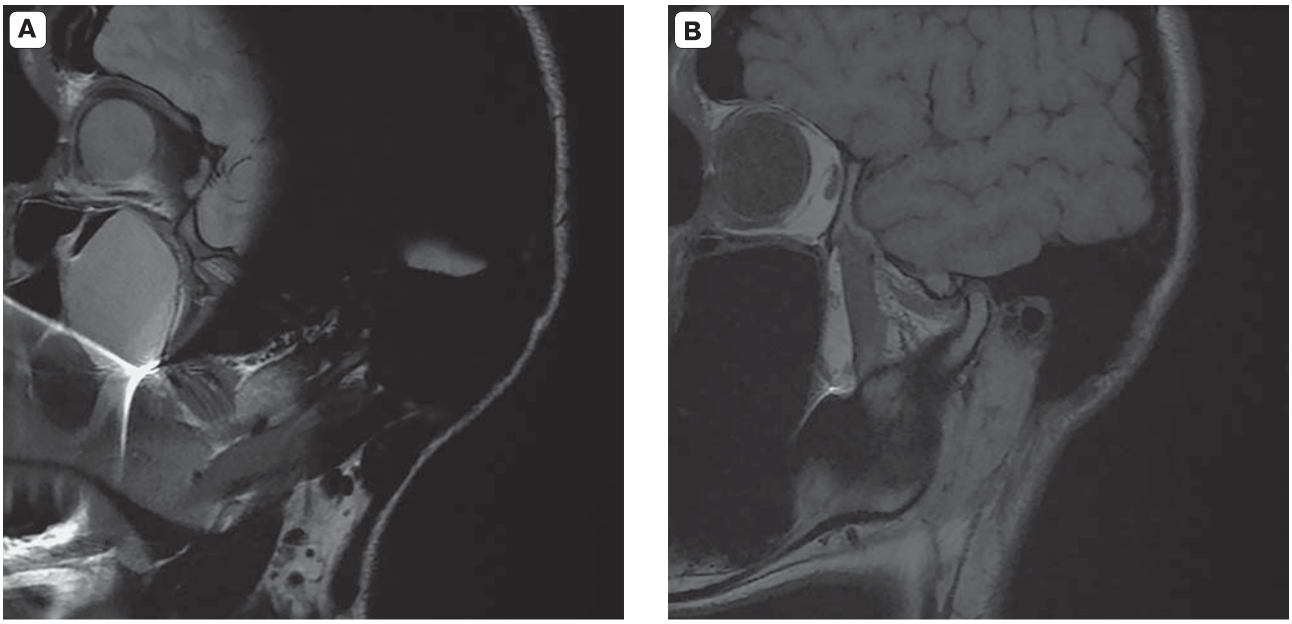

Fig. 1. MRI of the TMJ without considering metal structures in the ROI, sagittal plane. **A** – PD GRE, open mouth position; **B** – T1 GRE, closed-mouth position.

Table 2. Special MRI protocol for TMJ considering metal structures in the ROI

Static closed-mouth position	a.	AX T2
	b.	COR T2 (positioning is based on the obtained scans in parallel to the axis of the mandibular ramus)
	c.	SAG T2
	d.	AX T1
	e.	COR T1
	f.	SAG T1 (positioning is based on the obtained scans in parallel to the axis of the mandibular ramus)
	g.	Oblique-coronal T2 (to assess lateral displacement of the intraarticular disc; positioned in parallel to the mandibular ramus and perpendicular to the meniscus)
Static open mouth position	a.	AX T2 HR OPEN
	b.	COR T2 HR OPEN
	c.	SAG T2 HR OPEN
		Dynamic MRI
	a.	SAG T2
Slice thickness		2 mm
Field of view		100 × 100
Bandwidth		120

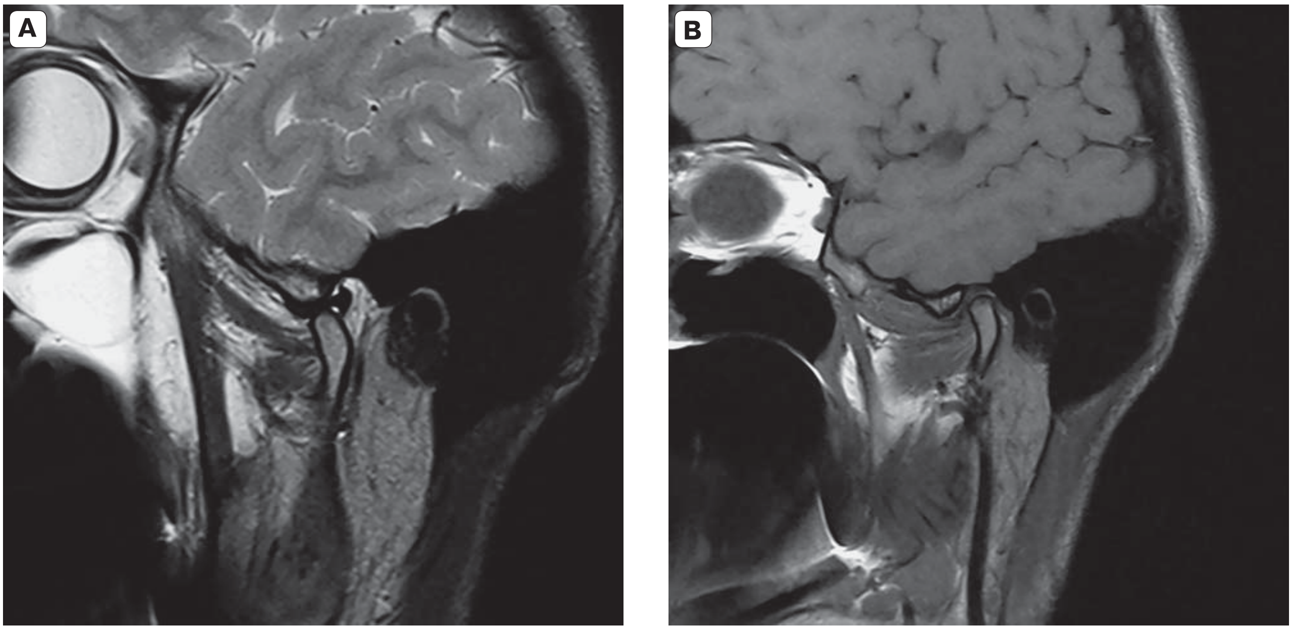

Fig. 2. MRI of the TMJ considering metal structures in the ROI, sagittal plane. **A** – T2 FSE, open mouth position; **B** – T1 FSE, closed-mouth position.

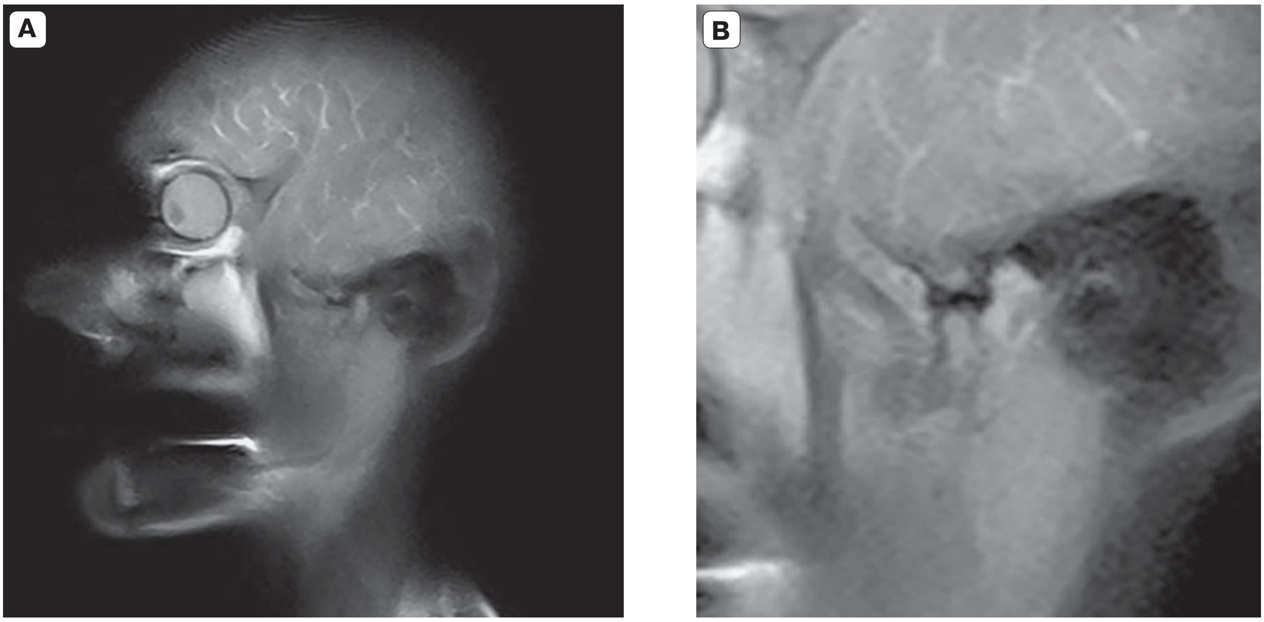

Fig. 3. Real-time MRI of the TMJ considering metal structures, sagittal plane: **A** – T2 VI, closed-mouth position; **B** – T2 VI, approximate image, wide open mouth position. In this case, the artifacts did not affect the ROI during dynamic MRI.

Discussion

TMJ has a unique and complex anatomy, so choosing the right diagnostic method is critical. Visualization of TMJ structures can be carried out using a number of radiological diagnostic methods: X-ray, computed tomography (CT), sonography (USG), as well as MRI [12, 13].

Bone changes are better visualized using CT and cone beam CT (CBCT). CBCT provides a multiplanar reconstruction of the TMJ with high resolution and low radiation dose. MRI provides a better contrast of soft tissues and other structures in the TMJ region compared to CT and CBCT [4]. MRI allows detecting changes in the localization of the articular disc, effusion in the joint cavity, evaluating articular cartilage, para-articular tissues, hypertrophy of the masticatory muscles, etc. [14]. Inexpensive and safe sonography provides sufficient contrast of soft tissues. However, a limitation for ultrasound is a visualization of the disc position. Thus, when articular disc is displaced laterally and posteriorly, the ultrasound method is uninformative due to the narrow acoustic window limited by bone structures [9]. The issue of examining patients with TMJ pathology is relevant due to its high functional significance. Obtaining high-quality images, including in patients with metal structures will help avoid treatment complications and subsequent disability.

The main recommendations for reducing artifacts from metal structures in the maxillofacial area include reducing the field of view (FOV) and the slice thickness, increasing the receiver bandwidth, the repetition time (TR), and the average value, abandoning gradient echo in favor of various types of spin echo. It is advised to conduct a study on the scanner with a magnetic field induction of 1.5 T, rather than 3 T. However, if software algorithms for suppressing metal artifacts (MAR – Metal Artefact Reduction) are available, higher quality images can be obtained on scanners with higher induction. Using parallel data acquisition, inversion-recovery sequences STIR and Dixon as fat suppression technologies instead of spectral fat suppression (FatSat) will also contribute to better visualization in the metal presence [11, 15].

The relative disadvantages of the MRI method include high cost, low availability, and absolute contraindications in the presence of active electronic medical devices (pacemakers), cerebral vascular clips in the body, etc. [7, 16]. Considering the method limitations, it is also worth taking into account a technical implementation of the study (equipment and personnel qualification) [8].

Protocol adjustments should be carried out jointly with an MRI engineer or a certified manufacturer representative. Also, a number and type of metal structures in the maxillofacial area are individual, therefore technical parameters of the MRI protocol may differ slightly from patient to patient.

Conclusion

The most informative method for visualizing the structures of TMJ is MRI. An active development of new approaches in the treatment of dental patients has led to increase in the number of interventions with the installation of metal structures, including non-removable ones, which complicate obtaining diagnostically significant results of radiological examinations. Performing MRI for such patients is not an easy task and requires setting up a specialized scanning protocol to obtain images of proper quality.

Conflicts of interest

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Authors' participation

Yuri A. Vasilev – conducting research, approval of the final version of the article.

Dmitry V. Burenchev – responsibility for the integrity of all parts of the article.

Yulia N. Vasileva – conducting research, analysis and interpretation of the obtained data.

Olga Yu. Panina – concept and design of the study, text preparation and editing.

Varvara A. Ignatieva – writing text.

Daria V. Dushkova – analysis and interpretation of the obtained data.

Alexander V. Bazhin – collection and analysis of data.

Ekaterina G. Privalova – review of publications.

Violetta A. Ulyanova – review of publications.

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