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Exploring the potential of MRI studies in assessing risks during arthroscopy – insights on maxillary artery encounter

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Summary

The anatomy and variability of the maxillary artery have been extensively studied through cadaveric dissections and CT angiography, revealing diverse courses of its terminal branches. These studies underscore the importance of understanding regional anatomy, particularly in surgical contexts such as intraoral vertical ramus osteotomy and temporomandibular joint (TMJ) arthroplasty, where proximity to the maxillary artery in the infratemporal fossa poses risks of complications. MRI offers distinct advantages in visualizing soft tissues critical to TMJ function, surpassing conventional imaging modalities like orthopantomography in providing detailed anatomical insights. This study aims to assess the risk of iatrogenic damage to the maxillary artery during arthroscopic procedures using MRI scans. A total of 42 patients, comprising both sexes and varying ages, underwent MRI at the Department of Maxillofacial Surgery, University Hospital Louis Pasteur in Košice. Imaging protocols were standardized on a Toshiba Atlas 1.5 Tesla MRI scanner, ensuring consistent quality with a slice thickness of 6 mm and standardized imaging matrices. Measurements of the maxillary artery's proximity to anatomical landmarks were conducted in axial and parasagittal sections to delineate precise anatomical relationships.

Key words

arthroscopy – temporomandibular joint – maxillary artery – surgical risk

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Introduction

The maxillary artery anatomy has been a subject of extensive study, including both cadaveric [1,2], and more recent CT angiographic investigations [3–5]. As these studies have revealed, the previously understood course of the terminal branch of the external carotid artery is more varied than previously anticipated. Given that various surgical procedures, including intraoral vertical ramus osteotomy, internal rigid fixation for condylar fractures, and radical maxillectomy, are performed in close proximity to the maxillary artery (MA) in the infratemporal fossa, it is crucial to have a thorough understanding of the regional anatomy to minimize the risk of complications during these operations [6]. Similarly, procedures connected with the diagnosis of the temporomandibular joint (TMJ) arthrosis such as complete joint replacement can be associated with high risk of injuring the MA. The treatment for this disorder typically involves either condylectomy or gap arthroplasty [7]. Previous studies have examined various anatomical bony landmarks that can guide surgeons during intraoperative procedures. Although useful, during the arthroscopic procedures the marginal orientation is smaller, as well as operative field. Thus, the absolute significance of operators' knowledge and understanding of the surrounding tissues. While previous studies may have favored CT scans due to their faster acquisition times, MRI offers significant advantages, including unparalleled soft tissue contrast, absence of ionizing radiation, and comprehensive diagnostic capabilities. Despite potential for motion artifacts, MRI remains the preferred modality for detailed assessment and differential diagnosis of TMJ disorders, as it enables the comprehensive evaluation of articular soft tissues, bony landmarks and vascular structures [3].

MRI studies have gained the interest of the clinicians specializing in TMJ disorders mainly due to the ability to visualize the soft tissues which are impartial in correct function of the joint. The availability to look at discal and capsular tissue has tremendously broadened the diagnostic approach. The preferred clinical examination and standard panoramic radiograph of the region of interest is usually sufficient during the estab-

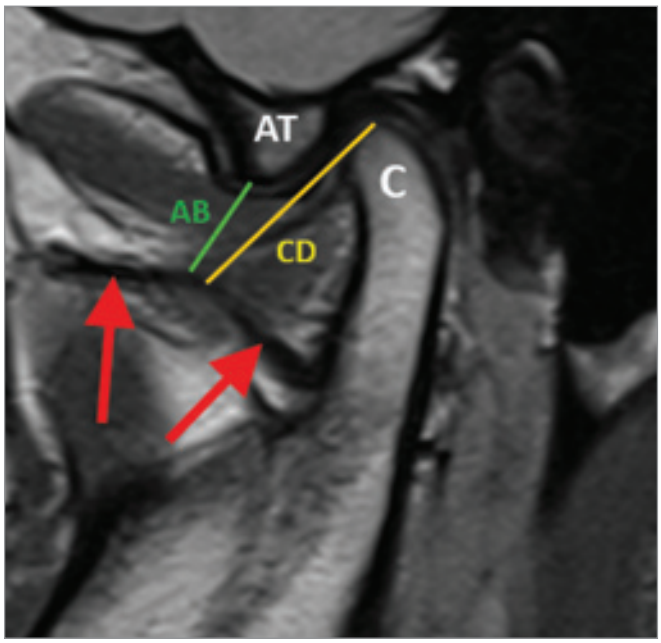

Fig. 1. MRI of the temporomandibular joint, parasagital view. Red arrows – maxillary artery, C – mandibular condyle, AT – articular tubercule, AB – distance between inferior point of articular tubercule and maxillary artery, CD – distance between top of the condyle and maxillary artery

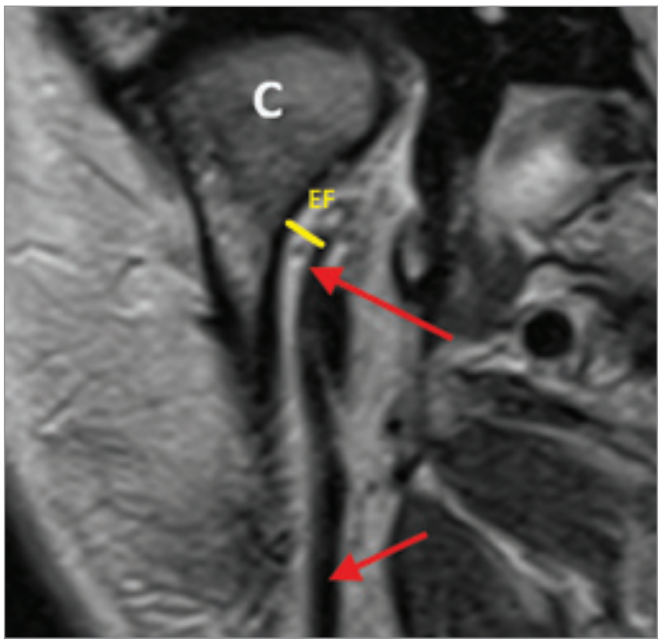

Fig. 2. MRI of the of the temporomandibular joint, coronal view. Red arrows – maxillary artery, C – mandibular condyle, EF – distance between medial margin of the neck of the condyle and maxillary artery

lishment of working diagnosis. If unclear or primary approach has been proven to be unsuccessful, MRI can lead to correct differential diagnosis. Usually, the approach to directing patient to MRI study is worsening of the clinical symptomatology on the course of the treatment as well as unexplainable, prolonged pain. The next step on the ladder of diagnosis is the minimal invasive approach of arthroscopy after 3–6 months of conservative therapy [8]. Arthroscopic approach was proven to be a significant way to diagnose disorders as well as providing the ability to a guided lavage and lysis of the upper joint space. Arthroscopic approach is indicated due to unsuccessful conservative therapy with indication of the presence of intraarticular degeneration: disc dislocation, disc deformation, presence of intraarticular adhesions, osteoarthritis, synovial chrondromatosis as well as the need of biopsy taken from the area and need of pathological examination. The contraindication to the arthroscopic approach due to clinical reasons is the presence non-identifiable articular space on the panoramic radiograph joint as well as extraarticular disorder [9].

A thorough understanding of TMJ anatomy is essential to prevent potential complications. The aim of this study is to assess the risk of iatrogenic damage to the maxillary artery during endoscopic and open surgery procedures by comparing the TMJ structures relative to the maxillary artery using MRI scans.

Materials and methods

A total of 42 individuals, comprising both women and men, who underwent MRI as part of the routine diagnostic workup for TMJ disorder differential diagnosis between 2022 and 2024 at the Department of Maxillofacial Surgery, University Hospital of Louis Pasteur in Košice, were included in this study.

Data were obtained using Siemens Magnetom Sola 1.5T MRI system with BioMatrix, with the following settings: slice thickness of 6 mm and an acquisition matrix of 512 × 512 – standardized imaging acquired from single radiological department were used assuring the same calibration and quality of the studies.

Several variables were noted together with measurement regarding the patient demographics, such as age and sex.

The inclusion criteria were age 18 ≥ years at the time of imaging, a diagnosis of TMJ disorders. Exclusion criteria included: poor-quality images (usually due to movement artifacts), previous TMJ trauma, previous surgical intervention on TMJ, presence of the osteosynthetic material, being unable to identify the course of the maxillary artery, due to poor image quality or presence of artifacts.

Study focusing on MRI visualization of the MA to the anatomical landmarks: top of condylar head and capsular tissue. Assessment was done in regards of two planes: coronal and parasagittal plane (parallel to the mandibular ramus).

Distance AB: the distance between the inferior margin of the articular tubercule in relation to the maxillary artery in parasagittal section of the patient with closed mouth (Fig. 1).

Distance CD: the distance between the tip of the condyle in relation to the maxillary artery in parasagittal section (Fig. 1).

Distance EF: the distance between the medial margin of the condylar neck in relation to the maxillary artery in coronal section (Fig. 2).

Single, experienced in MRI reading clinician was responsible for measurement and confirmation of the path of the maxillary artery with regards to anatomical structures.

Results

The following variables have been noted:

1) AB – measurement 1;
2) CD – measurement 2;
3) EF – measurement 3;
4) gender;
5) age;
6) side (P for right, L for left).

Gender distribution: female (F) – 24 subjects, male (M) – 18 subjects.

Age distribution: the age ranges from 18 to 78 years. The average age is approx. 45.9 years.

For measurements, see Tab. 1: AB ranges from 3.5 to 19.6, with an average of 12.2. CD – ranges from 11.6 to 29.4, with an average of 21.7. EF – ranges from 1.8 to 8.4, with an average of 4.5.

Tab 1. Results of anatomical measurements of MRI scans of the temporomandibular joint.

Measurement	Min	Max	Mean	Median	SD
AB	3.5	196	12.2	12.0	3.8
CD	11.6	294	21.7	21.5	4.2
EF	1.8	8.0	4.5	4.4	1.6

SD – standard deviation

Discussion

This study offers a unique contribution by meticulously accounting for the distance between the maxillary artery and the surrounding soft tissues. However, several limitations must be considered. The study was conducted on participants from a single race, which limits the generalizability of the findings. Additionally, the small sample size may not provide a comprehensive representation of the wider population. Data was measured by a single operator, introducing the possibility of measurement errors. Furthermore, the reliance on a single observer could lead to biased results, whereas multiple observers could provide more reliable and consistent data.

Due to the potential for significant blood loss caused by damage to the maxillary artery, selective embolization was recommended before undertaking complete joint replacement surgery [10]. Traditional methods of hemostasis are challenging and risky in this region due to the proximity of vital structures, such as the facial nerve [11]. Bleeding in this area must be avoided at all costs, especially considering the difficulty of controlling bleeding through the limited operative field of arthroscopy. This procedure requires specialized equipment and skilled operators [12].

Arthroscopic procedure of TMJ is usually performed with an mouth open. Intraarticular anatomic orientation is made difficult by distortion and difficult identification of some TMJ structures. The position of the condyle changes during the procedure, moreover, in the presence of a preserved articular disc, it is not possible to take the condyle as a reference anatomical landmark. Our study therefore investigates the relationship of the articular tubercule and maxillary artery (distance AB), since during arthroscopy the tubercule (its posterior slope) can be reliably identified, and its position does not change.

Measuring the distance between the condyle and the artery with the mouth open would provide a more accurate assessment of the anatomical proportions. Due to difficulty opening the mouth in patients with TMJ disease, the position of the condyle was variable, and the images were often distorted by the patient's movement during the examination. However, for open joint surgery, the condyle represents an important landmark for assessing the position of the maxillary artery.

Anatomic variations in the maxillary artery are inherent and can significantly impact its vulnerability during arthroscopic procedures. These variations encompass differences in the artery's location, branching pattern, and size among individuals. Such natural differences in anatomy may introduce variability that affects surgical approaches and outcomes [5,13].

Furthermore, proximity to other anatomical variations, reliable differentiation from middle meningeal artery, might lead to difficult orientation while analyzing MRIs.

Cadaveric studies in the past have provided valuable insights despite their limitations. Dissections were typically performed in a single plane, which restricted the view and statistical data gathered. These studies were time-consuming and often limited by sample size [1,6,7]. In contrast, CT studies are now commonly integrated into stroke patient protocols, resulting in large datasets. These studies offer comprehensive evaluations of various structures, leveraging the influx of patient data to explore different aspects [3,5].

MRI studies, on the other hand, offer detailed imaging capabilities without the invasiveness of cadaveric dissec-

tions. They provide high-resolution views of anatomical structures and are particularly valuable for studying soft tissues and dynamic processes [14–16].

Standardized 3D reconstructions hold promise in preventing complications such as bleeding and perforation during arthroscopy. By accurately mapping anatomical structures and variations beforehand, surgeons can better plan their approach and navigate complex surgical sites with greater precision. This proactive approach minimizes the risk of inadvertent damage to vital structures, thereby improving patient outcomes and reducing recovery times. 3D reconstructions pave the way for advanced training simulations, providing trainees with realistic environments to practice procedures. These simulations can replicate patient-specific anatomy, allowing trainees to hone their skills in a controlled setting before performing actual surgeries. This not only improves proficiency but also enhances patient safety by reducing procedural errors [17,18].

While this study provides valuable insights into the anatomical relationship between the maxillary artery and TMJ structures using MRI, certain limitations must be acknowledged. The MRI scans had a slice thickness of 6 mm, which may limit the resolution of smaller anatomical details and affect measurement accuracy. The relatively small sample size of 42 patients and the single-institution setting restrict the generalizability of findings. Additionally, all measurements were conducted by a single observer, introducing potential bias that could have been mitigated by multi-observer validation. MRI captures static images, which may not fully reflect the dynamic nature of TMJ function, and the lack of comparison with other imaging modalities, such as CT angiography, limits the broader applicability of the results.

Despite these limitations, the study offers notable strengths. Unlike previous studies using cadaveric dissections or CT angiography, this study utilizes MRI's superior soft tissue visualization to assess the maxillary artery's relationship with TMJ structures in a clinically relevant manner. It provides crucial data for surgical planning, particularly in arthroscopic and open TMJ surgeries, helping to minimize iatrogenic complications. The use of a standardized imaging protocol enhances consistency, and the identification of the articular tubercule as a stable reference point offers practical value for surgical orientation. Furthermore, the findings could contribute to the development of 3D reconstructions and surgical simulations, aiding both preoperative planning and surgical training.

Conclusion

MRI emerges as a pivotal tool in evaluating maxillary artery risks during TMJ surgeries, offering precise anatomical insights that guide safer procedural approaches. Future research should explore interdisciplinary approaches integrating MRI with surgical simulations to optimize clinical outcomes and patient safety. Future research should integrate MRI with 3D surgical simulations for enhanced safety.

Roles of authors

Branislav Borza – main author and investigator, study design and data assessment, analysis and interpretation of data, critical revision of the manuscript; Karolina Glinska – analysis and interpretation of data, crafting of the manuscript, statistical analysis; Peter Kizek – critical revision of the manuscript.

Disclosure statements

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Ethics approval

Ethical approval was obtained from the responsible Ethics committee. This study thus fulfils the criteria of the Declaration of Helsinki.

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