MRI Imaging of Claustrophobic Patients Using the ASG MrOPEN 0.5 T Scanner: Motion Artifacts and Patient Acceptability Compared to Traditional "Closed" Systems. – Written by Dr. Andrea Romagnoli and Dr Maurizio Fratini

INTRODUCTION

Patient anxiety related to medical imaging procedures is common, with a reported incidence ranging from 49% to 95%.(1,2)

The underlying causes may be associated with specific aspects of the procedure itself or concerns about the results of the examination.

In the case of magnetic resonance imaging (MRI), these factors are compounded by discomfort and anxiety induced by claustrophobia, resulting from the enclosed nature of the scanning apparatus (Image 1), along with the scanning noise, duration, and supine positioning. (3,4)

Image 1
Example of a Traditional High-Field MRI Scanner - Closed Configuration

A wide range of responses has been reported, from mild discomfort to extreme panic.

Increased anxiety is noted in 29–56% of patients(1,2) , leading in some cases to an inability to tolerate or even attempt a scan.

Meta-analyses have demonstrated a premature termination rate in MRI ranging from 0.46–5.29%, with some studies reporting rates as high as 10%.(5,6)

Additionally, a significant, though not scientifically quantified, number of patients choose to avoid undergoing MRI examinations altogether. (10)

Magnetic Resonance Imaging (MRI) is a highly valuable diagnostic tool in a wide range of clinical scenarios.
Its effectiveness and diagnostic accuracy, however, are directly proportional to the patient's ability to remain still, minimizing motion artifacts.

Various techniques have been explored to make MRI imaging more tolerable for claustrophobic patients (6,7,8,9) , including the intravenous or intranasal administration of benzodiazepines.

However, these approaches are often time-consuming, costly, and associated with potential drawbacks, such as reduced patient cooperation.

These techniques are often time-consuming, costly, and pose challenges related to potential reductions in patient cooperation.

Manufacturers have developed open-configuration MRI systems to facilitate interventional procedures, functional MRI examinations, and improve patient comfort.

Historically, open MRI scanners were low-field systems which, despite featuring a more spacious gantry, still required the patient to be positioned inside the bore. (Image 2)

Image 2
Examples of Open MRI Systems with Different Gantry Widths and Configurations.

The open design can be more comfortable for claustrophobic patients (11,12). However, the lower magnetic field strength of open-configured MRI systems, compared to cylindrical MR systems, can reduce image quality (13,14,15) and limits the variety of possible MRI examinations compared to traditional equipment.

Therefore, a higher magnetic field strength (0.5 T) combined with an open magnet configuration is desirable to achieve high MRI image quality, especially for claustrophobic patients.

Among all the so-called open magnets currently available on the market, one of the most innovative and revolutionary in terms of technology and design is the ASG MrOPEN MRI.

This device is U-shaped, where, unlike conventional systems, there is no barrier between the patient and the surrounding environment. The adjustable bed and the wide space between the magnet poles offer unprecedented flexibility of use compared to conventional equipment.

In summary: dynamic imaging, weight-bearing imaging, and interventional procedures become immediately accessible applications. The upright position or seated positioning at various angles undoubtedly enhances the comfort of claustrophobic patients during MRI studies. (Image 3)

Image 3
MrOpen ASG Open Sky MRI

The aim of this study is to evaluate patient acceptability and the impact of corresponding motion artifacts on image quality in MRI examinations of claustrophobic patients across a wide range of clinical applications, using the 0.5 T MrOpen "open sky" magnet, in comparison with a standard high-field closed MRI system (1.5 T).

MATERIALS AND METHODS

From FEBRUARY to JULY 2024, 56 claustrophobic patients were prospectively enrolled in the study, all of whom had previously undergone MRI exams with a "closed" magnet (PHILIPS INGENIA AMBITION C 1.5T) at the DIAGNOSTICA NOBILIORE Radiology Center.

31 men and 24 women (age range 18-78; mean age 56 years).

29 of the included patients had undergone joint MRI studies (15 knee MRIs, 4 ankle MRIs, 2 wrist MRIs, and 8 shoulder MRIs).

The remaining 27 patients had undergone spinal MRI studies (lumbar region 15, cervical region 10, and dorsal region 7).

Inclusion Criteria:

1. Premature termination of a previous high-field MRI study during the procedure (non-diagnostic exam) – 34 patients
2. Completed exam but with suboptimal quality due to motion artifacts – 22 patients

Additionally, 25 more patients were included in the study, who had refused to undergo an MRI on a closed magnet just prior to the start of the exam due to claustrophobia.

Upon obtaining informed consent, all 81 patients included in the study were invited to repeat the MRI examination using the MrOPEN EVO MRI system (AGS) 0.5 T.

This device features a U-shaped superconducting open magnet, which, under certain conditions, allows anxious patients to undergo the study in a seated position or standing (orthostatic position).

The degree of anxiety and stress reported by patients during the MrOPEN MRI exam was assessed using visual analog scales and a questionnaire completed at the end of the examination. In this questionnaire, each patient rated their feelings during the exam on a scale from 1 to 10, with 1 indicating no anxiety or stress and 10 indicating an almost panic-like state.

Additionally, all 56 patients who had previously undergone an MRI on a high-field magnet filled out the same scale, expressing the level of anxiety experienced in the closed magnet compared to the MRI exam just performed on the MrOPEN system.

Previo ottenimento del consenso informato tutti gli 81 pazienti inclusi sono stati invitati a ripetere l'indagine RM su magnete RM MrOPEN EVO (AGS) 0,5 T.

The impact of motion artifacts on image quality was independently assessed by two radiologists using a four-point scale:

(1) Significant motion artifacts present in all sequences (non-diagnostic exam)
(2) Severe motion artifacts not present in all sequences (partially diagnostic exam)
(3) Moderate motion artifacts, diagnostic exam but suboptimal image quality
(4) No motion artifacts

RESULTS

Of the 25 patients who had never been able to undergo an MRI and had previously refused the examination on the day of the appointment, 19 (76%) completed the exam with the MrOPEN magnet.

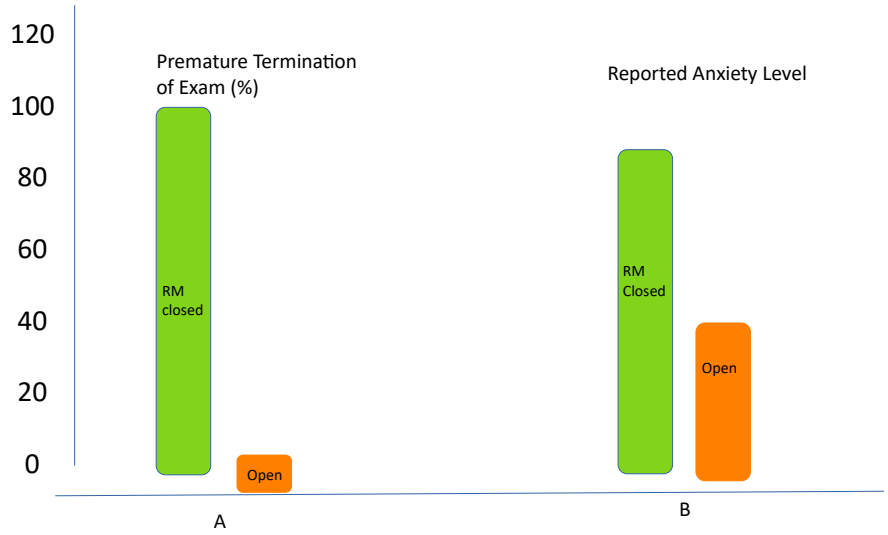
In 11 cases, the examination involved a joint study, and in 9 cases, a spinal segment study was

conducted.
Among the remaining 6 patients, 4 requested premature termination of the study, while 2 refused to undergo the MRI even with the MrOPEN magnet.

In the 56 patients who had previously interrupted an MRI on a closed magnet due to anxiety and claustrophobia, 51 completed the examination, while 5 requested premature termination of the study.
The premature termination rate for the MRI examination in this group decreased from 100% (closed magnet) to approximately 9% when using the MrOPEN system.

Regarding the evaluation of anxiety and stress levels, a questionnaire was completed exclusively by the 56 patients who had undergone an MRI on a closed magnet to compare the values with those from the open MRI examination.

On a scale from 1 to 10, the average value for the closed magnet examination was 8.7, while the average value for the open MRI was 4.2.



Tab 1

A – Percentage of MRI Exam Termination in Claustrophobic Patients in Closed vs. Open Magnet

B – The graphical representation of the anxiety state (severity according to Score) perceived by the patient during the two different studies.

Image Quality

Analysis conducted on all patients in whom the MrOPEN study was completed, for a total of 70.

In 3 (4.2%) of the total studies, the extent of artifacts was quantified as class 2 in an independent assessment performed by two radiologists.

7 (10%) studies were classified as class 3.

Nei restanti 60 (89,2%) nessun artefatto da movimento significativo è stato riconosciuto in tutte le sequenze eseguite.

Discussion and Conclusions

Most people, at least once in their lifetime, need to undergo a magnetic resonance imaging (MRI) scan for diagnosis or to monitor a progressive condition.

For some individuals, this common test can provoke significant fear and apprehension. Anxiety about potential outcomes, uncertainty about what to expect, and the loud noises emitted by the MRI machine can intensify this discomfort.

Another concern for people undergoing MRI testing is claustrophobia, or the fear associated with remaining still in a small or enclosed space. It is estimated that about 7-10% of the population experiences this condition.

Some of the physical symptoms associated with anxiety in adults include progressively increasing muscle tension, sweating, shortness of breath, and even full-blown panic attacks (16,17). These symptoms often lead to the interruption of the MRI exam or, alternatively, to a degradation in the study's quality due to motion artifacts.

The study is interrupted in 5-10% of cases (18,19,20), and in at least another 15-20% of cases, according to our experience, the MRI investigation is so degraded by artifacts that it does not allow for definitive diagnostic conclusions.

The use of MrOPEN MRI systems in this group of patients undoubtedly helps limit the incidence of motion artifacts, reduces study interruptions during the exam, and allows for MRI investigations in most patients who would otherwise refuse to undergo a study in a closed magnet due to claustrophobia.
In our study, it was possible to obtain diagnostically adequate MRI scans in 76% of patients who had previously completely refused to undergo a traditional closed magnet MRI.

Additionally, in the group of 56 patients who had previously interrupted MRI exams due to claustrophobia or anxiety, 51 (91%) completed the MRI study on the MrOPEN magnet without reporting any anxiety or claustrophobia.

The early termination rate thus dropped from 100% to approximately 9% when using MrOPEN equipment.

These results are directly related to the sensation experienced by the patient during the examination. In the group of patients examined on the MrOPEN magnet, the average reported anxiety-stress level, assessed on a scale from 1 to 10, was approximately 4, compared to a value near 9 described by the same patients when undergoing the exam on a closed magnet.
It is important to emphasize that all patients examined using the MrOPEN system completed the study without the need for pre-sedation or anxiolytic therapy.

The incidence of motion artifacts in the group we analyzed was extremely low; only 3 of all the studies performed (4.2%) had artifacts that affected the image quality, partially but not completely limiting diagnostic capabilities.

In summary, using the MrOPEN system, a larger number of patients, including those with claustrophobia, can undergo MRI exams. The early termination rate of the study is significantly

reduced, and the incidence of motion artifacts in completed exams is much lower, enabling the acquisition of reliable diagnostic information in all studies.

These results are naturally due to the configuration of the open magnet, which reduces the sensation of claustrophobia, anxiety, and discomfort experienced by the patient.

These advantages, while valid for all open MRI systems, are amplified in the MrOPEN AGS equipment, which has an open-sky configuration and allows for studies even in a seated or upright position.
The current limitation of this type of open-sky equipment is the strength of the magnetic field and gradients, which still do not allow for the evaluation of more complex anatomical structures, such as the chest, heart, and upper abdomen, on this type of equipment.

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