70 cm Bore in Clinical Practice: Why It Works

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The first MAGNETOM Espree Open Bore system was installed at the Mayo Clinic in Jacksonville, Florida, USA in August 2004.

Patients accept Open Bore

Mayo Clinic presented a poster at the 2005 RSNA Scientific session: "Open-Bore MRI: Patient Acceptance and Image Quality", in which they surveyed patients on their experience with the 70 cm bore. Over 70% of patients previously scanned on a vertical field open found it more comfortable, while 27% found it equivalent. Over 90% indicated that they would agree to another scan on the Espree. Jeffrey Towers, MD of University of Pittsburgh Medical Center (UPMC) presented additional data to support patient tolerance of the open bore at the 2006 MAGNETOM World Summit in San Diego. St. Margaret's (one of multiple Esprees installed in the UPMC network) previously scheduled 4 sedations per week (on two traditional bore MRIs), each sedation requiring 5 hours of personnel time (scheduling, same day admission, nursing, radiologist, and anesthesia standby). Scan time took 1 ½ hours – but had a failure rate of 30%. After installing the MAGNETOM Espree next to the traditional bore systems, patients were redirected to the open bore system. St. Margaret's was able to eliminate outpatient IV sedations, and schedule claustrophobics on arrival. Tim Gutsie, R.T., Manager of Hazelton Radiology Associates in Hazelton, PA, USA replaced a traditional 60 cm bore magnet with the Open Bore Espree and reduced patient rejections from 5 per week to only 1, which results in over $75,000 in revenue gains per year.

Obesity epidemic requires Open Bore + Tim technology

Historically, larger patients that could not fit into traditional 60 cm bores were directed to vertical field open systems. However, these systems still underserved obese patients in four ways.
Firstly, it is already challenging to obtain sufficient signal-to-noise (SNR) when imaging obese patients and to achieve an image quality equivalent to that in thinner patients. Since the vast majority of tradi-

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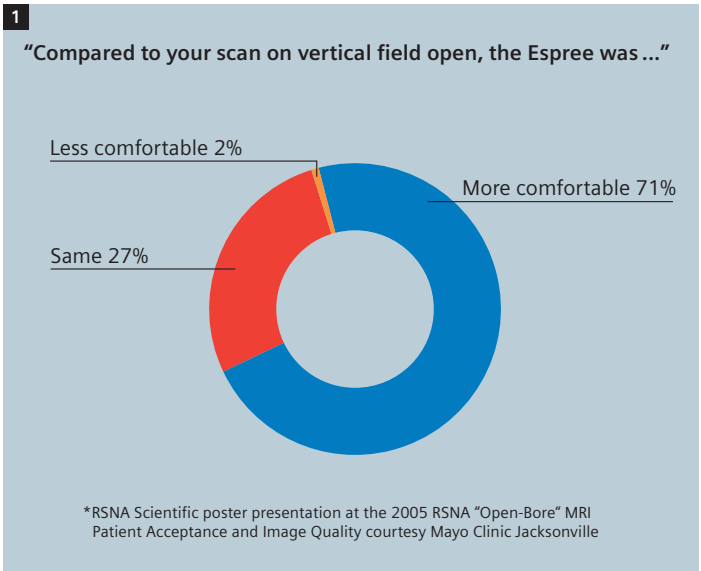

1 MAGNETOM Espree's proven patient acceptance. 71% of patients found their experience with the 70 cm bore more comfortable than a previous scan on a vertical field open system.

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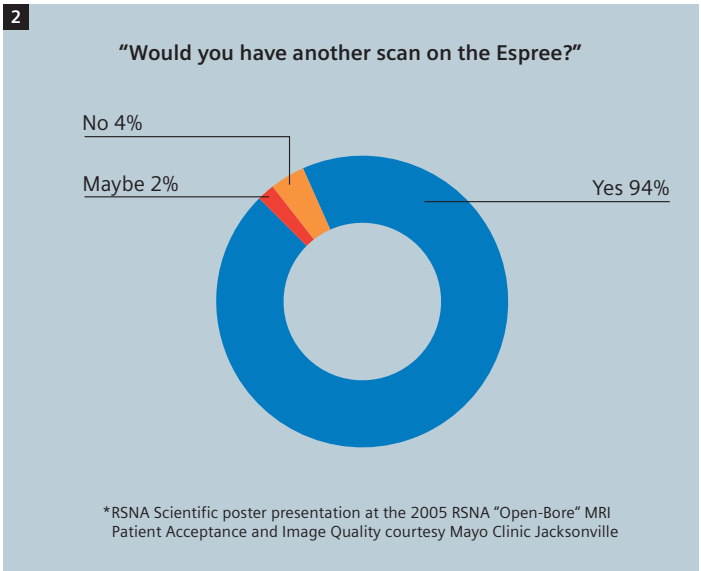

2 Over 90% of patients indicated that they would agree to another scan on the MAGNETOM Espree.

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3 MAGNETOM Espree at the University of Pittsburgh, PA, USA.

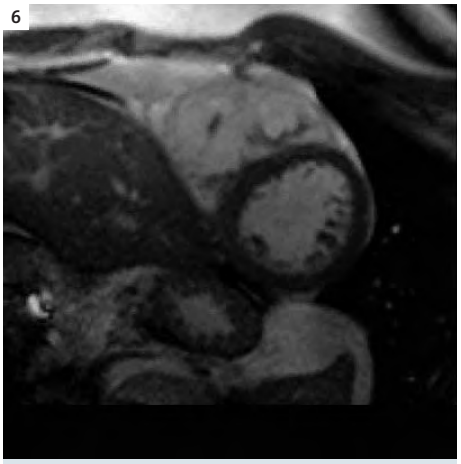
tional opens were 0.2–0.3 Tesla, MR images of obese patients were further signal-starved. Their routine scan times simply needed to be lengthened.
Secondly, the vertical gap on many opens is below 45 cm (with patient table), which precludes access for certain large patients.
Thirdly, diseases associated with obesity (peripheral vasculature disease, cardiac disease, liver and pancreatic disease) are typically imaged with high performance sequences at high resolution.
Lastly, the coils that are both used to image obese patients on low field vertical magnets are both difficult to position and difficult to optimize for patients of different body habitus, once again limiting SNR which is so necessary to do good quality exams for these patients.
The MAGNETOM Espree delivered improvements to all four areas mentioned above. The 1.5 Tesla field strength gave a boost of up to four times the SNR over traditional vertical field opens. The distance from table top to magnet cover (55 cm) was also greater than all vertical field opens on the market – to accommodate even larger patients. The Espree now offered the obese patients access to more high field applications: diffusion, pMRA, cardiac and abdominal studies (Figs. 4–6).
Tim Matrix coil technology not only made patient positioning easier, but also offered creative solutions to those patients who could not fit into rigid coils. For instance, the Body Matrix coil can be draped over the largest knees (Figs. 7A, B). Elements are then selected from both the Spine and Body Matrix coils to create a bariatric knee coil, producing high image quality.

4 MAGNETOM Espree, 240 kg (530 lb) uncooperative patient. *syngo* BLADE (T2-weighted). Visualizes pituitary mass that was obscured by motion in the original scan.

Courtesy of Mayo Clinic, Jacksonville, Florida, USA.

5 MAGNETOM Espree, 250 kg (550 lbs) patient with acute panniculitis, unable to be scanned in any other MR system. Coronal and sagittal images were obtained (1.5 s per slice). Scan confirmed there was no abscess, avoiding surgery for the patient.

Courtesy of Laurel Highlands Advanced MRI, Johnstown, PA, USA.



6 MAGNETOM Espree, 198 kg (438 lbs) cardiac patient.

Courtesy of Suburban Hospital, NIH, Bethesda, MD, USA.

7A MAGNETOM Espree, build your own coil with Tim: Body Matrix coil + Spine Matrix coil.

7B Tim technology offers unique benefits in imaging of larger patients, the Tim Body Matrix coil can, for example, be draped over the largest knees: 167 m (5'5"), 204 kg (450 lbs) patient.

Open Bore brings benefits beyond obesity and claustrophobia

As more open bore MAGNETOM Espree systems were installed, customers found novel ways to use the 70 cm diameter to solve diagnostic challenges.

Positioning on the side: unique to Open Bore

There are various clinical situations that, in order to complete the MR scan, a patient might need to lie on his/her side. But, as most adult patients would not fit in any other magnet lying on their side, this is a relatively new application.

Positioning on the side for respiratory issues

One example was sent in by Stephen Cool R.T. (R) (N) (MR), Technical Director, Oregon Advanced Imaging, Medford, Oregon, USA. A claustrophobic patient with respiratory issues was referred for a lumbar spine exam. He very was very clear: "You need to get me out in 15 minutes!" Advanced Imaging was able to scan the patient on his side, with the Body Matrix coil wrapped around his back (Fig. 8A); This allowed him to breathe comfortably. Using the high SNR and integrated Parallel Acquisition Techniques (iPAT) capabilities of the Tim Matrix coils, the site was able to meet the patient's needs, as well as deliver excellent image quality (Fig. 8B).

Positioning on the side for isocenter imaging

Another example was presented by Robert Prost, Ph.D. of Froedert Memorial Lutheran Hospital, Milwaukee, WI, USA. This patient, also claustrophobic, needed her wrist and digits scanned. Positioning on the side allowed the head of this 1.64 m (5'1") patient to be outside the back of the magnet (Fig. 9), easing her fears, but also delivered the best homogeneity for excellent FatSat and highest SNR for best resolution.

8A

8A Special positioning for special needs. Patient positioned on his side with the Body Matrix coil wrapped around his back.

8B

8B MAGNETOM Espree, PAT 2, 4 mm slices, 28 cm, TA 1:17. Scoliosis, kyphosis.

Image courtesy of Advanced Oregon Imaging, Medford, OR, USA.

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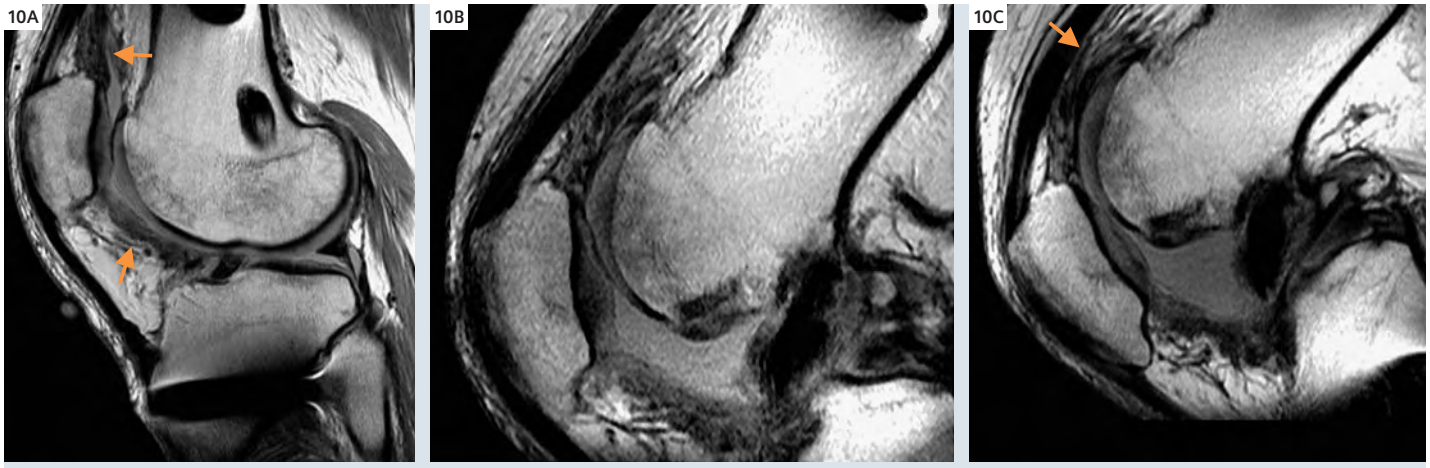
9 1.64 m (5'1") tall patient has head out of magnet!

11 MAGNETOM Espree with ancillary equipment.



10 MAGNETOM Espree: Knee flexion with Arthrofibrosis. Post op ACL, limited range of motion.
Courtesy of University of Pittsburgh Medical Center, Pittsburgh, PA, USA.

Positioning on the side for knee flexion studies
Dr Towers of University of Pittsburgh Medical Centers has studied the knee in the flexed position in the 70 cm bore. The patient lies on the side, with the affected knee on the Spine Matrix coil. The Body Matrix (or 4-channel flex) coil is draped over the patient, and elements are selected from both to create a "Tim Flexion" coil (Fig. 10).

Room for ancillary support equipment
The 70 cm bore also provides extra room for ancillary equipment – vital for intra-operative installations (Fig. 11).

Get creative with the 70 cm bore!
Mayo Clinic, Rochester, MN, USA discovered a novel way to use the bore: the "recliner".
The "recliner", uses the standard system cushions to prop the patient up in the 70 cm bore. The Body Matrix or Neck Matrix coil is placed between the patient and the cushion, and images are scanned in this semi recumbent position (Fig. 12). Patients with lower back pain can also lie with knees up during lumbar spine scan, thereby reducing discomfort and maximizing image quality (Fig. 13).

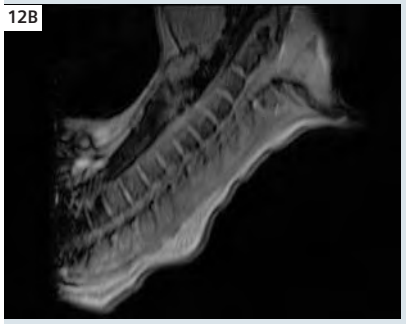
Conclusion

70 cm Open Bore has set a new standard in MRI. 70 cm Open Bore offers high quality, high-field diagnostic scans to patient populations underserved before, increases patient comfort, increases image quality and opens the door to new applications such as kinematic studies and intervention.

12A

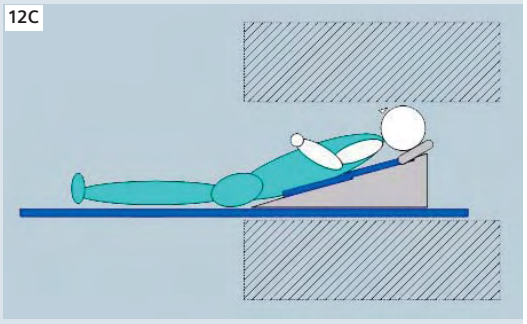
12A „Recliner" imaging: Propped up patient in the 70 cm bore.

12B



12B Semirecumbent cervical spine.
Courtesy of Mayo Clinic, Rochester, MN, USA.

12C



12C Propped up patient in the 70 cm bore.

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13 Patient with lower back pain in the MAGNETOM Verio's 70 cm Open Bore.

MAGNETOM Verio, delivering the most exciting equation in MRI

Siemens has set a new benchmark in MRI again.
The significance of Open Bore MR in patient care is so great that Siemens applied the innovations necessary to be able to offer 70 cm at two field strengths! By bringing the benefits of Open Bore to 3T, Siemens has set a new benchmark in MRI.
3T field strength + 70 cm Open Bore + Tim (Total imaging matrix) together in one powerful system, MAGNETOM Verio. With the first Open Bore system introduced in 2004, at 1.5T it is only appropriate that Siemens innovations make it possible at 3T. Regardless of the clinical demand of 1.5T or 3.0T now 70 cm is available and can serve patients:

More space puts your patients at ease
- Limit claustrophobic rejections.
- Sedate fewer patients.
- Capture sharper images due to less anxiety-related movement.

Accommodate patients with special needs and conditions
- Pain and mobility issues.
- Respiratory problems.
- Kyphosis.

Expand your care to a wider range of patients
- Obese population.
- Claustrophobic patients.
- Pediatric and elderly patients.
- ICU patients or those dependent upon medical equipment.

Broaden your clinical possibilities
- Easy access in interventional MRI.
- Opportunities to perform more kinematic studies.

Chronology of the Open-Bore MR systems

1983: In the beginning
At the commercial introduction of MR systems in the early nineteen-eighties, there was a wide variety of magnets available: permanent, resistive or superconducting designs. By 1984 field strengths choices ranged from 0.2 to 1.5 Tesla. All MR systems were relatively large and "boxy". By 1988 1.5 Tesla machines had established market dominance with 45% of sales.

1988: Paradigm shift
During this decade, the MR referral mix evolved from patients with life altering neuro-based diseases (brain tumors, multiple sclerosis, disk herniations, etc.) to orthopedic injuries (meniscal, cartilage and ligament injuries of the knee, shoulder, wrist and ankle).

1990s: Comfort is king
By 1993, the market began to recognize the need for patient cooperation. Vertical field open systems not only appealed to patient comfort, but also the burgeoning referrals for obese patients who could not be scanned in traditional 60 cm horizontal bore magnets.
The market share of vertical field open MR systems (typically 0.2 – 0.35 Tesla) rose dramatically from 15% in 1993 to 43% in 1997, surpassing even 1.5 Tesla systems, which represented only 33% during that year.

1999: Return of high field
But even as vertical field open magnet sales surged, MR applications at high field were making strides. MR Angiography (MRA) was being performed throughout the body to visualize pathology formally diagnosed only by digital angiography. Early changes in brain anatomy brought on by stroke could now be visualized in seconds by Diffusion techniques. Breast MR was starting to be recognized as a tool that could provide valuable diagnostic information. New strategies to diminish or avoid motion artifacts (breath-holding, 2D PACE) allowed 1.5 Tesla systems to better handle abdominal studies.
In 1997 the 1.5 Tesla MAGNETOM Symphony was introduced. Not only did the Symphony provide access to high end applications, but its compact design was a departure from the former "boxy" high field designs, making it more patient friendly. The new Integrated Panoramic Array (IPA) design also addressed an area all but ignored by most MR manufacturers: streamlining patient handling by minimizing coil changes.
By 1999, the market had once again reversed: 1.5 Tesla sales now passed vertical field open sales.

2000: "Higher-field" opens
The market wanted the best of both worlds: the comfortable environment associated with vertical field opens and 1.5 Tesla applications, image quality and throughput. A higher field vertical open seemed to be the answer, and several 0.7 Tesla products hit the market between the years 2000 – 2001.

2004: Open Bore concept: CT-like comfort, advanced applications
Siemens delivered the first 1 Tesla vertical field open, the MAGNETOM Rhapsody. But despite the acceptance of these systems by the first installations, there were several inherent limitations associated with any 1 Tesla vertical field open. Firstly, the 1 Tesla market had diminished to less than 5% of new sales – 1.5T was the standard and preferred field strength worldwide. Secondly, project costs (equipment + siting) would exceed that of horizontal bore 1.5T systems. Thirdly, the new Tim (Total imaging matrix) technology, introduced in 2003 on the MAGNETOM Avanto, would not be able to be implemented.
Computed Tomography (CT) systems with 70 cm bores never experienced the same wave of patient discomfort or inability to accommodate larger patients that MR did. It stood to reason that if Siemens could design a horizontal bore 1.5 Tesla MR that more closely resembled a CT, then patients would accept and fit into it. Additionally the boost in signal-to-noise would also better serve the obese patient by providing better image quality, reduced exam times and more advanced applications than low field, vertical opens. Tim technology could be implemented in a horizontal bore design. Enter a new concept: the Open Bore MR.

2005 – 2007 Open Bore proof of concept
The Open Bore design incorporated CT's 70 cm bore diameter with a magnet length of 125 cm – only a piece of paper longer than a CT system. When scanned feet first, the patient's head would remain outside of the magnet for a majority of scans (lumbar spine to ankles). The 70 cm bore also provided a foot (30 cm) of space above the patient's face – about twice that of vertical field opens.