

## History of the Magnetic Resonance Imaging Patient Stereo Sound System

a report by

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Barry Leeper's early interest in patents began with his invention of the Magnetic Resonance Imaging (MRI) Patient Stereo Sound System in 1985. He is the founder of Scan Sound, Inc. and works for InterCept Payment Solutions as Director of Intellectual Property. Mr Leeper is a member of the International Trademarks Association (INTA) and is certified by the Association for the Advancement of Medical Instrumentation (AAMI) as a biomedical engineering technician. He worked for 23 years in the medical imaging field, specialising in diagnostic ultrasound prior to his 15 years as an MRI specialist for Toshiba America Medical Systems. Having switched careers in 1999 he now pursues his interest in inventions, patents, trademarks and computers on a full-time basis. Mr Leeper holds degrees in Biomedical Engineering Technology, from Owens College, Oregon, Ohio, and a Bachelor's Degree in Electronic Engineering Technology from the University of Toledo, Ohio.

The scenario outlined in *Box 1* provides an example of how music can be used to comfort magnetic resonance imaging (MRI) patients. It can expedite the process of easing the patient into the scanner, so that the technologist does not have to spend time putting the patient at ease or trying to help them overcome their fears of the scan itself. Music has a way of soothing the soul, and patients appreciate that care-givers have spent the time and money to create a warm, inviting atmosphere for scans. When the patient leaves, he/she will report back to their doctor, family and friends that the MRI experience at this particular imaging centre was a pleasant one, because the music enabled the patient to relax easily.

A patient may be marginally claustrophobic and, by closing his/her eyes, the patient can totally relax and forget any concerns that he/she may have about the scanner, as well as his/her own medical condition. Knowing that he/she is being taken care of, and having the ability to readily communicate with the technologist, provides the patient with the security required to hold still for a longer period of time; all critical to turning out the most optimal MRI images.

Music has a way of helping borderline claustrophobic patients to relax so that they can 'tune out' their surroundings, thereby helping them to overcome their fears. Many patients do not actually realise that they have a fear of being inside an MRI scanner until they lie down and are actually inside. When being manoeuvred into the bore of a superconducting magnet, the patient suddenly senses changes in the surrounding airflow, typical room noise is deadened and a sense of being 'entombed' develops. Unable to move, as the shoulders are compressed by the inner bore of the magnet, the patient is overwhelmed with the feeling that he/she will not be able to climb out should they want to. In other words, the patient's mind tells them that they are trapped. This triggers a feeling of claustrophobia and some patients have been known to literally climb out of the scanner during a scan, sometimes damaging equipment in the process. Most patients will communicate early on that they are uneasy and this fear can quickly turn to terror in a matter of seconds.

Patient stereo systems often can enable patients to overcome many such feelings of 'scanner fear', through communication and the soothing sounds of music. For many, this can mean the difference between being able to undergo an MRI or to forego it altogether. Fidgety or unruly patients can severely disrupt an MRI centre's entire schedule, taking time away from patient scanning. Sometimes patients resist being scanned or become so fidgety that the technologist has to abort the procedure altogether, rescheduling the patient when they can return with a prescribed sedative. When a time slot in the schedule is lost because a patient cannot go through with the scan, 'dead time' results as the scanner sits idle. The patient is typically unhappy with the outcome and the MRI scanning facility loses money by having a gap in time when the MRI scanner is not being used. This scenario is all too common and can be extremely costly when the idle time is aggregated over the course of a month or year.

By properly preparing the patient for the scan and reassuring them that additional comfort will be provided through the use of a patient stereo system, several messages are actually being conveyed to the patient, indicating an understanding of their anxiety and a willingness to help them overcome their fears. It is a win-win scenario when referring physicians know that they can send the bulk of their patients to such a facility, ultimately resulting in positive feedback from their patients. The MRI patient stereo is not merely a public relations tool; it literally can pay for itself in terms of capturing scans that might otherwise have resulted in idle scanning time.

Although there have been steady improvements in Open-style magnets, it has generally been understood that optimal scanning sequences are performed on high-field closed-bore magnets. Claustrophobic patients can choose to obtain their scans from open MRI systems. It is interesting to note that more and more open-style MRI scanners are obtaining music systems these days, yielding to the features that patients demand. Today, many open scanners still produce gradient sounds that are annoying to the patient, so patients may want to wear a headphone during the scan and the MRI

### Box 1: Patient Case Scenario

A patient sits down next to the technologist, nervously awaiting his/her turn for an MRI scan. The patient, like many others, has lived through a period of time when technological changes have transformed simple ideas into scientific medical breakthroughs, yielding procedures and tests with such sophistication, that it absolutely overwhelms him/her. In questioning the patient about prior surgeries, the technologist is actually trying to ease the patient's fear of the unknown. The patient receives an explanation that he/she will have to lie still for the MRI exam, and that he/she may listen to music during the scan.

Still nervously awaiting his/her turn, the patient is soon asked to step into the MRI room. Brightly lit, the cold room looks surreal, sounds high-tech and contains a large machine with lights and digital displays over a small tunnel. The patient steps up onto a very high table and, after lying down, is asked about his/her music preferences. After donning a headset and immersing him/herself in the music selected, the patient has shifted from being nervous to being totally relaxed in a matter of seconds. This transformation enables the technologist to rapidly position the patient and manoeuvre him/her into the MRI magnet for the scanning process.

At the operator's console, the technologist prepares to start up the initial scout scan and speaks to the patient through a microphone. The music level lowers automatically, so the patient can clearly hear the technologist's instruction to lie still and relax for the next few minutes. Within seconds, the door closes and the music volume returns to its original level. The patient is once again immersed in the music and the first scan gets under way. The patient may be asked if the music sound, selection and level are suitable and he/she can request that the music be raised (or lowered) slightly as he/she grows accustomed to the surroundings and the music.

patient stereo system can be configured to provide audio for the patients, in addition to individuals who may be sitting adjacent to the patient who is undergoing the MRI scan.

MRI scanners have undergone many changes since they were first approved for patient scanning. The gradient sequences have become faster and significantly louder. It has become almost a necessity to provide some form of hearing protection for patients and the use of an MRI stereo equipped with a headphone that can cup the ear, driving down the level of the outside gradient pounding sounds is almost essential. Unfortunately, the coils used for most brain scans may wrap around the head so closely that the coil itself may actually prevent the use of the sound-reduction earmuff-style headphones. In those situations, stethoscope-shaped plastic headphones are typically worn by the patient and the foam ear-tips are replaced before each scan, keeping the headphone hygienic.

Other trends in the design of the MRI systems have included narrowing the bore of the magnet, so that broad-shouldered individuals being manoeuvred into the bore of a superconductive magnet feel as though they are being squeezed into a tube. MRI manufacturers have responded, trying to ease claustrophobia through the use of short-bore magnets, so that only a small portion of the patient is inside the scanner.

Many patients may not realise that they are about to experience claustrophobia and MRI technologists are vigilant for the first signs. A small percentage of those patients will find that music helps them to close their eyes and, afterwards, cope well with the scan. The music helps everyone to pass time in the scanner, which is critical since most people actually lose all concept of how much time passes during MRI scans. To some, 30 minutes can seem like hours, but it is put into perspective when the patient can relax to music, that he/she has not been in the scanner all that long. Music generally will keep the patient occupied much longer, enabling them to hold still, which will contribute to the optimisation of the overall image quality.

Children find that music is a special treat. They may not understand the full complexity of the reason for the MRI scan, but they definitely react positively to being able to wear a headphone and listen to music. Achieving the required results with children because of the music and not having to use sedation is a real accomplishment.

Development of the first MRI patient stereo systems transpired after the realisation that patients needed a system that would help them relax. Each time a patient aborted their scan, the MRI centre would lose money as the MRI system sat idle. Realising that it would not be possible to wear a

conventional headphone or hear a loudspeaker inside the scanner, initial experiments delivered audio through vinyl tubing.

money by installing it themselves. Custom-cut cables were provided and mounting hardware and an illustrated manual made it easy to install the stereo.

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A successful prototype system, designed in 1985, used a consumer-type stereo system placed at the operator's console, with a microphone used to override the music, sending the audio to a transducer within the scan room. This transducer had to operate within the range of the high magnetic fields, converting the electronic signals from an audio amplifier to acoustically driven audio that would pass through vinyl tubing to the patient's all-plastic headphone, producing quality sound without interfering with the MRI scans in any way.

The concept was geared to provide patient stereo systems in kit form, so MRI facilities could save

Today, almost all patients can enjoy the comfort of listening to relaxing music as they undergo their MRI scan. Some companies even have built-in video systems, so patients can bring a DVD and watch a film while undergoing their MRI scan.

Ultimately, patients and MRI centres have both become the beneficiaries, as patients experience less claustrophobia and the MRI centres have saved money by tightening up their schedules, improving image quality and reducing idle time. All agree that this win-win scenario has enabled the MRI patient stereo to literally pay for itself and become a benefit to all. ■