Development of a two-room MR/OR suite: concept to clinical implementation

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Introduction: The wealth of both anatomical and functional data that MR provides makes this modality an ideal candidate for image guided surgery and in particular image guided neurosurgery. While pre surgical MR imaging is considered routine, the need for more 'real-time' imaging data has initiated the development of interventional MR suites. These suites enable procedures to be performed within the MR environment [1], allowing for imaging during, rather than before and after surgery. Initial designs focused on the development of a single room concept whereby the procedure was performed immediately adjacent to or inside of the MR scanner. While successful, this design concept posed several unique challenges [2] including the introduction of a variety of instrumentation generally considered non MR compatible, workflow and patient access restrictions imposed by the MR environment, and more recently optimization of limited and expensive capital equipment. The purpose of this work is to describe the development and initial use of a two room MR – operating room (MR-OR) facility.

Materials and Methods: Our MR-OR suite was initially designed and developed with the concept of a single room facility. The design group, which included members of the departments of Radiology, Neurosurgery, Anesthesia, Engineering, MR Service, and Facilities rapidly converged upon the concept of a two room design based on the following criteria:

1. Fully functional surgical environment without physical limitations including environmental, space and equipment compatibility.
2. High field, state of the art MR imaging capabilities.
3. Full anesthesia functionality and airway access during procedures
4. Maintain maximum MR safety by limiting introduction of non MR compatible equipment into the MR environment.
5. Rapid and safe transportation of the patient from the surgical environment to MR imaging volume.
6. Optimize use of limited capital resources (MR and OR rooms) by providing dual use functionality MR-OR use as well as independent surgical and imaging capabilities.

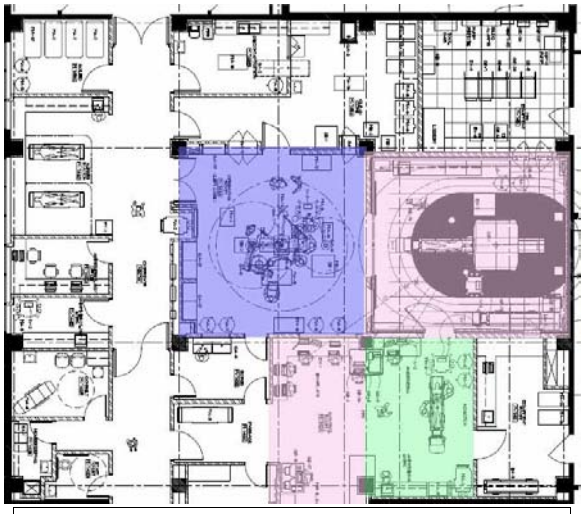

Figure 1: MR-OR suite layout including surgical (blue), MR (pink), and anesthesia (green) areas.

Figure 1 is a schematic layout of the MR-OR facility identifying the MR scanner and operating console (pink), OR room(blue) and anesthesia induction area (green) used for MR imaging with patients under sedation.

Figure 2 shows a view from the OR towards the MR scan room. The brown double doors are RF shielded sliding double doors that allow patient transfer between the two rooms.

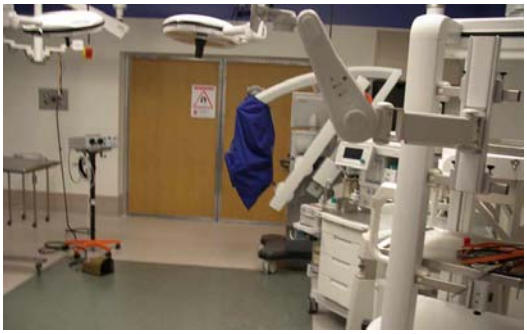

Figure 2: View from OR towards MR room

Results: The MR-OR suite was completed in August, 2006. Equipment includes a 1.5T Signa EXCITE scanner and modified MR table (GE Healthcare, Waukesha, WI), a fully functional surgical table (Maquet, Rastatt, Germany) that provides docking with and transfer of the patient to and from the MR table, customized RF coils, and MR compatible MR Mayfield clamp.

Figure 3 shows a T2-weighted fast spin echo image for the first MR – OR procedure, the placement of deep brain stimulator (DBS) electrodes. 2mm thick images were acquired in a T/R head coil with TR=15 seconds and a limited pack of slices to reduce SAR.

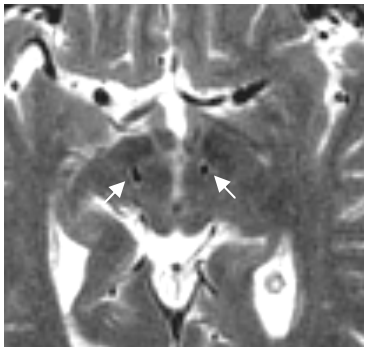

Figure 3: T2-weighted FSE showing deep brain stimulator lead location (white arrows).

Discussion: A multi functional MR-OR facility has been designed, constructed and is now in routine clinical use for both surgical and radiological procedures. The facility provides a variety of activities including independent OR, sedation MR, general MR and complete MR-OR procedures. Development of separate yet contiguous MR, OR, and anesthesia environments has enabled each area complete functionality that may be limited by a one room design. The integration of a high field 1.5T closed bore MR scanner provides high resolution imaging capabilities for not only MR only imaging but also for all other MR-OR related activities.

References

1. Hall WA, Truwit CL., Magn Reson Imaging Clin N Am. 2005 13(3):533-43
2. Kettenbach J et al. Minim Invasive Ther Allied Technol. 2006;15(2):53-64.