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# SAFE AND SOUND

**Managing acoustic noise, gradient field applications, and static magnetic field exposure in MR – A radiography perspective**

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## Akademisk avhandling

som med vederbörligt tillstånd av Rektor vid Umeå universitet för avläggande av medicine doktorsexamen framläggs till offentligt försvar i Aula Biologica, Biologihuset, fredagen den 27 september, kl. 09:00.

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## Abstract
**Background:** Magnetic resonance (MR) imaging produce loud noises due to the interaction between the gradient coil's alternating currents and the static magnetic field (SMF). This noise can be harmful and necessitates hearing protection. Novel acoustic noise reduction (ANR) software can reduce this noise by altering the gradient currents, but might affect image quality and scan duration. It is important to evaluate these software options to understand their clinical use. We also need to know how MR personnel manage noise in clinical MR settings overall. Exposure to the SMF can cause temporary adverse health effects like dizziness, nausea, and headaches, but more research is needed to understand how common these effects are. Improving noise management and understanding SMF exposure can make MR safer and more comfortable for both patients and personnel.
**Aim:** The overall aim of this thesis was to present a radiography perspective on acoustic noise management, gradient field applications and SMF exposure in MR.
**Methods:** This thesis includes four studies. In Study I, we distributed a cross-sectional survey to MR and CT radiographers (CT used as controls) across Sweden to assess health complaints related to SMF and noise exposure. Data from 529 participants were analyzed using logistic regression. In Study II, we interviewed 15 MR radiographers to explore how they manage noise in clinical settings. Data were analyzed thematically. Studies III and IV were experimental studies that evaluated ANR software. Study III compared two different software (Whisper Mode and Quiet Suite) with conventional imaging during lumbar MRI at 1.5 Tesla, involving 40 patients. Study IV evaluated the SofTone software on two image sequences during brain MRI at 7 Tesla, involving 28 healthy volunteers. Both studies compared sound pressure levels, perceived noise levels, image quality, and observer agreement.
**Results:** We found no significant differences in symptoms between MR and CT radiographers, but working at higher SMF levels (≥3 Tesla) increased symptoms, and stress was a significant confounder of symptoms. CT radiographers found work-related noise more troublesome than MR radiographers did. We identified three themes for noise management in Study II: risk management and adaptation, patient protection, and organizational support. ANR software significantly reduced sound levels and maintained diagnostic image quality in both Studies III and IV. Whisper Mode and Quiet Suite reduced noise by 72% and 84%, respectively, while SofTone reduced noise by 89% and 92%. Gradient field exposure was also reduced.
**Conclusion**: While no significant differences in symptoms were found between MR and CT radiographers, higher SMF levels and stress increased temporary adverse health effects. Noise remains a concern, and MR radiographers actively manage it to improve safety and comfort, suggesting a need for better tools and support from work organizations. ANR software effectively lowers noise without compromising image quality, and were perceived as quieter.

## Keywords
Magnetic resonance, MR safety, patient safety, occupational health, acoustic noise reduction, gradient field, static magnetic field, symptom, radiography, human factors and ergonomics

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