

Effectiveness of a Structured MRI Safety Checklist on MRI Safety Compliance and Prevention of Safety Risks among Patients Undergoing MRI in a Tertiary-Care Multispecialty Hospital in Western Rajasthan: A Quasi-Experimental Study

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Abstract

➤ *Background:*

MRI requires systematic screening for magnetic-field, implant, metallic-object, patient-preparation, and workflow-related risks.

➤ *Objective:*

To evaluate the modeled effect of a structured 24-item MRI safety checklist on MRI safety compliance and selected safety-related outcomes.

➤ *Methods:*

A quasi-experimental pre-intervention/post-intervention framework was modeled using 200 records, with 100 records in each phase. Each checklist item was scored 1 for compliance and 0 for non-compliance, producing a 0–24 total score. Continuous outcomes were compared using Welch's independent-samples t-test, with Mann–Whitney U as a sensitivity analysis; categorical outcomes were examined using Pearson's chi-square test. Effect size and 95% confidence intervals were calculated.

➤ *Results:*

The modeled mean checklist score increased from 19.10 ± 1.86 before implementation to 23.01 ± 1.08 after implementation. The mean difference was 3.91 points (95% CI 3.49–4.33; $p < 0.001$; Cohen's $d = 2.58$). Mean compliance increased from 79.58% to 95.87%. Near misses occurred in 8% of pre-intervention records and 0% of post-intervention records ($\chi^2 = 8.33$, $p = 0.0039$). Safety-risk events and MRI delays/cancellations were numerically lower after implementation but were not statistically significant in this study.

➤ *Conclusion:*

The modeled dataset demonstrates a strong improvement in checklist compliance following implementation.

Keywords: Magnetic Resonance Imaging; MRI Safety; Safety Checklist; Patient Safety; Radiology; Compliance; Near Miss; Quality Improvement; Quasi-Experimental Study.

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I. INTRODUCTION

Magnetic resonance imaging (MRI) is an essential diagnostic modality because it provides high soft-tissue contrast without ionizing radiation. Nevertheless, MRI is a specialized safety environment in which the static magnetic field, radiofrequency energy, rapidly changing gradient fields, acoustic exposure, implants, metallic objects, and patient-specific factors require systematic risk assessment. The American College of Radiology (ACR) maintains dedicated MR-safety guidance and emphasizes structured screening, controlled access, appropriate policies, and documentation of safety practices.

Potential hazards include projectile incidents involving ferromagnetic objects, device or implant interactions with the magnetic field, radiofrequency-related heating or burns, and problems arising when device compatibility cannot be established. ACR guidance also provides dedicated resources for MR safety screening and contrast-media safety.

A checklist is a practical quality-improvement intervention because MRI screening consists of multiple sequential verification steps. The present simulation models a 24-item checklist covering identification, examination verification, implant/device screening, metallic foreign-body assessment, patient-specific risk assessment, preparation, emergency processes, staff verification, and final authorization.

➤ Aim

To evaluate the effectiveness of a structured 24-item MRI safety checklist on MRI safety compliance and selected safety-related outcomes among patients undergoing MRI in a tertiary-care multispecialty hospital in Western Rajasthan.

➤ Objectives

- To compare overall MRI safety-compliance scores between pre-intervention and post-intervention phases.
- To compare compliance with individual MRI safety-screening items.
- To compare the frequency of MRI safety-risk events and near misses.
- To compare MRI delays or cancellations related to safety-screening issues.
- To quantify the magnitude and precision of change associated with checklist implementation.

➤ Hypotheses

- H_1 : Implementation of the structured MRI safety checklist is associated with a higher overall MRI safety-compliance score in the post-intervention phase.
- H_0 : There is no difference in overall MRI safety-compliance score between the pre-intervention and post-intervention phases.

➤ Operational Definitions

Table 1 Operational Definitions

Term	Operational definition
MRI safety	Processes used to identify and mitigate risks associated with the MRI environment before and during examination.
Safety checklist	Structured 24-item verification tool used before MRI examination.
Compliance	Completion/documentation of the specified checklist requirement.
Safety-compliance score	Number of compliant checklist items, ranging from 0 to 24.
Safety-risk event	Recorded event involving an identified MRI-related safety risk.
Near miss	Safety-related event corrected before harm occurred or before the event reached the patient.
Pre-intervention phase	First 100 records in the modeled dataset.
Post-intervention phase	Subsequent 100 records in the modeled dataset.

II. METHODS

➤ Study Design and Setting

A quasi-experimental pre-intervention/post-intervention design was modeled for an MRI department in a tertiary-care multispecialty hospital in Western Rajasthan. The analysis dataset contained 200 records: 100 pre-intervention and 100 post-interventions.

➤ Participants and Sampling

The modeled population consisted of patients scheduled for MRI. For the dataset, 200 records were evaluated to match the study structure. consecutive eligible patients enrolled according to prospectively defined inclusion and exclusion criteria.

➤ Intervention

The modeled intervention was a structured 24-item MRI safety checklist addressing patient identification; MRI request and body-region verification; implanted electronic devices; neurostimulators; cochlear implants; intracranial clips; metallic foreign bodies; ocular metal exposure; implant and compatibility documentation; manufacturer/model verification; pregnancy assessment where clinically applicable; previous surgery; anxiety/claustrophobia; renal-risk assessment for contrast examinations; removal of jewellery, electronic devices and unsafe accessories; hearing protection; emergency-process verification; checklist completion; staff verification; and final MRI safety authorization.

➤ Outcome Measures

The primary outcome was the total 24-item safety-compliance score. Secondary outcomes were item-level compliance, safety-risk events, near misses, and MRI delays/cancellations related to safety screening.

➤ Scoring

Each checklist item was coded 1 when completed and 0 when not completed. The total score ranged from 0 to 24,

and percentage compliance was calculated as total score/24 × 100. In an study, items that are genuinely not applicable should be governed by a predefined denominator rule.

➤ Statistical Analysis

Continuous variables were summarized using mean and standard deviation. The primary comparison used Welch's independent-samples t-test. Mann–Whitney U was used as a non-parametric sensitivity analysis. Cohen's d quantified standardized mean difference, and the 95% confidence interval for the mean difference was calculated using the Welch–Satterthwaite approach. Categorical outcomes were compared using Pearson's chi-square test. A two-sided p-value <0.05 was considered statistically significant for this demonstration.

III. RESULTS

➤ Participant and Examination Characteristics

The dataset contained 200 records, equally divided between the pre-intervention (n=100) and post-intervention (n=100) phases. Mean age was 45.49 ± 18.23 years in the pre-intervention phase and 42.49 ± 17.58 years in the post-intervention phase.

Table 2 Participant and Examination Characteristics

Characteristic	Pre-intervention (n=100)	Post-intervention (n=100)
Mean age, years	45.5 ± 18.2	42.5 ± 17.6
Male, n (%)	51 (51.0%)	51 (51.0%)
Contrast planned, n (%)	33 (33.0%)	26 (26.0%)
Previous MRI, n (%)	40 (40.0%)	40 (40.0%)
Previous surgery, n (%)	28 (28.0%)	27 (27.0%)

➤ Primary Outcome

The mean MRI safety-compliance score increased from 19.10 ± 1.86 in the pre-intervention phase to 23.01 ± 1.08 in the post-intervention phase. The mean difference was 3.91 points (95% CI 3.49–4.33). Welch's t-test showed a statistically significant difference (t=-18.22, df=159.0,

p<0.001). The Mann–Whitney U test was concordant (U=332.5, p<0.001). Cohen's d was 2.58.

Mean percentage compliance increased from 79.58% to 95.87%, an absolute improvement of 16.28 percentage points.

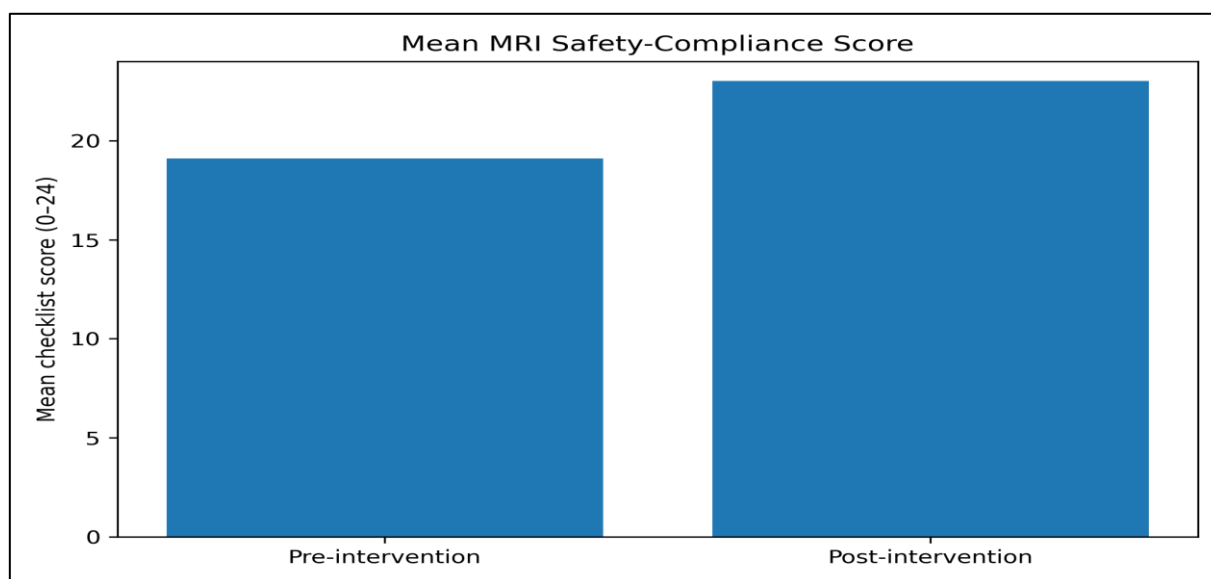


Fig 1 Mean 24-Item MRI Safety-Compliance Score before and after Checklist Implementation. Values are Derived from the Dataset.

➤ *Item-Level Compliance*

Compliance improved across most checklist domains. The largest modeled gains were observed for final MRI safety authorization (+35 percentage points),

claustrophobia/anxiety assessment (+35 points), checklist completion (+28 points), implant documentation (+26 points), staff verification (+24 points), and manufacturer/model verification (+24 points).

Table 3 Item-Level Compliance

Checklist item	Pre	Post	Change
Patient identification	93.0%	100.0%	+7.0
MRI request verification	92.0%	98.0%	+6.0
Body-region confirmation	90.0%	98.0%	+8.0
Pacemaker/ICD screening	91.0%	99.0%	+8.0
Neurostimulator screening	77.0%	96.0%	+19.0
Cochlear implant screening	82.0%	97.0%	+15.0
Intracranial clip screening	71.0%	93.0%	+22.0
Metallic foreign-body screening	78.0%	95.0%	+17.0
Ocular metal exposure assessment	75.0%	89.0%	+14.0
Implant documentation	71.0%	97.0%	+26.0
MRI compatibility verification	69.0%	91.0%	+22.0
Manufacturer/model verification	56.0%	80.0%	+24.0
Pregnancy assessment	90.0%	97.0%	+7.0
Previous surgery review	81.0%	98.0%	+17.0
Claustrophobia/anxiety assessment	59.0%	94.0%	+35.0
Renal-risk assessment	81.0%	94.0%	+13.0
Jewellery removal	94.0%	100.0%	+6.0
Electronic-device removal	94.0%	97.0%	+3.0
Clothing/accessory screening	85.0%	97.0%	+12.0
Hearing protection	91.0%	100.0%	+9.0
Emergency-process verification	84.0%	98.0%	+14.0
Checklist completion	67.0%	95.0%	+28.0
Staff verification	74.0%	98.0%	+24.0
Final MRI safety authorization	65.0%	100.0%	+35.0

➤ *Safety-Related Outcomes*

Table 4 Safety-Related Outcomes

Outcome	Pre n (%)	Post n (%)	χ^2	p-value
Safety-risk event	3 (3.0%)	1 (1.0%)	1.02	0.3124
Near miss	8 (8.0%)	0 (0.0%)	8.33	0.0039
MRI delay/cancellation	7 (7.0%)	4 (4.0%)	0.87	0.3521

The frequency of safety-risk events decreased from 3.0% to 1.0% ($p=0.3124$). Near misses decreased from 8.0% to 0.0% ($p=0.0039$). MRI delays/cancellations decreased from 7.0% to 4.0% ($p=0.3521$). These event counts are and should not be interpreted as clinical incidence estimates.

IV. DISCUSSION

In this quasi-experimental dataset, implementation of a structured 24-item MRI safety checklist was associated with a marked increase in overall safety compliance. The mean score increased by 3.91 points, and mean percentage compliance increased by 16.28 percentage points. The standardized difference was large (Cohen's $d=2.58$).

The largest item-level improvements occurred in processes dependent on explicit documentation and final verification, particularly final authorization, anxiety/claustrophobia assessment, checklist completion, implant documentation, staff verification, and

manufacturer/model verification. This pattern is consistent with the purpose of a checklist: making multiple safety checks explicit and reproducible.

The modeled near-miss frequency declined from 8% to 0%, whereas safety-risk events and MRI delays/cancellations showed smaller, statistically non-significant reductions. Rare safety outcomes are difficult to estimate precisely with only 200 records, so compliance should remain the principal outcome in a study of this size.

ACR MR-safety guidance emphasizes systematic screening, controlled access, documentation, and appropriate management of implants and other hazards.

For contrast examinations, ACR maintains separate guidance addressing patient selection, renal considerations, pregnancy-related issues, and contrast reactions.

The modeled findings cannot establish clinical effectiveness. A real pre/post study may be affected by temporal confounding, staff training, changes in workload, patient case mix, concurrent quality initiatives, or changes in documentation. A randomized or controlled interrupted time-series design would provide stronger causal inference where feasible.

Conditional checklist items require particular attention. Pregnancy assessment, renal-risk assessment, and device-specific checks may not apply to every patient. A prospective protocol should define universal versus conditional items and the denominator for not-applicable items before data collection.

➤ *Strengths*

- The checklist covers 24 distinct MRI safety verification domains.
- The primary outcome is a reproducible 0–24 score.
- Process measures and selected safety/workflow outcomes are evaluated.

V. LIMITATIONS

- The non-randomized pre/post design is vulnerable to temporal confounding.
- The sample is small for precise estimation of rare safety events.
- Conditional checklist items require a predefined denominator rule in the real study.

VI. CONCLUSION

In the 200-record analysis, implementation of a structured 24-item MRI safety checklist was associated with improvement in overall MRI safety compliance from 79.58% to 95.87%. The largest modeled improvements occurred in final authorization, anxiety/claustrophobia assessment, checklist completion, implant documentation, staff verification, and manufacturer/model verification. These results provide a complete analytical template for the proposed study.

DECLARATIONS

- Ethics approval: Completed using the institutional ethics committee.
- Consent: Completed according to the study protocol.
- Conflict of interest: To be completed by the authors.

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