Standardizing Ultrasound-Guided HIFU Using a 3D-Grid Navigation Protocol: Technical Description and Clinical Implementation

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BACKGROUND

• Traditional USgHIFU remains highly operator-dependent.

• Lack of structured spatial navigation may result in uneven energy distribution, technical omissions ("cold spots"), and incomplete deep-core necrosis ("Hollow USgHIFU").

• A reproducible coordinate-based treatment framework is needed to improve procedural consistency and safety.

Objective

To describe a structured 3D-Grid Navigation Protocol developed through 2,992 consecutive USgHIFU treatments and to propose a practical framework for improving procedural reproducibility and clinical standardization of USgHIFU.

METHODS

Clinical implementation in 2,992 consecutive patients (2010–2025)

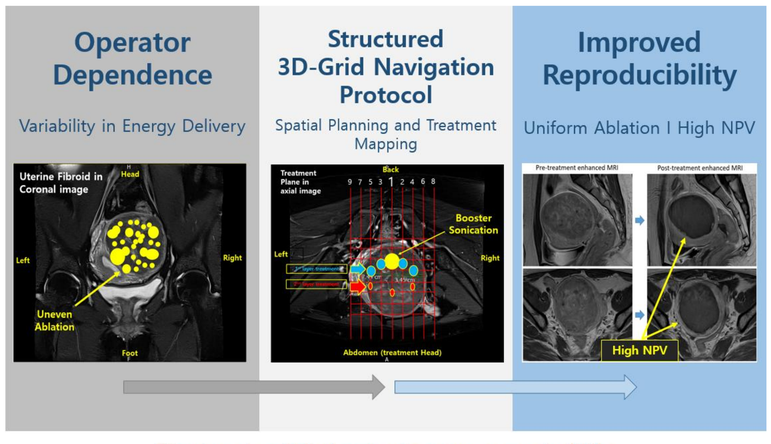
• MRI-based 3D spatial planning with predefined safety margins

• Structured Grid-Planning Chart (10-mm treatment-plane spacing and adaptive focal spacing of approximately 5–10 mm, according to lesion characteristics and real-time ultrasound response)

• Real-time MRI–US landmark alignment and layered thermal accumulation strategy

• Immediate post-treatment contrast-enhanced MRI verification

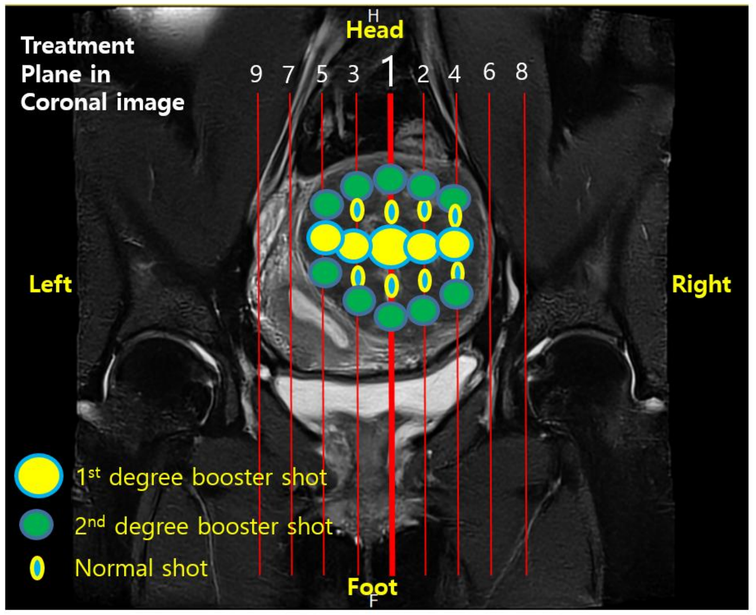
• Strategic booster sonications with MRI-based lesion classification and energy titration according to tissue characteristics (Types 1–3).



Structured spatial planning improves reproducibility

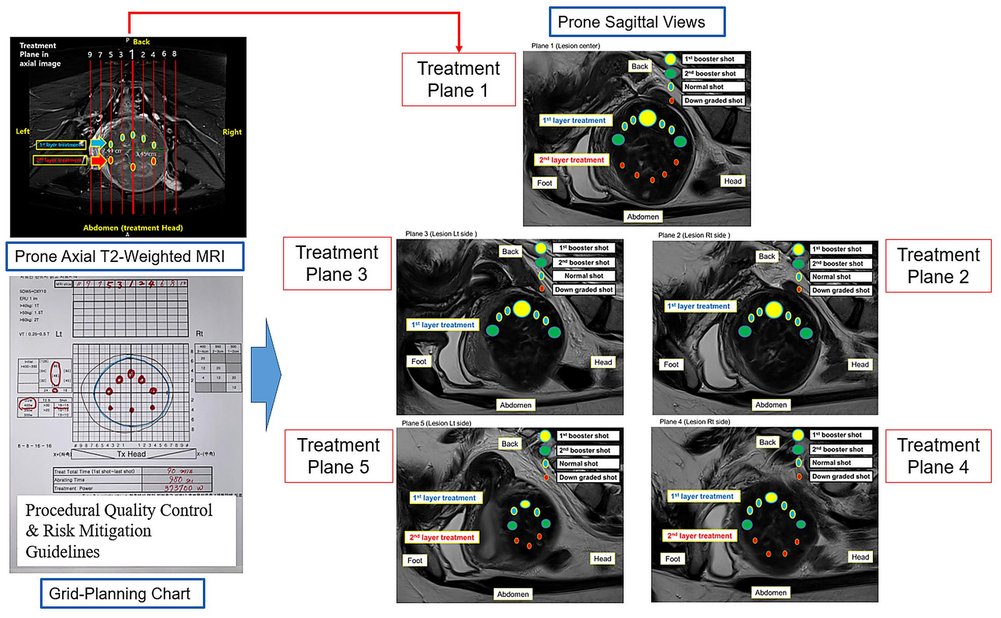
Structured spatial planning improves reproducibility. MRI-based treatment planning and coordinate-guided 3D-grid mapping reduce operator dependency and facilitate more uniform ablation in USgHIFU.

Figure 1. Coronal MRI-Based Grid Mapping and Booster Sonication Layout



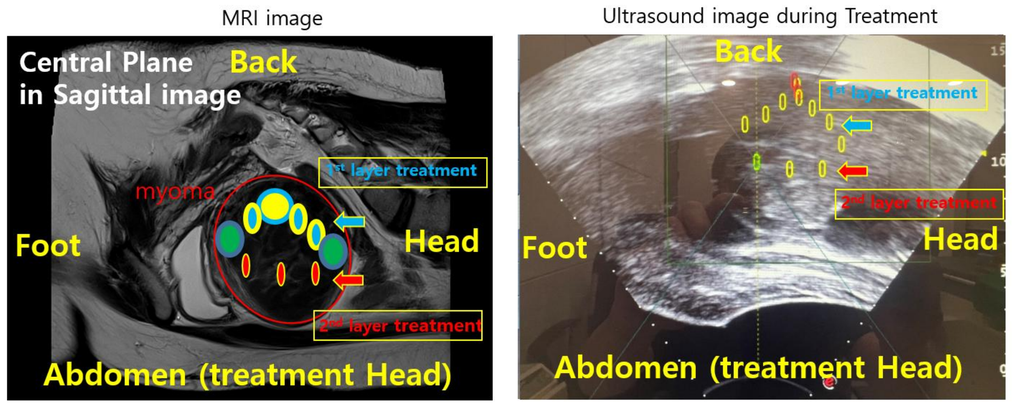
Coronal grid mapping defines treatment planes and booster sonication locations.

Figure 2. MRI-Based Grid Planning and Sequential Multi-Plane Treatment Design



Axial MRI findings are translated into a grid-planning chart and sequential sagittal treatment planes.

Figure 3. MRI–Ultrasound Integrated Layered Thermal Accumulation Strategy



Deep-to-superficial layered sonication is designed to support systematic thermal coverage. Across 2,992 consecutive USgHIFU treatments, the observed mean NPV ratio was 86.5%.

MAIN TAKEAWAY

1. MRI-based 3D spatial planning transforms USgHIFU from an operator-dependent procedure into a structured and reproducible treatment protocol.

2. The proposed 3D-Grid Navigation Protocol integrates anatomical MRI planning, coordinate-based sonication mapping, MRI-ultrasound alignment, and immediate MRI verification.

- Consistent thermal coverage
- Reproducible high-NPV achievement
- Reduced operator variability

CONCLUSIONS

• The 3D-Grid Navigation Protocol provides a structured framework for MRI-informed spatial planning and ultrasound-guided HIFU execution.

• Adaptive focal spacing, layered treatment, and targeted booster sonication are designed to support systematic lesion coverage while respecting safety margins.

• Immediate post-treatment contrast-enhanced MRI enables objective assessment of ablation extent. Further multicenter validation is needed to establish reproducibility across operators and devices.

REFERENCES

· Lee JS. 2026. 3D-Grid Navigation Protocol for USgHIFU. *WFUMB Ultrasound Open.* 2026;4(2):100121. doi:10.1016/j.wfumbo.2026.100121.

· Lee JS et al. 16-Year Clinical Outcomes of USgHIFU in Korea. *Int J Hyperthermia.* 2026;43(1):2700021. doi:10.1080/02656736.2026.2700021.

· Cheng et al. 2024 ISMIVS Guideline J Minim Invasive Noninvasive Med. 2024;2:1–15.

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