THA-Net: A Novel Deep Learning Solution for Templating and Patient-Specific Surgical Execution

Cody Wyles, Pouria Rouzrokh, Bardia Khosravi, John Patrick Mickley, Bradley James Erickson[1], Michael J Taunton[1]
[1]Mayo Clinic

INTRODUCTION: This study introduces THA-Net, a deep learning (DL) inpainting algorithm for simulating postoperative total hip arthroplasty (THA) radiographs from a single preoperative pelvis radiograph input, while being able to generate predictions either unconditionally (algorithm chooses implants) or conditionally (surgeon chooses implants).

METHODS: THA-Net is a denoising diffusion probabilistic model (DDPM), which receives an input preoperative radiograph, and subsequently inpaints the target hip joint with THA implants to generate a synthetic yet realistic postoperative radiograph. We trained THA-Net on 356,305 pairs of radiographs from 14,357 patients from a single institution's total joint registry and evaluated the validity (quality of surgical execution) and realism (ability to differentiate real and synthetic radiographs) of its outputs against both human-based and software-based criteria.

RESULTS: The surgical validity of synthetic postoperative radiographs was significantly higher than their real counterparts (mean difference: 0.8-1.1 points on 10-point Likert scale, $p<0.01$) but they were not able to be differentiated in terms of realism in blinded expert review. Synthetic images showed excellent validity and realism when analyzed with already validated DL models.

DISCUSSION AND CONCLUSION: We developed a novel THA templating and surgical execution tool that can generate synthetic radiographs graded higher on ultimate surgical execution than real radiographs from training data. Further refinement of this tool may potentiate patient-specific surgical planning and enable technologies such as robotics, navigation, and augmented reality.