Use of image-based navigation combined with a 12 inch flat plate detector maximizes the safety and efficiency of fluoroscopically-assisted total hip arthroplasty

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INTRODUCTION:

Contemporary total hip arthroplasty is among the most successful modern surgical procedures, with very high levels of satisfaction and prosthesis longevity measured in decades. A high performance hip arthroplasty is facilitated through the use of muscle-sparing surgical techniques, as well as accurate component positioning and restoration of leg lengths and offset. The latter has been shown to be facilitated by the use of intra-operative fluoroscopy and intra-operative navigation.

However, one concern with the use of intra-operative fluoroscopy is the use of ionizing radiation in the operating room and potential cumulative exposure risk to OR team members. Furthermore, while image-based intra-operative navigation and the use of larger-diameter fluoroscopic detectors may facilitate visualization and assessment, it is unclear to what extent these technologies it may influence intra-operative radiation use and surgical flow. Thus, the aim of our study was to evaluate how the use of intra-operative image based navigation as well as use of a 12" flat plate fluoroscope impact ionizing radiation use and health resource utilization during fluoroscopically assisted total hip arthroplasty, when compared to surgery performed with a standard 9" image intensifying detector alone.

METHODS:

We retrospectively evaluated 416 consecutive primary direct anterior approach THA cases performed by a single subspecialty-trained arthroplasty surgeon. Following exclusion of patients missing x-ray data, we split the patients into 3 consecutive cohorts reflecting the evolution of practice of the surgeon: 1) 115 patients who underwent surgery assisted with a 9" image intensifier fluoroscope, followed by 2) 28 patients who underwent surgery with the same fluoroscope supplemented by an intra-operative image based navigation system, followed by 3) 223 patients who underwent surgery using a 12" flat plate fluoroscope from the same vendor, supplemented by the same intra-operative image based navigation system. All fluoroscopic imaging was performed with the default equipment settings for orthopaedic surgery. The total radiation time in seconds and the total effective radiation dosage in mGy was collected for each case, along with incision to close surgical time. Additionally, NASA task load questionnaires were obtained from a sampling of medical radiation technicians operating the fluoroscope during cases for cohorts 1 and 2.

RESULTS:

The implementation of image-based navigation resulted in increased mean radiation time (50.0 +/-20.99 vs 39.4 +/- 14.14 seconds; p=0.002) and radiation dosage (13.7 +/-6.37 vs 10.63 +/-8.25 mGy; p=0.070) per case, but with no change in mean case time (77.59 +/-14.09 vs 78.14 +/-12.34 minutes; p=0.584).

Conversely, introduction of a 12" flat plate fluoroscopy in conjunction with image-based navigation resulted in lower total radiation time as compared to both 9" image intensifier + navigation (31.2 +/-15.85 vs 50.0 +/-20.99 seconds; p<0.001) and 9" image intensifier alone (31.2 +/-15.85 vs 39.4 +/- 14.14 seconds; p<0.001). Similarly, 12" flat plate fluoroscopy + navigation was associated with significantly lower mean effective radiation dosage as compared to both 9" image intensifier + navigation (5.16 +/-3.54 vs 13.7 +/-6.37 mGy; p<0.001) and 9" image intensifier alone (5.16 +/-3.54 vs 10.63 +/-8.25 mGy; p<0.001). However, there was no significant difference in mean case length (75.29 +/-18.76 minutes) when compared to the other cohorts (p =0.132 and p=0.257).

Despite the larger detector size, the 12" flat plate detector was associated with a lower mean effective radiation dose per second of radiation time as compared to the 9" image intensifier (0.165 vs 0.271 mGy/s; p<0.001). Thus the combination of image-based navigation and 12" flat plate fluoroscopy provided decreased radiation exposure both from decreased total radiation time as well as decreased dose per second.

There was no increased task load burden on medical radiation technologists associated with the introduction of image-based navigation as measured using the NASA task load index (mean 30 points (13-54) with fluoro alone versus 13 points (7-16) with navigation; p=0.044).

DISCUSSION AND CONCLUSION:

When performing fluoroscopically-assisted total hip arthroplasty, the use of image-based navigation in conjunction with a 12" flat plate fluoroscope allows surgeons to access the potential component positioning benefits of these assistive technologies while achieving lower total radiation time and effective radiation dose as compared to use of 9" image intensifier fluoroscope either alone or in combination with navigation. Thus, the combination of image-based navigation and 12" flat plate fluoroscopy would appear to best support the radiation safety principle of dosing As Low As Reasonably Achievable (ALARA) and minimizing radiation exposure of both patients and OR team members. Furthermore, this is achieved without any significant increase in OR time or task load on the medical radiation technologist. Further study is needed to better understand the relative impact of these assistive technologies on component positioning and post-operative outcomes.