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Designing an efficient MR imaging workflow utilizing advanced AI solutions

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As Poland's second largest diagnostic imaging network with 42 sites, the Voxel Group operates 30 MR systems, 16 CT scanners, seven PET/CT scanners and three SPECT cameras with a volume of nearly 500,000 exams each year. Most of our sites are open from 7 am to 10 pm, seven days each week, and are located in hospital and ambulatory settings, providing imaging services to the National Health Service (NFZ) and private insurance, as well as supporting independent clinical trials.

With a limited availability of radiologists in the country, we operate a highly efficient teleradiology service with nearly 70% of exam reporting completed remotely. An efficient examination throughput requires standardizing diagnostic imaging protocols for acquisition and reading/reporting. Our radiologists agreed on a harmonized, standard set of protocols to be used, with some local variations allowed for clinical trials and hospital referrals. To accomplish this, we have implemented GE HealthCare's Imaging Protocol Manager (IPM) to synchronize protocols across the entire multi-site network. In addition, the DIWatcher application (diCELLa, Kraków, Poland)allows us to monitor IPM use, standardization ratio over time and any changes to the standard protocols per site. Each radiologist receives their own worklist of "cases to report" from the RIS to ensure the quickest and most accurate reporting based on their specific competencies, availability, average reporting throughput, etc.

DIWatcher is software that allows users to monitor device usage from PACS by analyzing the DICOM data. Using this information, combined with the RIS details about patients' examinations, we can obtain a practical picture of the effectiveness of using medical imaging devices.

AIR™ Recon DL is a deep-learning-based reconstruction algorithm introduced by GE HealthCare in 2020. It allows the acquisition of pin-sharp images quicker by removing noise and ringing from raw images. Improved SNR means scan times can be cut by up to 50%, smoothing workflow and enhancing the patient experience. Our goal for implementing AIR Recon DL was to increase the average number of MR exams performed each day from 30 to 37 at each site. This required an evaluation of the entire imaging process workflow and synchronizing the staff's efforts from patient set-up through to exam reporting.

We expect to mitigate the impact of patient no-shows or missed appointments due to shorter acquisition times and RIS examination slots; since patient scheduling slots will be reduced, there will be a greater chance that the next patient will already be waiting in the waiting room.

We selected a sample of six representative systems across our MR fleet—SIGNA™ HDxt 1.5T, SIGNA™ Voyager 1.5T, SIGNA™ Pioneer 3.0T, Discovery™ MR750 3.0T, Optima™ MR450w 1.5T and Optima™ MR360 1.5T—to test how this deep-learning reconstruction technology will impact the workflow.

Before deciding to upgrade the entire fleet, we simulated the impact on the revenue per site based on the new protocol times

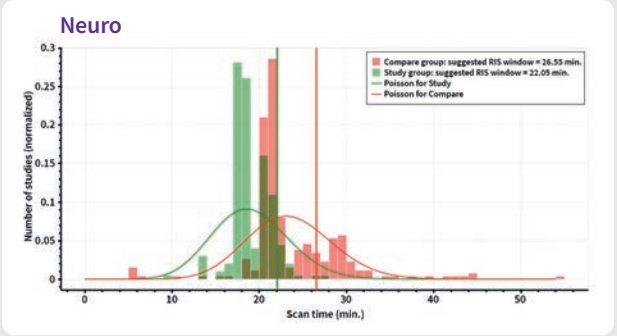

Figure 1. Comparison of the number of neuro MR examinations performed based on scan times. The study group consists of systems with AIR Recon DL while the compare group is the control, or systems without AIR Recon DL.

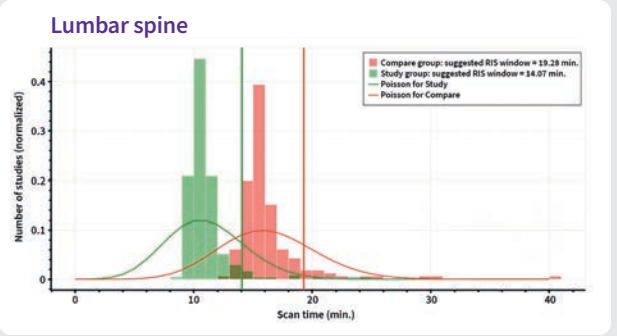

Figure 2. Comparison of the number of lumbar spine MR examinations performed based on scan times. The study group consists of systems with AIR Recon DL while the compare group is the control, or systems without AIR Recon DL.

and operator performance, combined with the specific mix of examinations conducted. We evaluated the impact of having more patient scheduling slots available (RIS window) on revenue and time savings during open MR hours. Our objective was also to increase or, at a minimum, maintain image quality with the shorter scan times.

Methods

Using data collected from January 1, 2023, to July 31, 2023, two statistical analyses were performed for daily and monthly MR scans. For the purpose of this comparison study, we focused on three common MR examinations: head, lumbar spine and knee (Figures 1-3).

We examined the actual scanning time of patients receiving these imaging services, as well as the interval between patient examinations, or the scanner idle time. This data was found to follow a Poisson distribution (using observations from the Shapiro-Wilk and Kolmogorov-Smirnov tests). The sample size for this study was determined according to the Poisson distribution. For each analysis, we verified that the number of studies analyzed reached the minimum value to ensure that the data met the statistical requirements.

According to the Poisson distribution, the presented boxplots have been adjusted for the skewness of the distribution using Hubert et al.[1]

Results

We assumed that 3 minutes of scanner idle time should be the requested idle time for the RIS examination slots per procedure. For each procedure, a Poisson distribution was fitted and a new RIS window was assigned. Presented in this article are examples of two SIGNA Voyager 1.5T sites with and without the AIR Recon DL option.

To assess the performance of technologists, who are responsible for handling the patients from the changing room to the in-gantry positioning in our workflow, we mapped each site and type of procedure performed, as well as scanning and idle times. Figures 4 to 6 are comparisons of two SIGNA Voyager sites with and without the 2D AIR Recon DL option for the three selected procedures.

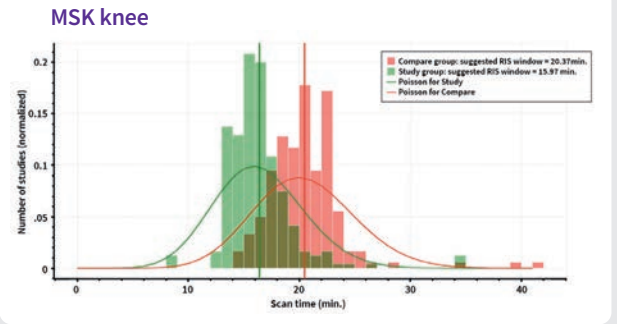

Figure 3. Comparison of the number of knee MR examinations performed based on scan times. The study group consists of systems with AIR Recon DL while the compare group is the control, or systems without AIR Recon DL.

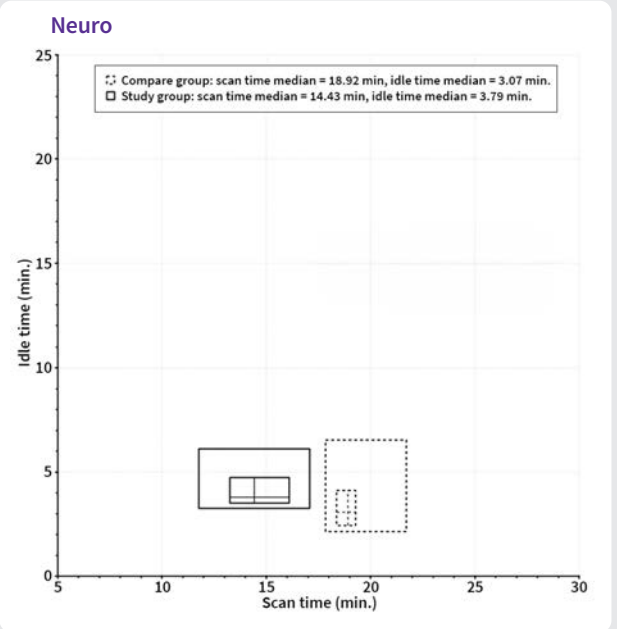

Figure 4. Comparison of scanner idle time with and without AIR Recon DL in neuro MR examinations.

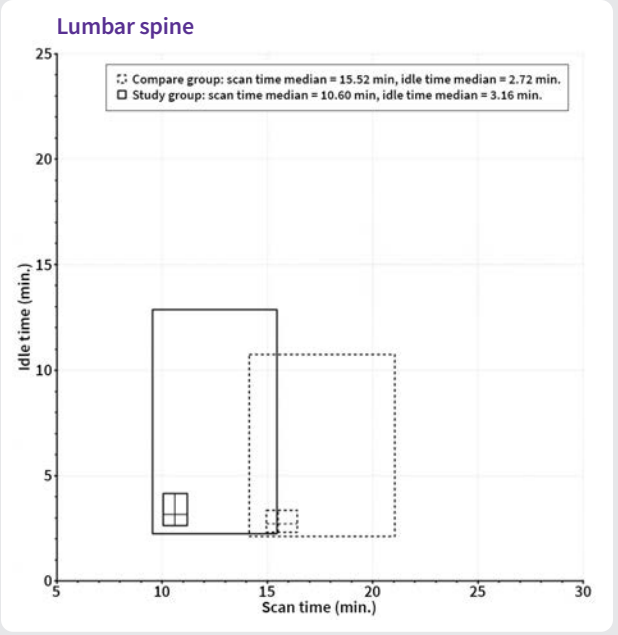

Figure 5. Comparison of scanner idle time with and without AIR Recon DL in lumbar spine MR examinations.

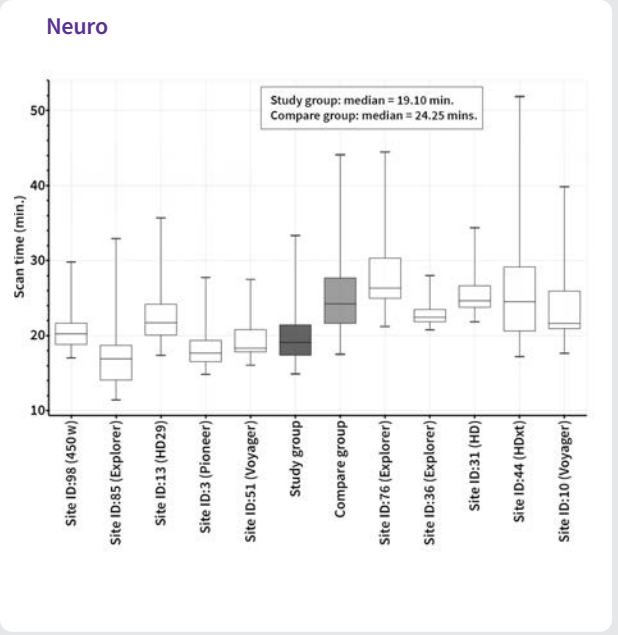

Figure 7. Comparison of scan time for neuro MR with and without AIR Recon DL. Line in boxplots represent median.

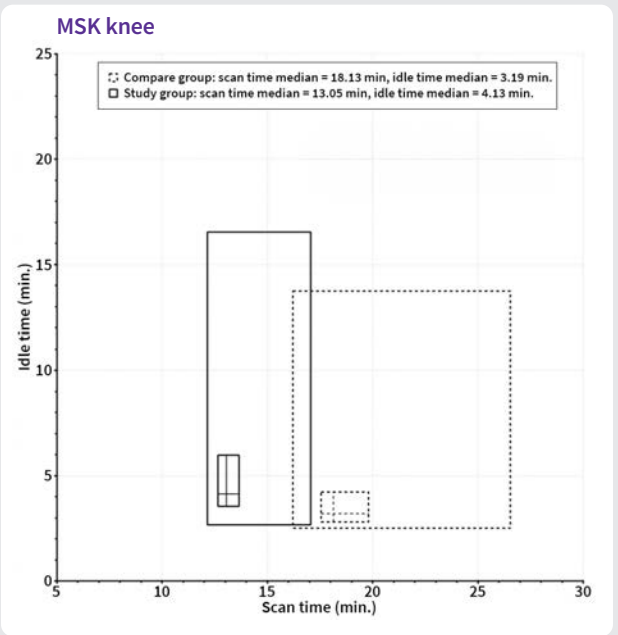

Figure 6. Comparison of scanner idle time with and without AIR Recon DL in knee MR examinations.

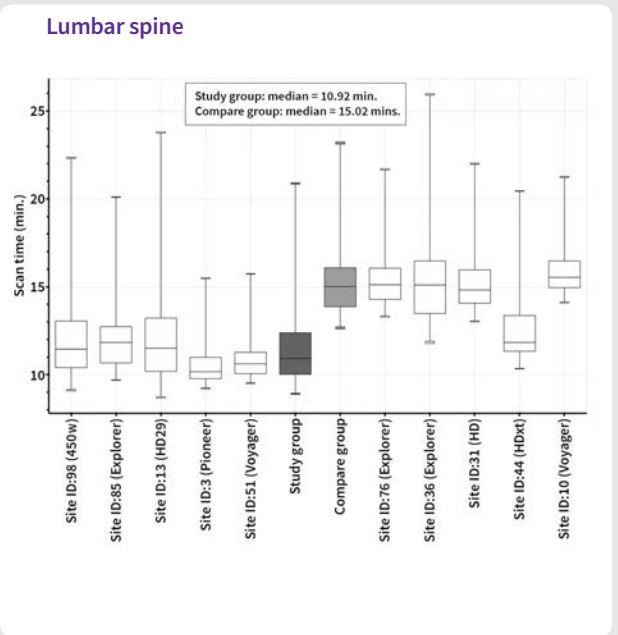

Figure 8. Comparison of scan time for lumbar spine MR with and without AIR Recon DL. Line in boxplots represent median.

The interquartile range (smaller boxes) represents 50% of performed procedures, while the larger boxes represent around 95% (of performed procedures); the median of the scan and idle times are also reported for each site.

We compared performance (scanning time) across sites running the same sequences with and without the AIR Recon DL option (Figures 7-9).

We simulate the influence of the AIR Recon DL upgrade per each site based on the specific procedure mix performed using median scan times measured in the AIR Recon DL upgraded sites. Results vary from 38 to 72 hours per month depending on the sites' specific working hours and idle time.

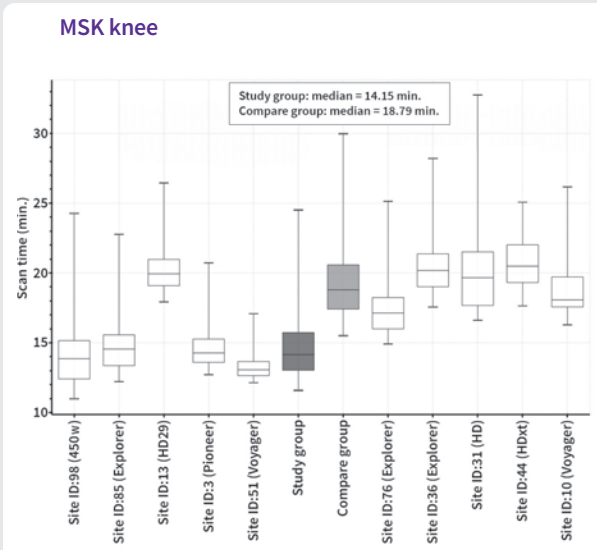

Figure 9. Comparison of scan time for knee MR with and without AIR Recon DL. Line in boxplots represent median.

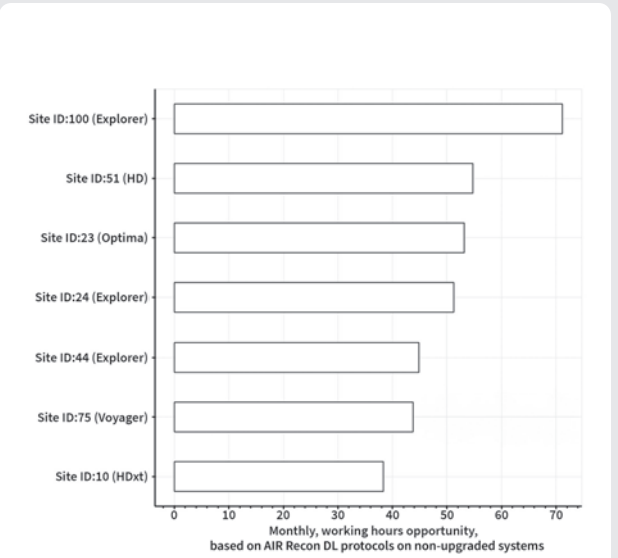

Figure 10. Simulation of the impact on working hours for non-upgraded sites (without AIR Recon DL).

Conclusion

Independent of organizational inefficiency in patient handling, AIR Recon DL significantly improved scanning times in all 2D examinations and also increased image quality qualitatively.

To achieve optimal operational and clinical benefits from the AIR Recon DL upgrade, it is critical to measure and monitor scanning and idle times using statistical analysis. The DIWatcher application provides all monitoring data to evaluate a site's performance and improvement.

The implementation of AIR Recon DL also affects changes in areas such as idle times, which should be addressed by adjusting the RIS patient examination slot schedule. Additionally, the front desk administrative tasks and patient site welcome area should also be redesigned to reflect the shorter examination/scanning slots. Standardizing MR acquisition protocols and monitoring any deviations using IPM is crucial for fast intersite protocol deployment, resulting in reduced staff working hours.

For more information on DIWatcher, visit:
https://diwatcher.com

Reference

1. Hubert M, Vandervieren E. An adjusted boxplot for skewed distributions. Comp Stat Data Anal. 2008. 52(12);5186-5201.