Canon

The Galan Encore Upgrade from Vantage Titan 3T to Vantage Galan 3T
Increased Productivity and Enhanced Image Quality

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Introduction

Southwoods Imaging is a free-standing imaging center affiliated with Southwoods Surgical Hospital, serving the Tri-county area and other nearby counties in northeastern Ohio, USA. The center offers most medical imaging services using a 64-slice CT scanner, PET/CT scanner, 5 ultrasound units, 2 digital tomosynthesis mammography units, nuclear medicine scanner, 2 X-ray systems, a dual-energy X-ray absorptiometry (DEXA) scanner, and several off-site centers with X-ray units. Additionally, the MR suite has two 3T Canon MRI scanners, and recently added a third.

In April 2014, the first Titan 3T MRI scanner was installed in Southwoods Imaging, and clinical utilization of the system began shortly after. Subsequently, the second Titan 3T MRI scanner was installed a few months after the first installation. After over seven years of collaborations between Southwoods Imaging and Canon Medical Systems and performing approximately 40K MRI studies, both MRI scanners were upgraded through the Vantage Galan 3T Encore Upgrade Program.

Vantage Galan 3T Encore Upgrade

In 2021, the two Titan 3T systems at Southwoods Imaging were upgraded to Encore Galan 3T. The Encore upgrades were performed in 14 days[1] and included deinstalling the Titan 3T electronics while keeping the magnets in place, performing the scanners upgrade to

Galan 3T systems, and finalizing all the required tests, quality assurances, and running procedures. In fact, comparative analysis for installation times required for new Galan 3T versus Encore Galan 3T for scanners that were installed over the last three years has demonstrated an average time saving of up to 37%. Moreover, the upgraded scanners employ the latest Canon MR software


Figure 1 The upgraded Vantage Galan 3T Encore scanner at Southwoods Imaging

version with Windows® 10 LTSC Enterprise operating system to significantly minimize Cybersecurity risks. The upgrade provided an opportunity to extend the life of the existing scanners while giving access to Canon's latest innovative MR technologies focusing on enhancing image quality, productivity, patient comfort, diagnostic confidence, and reducing scan time. These are some examples of the added technologies that were included in the upgraded scanners at Southwoods Imaging:

- **Saturn technology:** This technology increases gradient stability and reduces associated vibrations through hardening the gradient coil with high-pressure molding, as shown in Figure 2. This results in less signal blur, crisper images, and better image

resolution. In addition, the Saturn technology increases image sharpness by improving thermal stability and thus a more stable center frequency. Triple cooling layers (Figure 2) are used to suppress the temperature increase under high load, leading to more stable image quality over long scan sessions.

- **Intelligent gantry LCD color monitor:** The completely re-designed intelligent gantry interface displays important patient-related and coil information, enhances workflow, and saves set-up time.
- **Advanced intelligent Clear-IQ Engine (AiCE):** is a novel image reconstruction technique that utilizes deep learning reconstruction (DLR) to reduce image noise and improve the image's signal-to-noise ratio
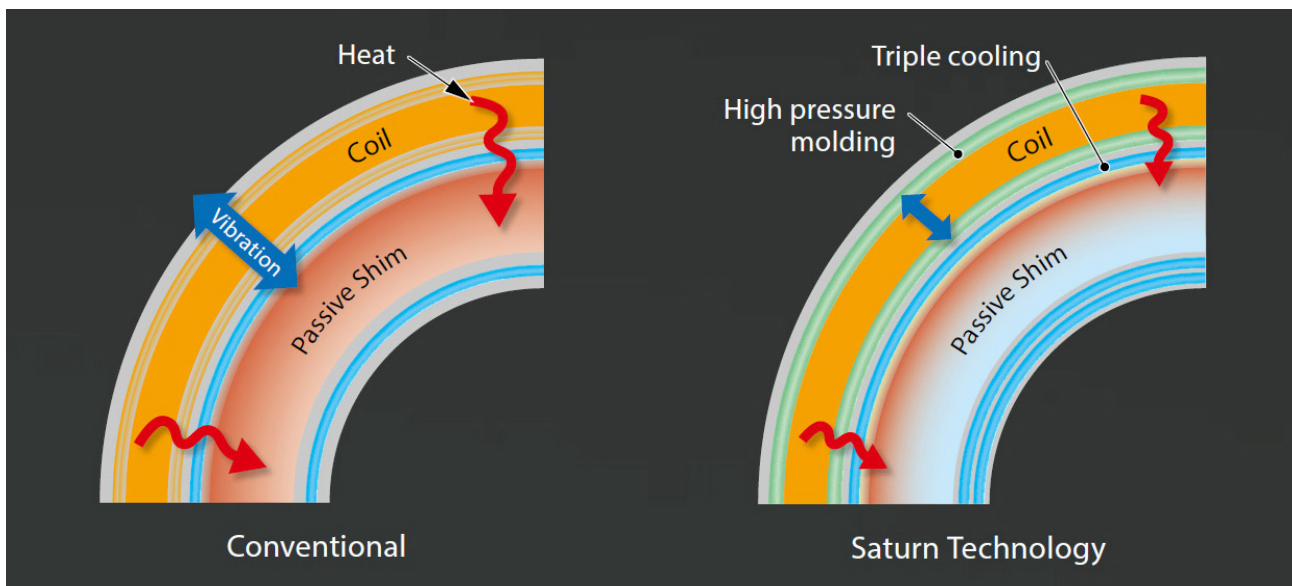
Figure 2 Canon's Saturn technology
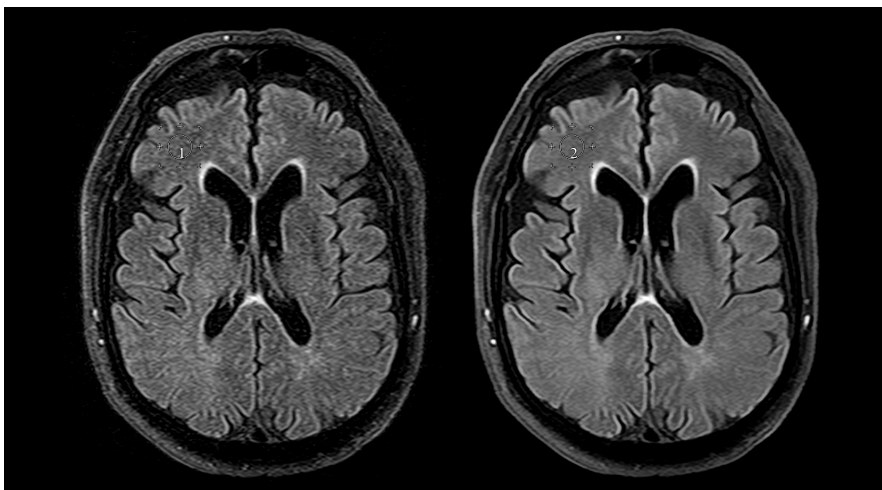
Figure 3 Brain axial FLAIR with Fat Suppression (FS) (left) acquired at Southwoods Imaging. The application of AiCE DLR (right) reduces noise from images, resulting in higher SNR images. In the indicated region of interest, the calculated average signal intensity did not change (121.6 and 121.2, respectively), but the standard deviations have significantly reduced from 14.6 (no AiCE) to 7.5 (with AiCE). This is reflected in an SNR increase of 94% which can be utilized to enhance image quality and/or reduce the scan time.

(SNR).[2] The algorithm is trained to effectively remove noise while maintaining anatomical and pathological integrity, as shown in Figure 3. AiCE is applicable to all body regions where it may enable the acquisition of high-quality MR images with higher SNR and/or shortened scan time.

- **Compressed SPEEDER (CS):** an imaging technique utilizing compressed sensing technology in both 2D and 3D acquisitions for accelerating the scan time or increasing SNR, resolution, and/or improving the image quality.
- **Quick Star:** A free-breathing and motion reduction technique that can be helpful for challenging patients who have difficulty holding their breath, especially for liver examinations or for uncooperative patients.
- **Non-invasive fat imaging and quantification:** In a single breath-held exam, Canon's Fat Fraction Quantification (FFQ) technique can simultaneously provide quantitative maps of the liver to measure proton density fat fraction (PDFF) and R2*.
- **Fast 3D Technology:** An advanced imaging technique that uses specific partial k-space filling schemes for 3D acquisitions, which allows acceleration of up to 50%. Fast 3D can be combined with other advanced technologies, such as CS and AiCE for further scan time reduction and/or image quality enhancement. This technology is compatible with most 3D sequences for both spin-echo and gradient-echo based sequences.

Figure 4 Sagittal T2W lumber acquired at Southwoods Imaging with a scan time of 3:20 min. (left). The application of CS can significantly reduce the scan time to 1:48 minutes (right).[3]

Free-breathing without Quick Star   Free-breathing with Quick Star
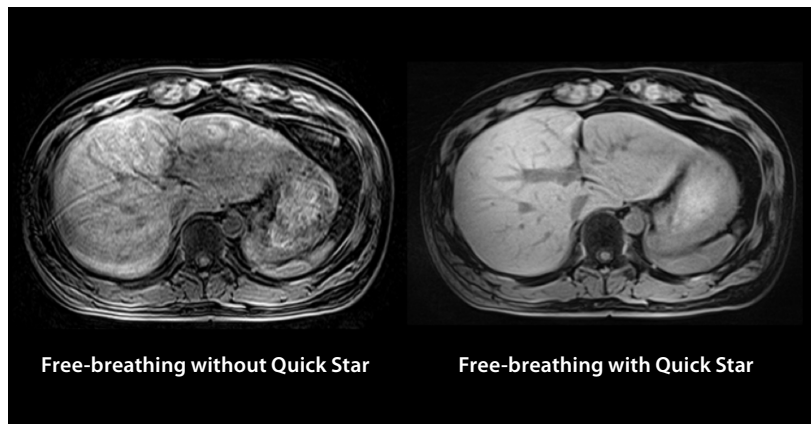
Figure 5 Axial liver free-breathing FFE acquired without (left) and with (right) Quick Star.

| PDFF | PDFF Colormap | R2* | R2* Colormap |
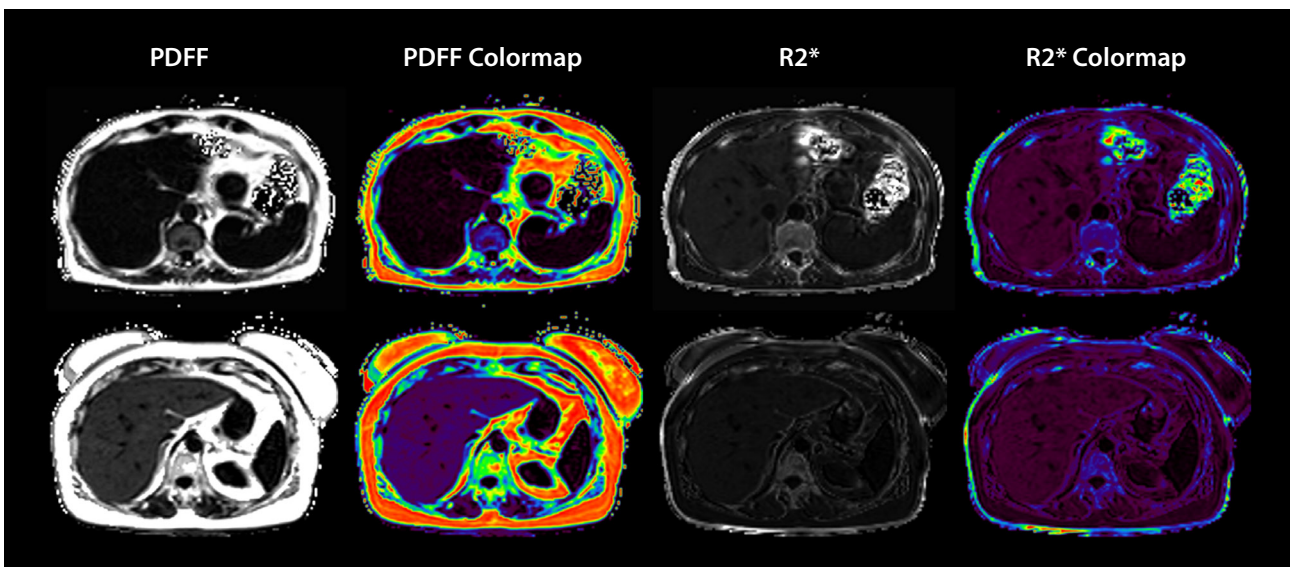
Figure 6 Two PDFF exams acquired at Southwoods Imaging in a healthy subject (first row) and a patient with mildly elevated liver fat (second row). The fat fraction measurements are 2.11 and 11.98, respectively.

- **Other features included with the upgrade:**
  - Real-time Motion Correction (RMC) can be utilized for FFE 3D, FASE 3D, and SE-EPI 2D sequences to obtain images with reduced respiratory motion artifacts by following the scanning cross section relative to diaphragm motion.
  - Water Fat Separation (WFS) DIXON provides separate water and fat images by calculating images acquired with two different echo times. It reduces the total number of scans and can be applied to the FSE 2D and FE 3D sequences.
  - Expanded SPEEDER (Exsper) is an acceleration technique in which the center of the k-space is fully sampled while higher frequencies are under-sampled. The application of Exsper in diffusion imaging allows further reduction of distortion artifacts.
  - Automatic visualization of coil selection on locator display.
  - Enhanced ForeSee View is an updated enhancement for slice planning workflow and operation. The slices in the slab for which planning is currently in progress are displayed for the MPR or MIP images in real-time. This can reduce the number of rescanned sequences due to slice planning and orientation issues.

Figure 7 Planning and scanning workflow with ForeSee View.

## Comparative Analysis Before and After the Encore Upgrade

A comparative analysis was performed on one of the upgraded scanners at the MR suite of Southwoods Imaging. The comparison window was a two-month period prior to the upgrade and then another two months post-upgrade were chosen during which the scanner was in a steady state of operation. The analysis included all MR studies performed at Titan 3T scanner (before the upgrade) in August and September 2021. Similarly, MR studies performed on the Galan 3T scanner (after the upgrade) in March and April 2022 were included in the analysis.

After the upgrade, the implementation of Canon's advanced technologies such as AiCE, CS, and Exsper along with other aforementioned technologies has helped the facility to achieve substantial improvements in workflow, scan time, image quality, productivity, and added clinical capabilities across MR exams. As shown in Figure 8 and Table 1, the average scan times from the Galan 3T were significantly reduced in all body regions compared to the Titan 3T for examinations performed during the selected two-month period.

Although the daily operation time for the MR suite at Southwoods Imaging is not changed after the upgrade, the accumulative numbers of MR studies performed are increased across the board for most of the body regions, as shown in Figure 9. This is predominantly due to enhancements in workflow and the reduction in examination times associated with the upgrade. Moreover, there is a significant increase in the overall productivity of the scanner by 28% (Figure 10) after the upgrade for the analyzed two months period. This increase in productivity has been reflected in an approximate revenue increase of 30%.[5]
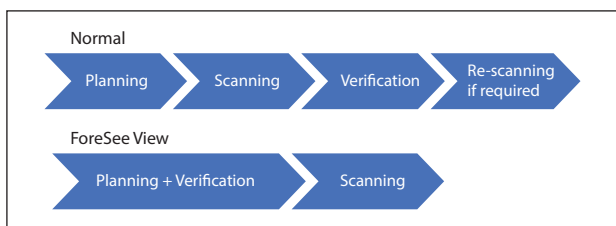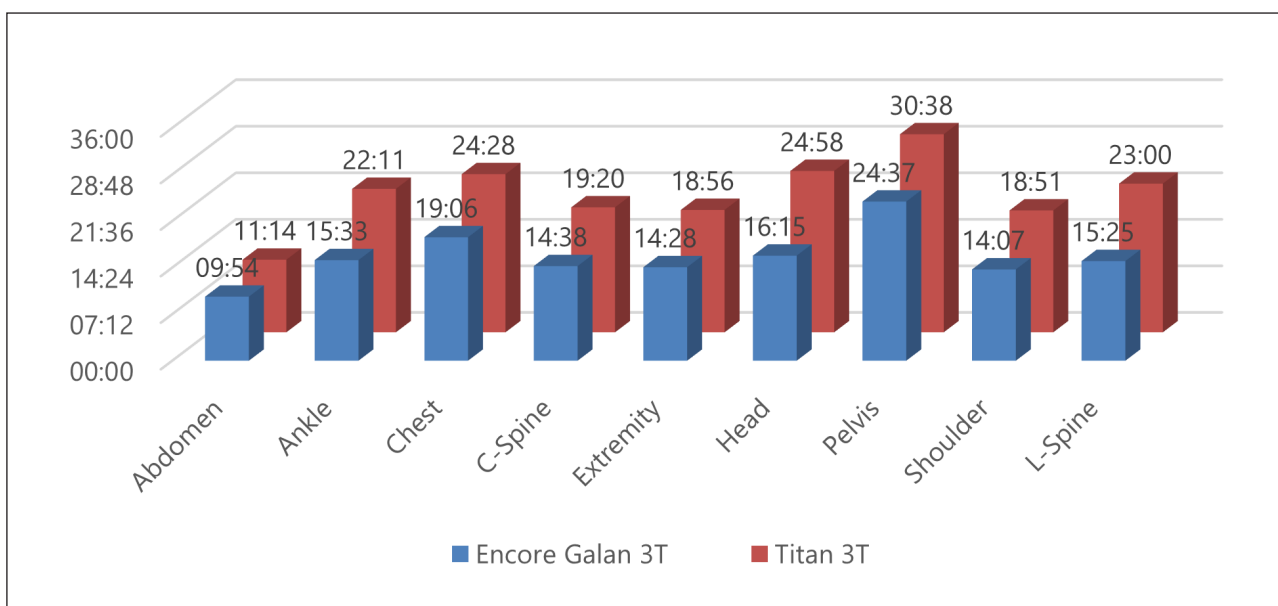

Figure 8 Average exam duration comparison over the selected two months before and after the upgrade per body region.[4]

| Anatomy	Encore Galan 3T	Titan 3T	% Change
Abdomen	09:54	11:14	12%
Ankle	15:33	22:11	30%
Chest	19:06	24:28	22%
C-Spine	14:38	19:20	24%
Extremity	14:28	18:56	24%
Head	16:15	24:58	35%
Pelvis	24:37	30:38	20%
Shoulder	14:07	18:51	25%
L-Spine	15:25	23:00	33%

Table 1 Average MR exam duration (in minutes) per body region. The last column shows the percentage of scan time reduction after the upgrade.
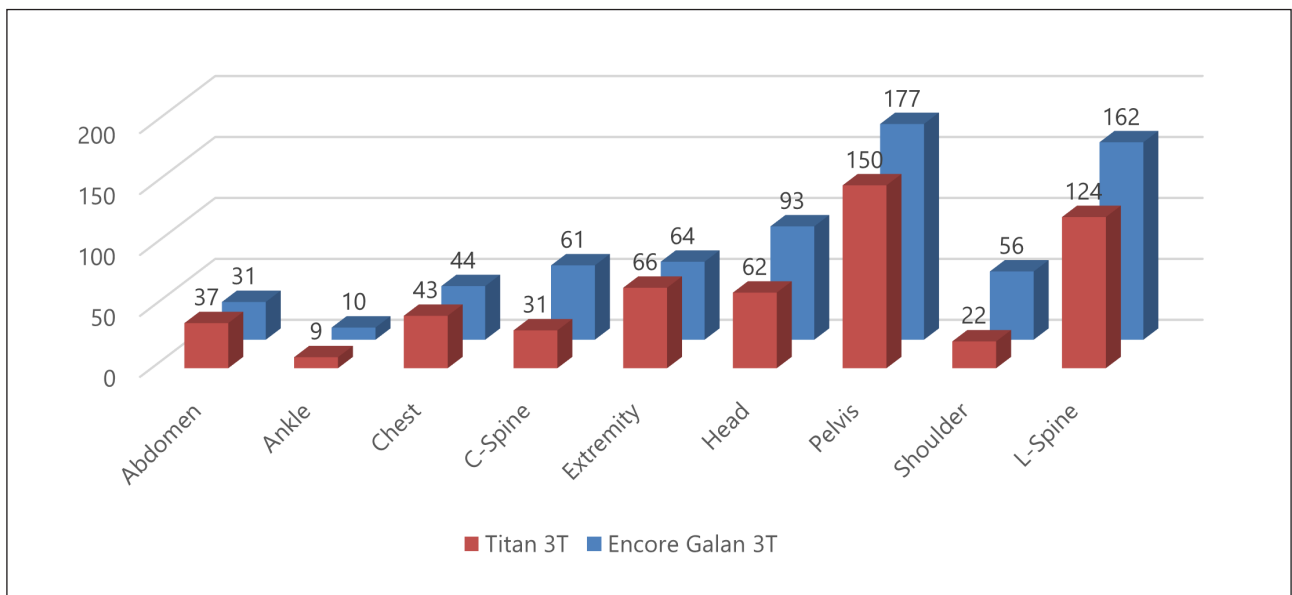
Figure 9 Comparison of the number of MR studies performed over the selected two months before and after the upgrade per body region.[6]
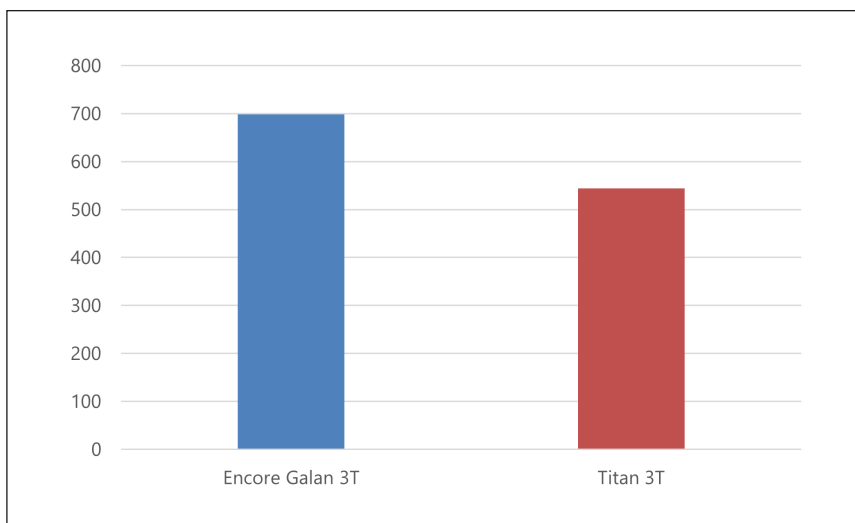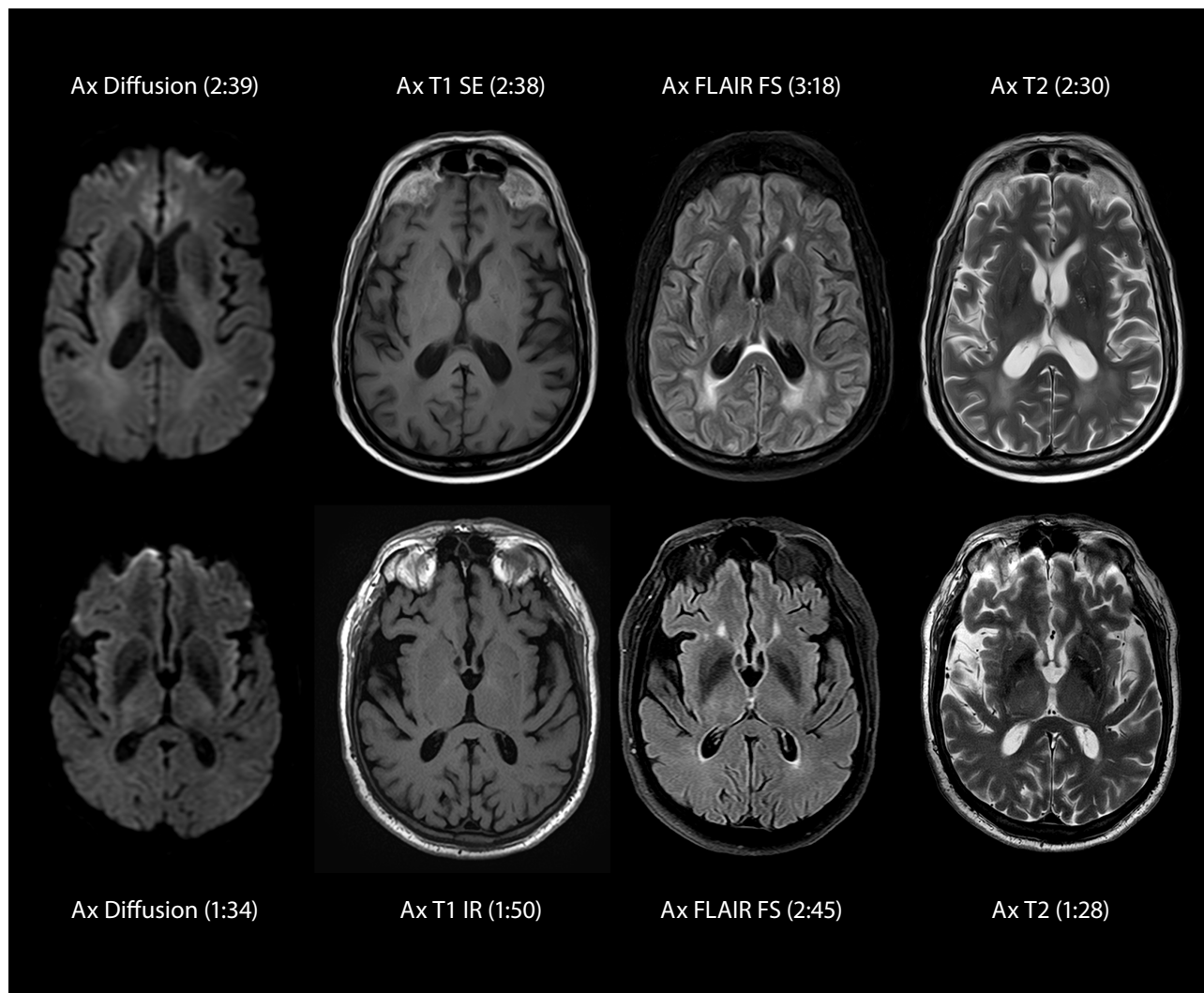

Figure 10 Cumulative number of performed MR studies with an increase of 28%.

Neurological MR Studies

For standard brain examinations, the protocol consists of axial Diffusion Weighted Imaging (DWI), T1 spine-echo (SE), FLAIR with fat suppression (FS), and T2 fast spin-echo (FSE) in addition to other sequences based on patients' exam requirements. After the upgrade, image weightings and orientations remained the same except for the T1 SE which was replaced with an inversion recovery (IR) T1 sequence. The incorporation of Canon's new technologies such as AiCE with most of the brain sequences has helped to reduce the scan time for most of the studies. With a visible enhancement in image quality, the total scan time for routine brain examinations has significantly reduced from 11:05 to 7:37 minutes[3] as shown in Figure 11.

Ax Diffusion (2:39)   Ax T1 SE (2:38)   Ax FLAIR FS (3:18)   Ax T2 (2:30)

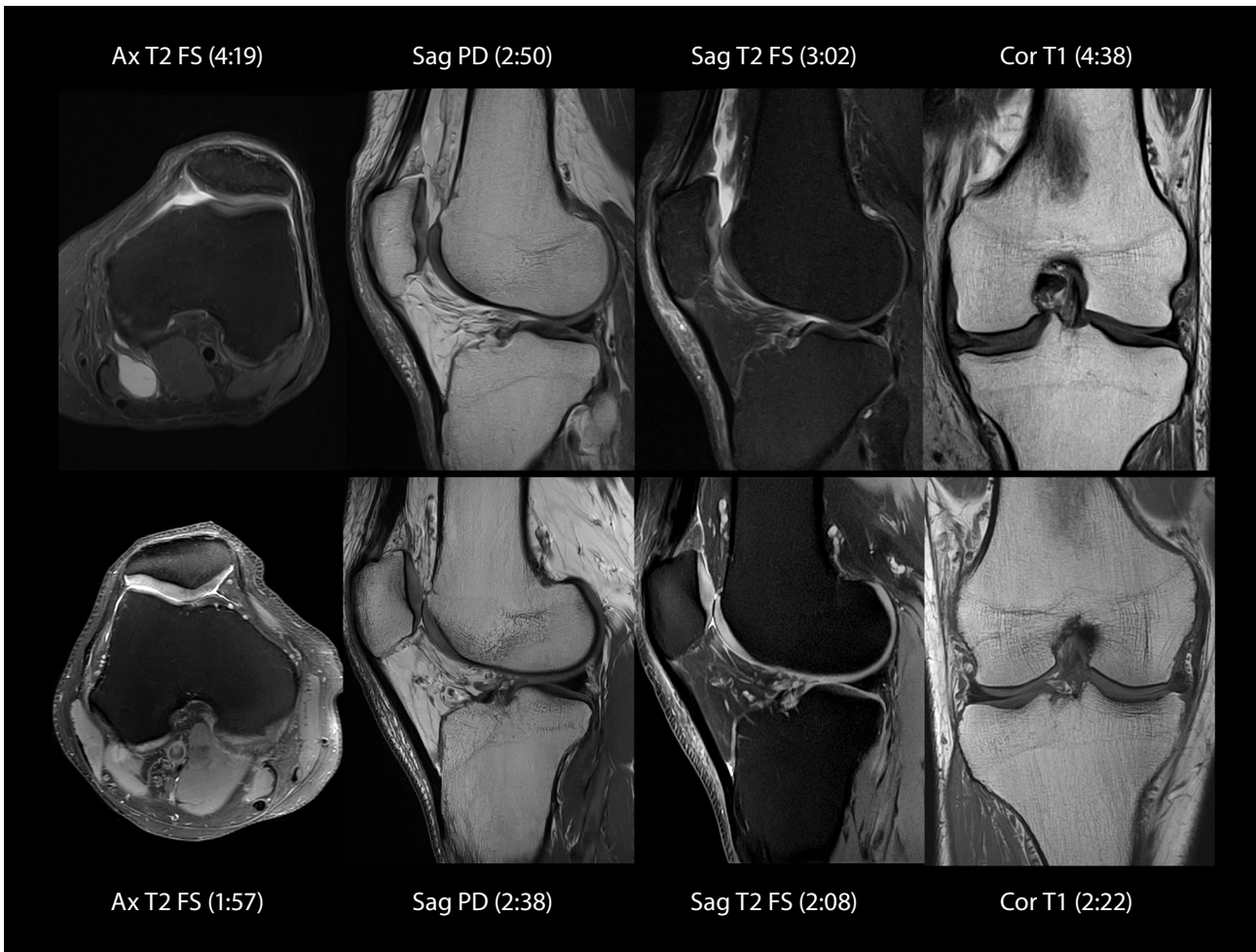Ax Diffusion (1:34)   Ax T1 IR (1:50)   Ax FLAIR FS (2:45)   Ax T2 (1:28)

Figure 11   First row is a routine brain exam acquired on Titan 3T scanner at Southwoods. The second row is another routine brain study acquired on the same scanner after the upgrade (Galan 3T) at shorter scan times for all sequences.[3]
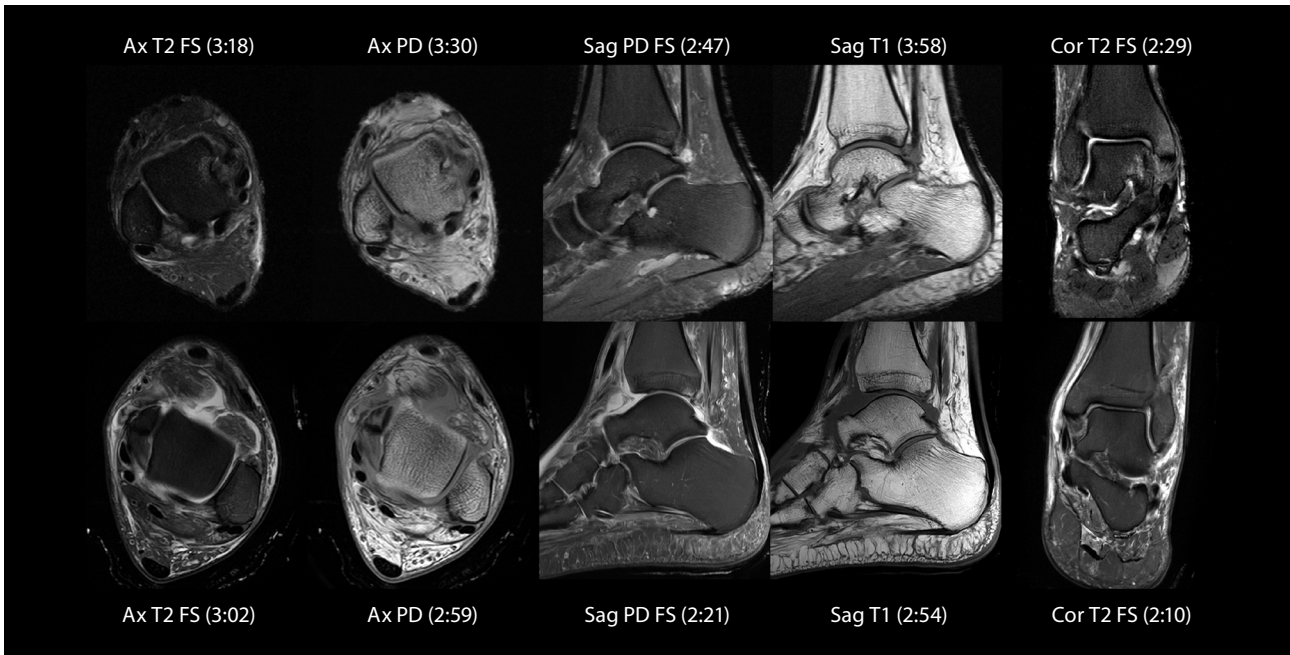
Musculoskeletal MR Studies

For most standard MSK examinations, Southwoods Imaging uses 2D proton density (PD) and T2 sequences with and without FS. For routine knee studies, axial T2 FS, sagittal PD, sagittal T2 FS, and coronal T1 are usually used along with other sequences to fulfill the clinical diagnostic requirements for each study. After the upgrade, image weightings and orientations remained the same. The addition of Canon's advanced technologies such as AiCE and CS, had helped to significantly reduce scan time for routine knee sequences from 14:49 to 9:05 minutes[3] while achieving high image quality, as shown in Figure 12.

For ankle studies, axial T2 FS, axial PD, sagittal PD FS, sagittal T1, and coronal T2 FS sequences are used before and after the upgrade. The addition of AiCE to all routine ankle sequences and CS to most has enabled scan time reduction with a significant enhancement in image quality, as shown in Figure 13.

Ax T2 FS (4:19) Sag PD (2:50) Sag T2 FS (3:02) Cor T1 (4:38)

Ax T2 FS (1:57) Sag PD (2:38) Sag T2 FS (2:08) Cor T1 (2:22)

Figure 12 First row is a routine knee study performed on Titan 3T scanner at Southwoods. The second row is another routine knee exam acquired on the same scanner after the upgrade (Galan 3T) at shorter scan times for all sequences.[3]

Ax T2 FS (3:18) Ax PD (3:30) Sag PD FS (2:47) Sag T1 (3:58) Cor T2 FS (2:29)

Ax T2 FS (3:02) Ax PD (2:59) Sag PD FS (2:21) Sag T1 (2:54) Cor T2 FS (2:10)

Figure 13 First row is a routine ankle study performed on Titan 3T scanner at Southwoods with a total scan time of 16:02 min. The second row shows the tremendous enhancement in image quality for a similar routine ankle exam acquired after the upgrade (Galan 3T) while reducing scan time to 13:26 minutes.[3]

Conclusion

The Encore Galan 3T upgrade at Southwoods Imaging has performed smoothly while both the Titan 3T's electronics de-installation and Encore Galan 3T installation processes are completed within 14 days. The full support and collaboration between Southwoods Imaging and Canon Medical Systems have allowed a successful utilization of the Encore Galan 3T upgrade. There are many benefits associated with the upgrade, such as image quality enhancement, increased patient comfort, diagnostic confidence, expanded clinical capabilities, and reduced scan time. Those benefits have directly impacted the increase of productivity on the upgraded scanners. Overall, the Galan 3T Encore upgrade program provides an opportunity to extend the life of an existing scanner, while providing access to Canon's MR latest innovative technologies enabling the facility to prioritize productivity and revenue.

Testimonials

Dr. Richard Barr, MD, Ph.D., FACR, FSRU, FAIUM
Radiologist, Southwoods Imaging

"With the upgrade to the Vantage Galan system we are scanning more patients in less scan time all while improving the image quality."

Tina Tinkey, R.T.(MR)
Chief MRI Technologist, Southwoods Imaging

"After the upgrade of the Vantage Titan to the Galan our images are better and scan times are shorter. AiCE and Compressed SPEEDER have cut our scan times by 25 to 30 percent for most of our exams providing more comfort and less chance for patient motion. We can do more patients in a day while having extra time to squeeze in any last-minute add-on patients. After the upgrade, our MR scheduling backlog has been reduced by half, our workflow has been more efficient, and our image quality has improved."

[1] Number of days required for the deinstallation and installation processes for the upgrade and doesn't include the construction time requested and performed by the site
[2] AiCE provides higher SNR compared to typical low-pass filters.
[3] Actual scan time reductions may vary by case.
[4] Average scan duration per body region may vary based on site-specific exam requirements
[5] Revenue is calculated based on the latest Medicare reimbursement rates per examed body region
[6] Number of scans per body region may vary based on scheduling and/or the selected analysis period

The clinical results, performance, and views described are the experience of the clinicians. Results may vary due to clinical setting, patient presentation, and other factors.

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