Arkadiusz Lech, MD
Exira Gamma Knife Center
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Katowice, Poland

DL-based 3D MR reconstruction leads to greater clinical confidence in Gamma Knife treatment planning

At the Exira Gamma Knife Center in Katowice, Poland, brain tumor patients are treated with a non-invasive method of stereotactic radiosurgery that uses very precisely delivered gamma rays (radiation) to treat brain tumors and other conditions. It does not require any incisions. Rather, the Leksell Gamma Knife®‡ utilizes a stereotactic headframe and 192 beams of radiation that alone are too weak to damage healthy tissue, but together deliver a powerful dose, limiting damage to surrounding tissue.

All patients undergo an MR exam on the day of treatment in the dedicated frame. As recommended in the literature, distortion correction (MP-RAGE) is utilized in the MR imaging to overcome any potential positional inaccuracies.[1]

"This stage is crucial to determining the exact size, shape and location of the lesion to be treated," says Arkadiusz Lech, MD, neurosurgeon, Head of the Exira Gamma Knife Center. "We rely on the MR imaging performed the same morning before the examination."

In 2023, the center performed approximately 600 Gamma Knife treatments on patients with meningiomas, neuromas, metastases and other pathologies such as trigeminal neuralgia in the brain. Patients come from all over Poland; however, the vast majority are in the same province as the center—Silesian Voivodeship. The total number of

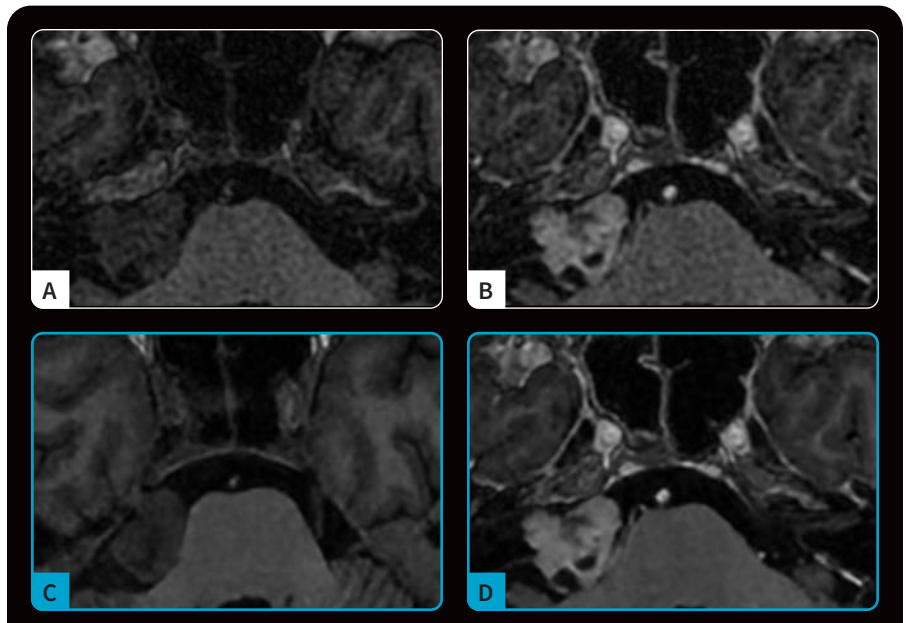

Figure 1. A 49-year-old male referred for Gamma Knife treatment of a vestibular schwannoma. Patient underwent MR imaging with full brain coverage in 6:10 min. for treatment planning. Axial 3D BRAVO, 1 x 1 x 0.6 mm (A) with conventional image reconstruction and (C) with AIR Recon DL. Post-contrast axial 3D BRAVO with same acquisition parameters, (B) with conventional image reconstruction and (D) with AIR Recon DL.

‡ Leksell Gamma Knife is a registered trademark of Elekta.

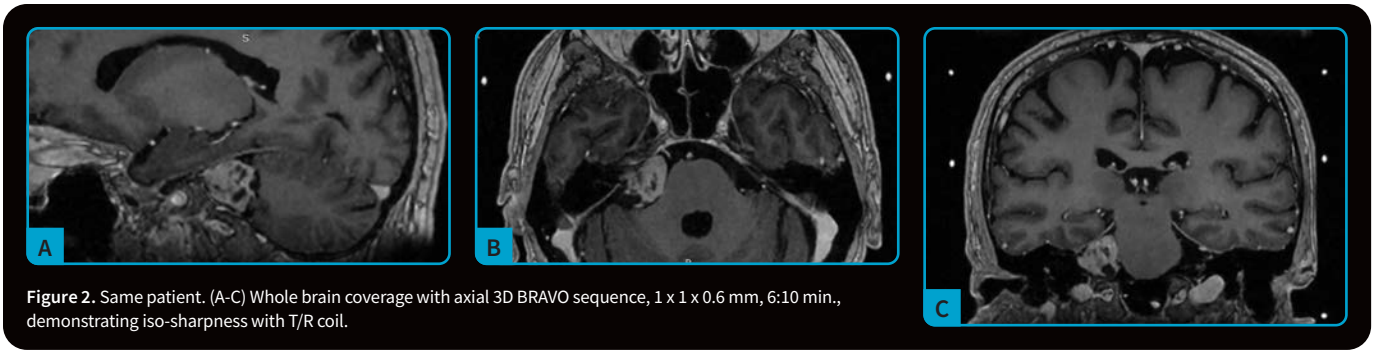

Figure 2. Same patient. (A-C) Whole brain coverage with axial 3D BRAVO sequence, 1 x 1 x 0.6 mm, 6:10 min., demonstrating iso-sharpness with T/R coil.

MR examinations performed in 2023 was 3,500, which includes the Gamma Knife patients as well as outpatient diagnostic imaging services. In 2024, the center also began to treat patients with Parkinson's disease and essential tremors using the Gamma Knife.

The center's SIGNA™ Voyager 1.5T was initially installed in 2020 and included AIR™ Recon DL, which was used with all compatible 2D sequences. In March 2024, the system was upgraded to the latest MR 30 for SIGNA™ software.

"After a short adaptation period with the initial AIR Recon DL software release and following GE HealthCare's announcement of its expansion to 3D, we couldn't wait to implement this new reconstruction technology into Gamma Knife planning. The 3D MR sequences are the core of these procedures," says Dr. Lech. "We started our adventure with AIR™ Recon DL 3D with a flex trial, but after the first test we knew there was no turning back."

While CT is often used for radiation therapy planning, the soft tissue imaging capabilities of MR make it a preferred choice for planning stereotactic radiosurgery brain tumor cases.[2]

According to Dr. Lech, CT is a supporting examination used to co-register images and is not required in most cases. In skull base tumors such as schwannomas, the team will utilize a co-registration option in the treatment planning software to superimpose CT with a bone window on MR scans to minimize potential distance/distortions errors.

"In the near future we would like to test whether the oZTEo sequence could be used in our practice for radiosurgery planning in patients with these type of tumors," he adds.

The sequences Dr. Lech relies on most for Gamma Knife planning are 3D BRAVO, both pre- and post-contrast, and 3D T2 Cube. Gamma Knife delivers an expected treatment accuracy of 0.15 mm and, therefore, 2D sequences are generally not used for treatment planning. Dr. Lech will employ the use of coronal 2D T2 in cases where the lesion is located close to the optic pathways, sinuses of the brain, in the cavernous sinus region, etc.

Prior to AIR Recon DL, reconstructed planes from isotropic (3D) sequences (e.g., scan in axial and reconstruct into sagittal and coronal) suffered from poor image quality. Now with AIR Recon DL 3D, he cannot tell the difference between the acquired plane and the post-processed plane.

"All reformatted planes are as good as the original plane. That gives us such comfort and greater confidence in our planning," Dr. Lech says. "What we appreciate the most is the iso-sharpness of the images."

Iso-sharpness, a term coined by Pascal Roux, MD, Centre Cardiologique du Nord, Paris, refers to the uniformity of image sharpness in each dimension of an isotropic acquisition. With AIR Recon DL, a user can achieve iso-sharp images in all planes, not just the acquisition plane.

In most patient cases, Dr. Lech uses images that are zoomed in to define treatment targets, which can result in additional SNR loss. For this reason, the center uses the highest strength for AIR Recon DL to capture the biggest potential SNR gain.

They also determined that fewer sequences could be acquired due to the better image quality and image sharpness with AIR Recon DL 3D. For example, in patients where changes in the lesion size or shape were difficult to define, the center would capture additional planes and sequences prior to implementing AIR

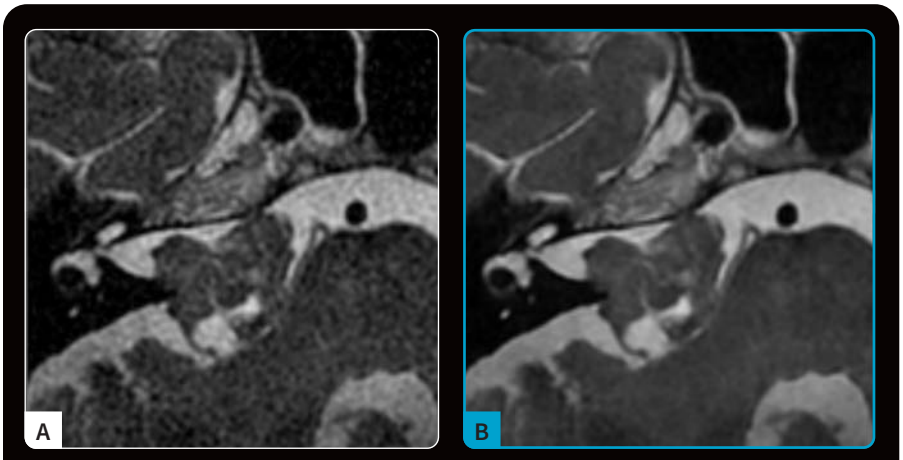

Figure 3. Same patient. Axial 3D T2 Cube, 0.7 x 0.7 x 1 mm, 4:49 min., 54 slices. (B) Image processed with AIR Recon DL.

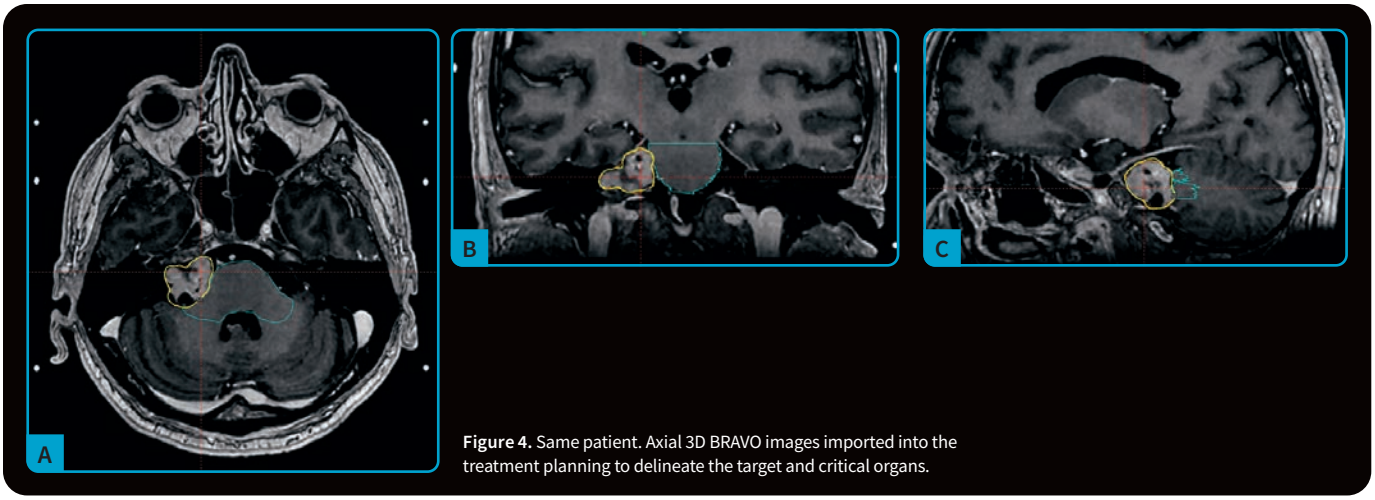

Figure 4. Same patient. Axial 3D BRAVO images imported into the treatment planning to delineate the target and critical organs.

Recon DL 3D. Now, they can more confidently determine these changes. With the boost in image sharpness, scan times were also reduced by changing NEX from 2 to 1.

"We were blown away by the difference with AIR Recon DL reconstructed images and conventional reconstruction."

Dr. Arkadiusz Lech

The center must use the T/R birdcage coil because it is the only coil that will fit over the Gamma Knife frame. This coil cannot be used with parallel imaging and the SNR is typically poorer than if other head coils could be utilized.

"In my opinion, now it would be difficult to tell that these images were acquired using a T/R coil. Our images look better than anything I've seen that our patients share from outside of our facility," says Dr. Lech.

The higher image quality allows for a smoother workflow and easier definition of structures/markers during treatment planning. "The isodose that we draw while planning matches perfectly the therapeutic isodose with an accuracy of 0.15 mm," Dr. Lech adds. "This method is super selective and coverage is 100% the same. We especially noticed a huge gain in pituitary tumor planning, where we've seen a massive leap forward when it comes to image quality."

In addition to higher clinical confidence, patient comfort has increased due to the shorter scan times and a shorter wing-to-wing procedure. He notes that the facility is dedicated to providing patients with an atmosphere where they feel comfortable and their stress levels are reduced.

"We treat patients the way we would want ourselves and our loved ones to be treated."

Dr. Arkadiusz Lech

"With AIR Recon DL 3D, we perform fewer sequences but gain in the quality of the examination," he says. "AIR Recon DL 3D is an important factor in our success, no one would even consider turning it off. The shorter MR examination with higher image quality allows us to define the target of treatment and critical organs with greater confidence and faster. Simply, we don't waste time determining where the border is."

References

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