

An Algorithm for Creating the Synthetic Myelography CT from the Plain CT of Lumbar Spine Using Generative Adversarial Networks -Multicenter study-

Ryo Itoga, Terufumi Kokabu, Katsuhisa Yamada, Yoshinori Hyugaji, Jun Wakasa, Yasushi Yanagibashi, Takahioko Hyakumachi, Yoshihiro Hojo, Ken Nagahama, Koji Kato, Masahiro Kanayama, Ryo Fujita, Tomohiro Shimizu, Hideki Sudo, Norimasa Iwasaki

INTRODUCTION:

Magnetic resonance imaging (MRI) is the gold standard for diagnosing lumbar spine diseases. However, it is contraindicated in certain patients, such as those with cardiac pacemakers, ferromagnetic implants, or claustrophobia. In such cases, alternative imaging modalities are required. CT myelography (CTM) is one such alternative, offering high diagnostic accuracy but at the cost of being highly invasive due to injection of a contrast medium into the intradural space. Although a less invasive method is the plain CT, it lacks sufficient visualization of the spinal canal for detailed assessment. Cycle-consistent generative adversarial network (CycleGAN) can learn the features of images with similar shapes in two domains and perform bidirectional translation between them. The purpose of this study is to develop an algorithm using CycleGAN that generates synthetic CTM from plain lumbar spine CT and to evaluate its accuracy.

METHODS: Data from 59 patients who underwent plain CT or CTM at two hospitals between December 2024 to March 2025 was included. The exclusion criteria were as follows; (1) Injection of a contrast medium into the inappropriate space; (2) Inserting implant into vertebrae; (3) Patients with bone metastasis and intradural tumor. Totally, 19391 images from 58 patients were used to train the CycleGAN model. For the validation, we prepared data from nine patients who underwent plain CT and MRI at another hospital; each three cases of lumbar canal stenosis (LCS), lumbar disc herniation (LDH) and controls without spinal disease. CT images with marked spinal canal (mscCT) images were generated based on corresponding MRI images. The plain CT images from these patients were translated into synthetic CTM using the trained CycleGAN model. To evaluate the consistency between the synthetic CTM and the mscCT images, the spinal canal regions and bone regions were binarized respectively: the target area was labeled as white, and the surrounding tissues as black. Precision, recall, intersection over union (IOU), and F1 score were calculated to quantify the overlap between corresponding regions in the two binary images (Figure1). The overall study flow is shown in Figure2.

RESULTS:

The examples of the synthetic CTM, the mscCT and the plain CT are demonstrated in Figure 3. In 2872 images of the synthetic CTM, there are 17 images (0.59%) where the trained CycleGAN model could not generate contrast enhancement from the plain CT. In the consistency between spinal canal regions on the synthetic CTM and on the mscCT images, the average precision, recall, IOU, and F1 score of all images were 0.82, 0.83, 0.71 and 0.82, respectively. For the bone regions, these values of all images were 0.69, 0.78, 0.57 and 0.73, respectively. Detail values of each disease group are presented in Table 1. The reconstructed sagittal and coronal images from synthetic CTM are illustrated in Figure 4.

DISCUSSION AND CONCLUSION: To our knowledge, there are no published studies about creating the synthetic CTM using CycleGAN. During the image translation, the spinal canal was well delineated, and bone morphology was preserved. Given the commonly accepted thresholds of IOU > 0.5 and F1 score > 0.7, our algorithm showed acceptable performance in both the spinal canal and bone regions in all disease groups. Other evaluation metrics demonstrated similar trends. These results suggest that synthetic CTM from plain CT has the potential as an alternative imaging modality for patients who can't undergo MRI. Meanwhile, there are some problems and limitations of this study. IOU and F1 values were lower on the bone regions than the spinal canal regions, because some of the synthetic CTM images exhibited erroneous enhancement inside bone regions although it may not affect the spinal canal evaluation. Second, the surrounding tissue apart from the spinal canal and bone regions were not evaluated. To solve these problems, it is necessary to increase more images from many cases and to modify CycleGAN model.

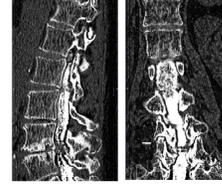
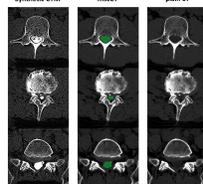
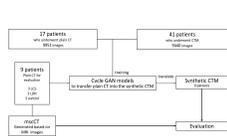
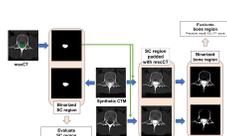
Figure 1. The evaluation of the synthetic CTM

Figure 2. Overall study flow

Figure 3. Examples of each images

Figure 4. Reconstructed images from synthetic CTM

Table 1. Detailed results for each disease group



	LCS	LDH	Control
Spinal canal regions			
Precision	0.80 (0.15)	0.82(0.15)	0.86(0.073)
Recall	0.81 (0.16)	0.84 (0.068)	0.83 (0.070)
IOU	0.68 (0.15)	0.71 (0.15)	0.73 (0.072)
F1 score	0.80 (0.15)	0.83 (0.074)	0.84 (0.053)
Bone regions			
Precision	0.69 (0.080)	0.67 (0.080)	0.72 (0.10)
Recall	0.77 (0.037)	0.77 (0.026)	0.76 (0.060)
IOU	0.56 (0.056)	0.56 (0.061)	0.60 (0.085)
F1 score	0.72 (0.047)	0.71 (0.051)	0.75 (0.067)

Mean (SD)