Original Article

# Evaluation of Radiography and CT Scanning for Diagnosing Intervertebral Disc Diseases and Complications in Dogs

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## ABSTRACT

**Background:** Intervertebral disc disease (IVDD) is a common cause of neurological disorders in dogs. Although radiography is widely accessible and economical, computed tomography (CT) may provide greater diagnostic accuracy for identifying intervertebral disc lesions and associated complications.

**Methods:** This study aimed to compare the diagnostic sensitivity and accuracy of radiography and CT in detecting intervertebral disc diseases and related complications in dogs and to evaluate the potential role of radiography as an initial screening method.

**Results:** CT scans had higher sensitivity and accuracy than radiography in diagnosing intervertebral disc complications. Radiography performed well in identifying decreased intervertebral disc space, disc calcification, and spondylosis, whereas CT scans showed higher accuracy in diagnosing disc herniation, extrusion, and protrusion.

**Conclusion:** Radiography is an accessible, rapid, and economical method for the initial screening of intervertebral disc complications. Although both methods are applicable in cases involving calcification, fracture, spondylosis, and luxation, CT scans offer greater accuracy and sensitivity, and their ability to produce three-dimensional images and display details makes CT scanning a more suitable option for definitive diagnosis, particularly when disc material extrusion or protrusion is suspected.

**Keywords:** Computed tomography scan (CT scan), Dog, Intervertebral disc, Radiography, Veterinary imaging

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## Introduction

Intervertebral discs connect vertebrae and support the axial skeleton. They also allow the passage of peripheral nerves and protect the spinal cord. Intervertebral disc disease (IVDD) is a common term in veterinary medicine, referring to a range of injuries and degenerative changes in intervertebral discs (Fenn et al., 2020). This disease is the most common cause of spinal cord dysfunction in dogs, accounting for approximately 2.3-3.7% of referrals to veterinary hospitals, with a lifetime risk of 2% in dogs (Bergknut et al., 2012; Priester, 1976).

Extensive studies have shown that the incidence of intervertebral disc degeneration in large dog populations, including samples of 677000 dogs, is approximately 27.8% (Bergknut et al., 2012). The first description of IVDD dates back to the late 1800s, and more advanced classification systems, such as the division based on histopathological changes presented by Hansen and Olsson, are still used in current studies. Diseases associated with the intervertebral disc include intervertebral disc extrusion (IVDE), intervertebral disc protrusion (IVDP), acute non-compressive nucleus pulposus extrusion (ANNPE), and hydrated nucleus pulposus extrusion (HNPE). (Da Costa et al., 2020; Hansen, 1959; Olsson, 1951).

Intervertebral disc herniation is a common type of IVDD that causes local displacement of a portion of the disc and is divided into three main types: Hansen type 1 (acute disc extrusion, IVDE), Hansen type 2 (chronic disc protrusion, IVDP), and Hansen type 3 (traumatic extrusion). Clinical signs of more acute types, such as Hansen types 1 and 3, usually include varying degrees of spinal cord compression and painful myelopathy with acute onset, while type 2 manifests as chronic, often painless myelopathy in older, non-chondrodystrophic breeds (Fenn et al., 2020).

The prevalence of IVDD varies among breeds and is higher in chondrodystrophic and older dogs. Several imaging modalities—including radiography, myelography, MRI, and CT scanning—are utilized to diagnose this disease (Da Costa et al., 2020). CT scanning is currently considered an accurate method for diagnosing IVDD; however, limited access to centers equipped with this technology, high costs, and concerns about the effects of radiation exposure, such as an increased risk of mutagenesis, have limited its widespread use. Furthermore, given the lack of comparative studies on the diagnostic value of radiography and CT scans for assessing IVDDs in dogs, this study aimed to evaluate and compare the diagnostic accuracy of radiography and CT scanning in assessing IVDD in dogs.

## Materials and Methods

Dogs with incomplete imaging records were excluded. Data from 61 dogs with intervertebral disc complications that underwent spinal radiography and CT scans at the Small Animal Hospital, Faculty of Veterinary Medicine, University of Tehran, over a three-year period (2021-2024) were analyzed. Dogs were included regardless of age, sex, breed, or weight.

Digital radiography (DR) images were taken using a Kodak Carestream device in two standard ventrodorsal (VD) and lateral views of the spine. Exposure factors were adjusted based on the animal's body size, with kilovoltage (kV) ranging from 50-80 and milliampere-seconds (mAs) set at 8. For computed tomography, a Siemens Somatom-Spirit 2-slices CT scanner was used. Animals were placed in sternal recumbency under general anesthesia, with their heads toward the gantry and their forelimbs extended forward. Imaging was performed at the highest achievable resolution, with a tube rotation time of 1 second and a slice thickness of 1 mm.

Statistical analysis was performed using SPSS. Chi-square and Fisher's exact tests were used to compare qualitative data. The kappa coefficient was used to assess the degree of agreement between radiography and CT scan results (Table 1). A $P<0.05$ was considered statistically significant.

## Results

Six indicators were evaluated to compare the accuracy of the two imaging methods: intervertebral disc space reduction (41 cases of disc space narrowing, Table 2), disc calcification (31 cases of disc calcification, Table 3), spondylosis (27 cases, Table 4), discospondylitis (8 cases, Table 5), luxation (6 cases, Table 6), and vertebral fracture (6 cases, Table 7). The results indicated a statistically significant difference between radiography and CT scanning across all assessed criteria ($P<0.05$). The kappa coefficient was used to measure the degree of agreement between the two methods. Agreement was considered adequate when the kappa value exceeded 0.6, suggesting that radiography and CT scanning can be used interchangeably in such cases. The results of the comparative analysis of radiography and CT scanning for assessing intervertebral disc complications and diseases are presented in Tables 2 to 7. Figures 1 to 3 illustrate some of the criteria listed above.

**Table 1.** Interpretation of kappa values

| Kappa Value | Agreement |
|---|---|
| <0.2 | No agreement |
| 0.2-0.4 | Poor agreement |
| 0.4-0.6 | Moderate agreement |
| 0.6-0.8 | Good agreement |
| >0.8 | Excellent agreement |
| 1 | Complete agreement |

The chi-square test showed a statistically significant difference between radiography and CT scanning in the decreased intervertebral disc space index (P<0.001). The kappa coefficient between radiography and CT scanning was estimated to be 0.486, indicating moderate agreement.

Radiography is more accurate then CT scanning for detecting decreased intervertebral disc space.

The Fisher's exact test showed a statistically significant difference between radiography and CT scanning in the calcified disc index (P<0.001). The kappa coefficient between radiography and CT scanning was estimated to be 0.836, indicating excellent agreement.

CT scanning is more accurate than radiography for detecting calcified discs.

The Fisher's exact test showed a statistically significant difference between radiography and CT scanning in the spondylosis index (P<0.001). The kappa coefficient between radiography and CT scanning was estimated to be 0.617, indicating good agreement.

CT scanning is more accurate than radiography for detecting spondylosis. The Fisher's exact test showed a statistically significant difference between radiography and CT scanning in the discospondylitis index (P=0.002). The kappa coefficient between radiography and CT scanning was estimated to be 0.510, indicating moderate agreement. CT scanning is more accurate than radiography for detecting discospondylitis.

The Fisher's exact test showed a statistically significant difference between radiography and CT scanning in the luxation index (P<0.001). The kappa coefficient between radiography and CT scanning was estimated to be 0.9, indicating excellent agreement. CT scan is scanning accurate than radiography for detecting luxation.

The Fisher's exact test showed a statistically significant difference between radiography and CT scanning in the fracture index (P<0.001). The kappa coefficient between radiography and CT scanning was estimated to be 0.783, indicating good agreement. CT scanning is more accurate than radiography for detecting fractures.

Some mild intervertebral disc complications may not be located at the center of the beam and may therefore remain outside the radiologist's view. CT scanning is more accurate than radiography for detecting fractures.

## Discussion

The results of current study indicated a significant difference between radiography and CT scanning in diagnosis of IVDD criteria, although the modalities agreed on some factors. The level of agreement between these two

**Table 2.** Comparison of radiography and CT scanning in the diagnosis of intervertebral disc space reduction

| Decreased Intervertebral Disc Space | No. (%) | | |
|---|---|---|---|
| | Diagnosed on X-ray | Not Diagnosed on X-ray | Total |
| Diagnosed on CT scan | 25(60.97) | 3(7.32) | 28(68.29) |
| Not diagnosed on CT scan | 13(31.71) | 0(0) | 13(31.7) |
| Total | 38(92.68) | 3(7.32) | 41(100) |

**Table 3.** Comparison of radiography and CT scanning in the diagnosis of calcified disc

| Calcified Disc | No. (%) | | |
|---|---|---|---|
| | Diagnosed on X-ray | Not Diagnosed on X-ray | Total |
| Diagnosed on CT scan | 26(83.87) | 5(16.13) | 31(100) |
| Not diagnosed on CT scan | 0(0) | 0(0) | 0(0) |
| Total | 26(83.87) | 5(16.13) | 31(100) |

**Table 4.** Comparison of radiography and CT scanning in the diagnosis of spondylosis

| Spondylosis | No. (%) | | |
|---|---|---|---|
| | Diagnosed on X-ray | Not Diagnosed on X-ray | Total |
| Diagnosed on CT scan | 16(59.27) | 10(37.03) | 26(96.3) |
| Not diagnosed on CT scan | 1(3.7) | 0(0) | 1(3.7) |
| Total | 17(62.97) | 10(37.03) | 27(100) |

**Table 5.** Comparison of radiography and Ct scanning in the diagnosis of discospondylitis

| Discospondylitis | No. (%) | | |
|---|---|---|---|
| | Diagnosed on X-ray | Not Diagnosed on X-ray | Total |
| Diagnosed on CT scan | 3(37.5) | 5(62.5) | 8(100) |
| Not diagnosed on CT scan | 0(0) | 0(0) | 0(0) |
| Total | 3(37.5) | 5(62.5) | 8(100) |

**Table 6.** Comparison of radiography and CT scanning in the diagnosis of luxation

| Luxation | No. (%) | | |
|---|---|---|---|
| | Diagnosed on X-ray | Not Diagnosed on X-ray | Total |
| Diagnosed on CT scan | 5(83.33) | 1(16.67) | 6(100) |
| Not diagnosed on CT scan | 0(0) | 0(0) | 0(0) |
| Total | 5(83.33) | 1(16.67) | 6(100) |

**Table 7.** Comparison of radiography and CT scanning in the diagnosis of fractures

| Fracture | No. (%) | | |
|---|---|---|---|
| | Diagnosed on X-ray | Not Diagnosed on X-ray | Total |
| Diagnosed on CT scan | 4(66.67) | 2(33.33) | 6(100) |
| Not diagnosed on CT scan | 0(0) | 0(0) | 0(0) |
| Total | 4(66.67) | 2(33.33) | 6(100) |

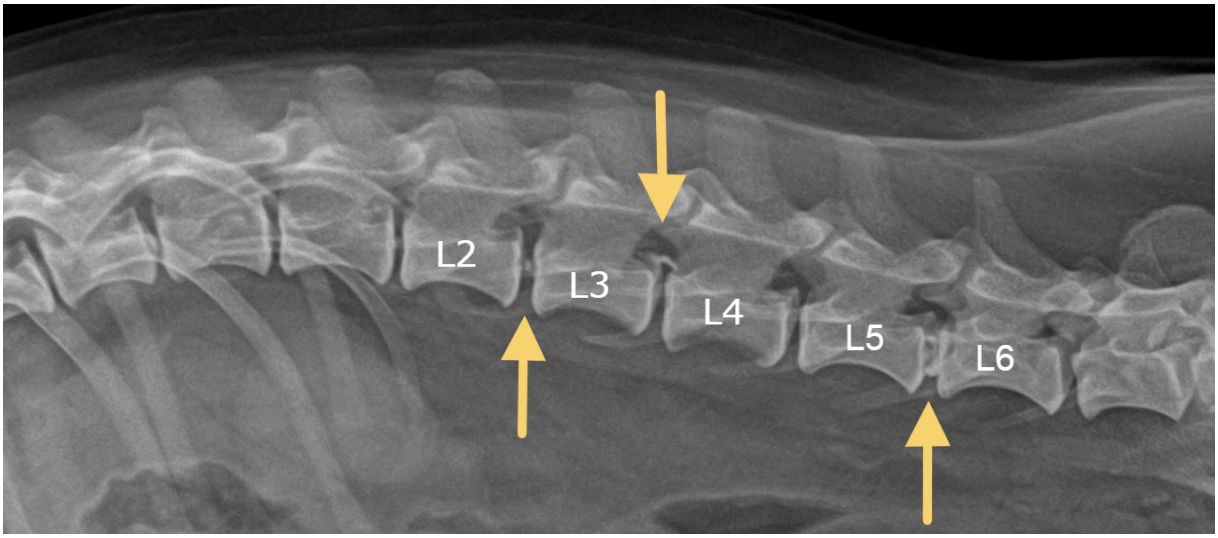



**Figure 1.** The lateral radiograph of this dog shows a focus of mineral opacity extruded into the intervertebral foramen between the L3–L4 vertebrae, associated with decreased joint space

Note: An in situ calcified disc between the L2–L3 and L5–L6 vertebrae is also noted.

imaging modalities was "excellent" for disc calcification and vertebral luxation, "good" for vertebral fracture and spondylosis, and "moderate" for intervertebral space reduction and discospondylitis. It can be concluded that, in cases, such as disc calcification, luxation, fracture, and spondylosis, radiography can yield results similar to those of CT scanning and can be used as an alternative, despite the superiority of CT scanning.

CT scans have higher accuracy in diagnosing disc herniation, extrusion, and protrusion. This superiority may be due to 3-dimentional images created by CT scans and the limitations of radiography in detecting lesions located behind bony structures. CT scans are more accurate in detecting calcified discs, spondylosis, discospondylitis, luxation, and fracture. This may be due to their ability to create three-dimensional images, their higher resolution, and their better display of

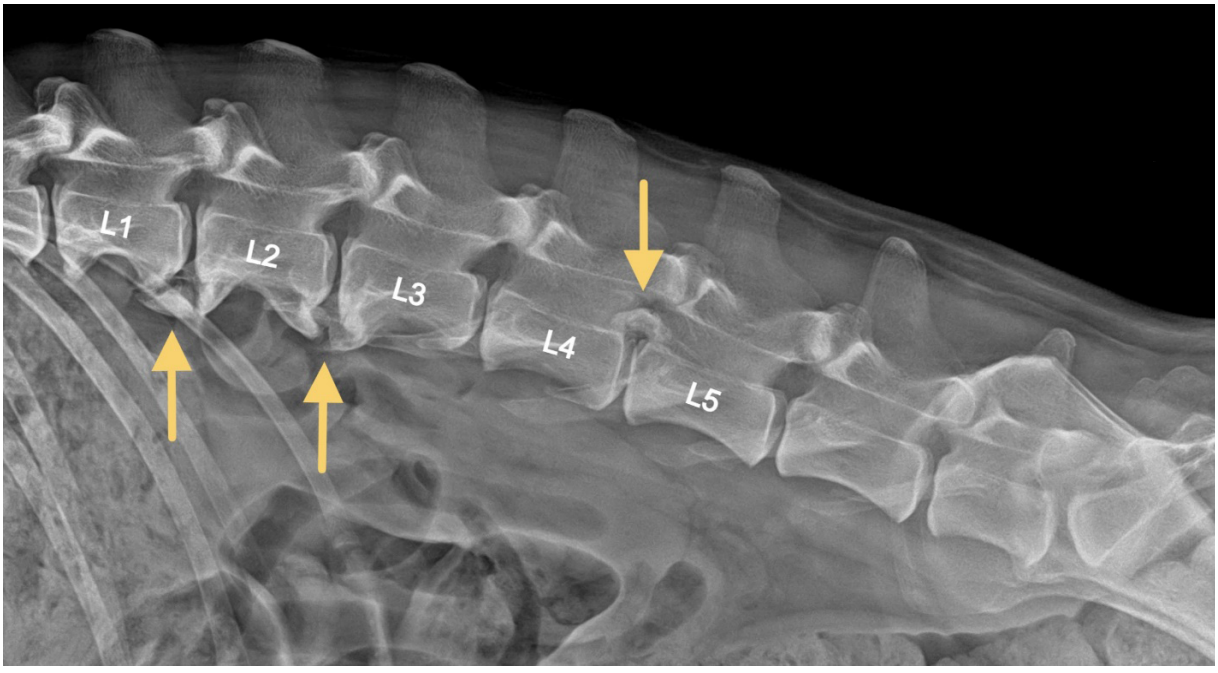



**Figure 2.** Ventral bridging spondylosis is present between the L2–L3 and L1–L2 vertebrae

Note: A focus of mineral opacity is extruded into the intervertebral foramen between L4–L5, along with decreased intervertebral disc space due to chronic discopathy.

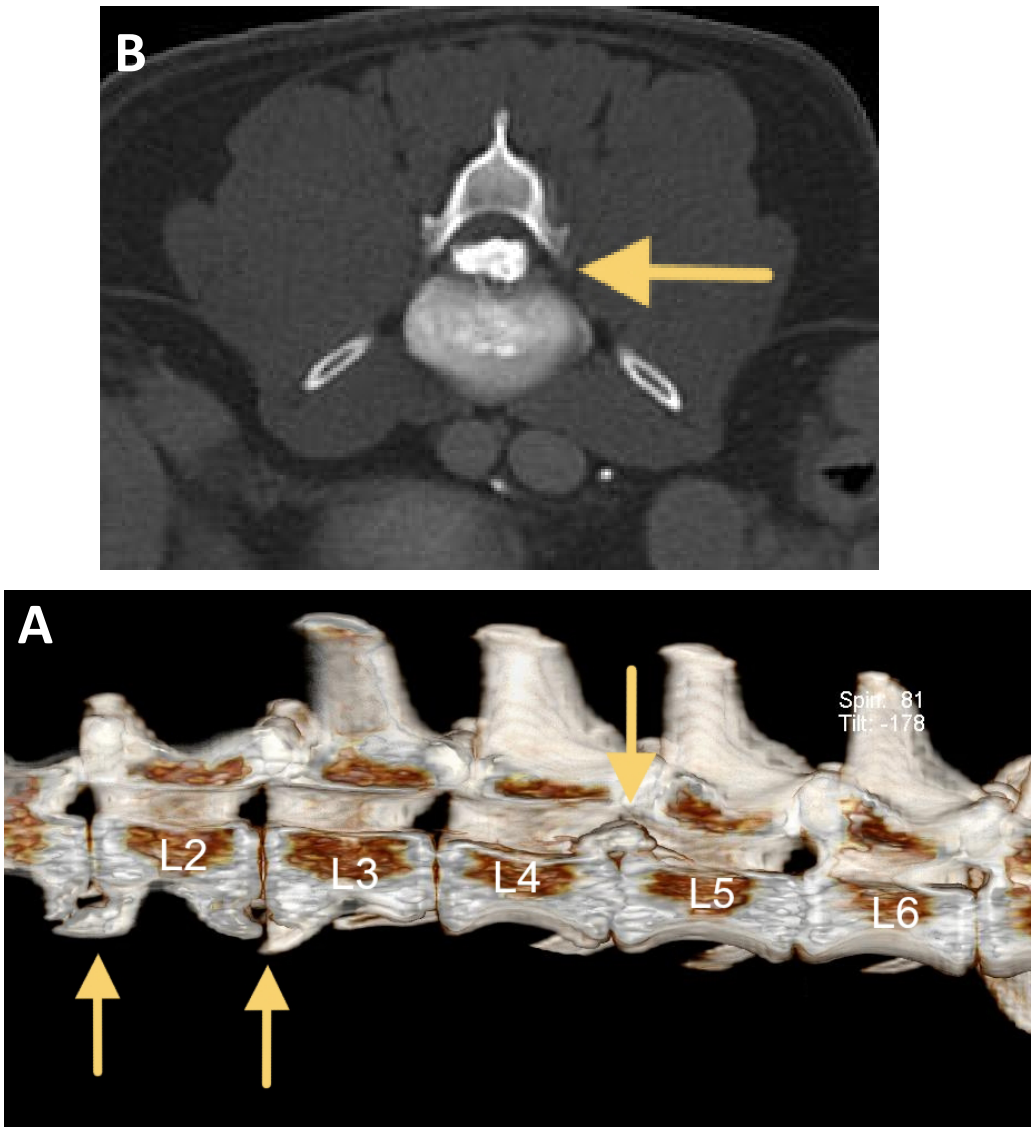



**Figure 3.** CT scan of the same patient as in Figure 2

A) At the L4-L5 level, mineralized intervertebral disc material has extruded into the spinal canal and is visible around the ventral half of the canal, extending 1.5 cm cranially and 1.5 cm caudally: The disc material occupies about 80% of the spinal canal; B) Three-dimensional reconstruction showing L4-L5 disc extrusion and ventral bridging and nonbridging spondylosis deformans between the L1-L2 and L2-L3 vertebrae

bony structures. Interestingly, contrary to expectations, radiography had higher accuracy than CT scans in detecting decreased intervertebral disc space. This finding may be related to pitfall in which radiologists overlook decreased disc space because of a major diagnosis, such as extrusion. It is possible that some mild intervertebral disc complications are not located at the center of the beam and therefore remain outside the radiologist's view.

Based on the results obtained from radiography and CT scans, the T12-T13 intervertebral space was the most common site of decreased intervertebral disc space, extrusion, and protrusion. However, for disc protrusion, involvement of the T13-L1 and L3-L4 intervertebral discs was also observed at similar proportions. Disc calcification was observed more frequently at the L1-L2 and L5-L6 vertebral intervals, and vertebral spondylosis was observed most often at L7-S1.

The present results are in significant agreement with the findings of Da Costa et al., who reported that radiography, despite its known limitations, is a reliable tool for identifying intervertebral disc degeneration and calcification during early screening. However, more accurate diagnosis of complex complications requires CT scanning, a high-resolution imaging method with superior diagnostic accuracy (Da Costa et al., 2020).

Hadžijunuzović-Alagić and Hadžimusić emphasized the capability of radiography in initial evaluation and identified CT scanning as the gold standard for diagnosing disc degeneration because it provides multidimensional images and can distinguish soft tissues (Hadžijunuzović-Alagić & Hadžimusić, 2024). Jeffery et al. considered radiography suitable for evaluating complications, such as discospondylitis, decreased intervertebral disc space, wedge-shaped changes in the disc space, and reduced distance between articular processes. However, they noted that this method has limitations in providing sufficient information for a definitive diagnosis. In contrast, CT scanning is considered an efficient and more accurate alternative to traditional imaging techniques due to its higher spatial resolution and ability to reconstruct three-dimensional images (Jeffery et al., 2013).

Hamdy et al. reported that simple radiography is not a reliable method for determining the location of intervertebral disc herniation in dogs and that advanced imaging methods, such as CT scanning, are necessary for an accurate diagnosis. The results of the current study, which indicated a high frequency of disc herniation at the T12-T13 vertebral level, are inconsistent with the findings of Hamdy et al., who reported that the most common sites of disc herniation in the thoracolumbar region are the L2-L3, L1-L2, and T13-L1 vertebral levels (Hamdy et al., 2016).

Formoso et al. and Rosenblatt et al. considered CT scanning a more accurate screening tool for detecting intervertebral disc calcification in dachshunds (Formoso et al., 2023; Rosenblatt et al., 2015).

A limitation of this study was the lack of a more precise imaging technique, such as MRI.

## Conclusion

The results of this research showed a significant difference between radiography and CT scanning in assessing intervertebral disc complications and diseases. Although both methods are used to diagnose conditions such as luxation, fracture, disc calcification, and spondylosis, CT scanning shows lesion details with greater clarity and accuracy. However, radiography alone is not sufficient due to its limitations in accurately identifying some intervertebral disc complications, such as disc extrusion and protrusion. Therefore, CT scanning at specialized centers is recommended to support more accurate final decision.

## Ethical Considerations

### Compliance with ethical guidelines

This study was not experimental in nature and did not involve the use of any animals. Consequently, no animals were harmed, as we used only pre-existing data from past cases.

### Funding

This study was extracted from the DVSC dissertation of Seyede Elahe Hoseini Amirabad, approved by the Department of Veterinary Surgery and Diagnostic Imaging, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran.

### Authors' contributions

Conceptualization and supervision: Majid Masoudifard and Sarang Soroori; Methodology: Seyede Elahe Hoseini Amirabad; Writing the original draft: Seyede Elahe Hoseini Amirabad and Farzin Bengar; Data collection: Seyede Elahe Hoseini Amirabad; Data analysis and interpretation: Hessammedin Akbarein; Review, editing and final approval: All authors.

### Conflict of interest

The authors declared no conflict of interest.

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