Canine and Feline MRI: How Does it Differ from Human MRI?

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The recognition of the importance of the human-animal bond has driven demand for veterinary services, with owners often prepared to seek out advanced diagnostics and treatments for their pets. Pandemic conditions saw a spike in pet ownership [1], with 69% of Australian households owning a pet. There has been a steady increase in the demand for advanced imaging (CT and MRI) in the last decade and the access to veterinary MRI has correspondingly increased. Companion animals (dogs and cats) are commonly affected by neurological and musculoskeletal conditions, which are suited to MR imaging.

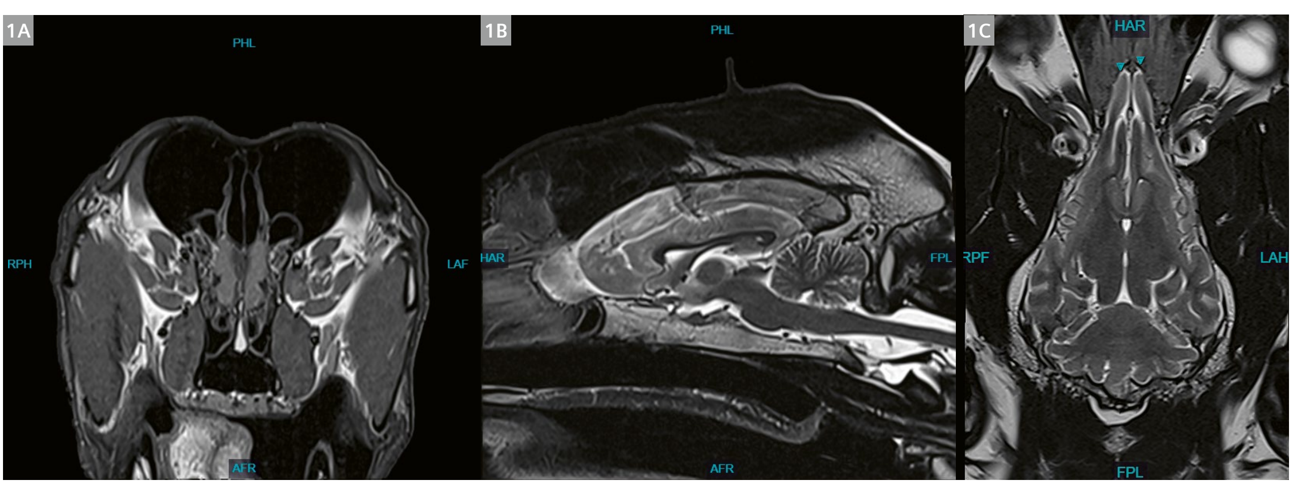
Whilst principles for MRI remain the same regardless of species, there are several important differences between veterinary and human patients.

Anatomic considerations

Dogs and cats are typically smaller than the average adult human. Veterinary patient size may have similarities with pediatric imaging, with body weights ranging from 1 to 2 kg for small-breed dogs, puppies, and kittens, and 50 to 80 kg for large-breed dogs. Mammalian anatomy is similar, but there are several species-specific quirks. For instance, dogs and cats have 13 thoracic and 7 lumbar vertebrae, compared to 12 and 5 in humans.

The obvious size discrepancy between humans and veterinary patients is often amplified, particularly in the head. The relative size of the canine or feline brain is much smaller than the human brain, because much of the carnivorous head is occupied by masticatory muscles, significant frontal sinuses, and a relatively massive nasal cavity (Fig. 1). This makes sense in an evolutionary sense: Predators and carnivores have evolved to have 2 to 3 times the bite force of humans, necessitating a significant investment in masticatory muscles.

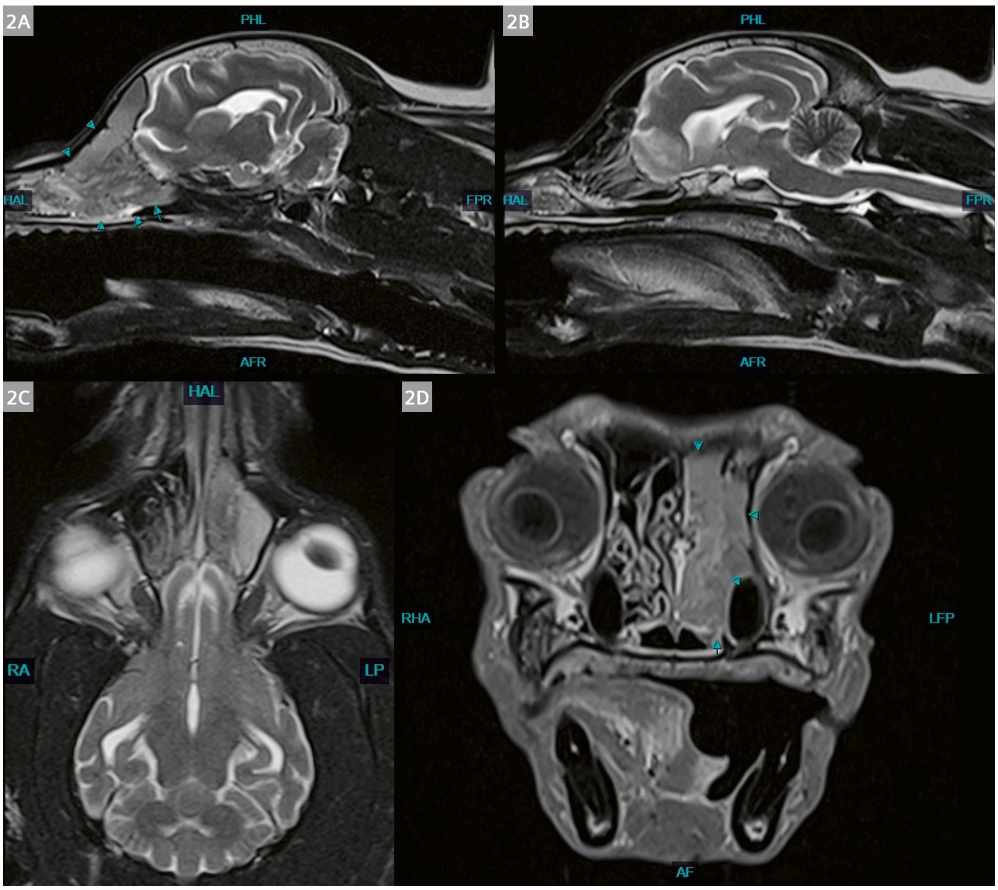
There is also considerable variation in skull length between individual dog breeds. And the length of the typical canine or feline nasal cavity puts a human's nose to shame. Intricate and delicate nasal turbinates fill a massive paired nasal cavity, opening to a cavernous paired frontal sinus. Many canine and feline nasal cavities are as long as (or longer) than the length of the brain. This can



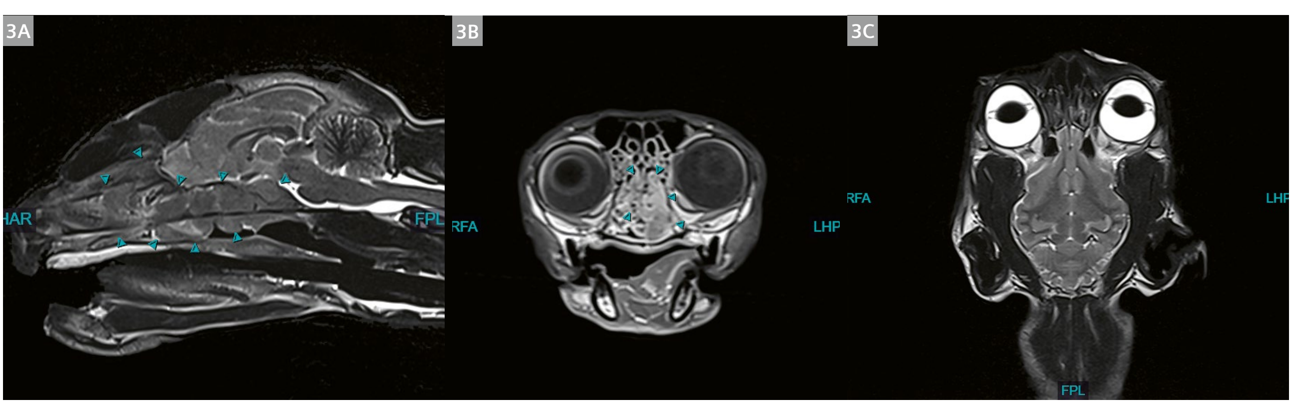
1 Great Dane
(1A) Transverse T1w image at the level of the interthalamic adhesion. Note the large masticatory muscles relative to the small size of the brain within the head. **(1B)** Sagittal T2w image at the level of the interthalamic adhesion. Note the long olfactory bulbs of the cerebrum (left, abutting the cribriform plate), the air-filled frontal sinuses dorsally, and the normal shape of the cerebellum caudally. **(1C)** Dorsal T2w image at the level of the interthalamic adhesion. Note the large olfactory bulbs of the cerebrum (arrow heads) and the large amount of muscle surrounding the skull.

lead to the development of massive nasal pathology, including nasal carcinomas or fungal rhinitis, which lend themselves to MRI evaluation (Figs. 2 and 3). Compare this to the human, where it would be unusual to have a nose longer than the diameter of the brain in any plane. The olfactory bulbs of the canine brain are significant structures on a large stalk (Fig. 1C), and the ability to detect smell (and emotion) far exceeds the analytical ability of modern instrumentation [2].

Recent decades have seen an increase in popularity of brachycephalic breeds as pets (including the French Bulldog or the British Shorthair cat). British sources suggest



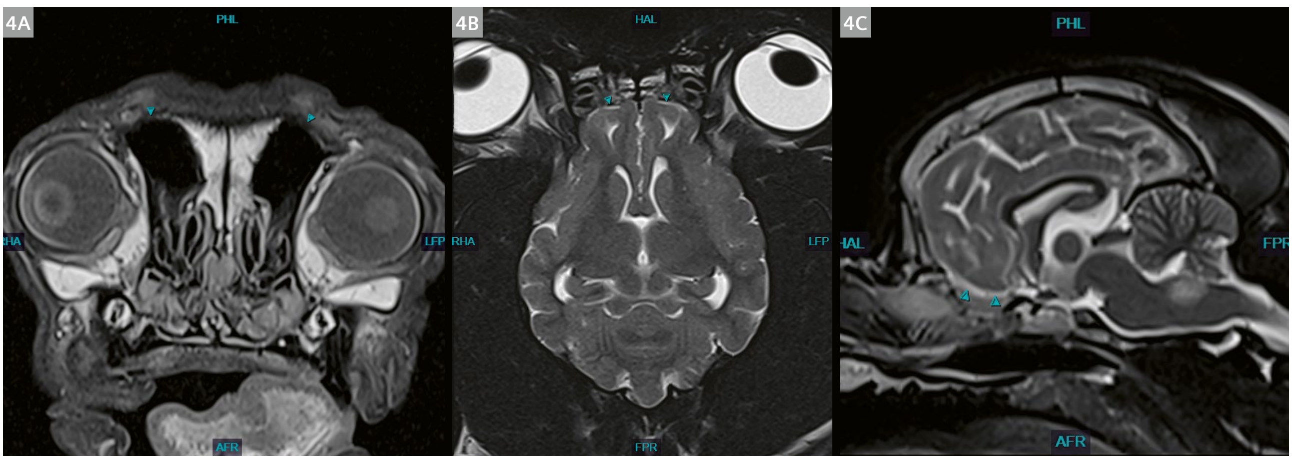
2 Maltese dog
(2A) Parasagittal T2w image through the left nasal cavity showing a large mass (arrows). **(2B)** Parasagittal T2w image through the right nasal cavity showing normal nasal turbinates. **(2C)** Dorsal T2w image showing normal right caudal nasal turbinate bones and the mass destroying the left nasal turbinate bones. Right is to the left. **(2D)** Transverse T1w with contrast showing left-sided nasal cavity mass (arrows).



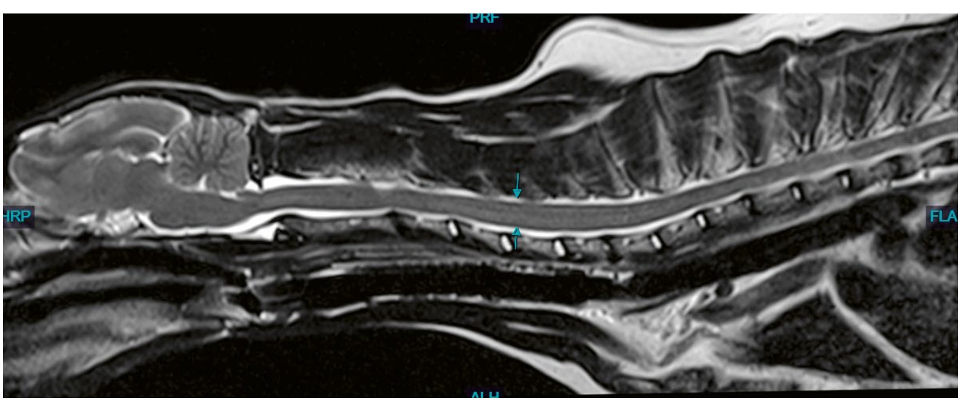
3 Cat
(3A) Sagittal T2w image showing large, isointense nasal cavity mass (arrows) throughout the ventral aspect of the nasal cavity and into the nasopharynx. **(3B)** Transverse T2w image showing isointense nasal cavity mass (arrows) throughout the ventral aspect of the nasal cavity and into the nasopharynx. **(3C)** Dorsal T2w image showing a normal dorsal feline nasal cavity with multiple fine turbinate bones.

a 400% increase in registrations of French Bulldogs over recent decades [3]. Their popularity is due to their appealing short, wide face and large eyes. The biomechanics of the canine and feline brachycephalic skull have been ethically disastrous, truncating the nasal cavity and obliterating frontal sinuses. Rather than emulating the human skull with its large brain, in these breeds, there is compression of the craniocaudal skull dimension, with the resulting deformation causing upper airway obstruction, caudal occipital malformation resulting in brain herniation, and ventriculomegaly and ocular abnormalities (Fig. 4). The results can be devastating and lead to conditions like hyperthermia, upper airway obstruction (asphyxiation), seizures, and neck pain.

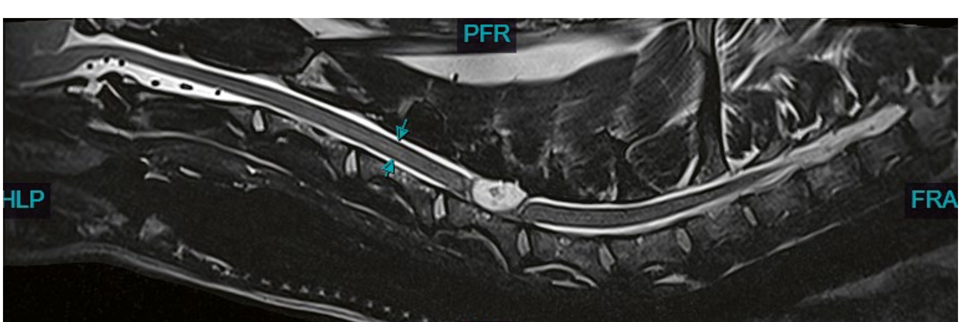
The spinal cord of a small dog or cat is relatively small and may measure only 3–5 mm in diameter. In a larger-breed canine, it may measure up to 9–10 mm in diameter (Figs. 5, 6). The increased number of thoracic and lumbar



4 French Bulldog
(4A) Transverse T1w image through the caudal nasal cavity showing small frontal sinuses (arrowheads) and minimal nasal turbinates compared to the Great Dane (1A). **(4B)** Dorsal T2w image through the interthalamic adhesion showing truncated cerebral olfactory bulbs (arrows) and minimal nasal turbinates compared to the Great Dane (1B). **(4C)** Sagittal T2w image showing truncated cerebral olfactory bulbs (arrowheads) and minimal nasal cavity.



5 Cat
Sagittal T2w image:
The height of the spinal cord between the arrows is 4 mm.

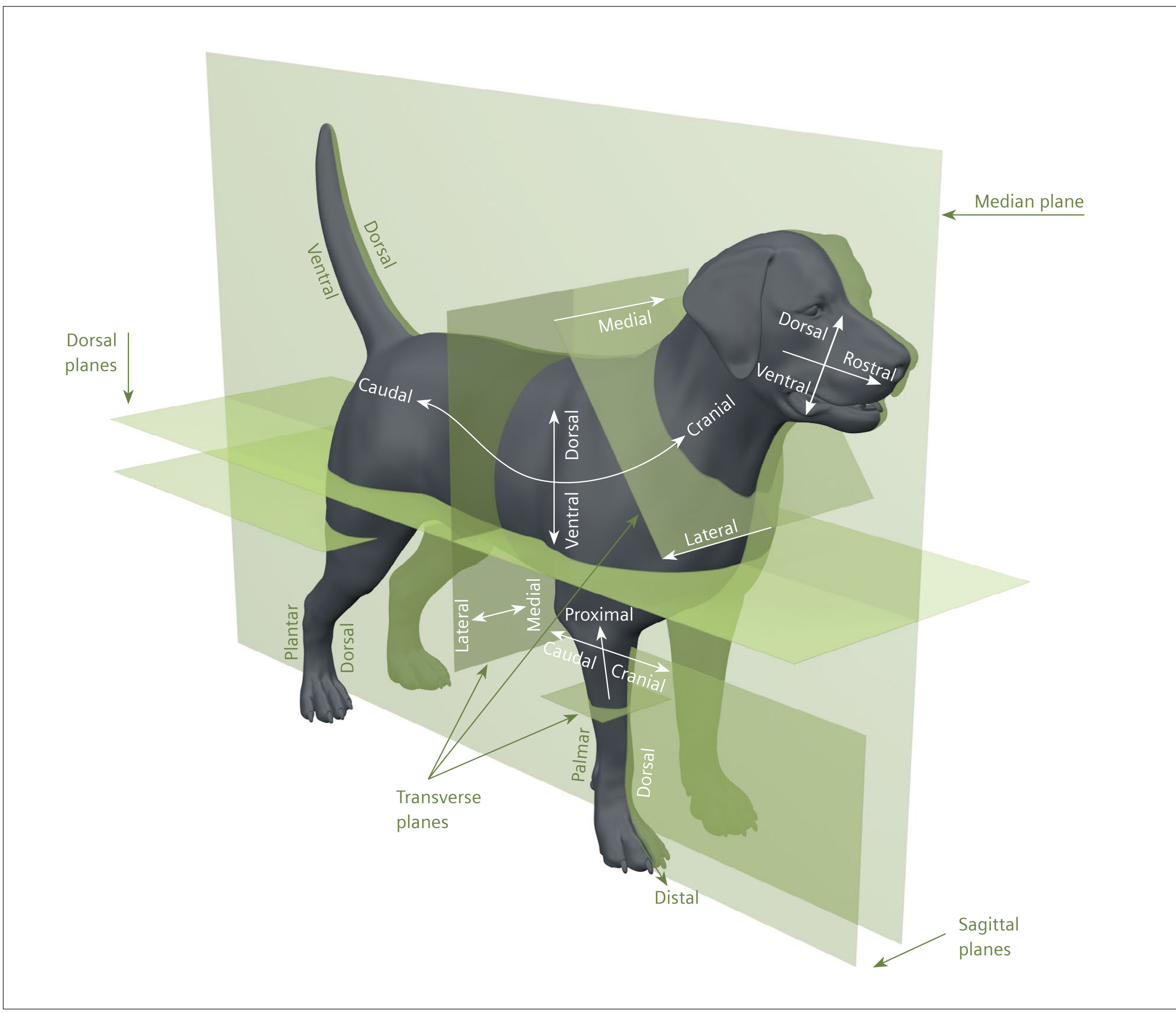


6 Labrador (35 kg)
Sagittal T2 image:
The height of the spinal cord between the arrows is 7 mm.

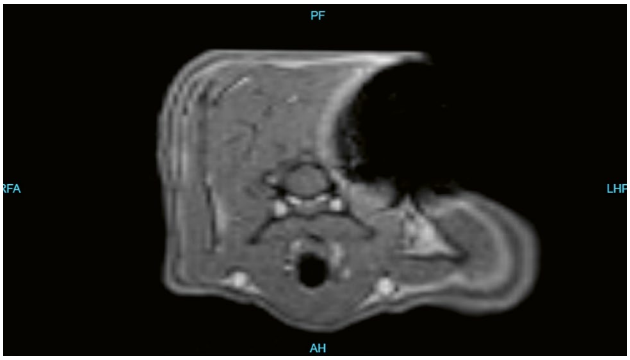
vertebrae in dogs and cats corresponds to an increased spinal cord length, with a relatively caudally located cauda equina (often caudal to L5–6, or indeed within the level of the sacrum). The longer spine and tiny cord can lead to challenges in maximizing signal from the small cord and may require longer scan times.

Anatomic planes

Anatomic planes in non-primate mammals are different from those in people because of a quadrupedal gait, compared to the bipedal gait of humans. In the head, there is a rotation of the anatomic plane reflected in a different nomenclature for veterinary patients. Whilst the sagittal plane is the same between species, the transverse plane in veterinary imaging correlates with the coronal plane in human imaging. Different terminology is used throughout the body (Fig. 7). For example, anterior and posterior planes are not routinely used in veterinary imaging (apart from some specific exceptions like the eye). The main planes are cranial (towards the head), caudal (towards the tail), dorsal (towards the spine), and ventral (towards the sternum). Differences like these can appear trivial but can lead to significant confusion when human terms are used in the veterinary context.



7 Orientations, planes of motion, and directional terms for the dog.



8 Transverse MPRAGE with contrast at the level of the caudal cervical spine of a cat. Note the left-sided magnetic susceptibility artifact created by the patient's microchip, typically placed in a deep subcutaneous location in the neck.

Artifacts

In many jurisdictions around the world, pet dogs and cats must be microchipped. Microchip placement is often in the subcutaneous tissue between the shoulder blades. This creates considerable signal void artifacts when imaging the caudal cervical spine (Fig. 8).

Anesthesia

Veterinary patients are usually completely anesthetized (with endotracheal intubation) for MRI studies. This results in still patients and excellent fidelity in positioning between different series. Anesthetized patients may still hear the noise in the magnet, so it is preferable to pack their ears with hearing protection.

Full anesthesia is useful for optimizing positioning without movement, but it comes at a cost. Body temperature tends to drop with anesthesia, which can prolong recovery time, and this effect is exacerbated in very small animals. Patients are commonly carefully wrapped in blankets for warmth, with particular attention on extremities (which, if exposed to the ambient temperature, can result in patient cooling).

Specific Absorption Rate (SAR) calculations are rarely helpful in veterinary patients. They are calculated based on assumptions about the cylindrical size of human body regions and may not correlate well with the different body size and shape of veterinary patients. Cats and dogs have smaller limbs (with much less muscle, particularly distally) than humans. Veterinary-specific calculations of SAR have not been developed. Early research suggests that body temperature tends to decrease in veterinary high-field MRI due to the effects of anesthesia [4], but careful monitoring (either way) is still required.

The best positioning for spinal imaging is dorsal recumbency, as it minimizes the effects of respiratory motion on the spine. Many veterinary centers may not have access to MRI-compatible anesthesia equipment, so the anesthetic machine (vaporizer and ventilator) is placed outside the RF cage, necessitating extra-long Bain or circle circuits with monitoring limited to heart rate, respiratory rate, expired CO_2, pulse oximetry, and blood pressure assessment. Intravenous fluid support similarly requires long extension sets to reach the patient if the fluid pumps are external to the RF cage.

Conclusion

Medical imaging technologists starting to work in the veterinary field face a steep learning curve as they adjust to different anatomy and body size, terminology, anesthesia requirements as well as different disease processes, and pathophysiology.

References

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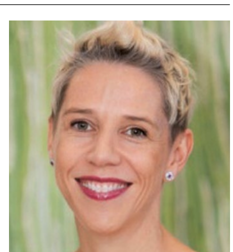

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